
Science
A Curriculum Guide
for the Secondary Level

Biology 20/30

Saskatchewan Education
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Preface

Much of the foundation for curriculum renewal in Saskatchewan schools is based on the *Directions* reports of the 1980s. The excitement surrounding the recommendations for Core Curriculum developments will continue to build as curricula are implemented to prepare students for the 21st century.

Science is one of the Required Areas of Study. It incorporates the Common Essential Learnings, the Adaptive Dimension, and other initiatives related to Core Curriculum. To make the appropriate connections from the *Directions* philosophy to the science classroom, a number of documents have been produced.

As we strive to achieve the goal of scientific literacy in Saskatchewan schools, much collaboration and cooperation among individuals and groups will be required. Science teachers, as a key part of the change process, must build on the best and prepare for the future. Others must provide support to enable this to happen.

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Introduction

Science Program Philosophy, Aim, and Goals

The philosophy and spirit of science education renewal in Saskatchewan is reflected not only in the program aim and goals, but in the documents developed to support the new curricula, and in the inservice packages designed and utilized for implementation. In addition, the philosophy for science education is closely related to the concept of Core Curriculum based on the *Directions* philosophy for Saskatchewan.

Science, as both a body of knowledge and a process of inquiry, extends beyond understanding of abstract laws and principles of nature into the realm of technology and applied sciences. Many important technological developments can be appreciated through a solid foundation in science. Applications in agriculture, engineering, medicine, and many other fields can be comprehended by someone who has a good basic understanding of science.

In an information-based society, with widespread public concerns relating to issues as complex as the protection of the environment, manipulation of genetic material, the proliferation of technologically advanced weapons systems, and various other serious and often controversial issues, a scientifically literate society is needed more urgently than ever before. While solutions to these kinds of issues are indeed difficult to find, science provides a way in which these types of problems can be understood and approached. It offers one world view which, when taken in conjunction with other world views, empowers society to make informed, rational decisions based on diverse ways of thinking about problems.

Through the exemplary leadership of a few dedicated scientists, issues of grave concern to society have been brought to the forefront of public attention. Internalized, clearly defined values need to form the foundation for decisions relating to science. Fundamental moral principles, such as respect for the dignity of all persons, respect for the value of all forms of life, the protection of the environment, the need to promote peace and understanding among all people throughout the world, and other principles of natural justice, need to be emphasized. In a world where advances in

science and technology have led to the development of nuclear weapons, with their potential for the annihilation of human life, the need for clarity and reason in scientific decision making is quite apparent.

After all is said and done, making rational decisions in a seemingly irrational world is the moral responsibility of an informed, well-educated society. While science can make no claims to have all of the solutions to complex human problems, it does provide us with the necessary knowledge, skills, and attitudes to begin to approach these problems in a unique way.

Aim and Goals

The major aim of the K-12 Science program is to develop scientific literacy in students. What, however, is scientific literacy?

For Saskatchewan schools, scientific literacy has been defined by seven **Dimensions of Scientific Literacy** (DSLs) that are the foundation for the renewed curriculum (Hart, 1987). Actively participating in K-12 Science will enable a student to:

- ! understand the **nature of science** and scientific knowledge as a unique way of knowing;
- ! understand and accurately apply appropriate science **concepts**, principles, laws, and theories in interacting with society and the environment;
- ! use **processes of science** in solving problems, making decisions, and furthering understanding;
- ! understand and appreciate the joint enterprises of **science** and **technology** and the interrelationships of these to each other in the context of **society** and the **environment**;
- ! develop numerous manipulative **skills** associated with science and technology, especially with measurement;
- ! interact with the various aspects of society and the environment in ways that are consistent with the **values** that underlie science; and,
- ! develop a unique view of technology, society, and the environment as a result of science education, and continue to extend this **interest and attitude** throughout life.

Each of these Dimensions has been defined further by a series of factors which delineate the Science curriculum. The factors of scientific literacy are defined and examples are given starting on page 31. Further information about the factors is covered in *Science Program Overview and Connections K-12*.

The study of science should help students understand the world in which they live. The objective is not to have students be able to repeat the words that teachers or scientists or others use to describe the world, although they may do that. It is to have students create their own conceptual maps of what surrounds them every day, and to realize that those concepts and the maps which describe the links between concepts are tentative, subject to questioning, and revised through investigation.

The Factors of Scientific Literacy

Before using this Curriculum Guide, teachers should be familiar with *Science Program Overview and Connections K-12*, a document that provides background information about the factors of scientific literacy. A list of the factors, their definitions, and examples of instances in science where these factors are important, or can be developed, is also found in this Curriculum Guide. Nearly all of the factors which have been identified as components of the **Dimensions of Scientific Literacy** (DSLs) can be developed in biology.

Different students will exhibit varying degrees of sophistication in dealing with some factors of scientific literacy. Some may be at a rudimentary level in understanding; others will be advanced. The teacher will need to adapt the course to meet these student variations.

In order to emphasize as many of these factors as possible during the course, and to concentrate on those less well developed, teachers must have a thorough understanding of each factor and exhibit good lesson planning and lesson reflection skills. Lesson reflection means that, at the end of the lesson, the teacher thinks about what happened. Based on assessment of student interests, understandings, strengths and needs, the teacher identifies what was covered and what needs more work. The teacher must map/web and verify the

connections among the goals, factors, and objectives. The section in this Curriculum Guide on Unit Planning, beginning on page 63, provides general and specific information regarding unit and lesson planning.

The K-12 science curriculum in Saskatchewan schools is intended to develop the understandings, abilities, and values specified by the factors of scientific literacy. The scope and depth of Biology 20 and Biology 30 is to be guided by these factors.

Related Documents

Saskatchewan Education has produced the following documents to support this Secondary Level science curriculum.

Science: A Curriculum Guide for the Secondary Level - Biology 20/30 contains the specific information needed to plan and deliver the biology courses.

Science Program Overview and Connections K-12 contains important sections on the philosophy and rationale behind the teaching of science, and on planning for instruction in science for all teachers from kindergarten to grade 12. Sections of this document will also be useful for administrators, teacher-librarians, and others.

Science: An Information Bulletin for the Secondary Level - Biology 20/30 Key Resources lists the key resources which have been recommended to help achieve the factors and objectives outlined in the Curriculum Guide. It is organized so that the resources, with page or chapter references, are listed for each topic in the Curriculum Guide.

Secondary Sciences: Biology 20/30, Chemistry 20/30, Physics 20/30 - An Information Bulletin for Administrators has information regarding the organization of this level of science, addresses implications for its implementation, and encourages support for the science program.

Science: A Bibliography for the Secondary Level - Biology, Chemistry, Physics contains an annotated listing of resources which can be used to enrich the biology program and to assist in implementing resource-based learning in the classroom. Each annotation contains a recommendation about the topic(s) for which the resource is most appropriate.

Using This Curriculum Guide

Each of the core units in this guide has a similar structure beginning with the **Unit Overview**. The **Overview** gives a brief synopsis of the unit, with some comments about the philosophy behind teaching the unit and its topics. The **Conceptual Development** section traces concepts through grades preceding grade 11.

The section **Factors of Scientific Literacy Which Should Be Emphasized** follows. The introduction and development of the factors of scientific literacy form the basis for the science program from kindergarten through grade 12. **The factors can be thought of as the prime foundational objectives for each science course.** All other elements of the curriculum support the development of these factors of scientific literacy.

The section lists the factors which should be emphasized in each core unit. Teachers are free to emphasize what they feel are the most appropriate factors in a unit, whether or not they appear on this list. This section indicates that the factors are important and should be considered and mapped when planning each unit. It is not meant to restrict the coverage to those factors listed.

The **Foundational Objectives for Biology and the Common Essential Learnings** are statements of what students should be able to achieve in biology. The stating of objectives for the Common Essential Learnings is a reminder that one of the primary foci of the biology curriculum is the incorporation of the Common Essential Learnings into science instruction. They are described as foundational because they are general, guiding objectives. Since foundational objectives in the Common Essential Learnings are meant to be achieved over a student's entire school experience, students should come to biology classes with some understanding of these concepts, gained in previous science classes and in other areas of study. Encourage the development of their understanding of the objectives which are listed, and others which are perceived as appropriate for that unit, during the study of biology.

The **Foundational Objectives** for biology describe the broad intent of the unit. They are intended to give the unit its focus and structure.

Learning Objectives which will promote accomplishment of each foundational objective can be selected from those listed or can be developed by the teacher and students. The learning objectives define more specifically what will be dealt with during the unit of study. By giving careful consideration to the learning objectives, the **Adaptive Dimension** enters the classroom, and the foundational objectives for both biology, and the Common Essential Learnings can be accomplished.

The specific content taught in the biology units of study represents selected course content that collectively is not as critical as developing the broad goals of scientific literacy. As in all other science courses from K-12, the main goal of biology is to develop the factors within the seven Dimensions of Scientific Literacy.

There are core units in Biology 20 and 30. See Figure 1. The topic(s) of the core units serve as the means for developing content, process, and values. **Full scientific literacy cannot be attained without emphasis on all of these domains.**

The sequencing of the topics is at the discretion of the teacher. Creative rearranging of the topics is encouraged. The order in which the topics are developed could be modified, or several topics could be integrated.

The **Webbing Highlights** and accompanying **Concept Web** encourage one to revisit other completed topics and will be noted in the concept web by the term "web" beside the unit referenced. Reinforcement of previously learned materials serves to emphasize the integrated nature of knowledge within the context of useful but artificial categories. This section of the concept web should only be a beginning place for teachers to discover and highlight other possible connections for students.

Science-Technology-Society-Environment (S T S E) Focus ideas are reminders to promote a critical thinking and literate scientific citizenry. Every unit should provide an opportunity for the evaluation of current technologies in terms of their own validity as scientific information and more importantly how they impact on the citizens of the local or global environment. Definitive answers are not always available and sometimes the issues may be controversial. Teachers should not mislead students but should work with the values and concerns of the community to raise to a conscious level those ideas that students will have to deal with as they make positive contributions to our society.

There are a variety of ways that the **Adaptive Dimension** can be incorporated into biology. One way is to modify teaching strategies and use correspondingly appropriate assessment. A second way is to use time for remediation, reinforcement, or enrichment. In addition, the learning environment can be adjusted. These methods, or some combination, are important. Additional ideas are given in *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) and in *The Adaptive Dimension in Core Curriculum* (Saskatchewan Education, 1992). Extension activities for the topics may also be included allowing further accommodation of the Adaptive Dimension in the program. For ideas see the Life Science section of the Science Challenge Core Unit in *Science 10: A Curriculum Guide for the Secondary Level*.

Biology is a unique curriculum designed to suit the various needs and interests of students and teachers. One biology lesson may be suited to emphasize many factors of scientific literacy, and many of the foundational objectives in both biology and the Common Essential Learnings. Another lesson may deal with only a few factors and one or two of the foundational objectives. In order to make best use of the time the teacher has with the students, each teacher should analyze the lesson before presentation to ensure that the appropriate factors and foundational objectives are developed to the maximum extent.

The diversity and flexibility of this curriculum encourages changes in teachers' roles, variety in student activities, and use of **Resource-Based Learning**. *Science: An Information Bulletin for the Secondary Level*) *Biology 20/30 Key Resources* provides suggestions for the use of specific resources. *Science: A Bibliography for the Secondary Level - Biology, Chemistry and Physics* provides an annotated listing of other resources which supports resource-based learning.

A single resource will not cover all of the core units of this Curriculum Guide. Instead, teacher-selected activities and content from a variety of sources should be integrated to produce a comprehensive, activity-based program.

The **Suggested Activities and Inquiries** are provided as ideas for a wider choice of approaches, permitting the biology program to be designed to suit the needs of students. During the pilot,

teachers and others submitted suggestions for activities which could be included in this section of the Curriculum Guide. In addition to the **Suggested Activities** in the Curriculum Guide, activities can be found in the resources which are referenced in *Science: An Information Bulletin for Secondary Level - Biology 20/30 Key Resources*. Fidelity to the intention of the biology curriculum can be attained best if activities form the basis of science instruction in biology classes.

It is not intended that all of the activities and inquiries listed in the Core Units of this Curriculum Guide be used, but rather that teacher-selected activities from the Key Resources and as many other sources as possible be integrated to produce a comprehensive program. The sequence of the activities and inquiries is at the teacher's discretion.

Program Overview

The following figure introduces the organization of the biology program.

Figure 1 Overview

Biology 20 Core Units	Minimum Time
1. Introduction	7 hours
2. Ecological Organization	25 hours
3. Diversity of Life	25 hours
4. Agricultural Botany of Saskatchewan	15 hours
* Various Options	Remaining Time

Biology 30 Core Units	Minimum Time
1. Chemical Basis of Life	10 hours
2. Cell Structure and Function	10 hours
3. Genetics	20 hours
4. Animal Systems	20 hours
5. Evolution	15 hours
* Various Options	Remaining Time

Note: Science K-10 courses are required prerequisites to Biology 20/30. Biology 20 is not a prerequisite for Biology 30. However, students planning to take Biology 30 should have above average abilities.

Each Secondary Level credit equals 100 hours of instruction.

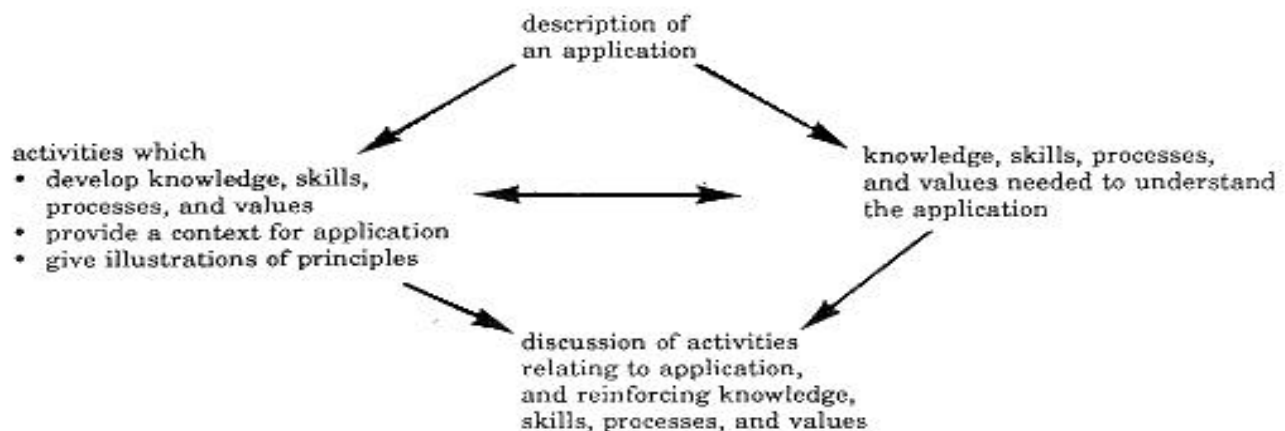
*See page 82.

A Science-Technology-Society-Environment (STSE) Approach to Science Education

The STSE approach recommended for Science K-12 differs from the way science has traditionally been presented. The ideal is to introduce a topic for study through the description of an application. In order to understand the science behind the application, knowledge and skills must be developed, along with activities which give purpose to the newly acquired knowledge and skills. Alternatively, the activities may immediately follow the discussion of the application, and serve to develop the knowledge and skills needed to understand the application. The arrows on Figure 2 are meant to show the variety of paths from the description of an application to the final discussion.

Figure 2

A Science-Technology-Society-Environment (STSE) Approach to Science Education



Guidelines To Using Resource Materials

Science: An Information Bulletin for the Secondary Level) *Biology 20/30 Key Resources* identifies resources appropriate for each core unit topic.

Science: A Bibliography for the Secondary Level - Biology, Chemistry, Physics provides an annotated listing of resources which further support resource-based learning. Teachers should consider the suggestions and recommendations in these documents. Other materials may also be used.

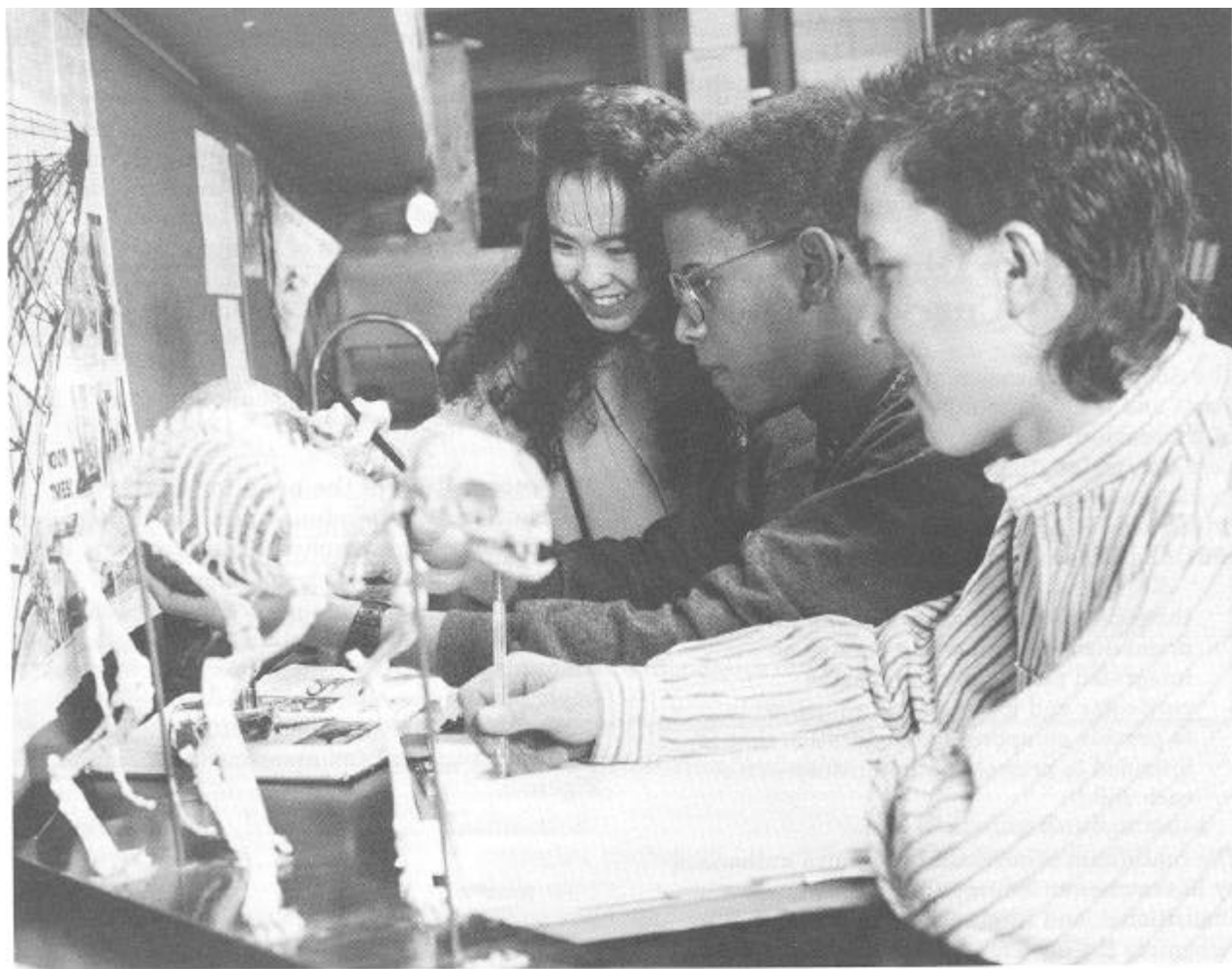
As was indicated earlier, no single resource matches the biology curriculum. To facilitate a resource-based approach, the use of a variety of resources instead of a single textbook is highly recommended.

As new resource materials become available, updates will be issued. They will indicate which new resources can be used, as well as those resources that are no longer available.

Teachers may wish to choose some of the topics that are not selected for Science 10 for the 20 and 30 level science courses. This should be coordinated within schools. Resources should be selected with this in mind.

A resource-based learning approach requires long-term planning and coordination within a school or school division. In-school administrators, teacher-librarians, and others need to take an active role to assist with this planning.

Instructional methods which emphasize group work and develop independent learning abilities make it possible to utilize limited resources in a productive way. Refer to *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991), and to *The Adaptive Dimension in Core Curriculum* (Saskatchewan Education, 1992).



Core Curriculum and Other Initiatives

Core Curriculum: Plans for Implementation (Saskatchewan Education, 1987) defines the Core Curriculum as including seven Required Areas of Study, the Common Essential Learnings, the Adaptive Dimension, and Locally-Determined Options. Science is one of the Required Areas of Study.

Understanding the Common Essential Learnings: A Handbook for Teachers (Saskatchewan Education, 1988), as a foundation document for Saskatchewan Education, defines and expands on an understanding of these essential learnings. Other Saskatchewan Education documents elaborate on the concept of Core Curriculum. See the references in this Curriculum Guide and in *Science Program Overview and Connections K-12*.

In addition to Core Curriculum, at Saskatchewan Education, there are other initiatives. These include Gender Equity, Indian and Métis perspectives, and Resource-Based Learning. **These initiatives can be viewed as principles which guide the development of curricula as well as instruction in the classroom.** The initiatives outlined in the following statements have been integrated throughout the curriculum.

The Adaptive Dimension in the Biology Curriculum

The Adaptive Dimension aims to meet learner needs and is an expectation inherent in the **Goals of Education**. See *The Adaptive Dimension in Core Curriculum* (Saskatchewan Education, 1992). In *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) the Adaptive Dimension is defined as:

the concept of teachers exercising their professional judgement to develop an integrated plan that encompasses curricular and instructional adjustments to provide an appropriate education that is intended to promote optimum success for each child.

The continuum of curricular programs authorized by Saskatchewan Education) Regular, Transitional, and Alternative Programs) recognizes the need for variation in curriculum

content and delivery mechanism. See *Policy and Procedures for Locally Developed and Modified Courses of Study, and Alternative Education Programs* (Saskatchewan Education, 1992). The continuum indicates that within each program, and therefore within each course of study, adaptation is required. **Teachers are empowered to adjust the curriculum content in order to meet student needs; as professionals they must ensure that the instructional approaches are also adapted.** This implies that teachers have at their "fingertips" a broad, strong repertoire of instructional strategies, methods, and skills and that conscious planning takes place to adapt these approaches to meet student needs.

The cues that some students' needs are not being adequately met come from a variety of sources. They may come to the perceptive teacher as a result of monitoring for comprehension during a lesson. The cue may come from a unit test, or from a student need or background deficiency that has been recognized for several years. A student's demonstrated knowledge of, or interest in, a particular topic may indicate that enrichment is appropriate. The adaptation required may vary from presenting the same content through a slightly different instructional method, to modifying the content because of a known information background deficit or to establishing an individual or small group enrichment activity. The duration of the adaptation may range from five minutes of individual assistance, to placement of the student in an alternative or enrichment program. The diagnosis of the need may be handled adequately by the classroom teacher, or may require the expertise of other support specialists such as the school's resource teacher or the regional coordinator) special education.

The recognition of the need for adaptive instruction is dependent upon the professional judgement of the teacher. The decision to initiate adaptive practices must be an informed one. While the practice of adapting instruction may occur through the placement of students in programs other than those defined as regular, the most frequent application of the Adaptive Dimension will occur as teachers in regular classroom settings adjust their use of instructional and assessment approaches. See Figure 3.

Figure 3
Correlating Instruction, Evaluation, and Science Goals

Instructional Strategies	Some Important Instructional Methods for Science (See p. 20, Instructional Approaches: A Framework for Professional Practice)	Some Corresponding Assessment Techniques* (See p. 23, 45 Student Evaluation: A Teacher Handbook)	DSL Emphasis (See pp. 1-2 this Guide)
Direct	! Demonstrations ! Mastery Lecture ! Structured Overview	! Group/Individual (Peer/Self): Performance Assessments ! Short-Answer Quizzes & Tests	B, E
Indirect	! Concept Mapping/Formation/Attainment ! Inquiry ! Problem Solving	! Individual/Group: Presentations ! Oral Assessments ! Performance Assessments ! Written Assignments	A-D
Experiential	! Conducting Experiments ! Field Observations & Trips ! Model Building ! Simulations	! Group/Individual: Performance Assessments; Written Assignments; ! Peer/Self: Oral Assessments ! Technical Skills	B, C, E
Independent Study	! Computer Assisted Instruction ! Essays & Reports ! Homework ! Research Projects	! Performance Assessments ! Portfolios ! Presentations ! Quizzes ! Written Assignments	All
Interactive	! Brainstorming ! Co-operative Learning Groups ! Discussion ! Laboratory Groups	! Group/Peer: Oral Assessments ! Written Assignments	All
* Anecdotal Records, Observation Checklists, and Rating Scales can be used as methods of data recording with all of the categories.			

Some Adaptive Dimension Variables

Curriculum

- ! concepts
- ! content
- ! materials
- ! evaluation

Instruction

- ! strategies, methods, skills
- ! pacing and time
- ! feedback, modification, reflection

Learning Environment

- ! classroom climate
- ! grouping
- ! support
- ! physical setting

Instructional Approaches: A Framework for Professional Practice identifies a hierarchy of approaches) models, strategies, methods, and skills. The four basic **models** of instruction do not change, whether used in a "regular" class setting, or with a small group as an adaptive approach. The strategies, methods, and skills may be altered or adapted. Hence a framework for inservice, investigation, and discussion among professionals has been established.

The flexibility inherent in the biology curriculum accommodates the Adaptive Dimension. All science teachers will have to take advantage of and create inservice opportunities to adjust their repertoire of instructional strategies, methods, and skills.

Common Essential Learnings

Science offers many opportunities for incorporating the Common Essential Learnings into instruction. The purpose of this incorporation is to help students better understand the subject matter under study and to better prepare students for their future learning both within and outside the K-12 educational system. The decision to focus on a particular Common Essential Learning within a lesson is guided by the needs and abilities of individual students and by the particular demands of the subject area. Throughout a core unit, it is intended that the **Foundational Objectives for the Common Essential Learnings** will have been developed to the extent possible, regardless of the topics selected.

It is important to incorporate the **Foundational Objectives for the Common Essential Learnings** in an authentic manner. For example, some topics may offer many opportunities to develop the understandings, values, skills, and processes related to a number of the foundational objectives. The development of a particular foundational objective, however, may be limited by the nature of the subject matter under study.

It is intended that the Common Essential Learnings be developed and evaluated within subject areas. Therefore, **Foundational Objectives for the Common Essential Learnings** are included in the introductory section of each core unit in this Curriculum Guide. Since the Common Essential Learnings are not necessarily separate and discrete categories, it is anticipated that working toward the achievement of one foundational objective may contribute to the

development of others. For example, many of the processes, skills, understandings, and abilities required for the Common Essential Learnings of Communication, Numeracy, and Critical and Creative Thinking are also needed for the development of Technological Literacy.

Incorporating the Common Essential Learnings into instruction has implications for the assessment of student learning. Assessment in a unit which has focused on developing the Common Essential Learnings of Communication and Critical and Creative Thinking should reflect this focus. Assessment strategies can allow students to demonstrate their understanding of the important concepts in the unit and how these concepts are related to each other and to previous learning. Questions can be structured so that evidence or reasons may accompany student explanations. If students are encouraged to think critically and creatively throughout a unit, then the assessment strategies for the unit should also require students to think critically and creatively.

It is anticipated that teachers will build from the suggestions in this Curriculum Guide and from their personal reflections in order to better incorporate the Common Essential Learnings into the teaching of science.

Throughout this Curriculum Guide, the following symbols may be used to refer to the Common Essential Learnings:

COM	Communication
CCT	Critical and Creative Thinking
IL	Independent Learning
NUM	Numeracy
PSVS	Personal and Social Values and Skills
TL	Technological Literacy

Incorporating the Common Essential Learnings into Biology Instruction

The science curriculum from Kindergarten to grade 12 involves the development of the factors within the Dimensions of Scientific Literacy. The main goal is to promote an interest in, and an understanding of, science.

The Common Essential Learnings should be planned and developed within the context of good science lessons. As lesson planning is taking place,

consideration should be given to how to incorporate the Common Essential Learnings. The **Factors of Scientific Literacy Which Should Be Emphasized**, and the **Foundational Objectives for Biology and the Common Essential Learnings** outlined at the beginning of each core unit, provide appropriate starting points in planning.

Science-Technology-Society-Environment Interrelationships (Dimension D) help to develop **Technological Literacy**. All eleven factors within Dimension D are developing by grade 10. Technology, as it is developed within this Dimension, is studied within a social context. The connections between science and technology are elaborated. Furthermore, the impact that technology has on society, on science, and on the environment is developed. Technology is defined as more than the gadgets and gizmos that are often the only things associated with it. Most of the topics within the core units of biology help to develop Technological Literacy.

Scientific and Technical Skills (Dimension E) also helps to develop Technological Literacy. Many scientific and technical skills in use today exist because of materials and instruments which have been developed through advances in technology. The impact that these new things have on our lives and on the environment is very important.

Numeracy can be developed through various factors of scientific literacy which are linked closely with this Common Essential Learning. Some of these include the empirical nature of science (A5), quantification (B8), probability (B19), accuracy (B21), measuring (C5), using numbers (C7), using mathematics (C17), and using quantitative relationships (E13). To anyone who understands science, the importance of Numeracy is readily apparent.

Problem solving can lend itself to developing Numeracy. Any other quantitative applications, of which there are many, further develop this Common Essential Learning. Students should be given many opportunities to develop ways in which quantities can be measured, recorded, manipulated, analyzed, and interpreted. Simply plugging numbers into obscure formulae is not nearly enough. Students must appreciate the importance of numeric information in the world of

science. Related skills such as estimating and approximating, rounding off, graphing, tabulating, calculating, using significant figures and scientific notation, can be developed in biology.

Specific factors relating to the Common Essential Learning of **Communication** include communicating (C2), and observing and describing (C3). The public/private nature of science (A1) reveals the underlying importance of communication in science. Scientists share their discoveries with others. This involves the use of language and of written and verbal communication. When students explore important scientific principles, and discuss their understandings orally or in writing, using their own language, their ability to communicate evolves. Skills which help to promote and develop effective communication need to be reinforced. They are important aspects of a good science program.

Values that Underlie Science (Dimension F) and Science-Related Interests and Attitudes (Dimension G) help to develop **Personal and Social Values and Skills**. Attaining the factors in these two Dimensions of Scientific Literacy can lead to positive attitudes about science. These Dimensions involve the affective domain. Other factors, such as working cooperatively with others (C4), scientists and technologists are human (D2), and the human/culture related nature of science (A9), further help to develop Personal and Social Values and Skills.

An activity-oriented science program will develop critical and creative thinkers. Among other things, scientific inquiry involves hypothesizing (C8), designing experiments (C16), observing and describing (C3), inferring (C9), arriving at conclusions, formulating scientific laws, developing or testing theories, etc. These kinds of activities require higher level thinking.

Any **Science Challenge** activities in the biology courses will support **Critical and Creative Thinking**. (Refer to the Life Science section in *Science 10: A Curriculum Guide for the Secondary Level*.) The emphasis on practical applications of science allows students to make meaningful connections with the real world, transferring their understanding of science to things which make their learning relevant. Problem solving activities and classroom outreach further develop the knowledge, values, skills, and processes related to Critical and Creative Thinking.

Considering controversial issues in science also leads students to develop Critical and Creative Thinking abilities when they analyze conflicting value positions. As they develop a knowledge base and begin to form their own value positions, Personal and Social Values and Skills are developed.

Independent Learning can also be developed well in biology because of the emphasis being placed on variety in instructional approaches. By placing less emphasis on traditional lecture presentations, teachers transfer more of the responsibility for learning from themselves to their students. The student assumes a more active role in the classroom experience. The teacher assumes the role of the learning facilitator.

Any **Science Challenge** activities have the potential for developing Independent Learning. By pursuing topics of interest, with direction and encouragement from their teachers, students can become highly motivated and enthusiastic about science. Topics in the course of contemporary interest, require that students keep up to date with current affairs. They may need to do independent study, using a wide variety of resources and different types of media, to investigate topics of current interest. This lends itself well to resource-based learning. As students examine issues and notice the effects that competing and conflicting points of view have on shaping those issues, an awareness and understanding of the social impact of science will likely emerge. Making these connections helps students recognize that learning takes place throughout life, continuing after formal schooling has ended.

While some science content can be identified with specific Common Essential Learnings, quite often it can not. The Common Essential Learnings developed in any given lesson do not depend on content as much as they do on process. The teaching strategies selected, through careful unit and lesson planning, are what determine which Common Essential Learnings will be developed, and how well they will be developed. **The key point is that a conscientious effort to incorporate the Common Essential Learnings can make a tremendous impact on students.**

For many topics in science, any of the Common Essential Learnings can be developed. Which ones are developed, and to what extent any of the Common Essential Learnings are emphasized in a topic, depend on the goals of the new science

curriculum, the foundational objectives being addressed in a particular core unit, as well as on the specific learning objectives for that topic. Just as there are many different ways to teach a lesson, so too there are many different ways of incorporating the Common Essential Learnings into that lesson. What matters is that teachers develop the Common Essential Learnings effectively, with the specific interests and needs of their students in mind. The beauty of incorporating the Common Essential Learnings into science is that, as in other subject areas, the ways in which this can be done are dynamic and flexible. The techniques used change as teachers perceive students' needs changing.

Gender Equity

Saskatchewan Education is committed to providing quality education for all students in the K-12 system. Expectations based primarily on gender limit students' ability to develop to their fullest potential. While some stereotypical views and practices have disappeared, others remain. Where schools endeavour to provide equal opportunity for male and female students, continuing efforts are required to achieve equality of benefit or outcome. It is the responsibility of schools to create an educational environment free of gender bias. This can be facilitated by increased understanding and use of gender balanced material and non-sexist teaching strategies. Both female and male students need encouragement to explore non-traditional, as well as traditional, options.

In order to meet the goal of gender equity in the K-12 system, Saskatchewan Education is committed to bringing about the reduction of gender bias that restricts the participation and choices of all students. It is important that Saskatchewan curricula reflect the variety of roles and the wide range of behaviours and attitudes available to all members of society. The new curricula strive to provide gender-balanced content, activities, and teaching approaches. It is hoped that this will assist teachers in creating an environment free of stereotyping, enabling both females and males to share in all experiences and opportunities which develop their abilities and talents to the fullest.

Indian and Métis Curriculum Perspectives

The integration of Indian and Métis content into the Kindergarten to Grade 12 curriculum fulfils a central recommendation of *Directions. The Five Year Action Plan for Native Curriculum Development* further articulates the commitment and process. In addition, the *1989 Indian and Métis Education Policy from Kindergarten to Grade 12* makes the statement:

Saskatchewan Education recognizes that the Indian and Métis peoples of the province are historically unique peoples and occupy a unique and rightful place in society today. Saskatchewan Education recognizes that education programs must meet the needs of Indian and Métis peoples, and that changes to existing programs are also necessary to benefit all students. (p.6)

It is recognized that, in a pluralistic society, affirmation of culture benefits everyone. Its representation in all aspects of the school environment enables children to acquire a positive group identity. Instructional resources which reflect Indian and Métis cultures similarly provide meaningful and relevant experiences for children of Indian and Métis ancestry and promote the growth of positive attitudes in all students towards Indian and Métis peoples. Awareness of one's own culture, and the cultures of others, forms the basis for positive self-concept. Understanding other cultures enhances learning and enriches society. It also promotes an appreciation of the pluralistic nature of Canadian society.

Indian and Métis students in Saskatchewan have varied cultural backgrounds and come from geographic areas encompassing northern, rural, and urban environments. Teachers must be given support that enables them to create instructional plans relevant to meeting diverse needs. Varied social, cultural, and linguistic backgrounds of Indian and Métis students imply a range of strengths and learning opportunities for teachers to draw upon. Explicit guidance, however, is needed to assist teachers in meeting the challenge by enabling them to make appropriate choices in broad areas of curriculum support. Theoretical concepts in anti-bias curricula, cross-cultural education, applied socio-linguistic, first and second language acquisition, and standard and non-standard usage of language are becoming increasingly important to classroom instruction.

Care must be taken to ensure teachers utilize a variety of teaching methods that build upon the knowledge, cultures, and learning styles students possess. All curricula need specific kinds of adaptations to classroom strategies for effective use.

The final responsibility for accurate and appropriate inclusion of Indian and Métis content in instruction rests on teachers. They have the added responsibility of evaluating resources for bias, and teaching students to recognize bias. The Science-Technology-Society-Environment focus of the new science curriculum provides teachers with many opportunities to begin these integration and evaluation processes.

The following points summarize expectations for Indian and Métis content and perspectives in curricula, materials, and instruction:

- ! concentrate on positive and accurate images;
- ! reinforce and complement beliefs and values;
- ! include historical and contemporary insights;
- ! reflect the legal, political, social, economic and regional diversity of Indian and Métis peoples; and,
- ! affirm life experiences and provide opportunity for expression of feelings.

Instructional Approaches

The factors of scientific literacy and the development of the Common Essential Learnings are the foundations of the K-12 Science program. In order to give students a chance to develop their understandings and abilities in these foundations, it is necessary for teachers to use a broad range of instructional approaches. *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) provides a framework to understand and implement a variety of approaches to teaching. The Biology curriculum has been designed to support teachers in using such a broad-based approach in the classroom by making the curriculum flexible enough to accommodate their plans. More specific information on teaching science using a variety of strategies can be found in *Teaching Science Through a Science-Technology-Society-Environment Approach: An Instruction Guide* (Aikenhead, 1988). See also the section on the Adaptive Dimension, on page 8 of this guide.

The verbs of the **Learning Objectives** listed for the core units suggest various approaches to teaching and learning, and reiterate some of the processes of science. For example:

! analyze	! explain
! compare	! formulate
! debate	! identify
! describe	! investigate
! determine	! outline
! develop	! recognize
! discuss	! research
! estimate	! review
! evaluate	! use
! examine	! view

The **Suggested Activities and Inquiries** section contains many other ideas.

Resource-Based Learning

Resource-based teaching and learning is a means by which teachers can greatly assist the development of attitudes and abilities for independent, life-long learning. Resource-based instruction means that the teacher, teacher-librarian, and other professional staff plan units which integrate resources with classroom assignments, and teach students the processes needed to find, analyze, and present information.

Resource-based instruction is an approach to curriculum which involves students with all types of resources. Some possible resources are people, books, magazines, films, audio and video tapes, computer software and databases, commercial games, maps, community resources, museums, field trips, pictures and study prints, real objects and artifacts, and media production equipment.

Resource-based learning is student-centred. It offers students opportunities to choose, to explore, and to discover. Students who are encouraged to make choices, in an environment rich in resources where their thoughts and feelings are respected, are well on their way to becoming autonomous learners.

These points will help teachers use resource-based teaching and learning.

- ! Discuss the objectives for the unit with students. Focus the discussion on how the students can relate the objectives to their environment, culture and other factors which are appropriate to their situation. Correlate needed research skills with the activities in the unit, so that skills are always taught in the context of application. Work with your teacher-librarian, if available.
- ! Plan in good time with other school staff so that adequate resources are available, and decisions can be made about shared teaching responsibilities.
- ! Use a variety of resources in classroom teaching, showing students that you are a researcher who constantly seeks out sources of knowledge. Discuss with them the use of other libraries, government departments, museums, and various outside agencies in their research.
- ! Ask the teacher-librarian (if available) to provide resource lists and bibliographies when needed.
- ! Participate in, and help plan, inservice programs on using resources effectively.
- ! Continually request good curriculum materials for addition to the library collection.
- ! Support the essential role of the library resource centre and the teacher-librarian in your talks with colleagues, principals, and directors.

More information on resource-based learning may be found in *Science Program Overview and Connections K-12*.

Assessment and Evaluation

Why Consider Assessment and Evaluation?

Much research in education around the world is currently focusing on assessment and evaluation. It has become clear, as more and more research findings accumulate, that a broader range of attributes need to be assessed and evaluated than has been considered in the past. A wide variety of ways of doing this are suggested. Assessment and evaluation are best addressed from the viewpoint of selecting what appears most valid in meeting prescribed needs.

In *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991) the difference between the various forms of evaluation is explained. Student evaluation focuses on the collection and interpretation of data which would indicate student progress. This, in combination with teacher self-evaluation and program evaluation, provides a full evaluation.

Phases of the Evaluation Process

Evaluation can be viewed as a cyclical process including four phases: preparation, assessment, evaluation, and reflection. The evaluation process involves the teacher as a decision maker throughout all four phases.

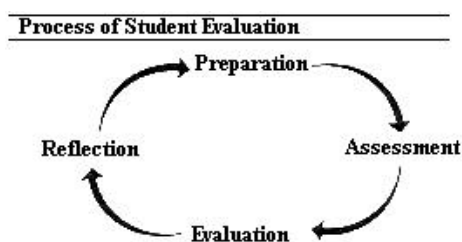
- ! In the **preparation** phase, decisions are made which identify what is to be evaluated, the type of evaluation (formative, summative, or diagnostic) to be used, the criteria against which student learning outcomes will be judged, and the most appropriate assessment strategies with which to gather information on student progress. The teacher's decisions in this phase form the basis for the remaining phases.
- ! During the **assessment** phase, the teacher identifies information-gathering strategies, constructs or selects instruments, administers them to the student, and collects the information on student learning progress. The teacher continues to make decisions in this phase. The identification and elimination of bias (such as gender and culture bias) from the assessment

strategies and instruments, and the determination of where, when, and how assessments will be conducted are examples of important considerations for the teacher.

- ! During the **evaluation** phase, the teacher interprets the assessment information and makes judgements about student progress. Based on the judgements or evaluations, teachers make decisions about student learning programs and report on progress to students, parents, and appropriate school personnel.
- ! The **reflection** phase allows the teacher to consider the extent to which the previous phases in the evaluation process have been successful. Specifically, the teacher evaluates the utility and appropriateness of the assessment strategies used, and such reflection assists the teacher in making decisions concerning improvements or modifications to subsequent teaching and evaluation. *Science Program Overview and Connections K-12* contains questions which encourage teachers to reflect on student assessment, their own planning, and on the structure of the curriculum.

All four phases are included in formative, diagnostic, and summative evaluation processes. They are represented below.

Process of Student Evaluation



Assessing Student Progress

Specific assessment techniques are selected in order to collect information about how well students are achieving objectives. The assessment technique used at any particular time depends on what facility with the knowledge, skills or processes the teacher wants the students to demonstrate. The appropriateness of the techniques therefore rests on the content, the instructional strategies used, the level of the development of the students, and what is to be assessed. The environment and culture of the students must be considered.

Various assessment techniques are listed below. The techniques listed are meant to serve only for reference, since the teacher exercises professional judgement in determining which techniques suit the particular purposes of the assessment. For further information on the various assessment strategies and types of instruments that can be used to collect and record information about student learning, refer to the *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991).

A Reference List of Specific Student Evaluation Techniques

Methods of organization

- ! assessment stations
- ! individual evaluations
- ! group evaluations
- ! contracts
- ! self- and peer-assessments
- ! portfolios

Methods of data recording

- ! anecdotal records
- ! observation checklists
- ! rating scales

Ongoing student activities

- ! written assignments
- ! presentations
- ! performance assessments
- ! homework

Quizzes and tests

- ! oral assessment
- ! performance tests
- ! extended open response
- ! short answer items
- ! matching items
- ! multiple choice items
- ! true/false items

Student Assessment in Biology

At the start of any class, a teacher has a group of new students. The students are new, even if they know each other or the teacher, because they will be dealing with different material, from a different point of view, within an evolving system of interactions. The factors of scientific literacy and the learning objectives for the curriculum become the criteria by which to assess the student. These may be attainable by the majority of students, but for some they will be outside their capabilities. Adaptations to expectations or procedures will be required.

"Graded" teaching resources and standardized tests are based on what is accepted as normal or average for a student of that age group and often for a specific segment of society. By using standardized tests a teacher is assessing how a child matches these cultural standards over a very narrow range of skills. The results must be considered in that context. This measure may be unattainable by some students. Alternately, some students may not reach full potential because they are not challenged but are allowed to remain at the acceptable "average". The Adaptive Dimension recognizes that the needs of all students must be considered for effective teaching and learning to occur.

In assessing the factors of scientific literacy, methods can be established for addressing knowledge (Dimensions A, B, D), values (Dimensions G and F), and abilities (Dimensions C and E) in ways that suit the nature of the factor.

The factors of scientific literacy in Dimensions A through E can be assessed through manipulation of factual knowledge. However, it is quite possible to assess only factual knowledge and this is a fault of much current student assessment. When examined, this assessment is often little more than simple recall or limited application of facts. When assessment does go further and appears to include abilities, often too much emphasis is still devoted to straight recall. Students deserve to be assessed on the range of abilities they have been using. The overall assessment plan should reflect the students' learning styles, and different ways of displaying their learning and the nature of the abilities being assessed. Self-referenced assessment may be encouraged.

Assessment can be based on oral or written response or observations of performance. Ideally it will be some combination of these. Performance tasks are

an excellent way to assess scientific and technical knowledge and skills (Dimension E). For example, reading a thermometer diagram is not the same as knowing how best to use and place the thermometer in order to measure temperature. The best way to assess whether students can perform an activity is to observe them while they are actually performing the activity. Ask them probing questions. The use of anecdotal records, observation checklists, and rating scales can assist in data collection when these observations have taken place.

Examples of performance tasks in biology are:

- ! microscope care
- ! microscope techniques
- ! wet-mount preparation
- ! dissection techniques
- ! equipment set-up
- ! demonstrations

See Dimension E and develop other performance tasks. **About 10% of the final grade should be based on performances tasks carried out either as separate activities or with laboratory investigations.**

The types of tasks and questions which students are expected to address influence their responses. When the tasks and questions are limited, so are the responses. Tasks and questions which elicit only one word or simple sentence answers test only basic recall of factual knowledge. It is very important to consider that once students have, for example, formulated a model in a particular context during a science activity, if that exact same context is given in the assessment, the response is only recall, and not a test of any conceptual or process ability. Assessment must require slightly different conditions so the ability is tested through a new set of events.

Good questioning is extremely important for effective teaching and testing. Avoid questions where there is only a single response. Structure questions so some type of reasoning is required. How? Why? Explain . . . Present problem solving activities. Develop Critical and Creative Thinking. All of these things promote and challenge higher level thinking.

Students may be asked to interpret a graph or photograph, or to answer a question orally. Assessment does not have to consist totally of written work. Varied formats adapt to students' differing learning styles.

Summative assessment items following the completion of a unit can cover more scope and depth than formative assessment items. Apart from the scope and depth of the activities selected, the format of summative assignments can be just as varied, including practical tasks (to reflect practical knowledge and abilities), interpretation of graphs and photographs, and investigative problems and assignments.

Multiple choice, true or false, or fill-in-the-blank tests usually assess only basic factual recall. Such tests should be used as little as possible and fewer "marks" should be awarded them in comparison with those items that require process abilities.

Essay questions are more useful tests. They can promote the processes of science and can be used in both formative and summative assessment. For those students who have difficulty writing, discuss the essay topic for the assessment. Illustrations or art projects, an oral report, a concept map, a project, journal writing, or a Science Challenge activity may serve as innovative alternatives to the written essay.

Projects are useful items for recording as summative assessments, because they usually cover a topic in depth as well as scope. They also involve the use of a range of process abilities. Difficulties might arise in assessing the individual participation of each child, if the project is a group effort. The contributions and participation of individuals within a group can often be determined by observing the ways in which the group members interact with one another and with other members of the class or by using student self-assessment. The number and type of assignments completed in a learning centre can also be recorded as a summative assessment. Test stations are particularly useful for allowing students to demonstrate competence.

Assessing values is the most difficult of all the areas of assessment and evaluation. At one time, values were not considered a part of the school's written curriculum. Parents and society certainly required that students develop acceptable behaviours and attitudes, but these were promoted through the "hidden curriculum") the teachers' and school's influences. Now, specific attitudes and values are to be openly promoted in students, so the teacher's

influence must be directed to these objectives. Accordingly, they must be assessed. For further information on values review Chapter VI in *Understanding the Common Essential Learnings: A Handbook for Teachers* (Saskatchewan Education, 1988).

There are valid reasons to assess students' value and attitude outcomes at school and to attempt to promote these with effective teaching methods and individual student reflection. Remember that the values listed in Dimensions F and G of the factors of scientific literacy develop over time. Emphasizing many of the same values through the grades can provide the reinforcement to help students to incorporate the values into their lives.

Through the school years, students display their current values and attitudes by what they say, write, and do. These three actions can be used for assessment purposes. When a value or attitude is observed, record the observation.

When setting an evaluation plan for the year, consider using an organizer such as Figure 4 to give the plan a broad base in direction and techniques. The figure suggests a philosophical framework for ensuring that all Dimensions of Scientific Literacy (DSLs) are considered during assessment and evaluation. For specific unit planning based on the concepts promoted in the figure, use the Instruction Plan on page 29 of ***Student Evaluation: A Teacher Handbook*** (1991). The ***Handbook*** provides advice on how to use the plan. **It reinforces the principle that planning for assessment goes hand in hand with planning for instructional strategies and methods.**

Figure 4 Including Dimensions of Scientific Literacy in Planning for Assessment

DSL	Evaluation techniques (abbreviation key below)												
	% wt.	ar	co	lr	oc	or	pa	pf	pr	pt	rs	sa	wt
A. nature of science	5-15		x	x		x			x	x	x	x	x
B. key concepts	25-40	x	x	x		x		x	x	x		x	x
C. processes	15-30	x	x	x	x			x	x		x	x	x
D. STSE	5-15					x	x	x	x		x	x	x
E. skills	5-15	x			x		x		x	x	x		
F. values	5-10	x			x	x	x	x		x	x	x	x
G. attitudes	5-10	x			x	x	x	x		x	x		x

Key to abbreviations of evaluation techniques:

ar anecdotal records
 co contract
 lr laboratory report
 oc observation checklist
 or oral response
 pa peer assessment
 pf portfolio
 pr project or written report
 pt performance test
 rs rating scale
 sa self assessment
 wt written test

An 'x' in a cell indicates a strategy that might be appropriate for assessing that Dimension of Scientific Literacy. The terms for evaluation strategies are taken from ***Student Evaluation: A Teacher Handbook***.

Summary of % weight by domains vs. DSLs.

! Cognitive knowledge (A, B, D, F) ~ 60%
 ! Cognitive process/skill (C, E) ~ 30%
 ! Affective (F, G) ~ 10%

Record-Keeping

To aid data collection in order for the factors of scientific literacy to be addressed in student assessment, checklists have been included in the *Science Program Overview and Connections K-12* and in this guide. Teachers should adapt these to suit their needs.

Teachers differ in the way they like to collect data. Some prefer to have a single checklist naming all the students in the class (or in one work group) across the top and listing the criteria to be assessed down the side. The students' columns are then marked if a criterion is met. In this case some information would have to be transferred later to a student's individual profile.

Other teachers prefer to have one assessment sheet per student, which is kept in the profile. That sheet would list the factors for assessment down the side, but along the top might be a series of dates indicating when assessment took place. Such an individual file would illustrate development over the year. In this case, information might have to be transferred from the profile to the official class mark book, as required.

Examples of these types of assessment sheets are also given in *Science Program Overview and Connections K-12*.

Program Evaluation

Program evaluation is a systematic process of gathering and analyzing information about some aspect of a school program in order to make a decision, or to communicate to others involved in the decision-making process. Program evaluation can be conducted at two levels: relatively informally at the classroom level, or more formally at the classroom, school, or school division levels.

At the classroom level, program evaluation is used to determine whether the program being presented to the students is meeting both their needs and the objectives prescribed by the province. Program evaluation is not necessarily conducted at the end of the program, but is an ongoing process. For example, if particular lessons appear to be poorly received by students, or if they do not seem to demonstrate the intended learnings from a unit of study, the problem should be investigated and changes made. By evaluating their programs at the classroom level, teachers become reflective practitioners. The information gathered through

program evaluation can assist teachers in program planning and in making decisions for improvement. Most program evaluations at the classroom level are relatively informal, but they should be done systematically. Such evaluations should include identification of the areas of concern, collection and analysis of information, and judgement or decision making.

Formal program evaluation projects use a step-by-step problem-solving approach to identify the purpose of the evaluation, draft a proposal, collect and analyze information, and report the evaluation results. The initiative to conduct a formal program evaluation may originate from an individual teacher, a group of teachers, the principal, a staff committee, an entire staff, or central office. Evaluations are usually done by a team, so that a variety of background knowledge, experience, and skills are available and the work can be shared. Formal program evaluations should be undertaken regularly to ensure programs are current.

To support formal school-based program evaluation activities, Saskatchewan Education has developed the *Saskatchewan School-Based Program Evaluation Resource Book* (1989) to be used in conjunction with an inservice package. Further information on these support services is available from the Evaluation and Student Services Division, Saskatchewan Education.

Curriculum Evaluation

During the decade of the 1990's, new curricula will be developed and implemented in Saskatchewan. Consequently, there will be a need to know whether these new curricula are being effectively implemented and whether they are meeting the needs of students. Curriculum evaluation, at the provincial level, involves making judgements about the effectiveness of provincially authorized curricula.

Curriculum evaluation involves the gathering of information (the assessment phase) and the making of judgements or decisions based on the information collected (the evaluation phase), to determine how well the curriculum is performing. The principal reason for curriculum evaluation is to plan improvements to the curriculum. Such improvements might involve changes to the curriculum document and/or the provision of resources or inservice to teachers. It is intended that curriculum evaluation be a shared, collaborative effort involving all of the major education partners in the province. Although Saskatchewan Education is responsible for conducting curriculum evaluations,

various agencies and educational groups will be involved. For instance, contractors may be hired to design assessment instruments; teachers will be involved in instrument development, validation, field testing, scoring, and data interpretation; and the cooperation of school divisions and school boards will be necessary for the successful operation of the program.

In the assessment phase, information will be gathered from students, teachers, and administrators. The information obtained from educators will indicate the degree to which the curriculum is being implemented, the strengths and weaknesses of the curriculum, and the problems encountered in teaching it. The information from students will indicate how well they are achieving the intended objectives and will provide indications about their attitudes toward the curriculum. Student information will be gathered through the use of a variety of strategies including paper-and-pencil tests (objective and open-response), performance (hands on) tests, interviews, surveys, and observation.

As part of the evaluation phase, assessment information will be interpreted by representatives of all major education partners including the Curriculum and Evaluation Divisions of Saskatchewan Education and classroom teachers. The information collected during the assessment phase will be examined, and recommendations, generated by an interpretation panel, will address areas in which improvements can be made. These recommendations will be forwarded to the appropriate groups such as the Curriculum and Instruction Division, school divisions and schools, universities, and educational organizations in the province.

All provincial curricula will be included within the scope of curriculum evaluation. Evaluations will be conducted during the implementation phase for new curricula, and regularly on a rotating basis thereafter. Curriculum evaluation is described in greater detail in the document *Curriculum Evaluation in Saskatchewan* (Saskatchewan Education, 1991).



Program Organization

Facilities and Materials

Facilities and materials, by themselves, do not create a science course. They are essential, but proper use of the facilities and materials is what is critical. Generally, the facilities which exist in most schools offering Secondary Level science courses will be adequate for teaching Biology.

Since a wide range of teaching strategies is desirable in this course, more flexible teaching areas are useful. This might be a well designed laboratory which can be reconfigured to accommodate small group discussions, small group and large group laboratory activities, lectures, research work or other activities. Or, it may be a combination of two or more existing rooms.

Some features of a good science laboratory/facility are:

- ! two exits, remote from each other;
- ! master shut-off controls for the water, natural gas, and electrical systems. These should be easily accessible and easy to operate;
- ! a spacious activity area where students can work without being crowded or jostled;
- ! safety equipment which is visible and accessible to all;
- ! a ventilation system which maintains negative pressure in the lab;
- ! enough electrical outlets to make the use of extension cords unnecessary. The plugs should be on a ground fault interruptor system or individually protected;
- ! emergency lighting;
- ! separate, locked storage rooms and preparation rooms to which students' access is restricted;
- ! adequate shelving so that materials do not have to be stacked, unless it is appropriate to store them that way;
- ! a separate chemical storage cabinet with provisions for proper storage of all classes of chemicals;

! an audiovisual storage area for charts, video and audio tapes, slides, and journals;

! areas for plant and animal care; and,

! a storage area for student assignments.

Materials which are normally available in a Secondary Level science laboratory will be adequate for doing most of the activities in Biology. Other materials may be needed, but they are readily available from suppliers of science materials.

Science equipment and supplies are valuable resources. Not only are they becoming more expensive, but they are also indispensable to the proper presentation of science. There are several reasons for having an efficiently operating inventory system. Such a system can prevent running short of a consumable supply, prevent ordering something already in adequate supply, and save time when ordering. It can act as a quick reference to determine whether a particular item is available. It may also be useful for insurance purposes.

In addition to inventory control, maintenance and storage are important considerations. A regular procedure for maintenance ensures that the equipment is ready for use when it is needed and is in safe operating condition. Adequate storage space ensures that the equipment can be preserved in good condition and that it is safely away from unauthorized use. It also helps convey the message that laboratory equipment and supplies are not toys, and that a lab is not a place to play with equipment.

Safety

Safety in the classroom is of paramount importance. Other components of education) resources, teaching strategies, facilities) attain their maximum utility only in a safe classroom. Safety is no longer simply a matter of common sense. To create a safe classroom requires that a teacher be informed, be aware, and be proactive. There are several ways the teacher can become informed. Consult the references below.

Refer to Science: A Bibliography for the Secondary Level) Biology, Chemistry, Physics for ordering information on these items.

Each school should have a copy of the B.C. Science Safety Manual.

Safety in the Secondary Science Classroom.

(1978). National Science Teachers Association, 1742 Connecticut Avenue North West, Washington, D.C. 20009.

A Guide to Laboratory Safety and Chemical Management in School Science Study Activities.

(1987). Saskatchewan Environment and Public Safety, Regina. A copy was sent to all schools.

Safety sessions are often offered at science teachers' conventions. Many articles in science teachers' journals provide helpful hints on safety. Professional exchange may provide teachers with an outside viewpoint on safety.

Awareness is not something that can be learned as much as it is developed through a visible safety emphasis: safety equipment such as a fire extinguisher, a fire blanket, and an eye wash station prominently displayed; safety posters on the wall; a "safety class" with students at the start of the year; and regular emphasis on safety precautions while preparing students for activities.

Proaction is accomplished by acting on what is known and on what one is aware of. **Six basic principles guide the creation and maintenance of a safe classroom.**

- ! Model safe procedures at all times.
- ! Instruct students about safe procedures at every opportunity. Stress that they should remember to use safe procedures when experimenting at home.
- ! Close supervision of students at all times during activities, along with good organization, can avert situations where accidents and incidents can occur. Inappropriate behaviours in a classroom, and more particularly in a laboratory, can result in physical danger to all present and destroy the learning atmosphere for the class.
- ! Be aware of any health or allergy problems that students may have.
- ! Display commercial, teacher-made, or student-made safety posters.
- ! Take a first aid course. If an injury is beyond your level of competence to treat, wait until medical help arrives.

To compile a complete list of safety tips is impossible. To compile a comprehensive list would be to duplicate the materials which have been referenced previously. To compile a "highlights" list would be to risk leaving out something important. To compile no list would be negligent. What follows is a highlight list. This list does not diminish the **responsibility of each teacher to be functioning at the highest level with respect to creating a safe classroom climate.**

- ! Check your classroom for hazards on a regular basis.
- ! Create a bulletin board with a safety theme.
- ! Make a rule that all accidents must be reported to the teacher.
- ! In case of a serious accident, pick one person who is present and send that person for expert, professional, or additional help. Then, take action. Remember, you are in charge of the situation.
- ! Become familiar with the school division's accident policy.
- ! Do not give medical advice.
- ! Move an injured person as little as possible until the injury assessment is complete.
- ! Emphasize that extra caution is needed when using open flames in the classroom.
- ! Require the use of goggles when using open flames, corrosive chemicals or other identifiable hazards.
- ! In case of fire, your first responsibility is to get students out of the area. Send **a specific person** to give an appropriate alarm. Then assess the situation and act.
- ! Avoid overloading shelves and window sills.
- ! Properly label all containers of solids, liquids, and solutions.
- ! Separate broken glass from other waste.
- ! Advise students not to touch, taste, or smell chemicals unless instructed to do so.

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- ! Each laboratory should have one first aid kit which is not accessible to students, but is only for the teacher's or administrator's use.
 - ! Master shut-off controls for gas, electricity, and water should be tested periodically to ensure that they are operable.
 - ! Safety equipment such as fire extinguishers, fire blankets, eye wash stations, goggles, fume hoods, test tube spurt caps, and explosion shields must be kept in good order and checked regularly.
 - ! Electrical cords must be kept in good condition, and removed from outlets by grasping the plug.
 - ! Students should use safety equipment) protective eye wear, protective aprons or coats, fume hoods, etc.) whenever practical and necessary.
 - ! Students should tie back long hair and refrain from wearing loose and floppy clothing in the laboratory.
 - ! Students should not taste any materials, eat, drink, or chew gum in a laboratory.
 - ! Students should follow recommended procedures and check with teachers before deviating from such procedures.
 - ! Students should be required to return laboratory equipment to its proper place.
 - ! Chemicals or solutions should never be returned to stock bottles.
 - ! Pipetting should be done only with a safety bulb, never by mouth.
 - ! Acids or oxidizers should never be mixed with compounds containing chlorine (e.g., bleach).
 - ! Mercury thermometers should be replaced with alcohol thermometers.
 - ! Asbestos centred wire mats should be replaced with plain wire mats or with ceramic centred mats.

! The use of human biological fluids in laboratory activities should be closely monitored.

- " Students should use only materials from their own body) blood, saliva, epithelial cells) when doing lab activities requiring those materials.
 - " Students should have no contact with bodily fluids from another student.
 - " The lancets used to obtain blood samples must be the disposable type, and must be used only once.
 - " The lancets must be immediately and properly disposed.
 - " Alcohol prep pads should not be used more than once.
 - " Students should wash their hands thoroughly with soap and water after handling any bodily fluids.
- ! Specimens for dissection, dissecting tools and equipment, and chemicals used in biology must be kept under locked storage.
 - ! When field materials such as pond or slough water, plants, soil, or insects are collected, assume that they are contaminated by pathogens and treat them as such.
 - ! Known pathogens should not be cultured. Exposure plates and culture plates with unknown bacterial colonies must be treated as though they are contaminated by pathogens until it can be shown otherwise.
 - ! Make sure that autoclaves are in good operating condition.
 - ! Adequate ventilation is essential when working with specimens preserved in formalin or formaldehyde.
 - ! Proper care must be given to animals kept in a classroom. Refer to a good animal care book, if needed.
 - ! Use rubber gloves and take great care when handling any plant growth hormones such as colchicine, gibberellic acid, indole acetic acid, or Rootone^(TM).
 - ! Chemicals should be stored in a locked area, to which access is restricted.
 - ! Be prepared to handle all chemical spills rapidly and effectively.
-

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- ! Inspect glassware (e.g., beakers, flasks) for cracks and chips before using them to heat liquids or hold concentrated corrosive liquids or solutions.
 - ! Many plants may contain toxins or allergens. Students should be cautioned not to taste or handle plants. Teachers are responsible for familiarizing themselves with any local, provincial, or federal legislation pertaining to plants and animals. If in doubt, inquire.
 - ! Chemical storage should be organized by groups of compatible compounds, rather than by alphabetical order. (Within a group of compatible compounds, alphabetizing can be used.)
 - ! Electrical equipment (e.g., transformers, induction coils, electrostatic generators, oscilloscopes, discharge tubes, Crookes tubes, magnetic effects tubes, lasers, fluorescent effects tubes and ultraviolet light sources) must be kept in locked storage.
 - ! Discharge tubes can produce x-rays which may penetrate the glass of the tube if operating voltages higher than 10 000 volts are used.
 - ! Lasers are capable of causing eye damage. The lens of the eye may increase the intensity of light by 1 000 000 times at the retina compared to the pupil. To reduce risk, lasers rated at a maximum power of 0.5 mW should be used.
 - " Lasers should be used in normal light conditions so pupils are not dilated.
 - " Everyone should stay clear of the primary and reflected paths.
 - " Everyone should be alert to unintended reflections.

- ! **Contact lenses** complicate eye safety. Dust and chemicals may become trapped behind a lens. Gases and vapours may cause excessive watering of the eyes and enter the soft material of the lens. Chemical splashes may be more injurious due to the inability to remove the lens rapidly and administer first aid. The loss or dislodging of a contact lens may cause a safety problem if it happens at a crucial moment.

On the other hand, contacts, in combination with safety eye wear, are as safe as eyeglasses in most cases. Contacts may prevent some irritants from reaching the cornea, thus giving the eye some measure of protection. The

Saskatchewan Association of Optometrists feels that, as long as proper, vented safety goggles are worn, there is no greater risk in a lab situation for a person wearing contacts than for one not wearing contacts. The Association recommends that:

- " teachers know which students wear contact lenses;
- " teachers know how to remove contact lenses from students' eyes should the need occur;
- " there be access to adequate areas for the removal and maintenance of contact lenses; and,
- " contact lens wearers have a pair of eye glasses to use in case the contact lenses must be removed.

A Broader Look at Safety

Normally, safety is understood to be concerned with the physical safety and welfare of persons, and to a lesser degree with personal property. The definition of safety can also be extended to a consideration of the well-being of the biosphere. The components of the biosphere) plants, animals, earth, air and water) deserve the care and concern which we can offer. From knowing what wild flowers can be picked to considering the disposal of toxic wastes from Secondary Level laboratories, the safety of our world and our future depends on our actions and teaching in science classes.

The Workplace Hazardous Materials Information System (WHMIS) under the **Hazardous Products Act** governs storage and handling practices of chemicals in school laboratories. All school divisions should be complying with the provisions of the Act.

Other good ideas on **Laboratory Practice** are given in **Science: A Curriculum Guide for the Secondary Level) Chemistry 20/30**.

Disposing of Chemicals

Some precautions should be followed when disposing of chemicals. **See A Guide to Laboratory Safety and Chemical Management in School Science Study Activities.**

- ! The disposal of liquid or aqueous wastes from categories 1 and 2 should involve dilution before pouring them down the drain, then running tap water down the drain to further dilute their strength.

! Solid wastes should be rinsed thoroughly with water. They should be disposed of in a specially marked waste container) not the general class waste basket. The janitor should be alerted to the existence of this container and be assured that none of the materials are hazardous.

If, for any reason, substitutions are made for materials, it is the responsibility of the teacher to research the toxicity, potential hazards, and the appropriate disposal of these substituted materials.

Federal, provincial, and municipal regulations regarding the labelling, storage, and disposal of hazardous substances should be followed. Under current Workplace Hazardous Materials Information System (WHMIS) regulations, all employees involved in handling hazardous substances must receive training by their employer. For more information, contact the Canadian Centre for Occupational Health and Safety, or Saskatchewan Human Resources, Labour and Employment.

Measurement

An understanding of the importance of measurement in science is critical for each student to acquire. The importance of measurement can be seen when it is viewed as one component of the Common Essential Learning of Numeracy. There is an implicit assumption in science, and in society, that quantitative statements are more authoritative than are qualitative statements. Yet, many important advances in science are made through intuition and through creative leaps. Advances in science are not restricted to data analysis. Students must see that measurement is important, but important in its context.

To make quantitative statements, measurements must be made. The accuracy of the measurements determines the confidence placed in the facts which are derived from the measurements. If the facts are represented as being accurate, the measurements must be equally accurate. But accuracy is not the only factor to consider when measurement is discussed.

The ability to make measurements depends on the technology available. A metre stick can be used to measure the length of a table. What technology is available to measure the diameter of an atom? Such measurements require a greater degree of faith in the technology. At the furthest reaches of

scientific inquiry, technology must be devised so that the results of exotic experiments can be detected, measured, and interpreted. What is measured depends upon the assumptions made in the design, and on the limitations of the technology.

The ability to make measurements depends on the correct use of the technology. Proper procedures must be followed, even with the use of simple devices such as thermometers, if measurements which accurately represent the system under observation are to be made. In addition to proper procedures, the measurement devices must be used appropriately. Even though a thermometer has a ruled scale, to measure the length of a pencil in degrees Celsius is not a useful way to represent length.

There must be as little interaction as possible between the technology, or application of it, and the object being measured. If the device used to measure the temperature of a system changes the temperature of that system by a significant amount, how useful is the measurement? Heisenberg faced a similar problem in attempting to determine the momentum and the position of the electron in the atom. Precision in determining one results in less information about the other.

Before the matter of accuracy is addressed, the student must have an understanding of what technology is available, its appropriateness for the situation, the proper use of that technology, and the limits which are inherent in the technology. Once that is understood, the student can then manipulate the technology to give the most accurate and precise results.

One aspect of accuracy pertains to the matter of uncertainty in measurement. The percentage error in a measurement, or the absolute error, is a concept which students must deal with. No measuring instrument has zero margin of error. No operator is capable of using an instrument so that no measurement error is introduced. Measurement error exists and must be accounted for in recording and interpreting data. A particular balance may have an uncertainty of measurement of 0.01 g, for example, if the balance is levelled, properly adjusted, and working well. This balance has a suitable accuracy for measuring a mass of 142.87 g but not for measuring a mass of 0.03 g. Calculate the percentage error in each case and the point is clear. However, the 0.007% measuring error for the 142.87 g mass which is due to the balance may be made entirely insignificant by operator errors such

as having the balance pan on the wrong hook, misreading the scale, not zeroing the balance before starting, stopping the oscillation of the beam with a finger, using a wet or dirty pan, and so on. Accuracy requires both good technology and good technique.

Another concern is that of significant figures. Measuring instruments can only supply a limited degree of accuracy. The problem most often encountered with students is to have them make use of the maximum precision possible, without having them overstate their case. If seven identical marbles have a total mass of 4.23 g, the average mass of a marble is not 0.604 285 714 g. A more reasonable report would express the average mass rounded off to two decimal places.

Many science texts have sections dealing with the reporting of uncertainty in measurement and significant figures. The teacher should find an approach that is comfortable for both the teacher and the students and then adopt and emphasize that approach.

Data analysis is an important related topic. Often, in order to make sense of measurements, data must be organized and interpreted. Students must learn to organize their data collection and recording so that it is ready for analysis. Graphical analysis is often useful and should be stressed. The use of computer software is also an option for recording and analysis. Databases can be used to store and then manipulate large amounts of data. Spreadsheets are also useful for organizing data. Many database and spreadsheet programs, as well as integrated software packages, contain graphing utilities and may contain statistical analysis options. Graphing and statistical analysis packages may also be purchased as stand-alone software. The use of computer analysis should be encouraged wherever possible.

In addition to the use of computer analysis, hardware interfaces to allow the input of data through sensors, which the software then interprets as measurements, are a valuable addition to a science lab. It should be emphasized that the use of a computer does not mean that the results will be error free. Accuracy is mainly a function of the technician and, to a lesser degree, of the technology.

Measurements should be expressed using SI units, or SI acceptable units, whenever this is realistic or feasible to do so. Common non-metric units may be used if necessary. Conversion factors from non-SI to SI or within the non-SI units may be necessary. Each teacher should follow the recommendations of the Canadian Metric Commission with respect to the basic and derived units of measurement and the proper symbols for those units.

If detailed information is required, refer to the *Canadian Metric Practice Guide* (CAN3-Z234.1-79 from the Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3), the *International System of Units (SI)* (CAN3-Z234.2-76 from the CSA) or the *SI Metric Guide for Science* (Saskatchewan Education, 1978).

Scientific notation should be used so that students become familiar with reading, manipulating, and writing numbers in that format. In addition to the value of SI-notation for ease in handling very large or very small numbers, students must be able to use this notation to express the number of significant figures in a large number, and to perform calculations using scientific notation.

Organizing a Field Trip

Field trips can and should be valuable learning experiences which allow students to apply their classroom learnings to an actual or "real" situation. Field trips also allow students the opportunity to learn directly rather than indirectly. Learning is enhanced through direct experience. Field trips are fun for everyone involved!

The key to successful field trip experiences is careful and thorough planning. This planning takes time and patience. Make sure to check to see if the school division has any special policies regarding field trips.

The simplest approach when planning a field trip is to treat the experience like the writing of a newspaper article, using the five Ws.

Why do you want to take your class on this particular trip?

- ! Is this mainly a science activity or does it integrate activities in other subjects as well?
- ! Are the planned activities valid learning experiences?

What learnings do you expect your students to gain from and apply to this experience?

- ! Have objectives for the field trip been established?
- ! Have appropriate activities and instructional approaches been selected?
- ! Have you and your students done your background research?
- ! Are expectations about student behaviour on the trip clear and realistic?

Where do you plan on going with your class?

- ! Is it accessible to all students?
- ! Is permission of landowners or officials required in order to visit this site?

! Does the site have facilities such as bathrooms, lunch areas, shelters, appropriate emergency facilities, etc.?

- ! Is it possible for you to visit the site beforehand?
- ! Are locations established at which various activities will occur?

When do you plan on taking this field trip?

- ! Is there adequate time to plan the trip?
- ! Will relevant information be provided to students **before** the field trip?



SAMPLE PERMISSION FORM FOR FIELD TRIPS

Date: _____

Dear Parent/Guardian:

As a part of the biology program in grade ____, we will be going on a field trip to _____. This field trip will provide your student with the opportunity to experience the following: (provide a brief list of the activities you have planned).

An itinerary and a schedule of our proposed activities during the field trip is included for your information. Please review this material and contact the school if you have any questions about our plans.

Your student should bring the following supplies on the field trip: (list any special needs).

If your student has any special physical or medical problems (i.e., allergies), please bring this to our attention. Contact the school if you feel that these problems may interfere with your student's participation in this activity.

We would like you to come along on this exciting learning experience. We encourage you to sign up as a volunteer. Thank you for your cooperation.

Teacher: _____ Principal: _____

CONSENT FORM

I will be able to take part in this field trip as volunteer.

Yes __ No __

Comments:

I permit _____ to take part in the field trip described above. I have notified the school of any physical or medical problems which might interfere with my student's participation in this activity.

DATE: _____

SIGNATURE: _____

Aids for Planning

Scope and Sequence of the Factors Forming the Dimensions of Scientific Literacy¹

Dimensions; Factors	Levels												
	Elementary						Middle				Secondary		
	K	1	2	3	4	5	6	7	8	9	10	11	12
A Nature of Science													
1. public/private													
2. historic													
3. holistic													
4. replicable													
5. empirical													
6. probabilistic													
7. unique													
8. tentative													
9. human/culture related													
B Key Science Concepts													
1. change													
2. interaction													
3. orderliness													
4. organism													
5. perception													
6. symmetry													
7. force													
8. quantification													
9. reproducibility of results													
10. cause-effect													
11. predictability													
12. conservation													
13. energy-matter													
14. cycle													
15. model													
16. system													
17. field													
18. population													
19. probability													
20. theory													
21. accuracy													
22. fundamental entities													
23. invariance													
24. scale													
25. time-space													
26. evolution													
27. amplification													
28. equilibrium													
29. gradient													
30. resonance													
31. significance													
32. validation													
33. entropy													
C Processes of Science													
1. classifying													
2. communicating													
3. observing and describing													
4. working cooperatively													
5. measuring													
6. questioning													
7. using numbers													
8. hypothesizing													
9. inferring													
10. predicting													
11. controlling variables													
12. interpreting data													
13. formulating models													
14. problem solving													
15. analyzing													
16. designing experiments													
17. using mathematics													
18. using time-space relationships													
19. consensus making													
20. defining operationally													
21. synthesizing													

¹Adapted from: Hart, E.P. (1987). *Science for Saskatchewan Schools: Proposed Directions. Field Study, Part B. A Framework for Curriculum Development.* A Saskatchewan Instructional Development Research Unit project funded by Saskatchewan Education.

Dimensions; Factors	Levels												
	Elementary					Middle				Secondary			
	K	1	2	3	4	5	6	7	8	9	10	11	12
D Science-Technology-Society-Environment Interrelationships													
1. science and technology	----	----	----	----	----	----	----	----	----	----	----	----	----
2. scientists and technologists are human	----	----	----	----	----	----	----	----	----	----	----	----	----
3. impact of science and technology	----	----	----	----	----	----	----	----	----	----	----	----	----
4. science, technology, and the environment	----	----	----	----	----	----	----	----	----	----	----	----	----
5. public understanding gap	----	----	----	----	----	----	----	----	----	----	----	----	----
6. resources for science and technology	----	----	----	----	----	----	----	----	----	----	----	----	----
7. variable positions	----	----	----	----	----	----	----	----	----	----	----	----	----
8. limitations of science and technology	----	----	----	----	----	----	----	----	----	----	----	----	----
9. social influence on science and technology	----	----	----	----	----	----	----	----	----	----	----	----	----
10. technology controlled by society	----	----	----	----	----	----	----	----	----	----	----	----	----
11. science, technology, and other realms	----	----	----	----	----	----	----	----	----	----	----	----	----
E Scientific and Technical Skills													
1. using magnifying instruments	----	----	----	----	----	----	----	----	----	----	----	----	----
2. using natural environments	----	----	----	----	----	----	----	----	----	----	----	----	----
3. using equipment safely	----	----	----	----	----	----	----	----	----	----	----	----	----
4. using audio-visual aids	----	----	----	----	----	----	----	----	----	----	----	----	----
5. computer interaction	----	----	----	----	----	----	----	----	----	----	----	----	----
6. measuring distance	----	----	----	----	----	----	----	----	----	----	----	----	----
7. manipulative ability	----	----	----	----	----	----	----	----	----	----	----	----	----
8. measuring time	----	----	----	----	----	----	----	----	----	----	----	----	----
9. measuring volume	----	----	----	----	----	----	----	----	----	----	----	----	----
10. measuring temperature	----	----	----	----	----	----	----	----	----	----	----	----	----
11. measuring mass	----	----	----	----	----	----	----	----	----	----	----	----	----
12. using electronic instruments	----	----	----	----	----	----	----	----	----	----	----	----	----
13. using quantitative relationships	----	----	----	----	----	----	----	----	----	----	----	----	----
F Values That Underlie Science													
1. longing to know and understand	----	----	----	----	----	----	----	----	----	----	----	----	----
2. questioning	----	----	----	----	----	----	----	----	----	----	----	----	----
3. search for data and their meaning	----	----	----	----	----	----	----	----	----	----	----	----	----
4. valuing natural environments	----	----	----	----	----	----	----	----	----	----	----	----	----
5. respect for logic	----	----	----	----	----	----	----	----	----	----	----	----	----
6. consideration of consequence	----	----	----	----	----	----	----	----	----	----	----	----	----
7. demand for verification	----	----	----	----	----	----	----	----	----	----	----	----	----
8. consideration of premises	----	----	----	----	----	----	----	----	----	----	----	----	----
G Science-Related Interests and Attitudes													
1. interest	----	----	----	----	----	----	----	----	----	----	----	----	----
2. confidence	----	----	----	----	----	----	----	----	----	----	----	----	----
3. continuous learner	----	----	----	----	----	----	----	----	----	----	----	----	----
4. media preference	----	----	----	----	----	----	----	----	----	----	----	----	----
5. avocation	----	----	----	----	----	----	----	----	----	----	----	----	----
6. response preference	----	----	----	----	----	----	----	----	----	----	----	----	----
7. vocation	----	----	----	----	----	----	----	----	----	----	----	----	----
8. explanation preference	----	----	----	----	----	----	----	----	----	----	----	----	----
9. valuing contributors	----	----	----	----	----	----	----	----	----	----	----	----	----

KEY: ---- Preparation. Emerging in these grades. Limited focus.
 _____ Development. Addressed in full, and appropriate to the grade level. Emphasized.

Explanations of the Factors in the Dimensions of Scientific Literacy

A. Nature of Science

The scientifically literate person understands the nature of science and scientific knowledge.

Science is both public and private. Science experiences should introduce students to the private and intuitive aspects of scientific inquiry and discovery as well as to the more formal public aspects of science.

The nature of scientific knowledge is such that it is:

A1 public/private D(K-12)

Science is based on evidence, developed privately by individuals or groups, that is shared publicly with others. This provides other individuals with the opportunity to attempt to establish the validity and reliability of the evidence.

Examples:

After scientists have gathered and organized evidence for their ideas, they publish the evidence and the methods by which it was obtained, so that other scientists may test the validity and reliability of the evidence.

When Pons and Fleischman withheld some of the evidence and procedures for their cold-fusion discovery in order to protect their claims for patent, the principle of public disclosure was violated.

A2 historic D(K-12)

Past scientific knowledge should be viewed in its historical context and not be degraded on the basis of present knowledge.

Examples:

Each refinement of the model of the atom by Thompson, Rutherford, Bohr, and the quantum theorists has relied on the previous work of others.

Selective breeding of corn by the Indian peoples of North America produced a high quality food plant.

A3 holistic D(K-12)

All branches of science are interrelated.

Example:

The structure of molecules is a topic of interest for physicists, chemists, and biologists.

A4 replicable P(K-2), D(3-12)*

Science is based on evidence which could be obtained by other people working in a different place and at a different time under similar conditions.

Examples:

Any procedure which is repeated should give similar results.

A group of students all perform the same experiment and discover similarities in their results.

A5 empirical P(K-2), D(3-12)

Scientific knowledge is based on experimentation or observation.

Examples:

The gravitational field strength of the Earth can be determined in the laboratory.

Scientific theories must always be tested experimentally.

* The code **P(K-2)** means that preparation for development of this factor is to take place from kindergarten until grade 2. Development, coded D(3-12), takes place from grades 3 to 12. **Preparation** involves such things as the teacher using the term or its concepts and the students being exposed to phenomena which illustrate or involve the factor. **Development** occurs when the student are encouraged to use the term or its concepts correctly.

<p>A6 probabilistic</p> <p>Science does not make absolute predictions or explanations.</p> <p>Examples:</p> <p>An electron orbital is a region in space where there is the greatest likelihood of finding an electron.</p> <p>A weather forecaster predicts a 20% chance of precipitation tomorrow.</p>	<p>P(2-8), D(9-12)</p>	<p>Examples:</p> <p>Vertebrates, and specifically humans, are regarded as being at the pinnacle of evolution by some people.</p> <p>The use of biotechnology has resulted in changes in rapeseed to remove erucic acid. This has led to the development of improved varieties of canola oil for human consumption.</p>
<p>A7 unique</p> <p>The nature of scientific knowledge and the procedures for generating new scientific knowledge are unique and different from those in other fields of knowledge such as philosophy.</p> <p>Examples:</p> <p>Compare the methods used for weather forecasting by meteorologists and those used by the people producing the forecasts for the Farmer's Almanac.</p> <p>Compare Galileo's experimental approach to investigating the rate at which heavy and light objects fall and Aristotle's approach, based on reason alone.</p>	<p>P(3-7), D(8-12)</p>	<p>B. Key Science Concepts</p> <p>The scientifically literate person understands and accurately applies appropriate science concepts, principles, laws, and theories in interacting with society and the environment.</p> <p>Among the key concepts of science are:</p> <p>B1 change D(K-12)</p> <p>It is the process of becoming different. It may involve several stages.</p> <p>Examples:</p> <p>An organism develops from an egg, matures, and eventually dies.</p> <p>Stars use up their fuel and thus undergo change.</p>
<p>A8 tentative</p> <p>Scientific knowledge is subject to change. It does not claim to be truth in an absolute and final sense. This does not lessen the value of knowledge for the scientifically literate person.</p> <p>Example:</p> <p>As new data become available, theories are modified to encompass the new and the old data. Our understanding of atomic structure has changed considerably for this reason.</p>	<p>P(6), D(7-12)</p>	<p>B2 interaction D(K-12)</p> <p>This happens when two or more things influence or affect each other.</p> <p>Example:</p> <p>Within an ecosystem some animals have to compete for available food and space.</p>
<p>A9 human/culture related P(6-9), D(10-12)</p> <p>Scientific knowledge is a product of humankind. It involves creative imagination. The knowledge is shaped by and from concepts that are a product of culture.</p>		<p>B3 orderliness D(K-12)</p> <p>This is a regular sequence which either exists in nature or is imposed through classification.</p> <p>Examples:</p> <p>Crystal structures can be identified by diffraction techniques because of the regular arrangement of their atoms.</p> <p>The periodic table of the elements displays an orderly arrangement of elements.</p>

<p>B4 organism D(K-12)</p> <p>An organism is a living thing or something that was once alive.</p> <p>Examples:</p> <p>Whether or not a virus is a living organism is an interesting topic for scientific scrutiny.</p> <p>Fossils found in sedimentary rock provide evidence of organisms which became extinct a long time ago.</p>	<p>B9 reproducibility of results P(K-2), D(3-12)</p> <p>Repetition of a procedure should produce the same results if all other conditions are identical. It is a necessary characteristic of scientific experiments.</p> <p>Example:</p> <p>Heating a pure sample of paradichlorobenzene should cause it to melt at about 50 °C</p>
<p>B5 perception D(K-12)</p> <p>Perception is the interpretation of sensory input by the brain.</p> <p>Example:</p> <p>Jet lag may impair the judgement of pilots during landing and takeoff.</p>	<p>B10 cause-effect P(K-2), D(3-12)</p> <p>It is a relationship of events that substantiates the belief that natural phenomena do not occur randomly. It enables predictions to be made. The advent of chaos theory has caused some rethinking of this principle.</p> <p>Examples:</p> <p>The acceleration of a cart depends on the unbalanced force acting upon the cart.</p> <p>Every event has a cause. It does not happen by itself.</p>
<p>B6 symmetry D(K-12)</p> <p>This is a repetition of a pattern within some larger structure.</p> <p>Example:</p> <p>Some molecular structures and living organisms exhibit properties of symmetry.</p>	<p>B11 predictability P(K-3), D(4-12)</p> <p>Patterns can be identified in nature. From those patterns inferences can be made.</p> <p>Example:</p> <p>When sodium metal reacts with water, the resulting solution turns red litmus paper blue.</p>
<p>B7 force P(K-1), D(2-12)</p> <p>It is a push or a pull.</p> <p>Example:</p> <p>The weight of an object decreases at higher altitudes.</p>	<p>B12 conservation P(K-4), D(5-12)</p> <p>An understanding of the finite nature of the world's resources, and an understanding of the necessity to treat those resources with prudence and economy, are underlying principles of conservation.</p> <p>Examples:</p> <p>Insulating a home may reduce the amount of energy needed to heat it in the winter.</p> <p>Smaller, more efficient internal combustion engines can be designed to use less fuel.</p>
<p>B8 quantification P(K-1), D(2-12)</p> <p>Numbers can be used to convey important information.</p> <p>Example:</p> <p>The gravitational force of attraction between two objects can be calculated by using Newton's Law of Universal Gravitation.</p>	

<p>B13 energy-matter P(1-2), D(3-12)</p> <p>It is the interchangeable and dependent relationship between energy and matter.</p> <p>Example:</p> <p>When a candle burns, some of the energy stored in the wax is released as heat and light.</p>	<p>The sun is the source of a gravitational field which fills space. The Earth's motion is affected by the influence of this field.</p> <p>B18 population P(3), D(4-12)</p> <p>A population is a group of organisms that share common characteristics.</p> <p>Example:</p> <p>Wildlife biologists monitor white tail deer to determine the number of permits for hunting that will be issued in a particular zone.</p>
<p>B14 cycle P(1-2), D(3-12)</p> <p>Certain events or conditions are repeated.</p> <p>Examples:</p> <p>The water cycle, nitrogen cycle, and equilibrium all serve as examples of cycles.</p> <p>Change occurring in cycles or patterns is one of the twelve principles of Indian philosophy.</p>	<p>B19 probability P(3-8), D(9-12)</p> <p>Probability is the relative degree of certainty that can be assigned to certain events happening in a specified time interval or within a sequence of events.</p> <p>Example:</p> <p>The probability of getting some types of cancer increases with prolonged exposure to large doses of radiation.</p>
<p>B15 model P(1-2), D(3-12)</p> <p>It is a representation of a real structure, event, or class of events intended to facilitate a better understanding of abstract concepts or to allow scaling to a manageable size.</p> <p>Example:</p> <p>Watson and Crick developed a model of the DNA molecule which allowed people to gain a better understanding of genetics.</p>	<p>B20 theory P(3-9), D(10-12)</p> <p>A theory is a connected and internally consistent group of statements, equations, models, or a combination of these, which serves to explain a relatively large and diverse group of things and events.</p> <p>Example:</p> <p>As new experimental evidence becomes available, atomic theory undergoes further change and refinement.</p>
<p>B16 system P(1-2), D(3-12)</p> <p>A set of interrelated parts forms a system.</p> <p>Example:</p> <p>Chemical equilibrium can be established only in a closed system.</p>	<p>B21 accuracy P(5-8), D(9-12)</p> <p>Accuracy involves a recognition that there is uncertainty in measurement. It also involves the correct use of significant figures.</p> <p>Example:</p> <p>A stopwatch which measures to the nearest 1/10th of a second would be an inappropriate instrument for determining the duration of a spark discharge.</p>
<p>B17 field P(1-2), D(3-12)</p> <p>A field is a region of space which is influenced by some agent.</p> <p>Examples:</p> <p>Similarly charged objects have a tendency to repel one another when they are in close proximity.</p>	

B22 fundamental entities**P(6), D(7-12)**

They are units of structure or function which are useful in explaining certain phenomena.

Examples:

The cell is the basic unit of organic structure.
The atom is the basic unit of molecular structure.

B23 invariance**P(6), D(7-12)**

This is a characteristic which stays constant even though other things may change.

Example:

Mass is conserved in a chemical reaction.

B24 scale**P(6), D(7-12)**

Scale involves a change in dimensions. This may affect other characteristics of a system.

Example:

A paper airplane made from a sheet of notebook paper may fly differently than a plane of identical design made from a poster-sized sheet of the same paper.

B25 time-space**P(6-7), D(8-12)**

It is a mathematical framework in which it is convenient to describe objects and events.

Examples:

An average human being has an extension in one direction of approximately 1 3/4 metres and in another direction of about 70 years.

According to general relativity, gravity is not a force, but a property of space itself. It is a curvature in time-space caused by the presence of an object.

B26 evolution**P(6-8), D(9-12)**

Evolution is a series of changes that can be used to explain how something got to be the way it is or what it might become in the future. It is generally regarded as going from simple to complex.

Example:

Organic evolution is thought to progress in small, incremental changes. Similarly, scientific theories undergo change to accommodate new data as they become available.

B27 amplification**P(8), D(9-12)**

Amplification is an increase in magnitude of some detectable phenomenon.

Example:

A loudspeaker produces an amplification of sound.

B28 equilibrium**P(9), D(10-12)**

Equilibrium is the state in which there is no change on the macroscopic level and no net forces on the system.

Examples:

Chemical equilibrium exhibits no change on the macroscopic level.

A first class lever in a condition of static equilibrium remains at rest. The sum of all of the moments of the forces acting is zero.

B29 gradient**P(9), D(10-12)**

A gradient is a description of a pattern or variation. The description includes both the magnitude and the direction of the change.

Examples:

Light intensity decreases in a predictable manner as the distance from the light source increases.

On a mountain, the direction in which the change of slope is smallest is the most desirable route to build a railroad line.

<p>B30 resonance</p> <p>It is an action within one system which causes a similar action within another system.</p> <p>Examples:</p> <p>A hollow wooden box can be used to amplify the sound of a tuning fork.</p> <p>A wine glass can be made to shatter by sound vibrations due to mechanical resonance.</p>	<p>P(9), D(10-12)</p>	<p>Complex or integrated processes include those which are more basic. Intellectual skills are acquired and practised throughout life so that eventually some control over these processes can facilitate learning.</p> <p>This can provide information processing and problem solving abilities that go beyond any curriculum.</p> <p>Process skills such as accessing and processing information, applying knowledge of scientific principles to the analysis of issues, identifying value positions, and reaching consensus are believed to include the more basic processes of science.</p>
<p>B31 significance</p> <p>It is the belief that certain differences exceed those that would be expected to be caused by chance alone.</p> <p>Example:</p> <p>An analysis of Brahe's data led to the development of Kepler's First Law.</p>	<p>P(9), D(10-12)</p>	<p>The basic processes of science are:</p> <p>C1 classifying D(K-12)</p> <p>Classifying is a systematic procedure used to impose order on collections of objects or events.</p>
<p>B32 validation</p> <p>Validation is a belief that similar relationships obtained by two or more different methods reflect an accurate representation of the situation being investigated.</p> <p>Example:</p> <p>Carbon-14 dating can be used to check the authenticity of archaeological artifacts.</p>	<p>P(9), D(10-12)</p>	<p>Example:</p> <p>Grouping animals into their phyla or arranging the elements into the periodic table are examples of classifying.</p> <p>C2 communicating D(K-12)</p> <p>Communicating is any one of several procedures for transmitting information from one person to another.</p>
<p>B33 entropy</p> <p>Entropy is the randomness, or disorder, in a collection of things. It can never decrease in a closed system.</p> <p>Example:</p> <p>When solid sodium chloride dissolves in water, its particles are dispersed randomly.</p>	<p>P(9-10), D(11-12)</p>	<p>Example:</p> <p>Writing reports, or participating in discussions in class are examples of communicating.</p> <p>C3 observing and describing D(K-12)</p> <p>This is the most basic process of science. The senses are used to obtain information about the environment.</p>
<p>C. Processes of Science</p> <p>The scientifically literate person uses processes of science in solving problems, making decisions, and furthering understanding of society and the environment.</p>		
<p>Example:</p> <p>During an investigation, a student writes a paragraph recording the progress of a chemical reaction between hot copper metal and sulphur vapour.</p>		

<p>C4 working cooperatively D(K-12)</p> <p>This involves an individual working productively as a member of a team for the benefit of the team's goals.</p> <p>Example:</p> <p>Students should share responsibilities in the completion of an experiment.</p>	<p>Example:</p> <p>Making predictions about the importance of various components of a pendulum which may influence its period is an example of hypothesizing.</p>
<p>C5 measuring D(K-12)</p> <p>An instrument is used to obtain a quantitative value associated with some characteristic of an object or an event.</p> <p>Example:</p> <p>The length of a metal bar can be determined to the nearest millimetre with an appropriate measuring device.</p>	<p>C9 inferring P(1-2), D(3-12)</p> <p>It is explaining an observation in terms of previous experience.</p> <p>Example:</p> <p>After noticing that saline sloughs have a different insect population than fresher sloughs, one might infer that small changes in an environment can affect populations.</p>
<p>C6 questioning P(K-1), D(2-12)</p> <p>It is the ability to raise problems or points for investigation or discussion.</p> <p>Example:</p> <p>A student should be able to create directed questions about observed events. When migratory birds are observed, questions such as, "Why do birds flock to migrate?", "Do some birds migrate singly?", and "How do birds know where to go?" should direct further inquiry.</p>	<p>C10 predicting P(1-2), D(3-12)</p> <p>This involves determining future outcomes on the basis of previous information.</p> <p>Example:</p> <p>Given the results of the hourly population counts in a yeast culture over a 4 hour period, one could attempt to predict the population after 5 hours.</p>
<p>C7 using numbers P(K-1), D(2-12)</p> <p>This involves counting or measuring to express ideas, observations, or relationships, often as a complement to the use of words.</p> <p>Example:</p> <p>1 litre contains 1 000 millilitres.</p>	<p>C11 controlling variables P(1-2), D(3-12)</p> <p>Controlling variables is based on identifying and managing the conditions that may influence a situation or event.</p> <p>Examples:</p> <p>If all other factors which may be important in plant growth are identified and made similar (controlled), the effect of gibberellic acid can be observed.</p> <p>In order to test the effect of fertilizer on plant growth, all other factors which may be important in plant growth must be identified and controlled so that the effect of the fertilizer can be determined.</p>
<p>C8 hypothesizing P(1-2), D(3-12)</p> <p>Hypothesizing is stating a tentative generalization which may be used to explain a relatively large number of events. It is subject to immediate or eventual testing by experiments.</p>	

<p>C12 interpreting data P(2), D(3-12)</p> <p>This important process is based on finding a pattern in a collection of data. It leads to a generalization.</p> <p>Example:</p> <p>Concluding that the mass of the pendulum bob does not affect the period of a pendulum might be based on the similarity of periods of 100 g, 200 g, and 300 g pendulums.</p>	<p>Example:</p> <p>Automobile manufacturers test seat belt performance in crash tests.</p>
<p>C13 formulating models P(2-6), D(7-12)</p> <p>Models are used to represent an object, event, or process.</p> <p>Example: Vector descriptions of how forces interact are models.</p>	<p>C17 using mathematics P(6), D(7-12)</p> <p>When using mathematics, numeric or spatial relationships are expressed in abstract terms.</p> <p>Example:</p> <p>Projectile trajectories can be predicted using mathematics.</p>
<p>C14 problem solving P(2-8), D(9-12)</p> <p>Scientific knowledge is generated by, and used for, asking questions concerning the natural world. Quantitative methods are frequently employed.</p> <p>Example:</p> <p>A knowledge of genetics and the techniques of recombinant DNA are used to create bacteria which produce insulin.</p>	<p>C18 using time-space relationships P(6-7), D(8-12)</p> <p>These are the two criteria used to describe the location of things or events.</p> <p>Example:</p> <p>Describe the migratory paths of the barren lands caribou.</p>
<p>C15 analyzing P(3-5), D(6-12)</p> <p>It is examining scientific ideas and concepts to determine their essence or meaning.</p> <p>Examples:</p> <p>Determining whether a hypothesis is tenable requires analysis.</p> <p>Determining which amino acid sequence produces insulin requires analysis.</p>	<p>C19 consensus making P(6-8), D(9-12)</p> <p>Consensus making is reaching an agreement when a diversity of opinions exist.</p> <p>Examples:</p> <p>A discussion of the disposal of toxic waste, based on research, gives a group of students the opportunity to develop a position they will be using in a debate.</p> <p>Scientists were initially divided regarding the cold fusion debate. They held conferences but were still unable to agree on this issue. Further experimental results were needed.</p>
<p>C16 designing experiments P(3-8), D(9-12)</p> <p>Designing experiments involves planning a series of data-gathering operations which will provide a basis for testing a hypothesis or answering a question.</p>	<p>C20 defining operationally P(7-9), D(10-12)</p> <p>It is producing a definition of a thing or event by giving a physical description or the results of a given procedure.</p> <p>Example:</p> <p>An acid turns blue litmus paper red and tastes sour.</p>

<p>C21 synthesizing P(9-10), D(11-12)</p> <p>Synthesizing involves combining parts into a complex whole.</p> <p>Examples:</p> <p>Polymers can be produced through the combination of simpler monomers.</p> <p>A student essay may involve the synthesis of a wide variety of knowledge, skills, attitudes, and processes.</p>	<p>D3 impact of science and technology P(3-5), D(6-12)</p> <p>Scientific and technological developments have real and direct effects on every person's life. Some effects are desirable; others are not. Some of the desirable effects may have undesirable side effects. In essence, there seems to be a trade-off principle working in which gains are accompanied by losses.</p> <p>Example:</p> <p>As our society continues to increase its demands on energy consumption and consumer goods, we are likely to attain a higher standard of living while allowing further deterioration of the environment to occur.</p>
<p>D. Science-Technology-Society-Environment Interrelationships</p> <p>The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each other.</p> <p>Some of the factors involved in the interrelationships among science, technology, society, and the environment are:</p>	<p>D4 science, technology, and the environment P(3-5), D(6-12)</p> <p>Science and technology can be used to monitor environmental quality. Society has the ability and responsibility to educate and to regulate environmental quality and the wise usage of natural resources, to ensure quality of life for this and succeeding generations.</p>
<p>D1 science and technology P(K-2), D(3-12)</p> <p>There is a distinction between science and technology, although they often overlap and depend on each other. Science deals with generating and ordering conceptual knowledge. Technology deals with design and development, and the application of scientific or technological knowledge, often in response to social and human needs.</p> <p>Example:</p> <p>The invention of the microscope led to new discoveries about cells.</p>	<p>Example:</p> <p>Everyone should share in the responsibility of conserving energy.</p>
<p>D2 scientists and technologists are human P(1-6), D(7-12)</p> <p>Outside of their specialized fields, scientists and technologists may not exhibit strong development of all or even most of the Dimensions of Scientific Literacy. Vocations in science and technology are open to most people.</p> <p>Example:</p> <p>By researching the biographies of famous scientists, students can begin to appreciate the human elements of science and technology.</p>	<p>D5 public understanding gap P(3-8), D(9-12)</p> <p>A considerable gap exists between scientific and technological knowledge, and public understanding of it. Constant effort is required by scientists, technologists, and educators to minimize this gap.</p> <p>Examples:</p> <p>Some people mistakenly believe that irradiation causes food to become radioactive.</p> <p>Buttermilk is often mistakenly regarded as having a high caloric content.</p> <p>Folklore has it that the best time to plant potatoes in the spring is during the full moon.</p> <p>Many believe that technology is simply applied science.</p>

**D6 resources for science
and technology****P(3-8), D(9-12)**

Science and technology require considerable resources in the form of talent, time, and money.

Example:

Further advances in space exploration may require the collective efforts of many nations working together to find the necessary time, money and resources.

D7 variable positions**P(3-9), D(10-12)**

Scientific thought and knowledge can be used to support different positions. It is normal for scientists and technologists to disagree among themselves, even though they may invoke the same scientific theories and data.

Examples:

The debate about the possibility of cold fusion illustrated variable positions among scientists.

There is a debate about whether or not controlled burning techniques should be used in national parks.

**D8 limitations of science
and technology****P(6-8), D(9-12)**

Science and technology can not guarantee a solution to any specific problem. In fact, the ultimate solution of any problem is usually impossible, and a partial or temporary solution is all that is ever possible. Solutions to problems can not necessarily be legislated, bought, or guaranteed by the allocation of resources. Some things are not amenable to the approaches of science and technology.

Example:

The solutions that technology now proposes for nuclear waste storage often have significant limitations and are, at best, only short-term solutions until better ones can be found.

**D9 social influence on science
and technology****P(7-9), D(10-12)**

The selection of problems investigated by scientific and technological research is influenced by the needs, interests, and financial support of society.

Example:

The race to put a person on the moon illustrates how priorities can determine the extent to which the study of particular scientific and technological problems are sanctioned and thus allowed to be investigated.

**D10 technology controlled by
society****P(9), D(10-12)**

Although science requires freedom to inquire, applications of scientific knowledge and of technological products and practices are ultimately determined by society. Scientists and technologists have a responsibility to inform the public of the possible consequences of such applications. A need to search for consequences of scientific and technological innovations exists.

Examples:

Einstein's famous letter to President Roosevelt, warning about the possibility of developing nuclear weapons, and his pacifist views, illustrate the responsibility that scientists must have as members of society.

Governments must make decisions regarding the support and funding of important scientific research.

**D11 science, technology, and
other realms****P(9), D(10-12)**

Although there are distinctive characteristics of the knowledge and processes that characterize science and technology, there are many connections to, and overlaps with, other realms of human knowledge and understanding.

Example:

The Uncertainty Principle in science, the Verstehen Principle in anthropology, and the Hawthorne Effect in social psychology all express similar types of ideas within the realm of their own disciplines.

E. Scientific and Technical Skills

The scientifically literate person has developed numerous manipulative skills associated with science and technology.

The list of skills that follows represents manipulative skills important to the achievement of scientific literacy:

E1 using magnifying instruments D(K-12)

Some magnifying instruments include the magnifying lens, microscope, telescope, and overhead projector.

Examples:

Fine dissections of earthworms are done with the aid of stereoscopic microscopes.

A student uses a microphone to make an announcement to a large group over the public address system.

E2 using natural environments D(K-12)

The student uses natural environments effectively and in appropriately sensitive ways (e.g., collecting, examining, and reintroducing specimens).

Example:

Students can do a study of the margin of a pond by observing and describing a particular section at two week intervals for three months. After they collect and examine specimens, they should reintroduce them to their natural environment.

E3 using equipment safely D(K-12)

The student demonstrates safe use of equipment in the laboratory, in the classroom, and in everyday experiences.

Example:

A student recognizes a situation where goggles should be worn, and puts them on before being instructed to wear them.

E4 using audiovisual aids D(K-12)

The student independently uses audiovisual aids in communicating information. (Audiovisual aids include such things as: drawings, photographs, collages, televisions, radios, video cassette recorders, overhead projectors.)

Examples:

A student shows the teacher how to operate the VCR.

A student uses a camera to record natural phenomena.

E5 computer interaction D(K-12)

The student uses the computer as an analytical tool, a tool to increase productivity, and as an extension of the human mind.

Examples:

Using photocells connected to the proper interface, the computer can be used as a timing device.

Logging on to an information service gives students an opportunity to perform a keyword search of a chemical database.

Computer software can be used to simulate a natural event or process which may be too dangerous or impractical to perform in the laboratory.

E6 measuring distance P(K-1), D(2-12)

The student accurately measures distance with appropriate instruments or techniques such as rulers, metre sticks, trundle wheels, or rangefinders.

Examples:

The length and width of a room can be determined using a metre stick.

Large distances can be determined using parallax or triangulation methods.

E7 manipulative ability	P(K-2), D(3-12)	<p>Example:</p> <p>Balances may be used to determine the mass of an object, within the limits of the precision of the balance.</p>
<p>The student demonstrates an ability to handle objects with skill and dexterity.</p>		
<p>Example:</p>		
<p>A student uses a graduated cylinder to measure 35 mL of liquid. The liquid is then transferred into a flask and heated.</p>		
E8 measuring time	P(1), D(2-12)	<p>E12 using electronic instruments P(5-8), D(9-12)</p> <p>The student can use electronic instruments that reveal physical or chemical properties, or monitor biological functions.</p>
<p>The student accurately measures time with appropriate instruments such as a watch, an hourglass, or any device which exhibits periodic motion.</p>		
<p>Example:</p>		
<p>A student uses an oscilloscope to measure a short time interval accurately.</p>		
E9 measuring volume	P(1), D(2-12)	<p>Example:</p> <p>Following the recommended procedures allows an instrument to be used to the maximum extent of its precision (e.g., ammeter, oscilloscope, pH meter, camera).</p>
<p>The student measures volume directly with graduated containers. The student also measures volume indirectly using calculations from mathematical relations.</p>		
<p>Examples:</p>		
<p>The volume of a graduated cylinder is read at the curve inflection point of the meniscus.</p>		
<p>Archimedes' principle is used to determine the volume of an irregular solid.</p>		
E10 measuring temperature	P(1), D(2-12)	<p>E13 using quantitative relationships P(5-9), D(10-12)</p> <p>The student uses mathematical expressions correctly.</p>
<p>The student accurately measures temperature with a thermometer or a thermocouple.</p>		
<p>Example:</p>		
<p>Thermometers must be properly placed to record accurate measurements of temperature.</p>		
E11 measuring mass	P(2), D(3-12)	<p>Examples:</p> <p>To calculate instantaneous acceleration, find the slope at one point on a velocity versus time graph.</p> <p>Calculate the volume of a cube given the length of one side.</p>
<p>The student accurately measures mass with a double beam balance or by using other appropriate techniques.</p>		

F. Values That Underlie Science

The scientifically literate person interacts with society and the environment in ways that are consistent with the values that underlie science.

The values that underlie science include:

FI longing to know and understand D(K-12)

Knowledge is desirable. Inquiry directed toward the generation of knowledge is a worthy investment of time and other resources.

Example:

A group of four students asks the teacher if they can do a Science Challenge project on a topic that they are all interested in.

<p>F2 questioning D(K-12)</p> <p>Questioning is important. Some questions are of greater value than others because they lead to further understanding through scientific inquiry.</p> <p>Example:</p> <p>Students ask questions which probe more deeply than the normal class or text presentation.</p>	<p>F6 consideration of consequence P(K-5), D(6-12)</p> <p>It is a frequent and thoughtful review of the effects that certain actions will have.</p> <p>Example:</p> <p>Experimental procedures can affect the outcome of an experiment.</p> <p>Transporting oil by tankers might cause an oil spill with very serious environmental consequences.</p>
<p>F3 search for data and their meaning D(K-12)</p> <p>The acquisition and ordering of data are the basis for theories which, in turn, can be used to explain many things and events. In some cases these data have immediate practical applications of value to humankind. Data may enable one to assess a problem or situation accurately.</p> <p>Example:</p> <p>In a Science Challenge activity, a group of students asks a question about a natural occurrence. They then design an experiment in an attempt to answer the question. Variables which may influence the results of the experiment are controlled. Careful observations are made and recorded. Data are collected and analyzed to test the hypothesis that is under scrutiny. Further testing then takes place.</p>	<p>F7 demand for verification P(3-5), D(6-12)</p> <p>Supporting data must be made public. Empirical tests must be conducted to assess the validity or accuracy of findings or assertions.</p> <p>Example:</p> <p>Media reports and research are reviewed critically and compared to other sources of information before being accepted or rejected.</p> <p>F8 consideration of premises P(9), D(10-12)</p> <p>A frequent review should occur of the basic assumptions from which a line of inquiry has arisen.</p> <p>Examples:</p> <p>In a lab investigation into the rate of chemical reactions, the control of variables is examined.</p> <p>A critical examination is made of the factors under consideration in explaining the extinction of dinosaurs.</p>
<p>F4 valuing natural environments D(K-12)</p> <p>Our survival depends on our ability to sustain the essential balance of nature. There is intrinsic beauty to be found in nature.</p> <p>Example:</p> <p>On a field trip the actions of the participants should be considerate toward and conserving of all components of the ecosystem.</p>	
<p>F5 respect for logic P(K-2), D(3-12)</p> <p>Correct and valid inferences are important. It is essential that conclusions and actions be subject to question.</p> <p>Example:</p> <p>Errors in logic are recognized. Information is viewed critically with respect to the logic used.</p>	<p>G. Science-Related Interests and Attitudes</p> <p>The scientifically literate person has developed a unique view of science, technology, society and the environment as a result of science education, and continues to extend this education throughout life.</p>

Science-related interests and attitudes include:		G5 avocation	P(3-5), D(6-12)
G1 interest	D(K-12)	The student pursues a science-related hobby.	
The student exhibits an observable interest in science.		Example:	
Example:		By pursuing a hobby such as bird watching, astronomy, or shell collecting, a student demonstrates a keen interest in science.	
Students and teachers who spend a great deal of time outside of class on science fair projects exhibit a keen interest in science.		G6 response preference	P(3-5), D(6-12)
		The way in which people behave can be an indication of whether or not they are striving to attain scientific literacy.	
		Example:	
		In an election, voters might consider the candidates' positions on environmental issues.	
G2 confidence	D(K-12)	G7 vocation	P(3-8), D(9-12)
The student experiences a measure of self-satisfaction by participating in science and in understanding scientific things.		The student considers a science-related occupation.	
Example:		Example:	
Students and teachers read science literature and are interested in discussing with others what they read.		By modelling appropriate behaviours, teachers can encourage their students to become interested in science education or other science-related fields.	
G3 continuous learner	D(K-12)	G8 explanation preference	P(6-9), D(10-12)
The individual has gained some scientific knowledge and continues some line of scientific inquiry. This may take many forms.		The student chooses a scientific explanation over a nonscientific explanation when it is appropriate to do so. The student also recognizes that there may be some circumstances in which it may not be appropriate to select a scientific explanation.	
Example:		Example:	
A person joins a natural history society to learn more about wildlife.		By resorting to logic in a debate, students demonstrate logical thinking similar to that used in science.	
G4 media preference	P(K-2), D(3-12)	G9 valuing contributors	P(6-9), D(10-12)
The student selects the most appropriate media, depending on the information needed, and on his or her present level of understanding.		The student values those scientists and technologists who have made significant contributions to humanity.	
Examples:		Examples:	
Students and teachers who watch science-related television programs demonstrate a real interest in science.		A person wears a T-shirt bearing the image of some famous scientist.	
When researching a science project, a student might have to determine which sources of information are most appropriate. The choice could include such things as television programs, newspaper articles, books, public displays, and scientific journals.		Students may hold the teacher in high regard.	

Templates for Assessment and Evaluation

Rating Scale Template

	_____	_____	_____			
1) _____	.)))2)))2)))2)))-	1	2	3	4	5
2) _____	.)))2)))2)))2)))-	1	2	3	4	5
3) _____	.)))2)))2)))2)))-	1	2	3	4	5
4) _____	.)))2)))2)))2)))-	1	2	3	4	5
5) _____	.)))2)))2)))2)))-	1	2	3	4	5
6) _____	.)))2)))2)))2)))-	1	2	3	4	5
7) _____	.)))2)))2)))2)))-	1	2	3	4	5
8) _____	.)))2)))2)))2)))-	1	2	3	4	5
9) _____	.)))2)))2)))2)))-	1	2	3	4	5
10) _____	.)))2)))2)))2)))-	1	2	3	4	5
11) _____	.)))2)))2)))2)))-	1	2	3	4	5
12) _____	.)))2)))2)))2)))-	1	2	3	4	5
13) _____	.)))2)))2)))2)))-	1	2	3	4	5
14) _____	.)))2)))2)))2)))-	1	2	3	4	5

Anecdotal Record Template

Report

Subject

Student

School

Teacher

Date

Teacher's Signature

Correspondence Template

--	--

Checklist of Laboratory Procedures

Name

Date

Activity

Key: 1 = Rarely 2 = Occasionally 3 = Frequently

1 2 3

Instructions followed _____

Safety precautions observed _____

Equipment handled correctly _____

Equipment cleaned thoroughly _____

Equipment stored properly _____

Lab area kept clean _____

Spills cleaned promptly _____

Chemical disposed of properly _____

Cooperation with others _____

Improvisation _____

Appropriate use of time _____

Observations noted and
recorded _____

Other: _____

Group Self-Assessment of Laboratory Activities

Group _____

Date _____

Activity _____

Use these descriptors to assess how effectively your group performed a specific activity. Choose one or several numbers from the list of criteria.

1 = yes

2 = no

3 = we think so

4 = needs improvement

5 = satisfactory

6 = excellent

Things to consider	
Did we develop a clear plan before we began?	
Did each group member have specific things to do?	
Were we able to work together as a team?	
Did we discuss the purpose for doing the activity?	
Was a hypothesis developed and recorded?	
How well did we predict what took place?	
Were instructions followed correctly?	
How well did we use equipment and materials?	
Did we observe all safety precautions?	
Were measurements made accurately?	
How well were data recorded?	
Did we clean up thoroughly after the activity?	
Were the data examined closely to search for meaning?	
Did we use accepted techniques for data analysis?	
Were the conclusions consistent with the data?	
Did we re-examine our initial hypothesis?	
Did we account for experimental error?	
Was relevant research used to support our work ?	
Other:	

Project Presentation) Individual Questionnaire

Your name

Topic

Group Members

Date

Circle the following on working within the group. Additional written responses may be included.

- | | | | |
|--|--------|-----------|-------|
| 1. I encouraged others. | Seldom | Sometimes | Often |
| 2. I shared ideas and information. | Seldom | Sometimes | Often |
| 3. I checked to make sure that others in the group knew what they were doing. | Seldom | Sometimes | Often |
| 4. I was willing to help others. | Seldom | Sometimes | Often |
| 5. I accepted responsibility for completing the work properly and on time. | Seldom | Sometimes | Often |
| 6. I was willing to listen to others in the group. | Seldom | Sometimes | Often |
| 7. I was willing to receive help from others in the group. | Seldom | Sometimes | Often |
| 8. I offered encouragement and support to others in the group. | Seldom | Sometimes | Often |
| 9. Others in the group shared ideas and information. | Seldom | Sometimes | Often |
| 10. The group checked with the teacher to make sure we knew what we were supposed to be doing. | Seldom | Sometimes | Often |
| 11. All members of the group contributed equally to this project. | Seldom | Sometimes | Often |

Answer the following questions about working in a group.

12. How did you distribute the workload within your group?
13. What problems, if any, arose within your group?
14. What would you do differently next time?
15. How is working in a group different from working by yourself?

Science Report Evaluation Form*		
Name:		Date:
Activity:		
Written Presentation	Weight	Score
Title Page	5	
Introduction	10	
Body	30	
Conclusion	20	
Supporting References	5	
Neatness	10	
Organization	20	
Content		
Communication Skills	25	
Originality	25	
Accuracy	20	
Appropriateness	30	
Creativity	25	
Overall Impression	10	
Total Score	185	
Other Comments:		

* Criteria for an oral presentation may be developed. Teachers are encouraged to develop criteria for each element on this page (e.g, Title page must include title centered left/right and vertically, student's name and class number) and share those with the students before they do their report.

Laboratory Report Evaluation

Name

Date

Activity

	Excellent	Good	Satisfactory	Unsatisfactory
Completeness				
Accuracy				
Organization				
Presentation				

Comments: _____

Overall Report Grade: _____

Data Collection/Notebook Checklist*

Name

Date

A checkmark indicates that the criterion is satisfactory. No mark indicates that the criterion is either missing or unsatisfactory.

Documentation is complete.	
The information or data collected is accurate.	
Written work is neat and legible.	
Tables and diagrams are completed neatly.	
Each new section begins with an appropriate heading.	
Errors are crossed out but not erased.	
Spelling and language usage are edited and corrected.	
Information is recorded in a logical sequence.	
Technological aids are used appropriately.	
Notes are collected in a folder or binder.	
Colour or graphics are used to enhance the appearance.	
Rough work is done separately.	

Comments/Overall Impressions:

* This checklist may be used by teachers, or by students for self-evaluation. It may be used to evaluate notebooks, laboratory data collection done during investigations, or more formal written laboratory reports. Students should be made aware of these criteria at the start of the term.

Observation of Group Behaviours

Student or Group

Activities:

- a _____
- b _____
- c _____
- d _____
- e _____
- f _____

1 = rarely 2 = occasionally 3 = frequently 4 = consistently

	a	b	c	d	e	f
Remains on task						
Follows directions						
Exhibits leadership						
Respects the ideas of others						
Works cooperatively						
Communicates effectively						
Shares tasks equitably						
Works safely						
Handles equipment correctly						
Displays initiative						
Exhibits scientific curiosity						

Science Challenge Suggested Marking Scheme

Name

Description of Activity

Due Date

	Weight	Score
Content		
Accuracy	5	_____
Completeness	10	_____
Range of coverage	10	_____
Concept attainment	30	_____
Presentation of Material		
Layout	5	_____
Neatness	5	_____
Organization of ideas	10	_____
Language usage	10	_____
Originality	10	_____
Sources acknowledged	5	_____
Graphs, tables, and charts	10	_____
Supporting exhibits (models, etc.)	10	_____
Deadline met	5	_____
Interest level	10	_____
	_____	_____
Oral Report	25	_____
	_____	_____
Bonus (submitted before due date)	5	_____
Total	_____	

Factors of Scientific Literacy Developed in Biology

These checklists may be used in a variety of ways. Teachers may wish to use them to determine which factors have been covered throughout the entire year to ensure that adequate coverage has been provided for them. The checklists could also be used when covering a particular topic. Once factors which have not been emphasized in that topic have been identified, teachers can then use that information in their planning of subsequent topics to ensure that all of the factors have been given sufficient coverage by the end of the course. Columns for core and optional units are shown.

Dimension A Nature of Science

Factors							
1. public/private							
2. historic							
3. holistic							
4. replicable							
5. empirical							
6. probabilistic							
7. unique							
8. tentative							
9. human/culture related							

Note: See the Appendices of *Science Program Overview and Connections K-12* for criteria on Dimension A useful for Rating Scales and Checklists.

Dimension B Key Science Concepts

Factors								
1. change								
2. interaction								
3. orderliness								
4. organism								
5. perception								
6. symmetry								
7. force								
8. quantification								
9. reproducibility of results								
10. cause-effect								
11. predictability								
12. conservation								
13. energy-matter								
14. cycle								
15. model								
16. system								
17. field								
18. population								
19. probability								
20. theory								
21. accuracy								
22. fundamental entities								
23. invariance								
24. scale								
25. time-space								
26. evolution								
27. amplification								
28. equilibrium								
29. gradient								
30. resonance								
31. significance								
32. validation								

Dimension C Processes of Science

Factors							
1. classifying							
2. communicating							
3. observing and describing							
4. working cooperatively							
5. measuring							
6. questioning							
7. using numbers							
8. hypothesizing							
9. inferring							
10. predicting							
11. controlling variables							
12. interpreting data							
13. formulating models							
14. problem solving							
15. analyzing							
16. designing experiments							
17. using mathematics							
18. using time-space relationships							
19. consensus making							
20. defining operationally							

Note: Teachers are encouraged to adapt this chart to create student Observation Checklists, Rating Scales, or Performance Assessments.

Dimension D Science-Technology-Society-Environment (STSE) Interrelationships

Factors								
1. science and technology								
2. scientists and technologists are human								
3. impact of science and technology								
4. science, technology, and the environment								
5. public understanding gap								
6. resources for science and technology								
7. variable positions								
8. limitations of science and technology								
9. social influence on science and technology								
10. technology controlled by society								
11. science, technology, and other realms								

Note: See the Appendices of *Science Program Overview and Connections K-12* for criteria on Dimension D useful for Rating Scales and Checklists.

Dimension E Scientific and Technical Skills

Factors								
1. using magnifying instruments								
2. using natural environments								
3. using equipment safely								
4. using audiovisual aids								
5. computer interaction								
6. measuring distance								
7. manipulative ability								
8. measuring time								
9. measuring volume								
10. measuring temperature								
11. measuring mass								
12. using electronic instruments								
13. using quantitative relationships								

Note: See the Appendices of *Science Program Overview and Connections K-12* for criteria on Dimension E useful for Rating Scales and Checklists.

Dimension F Values that Underlie Science

Factors								
1. longing to know and understand								
2. questioning								
3. search for data and their meaning								
4. valuing natural environments								
5. respect for logic								
6. consideration of consequence								
7. demand for verification								
8. consideration of premise								

Dimension G Science-Related Interests and Attitudes

Factors								
1. interest								
2. confidence								
3. continuous learner								
4. media preference								
5. avocation								
6. response preference								
7. vocation								
8. explanation preference								
9. valuing contributors								

Note: Teachers are encouraged to adapt these charts for student Rating Scales or Checklists. The Appendices of *Science Program Overview and Connections K-12* contain criteria for these Dimensions.

Another approach is: on a scale of 1 to 5 how have your values or interests/attitudes changed? For the top 4 scores, describe the changes.

References

See *Science 10: A Curriculum Guide for the Secondary Level*, *Science 10: A Bibliography for the Secondary Level*, and *Science: A Bibliography for the Secondary Level*) *Biology, Chemistry, Physics* for additional references.

Hummel, Monte (editor). (1989). *Endangered Spaces: the future for Canada's wilderness*. Toronto: Key Porter Books.

Saskatchewan Education. (1992). *The Adaptive Dimension in Core Curriculum*. Regina.

Saskatchewan Education. (1992). *Diverse Voices: Selecting Equitable Resources for Indian and Métis Education*. Regina.

Saskatchewan Education. (1991). *Native Studies 10*. Regina.

Saskatchewan Education. (1992). *Native Studies 20*. Regina.

Saskatchewan Education, Saskatchewan Outdoor and Environmental Education Association. (1991). *Out to Learn: Guidelines and Standards for Outdoor Environmental Education*. Regina.

Note: Have your teacher-librarian help you locate the various journal and other references in the activities, and addresses and contacts for Saskatchewan organizations.

What follows is one of many ways to plan a unit. No one method of planning is prescribed for use. What is important is that unit be planned. Through planning, the maximum benefit for the students in each classroom can be achieved. The topics can be adapted to the interest, needs, and conditions which prevail within each class. Unit planning is an important part of adapting the curriculum to the classroom.

Unit Planning Guide		
<p>Select the topics to be covered in biology for the year. Decide in what order they will be presented. Consult with teachers from other areas of study to see if team teaching or integration of topics is possible. You may have to adjust or write learning objectives for the topic chosen. Talk to the teacher-librarian about your yearly plan and the resources you are likely to need. Apply The Adaptive Dimension in Core Curriculum (Saskatchewan Education, 1992).</p>	<p>Analyze both the foundational and the learning objectives. Decide which learning objectives you will use to develop the foundational objectives and factors of Scientific Literacy. Create any new learning objectives which you feel will enhance the unit.</p>	<p>Analyze how the Common Essential Learnings (CELs) can be developed within the activities of each lesson. In some cases the activity will dictate which Common Essential Learnings are developed. In other cases, the activity may be such that the instructional approaches used to guide the learning can be selected to emphasize particular Common Essential Learnings. You may want to consult the resource bank of CELs objectives found with the teacher-leader package accompanying <i>Instructional Approaches</i>.</p>
<p>Scan the unit) the Factors of Scientific Literacy to Be Emphasized, the Foundational Objectives for Biology and the Common Essential Learnings, the Learning Objectives for the topic which has been selected) to give yourself an idea of the scope of the unit.</p>	<p>Develop, or select from the resources, activities which are appropriate for the objectives. Then, analyze those activities to determine which of the factors of scientific literacy are present. Modify, adapt, or extend the activities so that the factors of scientific literacy which should be emphasized in that unit will be addressed.</p> <p>When making activities, consider which instructional methods are appropriate for the activities, and ensure a selection which allows for the use of a variety of methods. Consult Instructional Approaches: A Framework for Professional Practice (Saskatchewan Education, 1991).</p>	
<p>Use Science: An Information Bulletin for the Secondary Level - Biology 20/30 Key Resources to identify the resources which have been correlated to this unit. Refer to Science: A Bibliography for the Secondary Level - Biology, Chemistry, and Physics to select additional resources. Check with the teacher-librarian in your school or division and in the resource centre of your school. Public libraries may have useful resources. Media House Productions and the National Film Board are two sources of video and film resources. List any people who may act as resources, or sites which may be appropriate for field trips. Retrieve any activities, lesson plans, or information from your or colleagues' files which you can use in the unit.</p> <p>Consider the special initiatives of Gender Equity, Indian and Métis perspectives, and Agriculture in the Classroom. How can they be stressed during this unit?</p>	<p>Consider each activity to determine how it might be linked to topics in other areas of study. Modify the activities to strengthen these connections.</p>	<p>Create a time schedule for the unit, which shows the lesson structure within the unit. Consider splitting the unit into sections which could be taught over an extended period of the school year.</p>
	<p>Organize the activities into lessons. A lesson need not be a specific length. It may extend over a number of days or weeks, using a variable amount of time each day. If a teacher-librarian is available for team teaching, those parts of the lessons which require research may be taught together.</p>	<p>Develop an evaluation plan for the unit. Help on this aspect of planning is available elsewhere in this guide and in Student Evaluation: A Teacher Handbook (Saskatchewan Education, 1991). Just as a variety of activities should accomplish the objectives, a variety of evaluation strategies should be employed so that all aspects of learning can be assessed.</p>

The Study of Ecology and the Analysis of an Ecosystem) A Model Unit for Unit 2: Ecological Organization

Unit Overview

This unit builds upon understandings developed during elementary and middle level science classes. How animals adapt to their environment, the effects of weather on living organisms and on the abiotic environment, food chains and food webs, human impact on the environment, characteristics of populations and of individuals, and nutrient cycles are all ideas which students entering grade 11 have encountered.

The initial lesson gives students a chance to describe their experiences in, and ideas about, the **ecosystems** of Saskatchewan, to listen to the experiences of others and to summarize their understandings. Following this introduction, each student group develops a fully articulated plan to study one aspect of one or more **ecoregions** of Saskatchewan. The plan must clearly outline time lines, types of data to be collected, initial sources of data, as well as how the data will be organized, analyzed and presented.

The students will report their findings to the class and prepare exam questions dealing with their study. These questions may be used on the unit exam. Finally, the class will consider the present and future Saskatchewan environment in a global context.

Ecology is an area of scientific study encompassing a wide range of disciplines such as botany, geology, chemistry, physics, meteorology, agriculture, population dynamics, and economics. Through the study of ecology, students have an opportunity to synthesize and restructure much of their previous experience and understanding to enhance their knowledge of the way the planet works.

Saskatchewan is rich in diverse and unique ecosystems. The study of the local ecosystem gives

the students a chance to examine the complexity of their surroundings. At the same time, this unit gives the opportunity to consider other areas of Saskatchewan and appreciate the **diversity** of the whole province. This study could be integrated with the unit on the diversity of life.

This unit has been written to illustrate how the Dimensions of Scientific Literacy and the Common Essential Learnings can be emphasized in the biology classroom. In addition, a variety of instructional methods and evaluation strategies are encouraged. There are opportunities for adapting the topics and the teaching to the needs and interests of the students. Incorporating the Indian and Métis perspective in the classroom and encouraging participation in a variety of roles by both females and males is illustrated and encouraged.

Many of the goals expressed in the previous paragraph can be achieved through appropriate use of cooperative learning groups. Group activities require individual commitment to the task and a sustained, quality commitment to the group. There must be concrete, legitimate evaluation of the group's performance at specified intervals by each individual member of the group. This stimulates individuals to maintain a commitment to the group, and provides information for the group about their progress in the task and about their progress as a functional group. Ideas on cooperative group learning can be found in *Together We Learn* by Judy Clarke.

Benefits of cooperative group learning include:

- ! student-centred learning, with the teacher as a facilitator;
- ! the opportunity to use alternative, and several, types of evaluation;
- ! teachers and student experiencing methods from each of the five categories of instructional strategies; and,
- ! using resource-based approaches.

Unit Outline

Part 1 - Discovery of information about the unique biological areas of the Saskatchewan (Ecoregions and Ecodistricts)) **3 hours**

Part 2 - Planning for the study (assignment of groups, timelines, discussion of the evaluation which will be used and collection of data)) **1-2 hours**

Part 3 - Collection and organization of data) **7 hours**

Part 4 - Writing group summaries of data and unit exam questions) **3 hours**

Part 5 - Sharing findings and synthesizing a picture of a functioning ecosystem) **4 hours**

Part 6 - Placing the Saskatchewan ecosystem into a global context and speculating about the environmental future) **6-7 hours**

Preplanning Requirements

As long as possible before starting this unit, start gathering resources for student to use in parts 1, 3 and 6. Keep in mind the principles outlined in *Selecting Fair and Equitable Learning Materials* (Saskatchewan Education, 1991) and *Diverse Voices* (Saskatchewan Education, 1992) when acquiring resources. The reference list in this model unit (page 77) is one place to start. *Science: A Bibliography for the Secondary Level*) *Biology, Chemistry, Physics* will have citations for useful sources of information. Scan newspapers and magazines for articles dealing with the environment of Saskatchewan and with world environmental issues. Consult immediately with the teacher-librarian and other school staff to enlist their help in locating resources.

Consider how this unit can be integrated in your course outline. Part 3 of the unit) the student research) would best be spread over four to eight weeks. This would allow students time for finding resources, for planning and executing experiments, and reflecting on what they are doing.

Guidelines for Groups

Some principles which should guide each group's work during this unit are outlined below. Detailed instructions for each task are included in the full description of the unit. Distribute this list to all students when beginning this unit.

- ! Within the limits of time and resources, gather information which is as complete as possible.
- ! Document all the information you collect. Documentation can include maps of an area, tapes of interviews, pictures of areas or organisms, drawings, bibliographical notations,

and so on. It should be possible for anyone to relocate or confirm your information or sources now or in years to come.

- ! Review the data you have collected for bias. One type of bias is indicated by the name of the publishing organization or information about the author(s). Another is in the presentation. *Selecting Fair and Equitable Learning Materials* (Saskatchewan Education, 1991) and *Diverse Voices* (Saskatchewan Education, 1992) give guidance on identifying bias in written and audio-visual materials.
- ! To facilitate information sharing among all groups in the class, ensure that the information collected daily is turned in as a group package to the teacher, as well as being recorded on the group's summary sheet. Each component of this group package must be identified by the individual collector's name and the date collected.
- ! Decide how to share your section with the class. A concise summary of the submitted information, checked by the teacher, should be duplicated for each member of the class.
- ! Create at least three test questions worth a total of 30 marks on a 100 mark one hour test, with an answer key for each question. These questions may become part of the unit test.

Unit Plan

References to objectives, factors of the Dimensions of Scientific Literacy and assessment strategies follow each of the activities of this unit. They are listed to help you become familiar with the full range of instructional goals during Biology 20. This is not meant to imply that the objectives listed are the only objectives which can be achieved, or that the evaluation techniques are the only ones which can be used. They are there to emphasize that consideration of these helps ensure the development of an understanding of science in all its facets.

The Biology learning objectives listed are taken from the Curriculum Guide. Some have been modified to fit the goals of this model unit. New objectives which arise from the students' ideas or concerns during the class discussions, or which are added from your experiences and perceptions of the study are encouraged. The Common Essential Learnings objectives are foundational objectives, and as such are much broader and less specific than the Biology learning objectives. Learning objectives directed towards achievement of these CEL foundational objectives can be found in *Incorporating the Common Essential Learnings and the Adaptive Dimension: A Resource Package* (Saskatchewan

Education, 1991), a resource distributed with the inservice/leadership package for *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991).

Adjust the time allotted, add, delete or modify activities as appropriate. **Customize this unit to fit the needs of your students and the facilities and resources with which you work.**

Part 1: Discovery of general understanding about the unique biological areas of Saskatchewan (Ecoregions and Ecodistricts)

Activity 1 (2 hours)

Remind the students that the information summarized by each group during this activity will be assumed to be part of all students' information base. Use a video such as "Communities of Living Things" a 15 minute introduction to the Biomes of North America from Media House. Follow that video with a brainstorming session in groups of three or four students. Ask each group to list what they know about the ecoregions and ecodistricts of Saskatchewan. How many distinct regions are there? What are the distinguishing characteristics of each region? Assign a person to be the recorder/reporter for this activity. Sources of information for this session should be their travels in province and their prior knowledge and ideas. After 7-10 minutes, share the collected information of each group with the rest of the class. Ask the students to use biological vocabulary in their statements, as much as is possible.

The information shared during the lesson should be recorded on large sheets of paper for posting on the walls of the classroom. After information has been shared, ask each group to draw a concept map or web with Saskatchewan ecosystems as the initial concept. Whether the concept maps are posted is optional.

During the second hour, give students access to resource materials (texts, atlases, newspapers, magazines, maps, etc.) to add more information to the posters created during the first hour. Such information should be recorded with a different colour ink than at first, so that the accumulation of information can be seen. These posters will remain on the wall during the entire unit. The type of soil, length of growing season, original and introduced plant and animal species, amount of rainfall,

prevailing winds, average temperature, climate, land use, and glacial landforms all are ways of describing the nature of an ecosystem.

The groups should also verify their initial information in the resources available. Help in focusing the search for information can be given by putting some key words) biosphere, biotic, abiotic, community, population) on the board.

At the end of this period, each group should share their new information. The different coloured inks allow students to observe the gradual accumulation of information, as might occur in the sharing of information in a place like the Veterinary Infectious Diseases Organization (VIDO) - a large research establishment that employs people in a wide variety of scientific disciplines and who work cooperatively to solve a common biological problem.

Suggested Resources

- ! *Atlas of Saskatchewan*
- ! *Managing Saskatchewan Rangeland.*
- ! *Landscapes: A Guide to the Landforms and Ecology of Southern Saskatchewan*

Objectives

- 6.1 Review and clarify the understanding students have of the following terms: biosphere, biome, ecosystem, community, and population.
- 6.2 Review several examples of biomes by discussing the major kinds of plants found in each.
- 6.3 Draw a climatogram and discuss temperature and moisture as major determiners of a specific ecological area.

COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of biology.

Factors: C1, C15, C19, E4, F3, F7, G6

Assessment: Concept mapping or webbing is a form of self-assessment. The initial concept map or web gives students an opportunity to organize their understandings. Comparison of their initial concept map or web with one produced at the end of the unit gives them a chance to evaluate the growth of their understanding and the development of their thinking about ecosystems and about Saskatchewan.

Activity 2 (1 hour)

Ask each student individually to summarize the information all groups have listed during activity 1. This should be recorded in their journals or notebooks.

Objectives

- CCT To develop an understanding of how knowledge is created, evaluated, and refined, and changed within biology.
- COM To enable students to understand and use the vocabulary, structure and forms of expression which characterized the study of ecology.

Factors: B16, C1, C2, C4, C12, C21, F3, G1, G3

Assessment: This entry in the journal or notebook can be treated as a written assignment. There may be some times when journal entries will be confidential. Decide with your students how the journals will be used in your class.

Part 2: Planning for the study

Activity 3 (1-2 hours)

Reinforce the information from the first section by highlighting the great variety of ecosystems in Saskatchewan. Outline the ecoregions of the province. One might use the regions as defined by Stan Rowe in *Landscapes: A Guide to the Landforms and Ecology of Southern Saskatchewan*) high relief terrain, drylands, floodplains, fresh and saline marshes, sand dunes, low relief terrain, coulees and river valleys) plus the aspen grove parklands of central Saskatchewan, the boreal forest of northern Saskatchewan, and aquatic ecosystems. *Project WILD* (pages 450-451) discusses the concept of ecozones. Ask the students to discuss how they would define the boundaries of each region.

Select as many of these regions as seems reasonable for your class to report on, given the resources, abilities, and facilities available. Be sure to select the region in which the school is located, and at least two others.

An alternative plan might be to do a very thorough, comprehensive analysis of your own region only. Such an analysis might include audiotape and videotape, photographs, maps, written description, sketches, and posters. Such a project would make

an excellent school display. Copies of the project could be exchanged with schools in different regions which had done similar projects. Set up a network among biology teachers to do this.

With students in the same working groups as in Part 1, assign to each group one of the categories for ecosystem study. Typical categories might be climate, soil, other abiotic factors, biota, and human impact. Depending on the size of the class, categories may be consolidated or subdivided. Each group is responsible for finding detailed information about that general topic for the ecoregion in which the school is located, and for whatever other regions the class has selected to report on.

Each group has two tasks to complete during the remainder of the period. They should decide what will be studied within their category. If the students have had experience working in groups and organizing and doing research, they could be left the entire task of identifying what to study, determining how the identified topics will be researched, and locating sources of information. The resources they used in Part 1 will be useful for ideas about what to study. Alternatively, they might be given an outline (examples below) which corresponds to their assigned area. It is not necessary for each group to have considered all of the possibilities but encourage them to create as comprehensive a framework as possible. This framework forms the basis for Part 3 of the unit.

Students should allocate responsibilities for finding and reporting data. All group members should be involved in searching for and summarizing information. Responsibility for reporting the information daily on the group's summary sheet and to the teacher (see the third point in Guidelines for Groups) should be rotated among all members. Once these tasks have been completed, ask each group to record their decisions and task schedule and submit one copy of their proposal to you. They should also post one copy on the wall beside their information poster.

If students have difficulty organizing their task and allocating responsibility, a chart such as the one which follows may help them. Prepare a large poster listing the Guidelines for Groups handed out at the beginning of the unit. This might also help to keep the students focused on their tasks through this research section.

Research topic	Names of researcher(s)	Due*

* Interim reports due daily. Research finished by this date.

Objectives

2.2 Identify the biotic and abiotic components and the interactions in the ecosystems observed.

3.1 Examine the evidence of life in the past.

CCT To develop an understanding of how knowledge is created, evaluated, and refined, and changed within biology.

COM To enable students to understand and use the vocabulary, structure and forms of expression which characterized the study of ecology.

CCT To promote intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and the objectives in the context of the study of the environment.

Factors: A3, A7, B3, B4, B8, B15, C1, C14, F5, F8

Assessment: Keep an observation checklist to confirm that the students are completing their group work, and whether groups are making necessary progress and adjustments to meet the final deadlines. Anecdotal records for filing in the students' portfolios can also be useful. Ideas about the use of anecdotal records and portfolios can be found on pages 65 and 69 of *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991). Ask the students to fill in the self-assessment instrument on page 53 of this guide.

Description of categories for research

These are to be used with the planning activity of Part 2 to give students assistance with designing their study. These categories might be introduced at the beginning, middle or end of the planning

process, depending on the abilities of the students and the purposes which you wish to accomplish. The objectives and factors described for each category deal with those which would result when the study is actually carried out in Part 3. Comments on assessment are made in Part 3.

Biota

Describe the populations of species in the ecosystem. Describe their niches and habitats. Both the ideas of energy use and conservation should be considered when identifying food chains and food webs. Classify species of plants and animals as native or as introduced.

Consider various methods of estimating (quantifying) both plant and animal populations within an area. Possibly try different methods of estimating. Look for various kinds of symbiotic and competitive relationships that exist wherever animals interact. Seek information about the seasonal and annual variations in animal populations. If possible, identify examples of succession within the ecosystem.

There are a number of possibilities for research. Ensure that clear explanations for all terminology used in this section is included in the summary. Make personal contacts in the community, where necessary, to obtain permission to do field collection of samples and data about the species, numbers, and niches of the organisms. Decide what samples you need to collect, remembering that you should try to leave the area intact. The best way to sample a site is to remove photographs, sketches, hand drawn maps, sound tracks, videotapes, counts, descriptions, and measurements of the area and its inhabitants.

These items can be used in the final presentation. Field research can be supplemented with library research and interviews with people familiar with the natural history of the area.

Sources of information include texts, teacher, and community members with relevant expertise or who own property on which you wish to do field studies. Municipal offices can provide information with maps of a given area. Books such as *Prairie Birds in Colour*, *Wildflowers Across the Prairies*, *Managing Saskatchewan Rangeland*, *Holistic Resource Management*, *The Wheatgrass Mechanism*, and *A Prairie Coulee* are useful resources.

Objectives

- 2.1 Understand the concepts of niche and habitat.
- 2.2 Identify the biotic and abiotic components and interactions in the ecosystem observed.
- 2.4 Formulate some food chains and webs involving the human community.
- 2.6 Identify both symbiotic and competitive relationships among organisms within a community.
- 2.7 Investigate a natural community in the neighbourhood of the school
- 2.10 Discuss succession in communities.
- 4.1 Recall the criteria which define a population.
- 4.3 Describe methods of estimation by sampling.
- 4.4 Estimate some populations using one or more methods.
- 5.1 Identify factors which influence reproduction rates and death rates.
- 5.2 Recognize factors which affect immigration and emigration.
- 5.3 Compare cyclic populations and stable populations.

NUM To strengthen students' knowledge and understanding of how to compute, measure, estimate, and interpret numerical data, when to apply these skills and techniques, and why these processes apply to the study of populations.

COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of ecology. (COM)

CCT To promote intuitive, imaginative thought and ability to evaluate ideas, processes, experiences and objects in the context of the study of the environment. (CCT)

Factors: B1, B8, B11, B12, B18, B21, B28, C1, C17, C20, E1, E2

Soil

Topics for study include identifying and classifying the living and nonliving components of soil. Identify the soil types that exist in each ecosystem under study and how these soil types influence the kinds of plants that grow there. Investigate the evolution of the soil since the time of European settlement. Measuring the variation in soil temperatures during the day, sketching soil profiles and describing the condition of the soil surface are all things that can be done onsite during a field study.

To explore these topics you might collect information about how soil is formed, what influences the kind of soil that forms and develops, how long it takes for soil to form, the contribution of the organisms found in soil to its development, and the effects of various agricultural practices on the quality of the soil.

Obtain permission from landowners to collect soil samples. Consider an exchange program with biology classes in other areas of the province to broaden this study. Advice about sampling strategies and techniques can be found in resources books. A regional soil conservation biologist or an extension agrologist may be able to help you with soil sampling or other aspects of this study. Activities to measure the water holding capacity of the soils, to collect the organisms inhabiting the soil, and to measure the amount of humus in the soil can provide useful information.

Information about the soil profiles and any soil salinity problems can also be investigated. Local farmers and horticulturists may be able to give you advice about your study.

Sources of information include *Guide to Farm Practice*, Canada Land Inventory soil maps, *Investigating Terrestrial Ecosystems*, Saskatchewan soils maps, and *Prairie Soils: The Case for Conservation*.

Objectives

- 1.1 Identify the components of soil.
- 1.2 Describe the soil types of Saskatchewan.
- 1.3 Determine how soil characteristics influence plant growth.
- 1.5 Investigate variations in plant growth on slopes.
- 1.6 Identify some soil microorganisms.
- 1.7 Discuss the importance of soil microorganisms.

2.9 Compare communities which have other soil types or other climate types.

COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of biology.

Factors: A4, B3, B8, C1, C12, D11, E1, E2, F7

Human impact

This study will include aspects from all other categories, analyzed with respect to how the presence of human life has influenced the ecology of the regions studied. The impact may appear to range from positive through neutral to lethal. **It will be interesting to explore not only what impact humans have on the ecosystem but why the human population does what it does.**

Everyone will have different views about why we interact with the environment in the way that we do so it will be important to collect data about the kinds of interactions that are visible and can be documented. Field data collected can include videotapes, audiotapes, photographs, sketches, maps, and samples.

Possible ways to explore the items include making a list of the way in which humans interact with the plants and animals and other life forms in the ecosystem and how humans bring about eventual change. A holistic view could include a survey of agriculture, forestry, fishing, industry, and personal use. It may be valuable to interview individuals from different cultures to discover how their societies view their relationship to the world around them. Perhaps invite an Elder to speak to the class. Sources include recent newspaper or magazine articles about the human interaction with the environment. It may also be possible to collect information from interviews, pictures, diagrams, and first hand observations. Local environmental societies, different cultural groups, and Saskatchewan Environment may be able to provide ideas for sources of information. *Managing Saskatchewan Rangeland* and *Holistic Resource Management* are two books worth investigating.

Objectives

2.8 Compare the similarities and differences between the natural community and the human community.

3.3 Investigate the role of humans in creating and sustaining conditions with alter the rate of ecological change.

6.2 Review several examples of biomes by discussing some of their major kinds of plants.

6.3 Draw a climatogram and discuss temperature and moisture as major determiners of a specific ecological area.

CCT To develop an understanding of how knowledge is created, evaluated, refined and changed within biology.

COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of biology.

IL To support the development of a positive disposition to life-long learning.

TL To develop an understanding that technology both shapes society and is shaped by society.

Factors: A3, B1, B2, B11, B12, C8, C12, D4, D7, F3, F4, F8, G6,

Climate

Distinguish between weather and climate. Identify some of the ways in which climate and weather information is collected. Draw climatograms for the selected regions under study. Obtain information about the changes in Saskatchewan's climate over the last several millions of years. Investigate how the differences of climate within Saskatchewan affect what vegetation and crops grow.

Written materials will provide the major source of information in this category. *Geological History of Saskatchewan*, *Climates of Canada*, and *Atlas of Saskatchewan* can be used to collect data on the climate. Extension agrologists may be able to help locate sources of information about the effect of climate and climate change on native and introduced plant species.

Objectives

1.4 Describe how climatic variations in Saskatchewan influence plant growth.

1.8 Appreciate that the soil and the climate are the keys to life in Saskatchewan and on this planet.

3.1 Examine the evidence of life in the past.

3.2 Debate change and extinction theories.

6.2 Review several examples of biomes by discussing some of their major kinds of plants.

6.3 Draw a climatogram and discuss temperature and moisture as major determiners of a specific ecological area.

- NUM To strengthen students' knowledge and understanding of how to compute, measure, estimate, and interpret numerical data, when to apply these skills and techniques, and why these processes apply to the study of populations.
- CCT To develop an understanding of how knowledge is created, evaluated, refined and changed within biology.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of ecology.
- CCT To promote intuitive, imaginative thought and ability to evaluate ideas, processes, experiences and objects in the context of the study of the environment.

Factors: A2, A6, B19, B20, B24, B26, B28

Other abiotic factors

Other abiotic factors include slope of the land, surface water present - rivers, sloughs, lakes, ground water, deep aquifers, and the matter cycles (water, carbon dioxide) oxygen, and nitrogen).

Possible ways to explore these include contacting the Saskatchewan Water Corporation for ground water information. Field data collection could include describing, recording and measuring information about the size, shape, and mineral composition of bodies of water. In a joint effort Saskatchewan Water Corporation and Environment Canada have released a study call the "South Saskatchewan River Basin Study" which contains information about the criteria for conducting a water study. During the 1970's a major study of the Qu'Appelle River system was done by Environment Saskatchewan.

Contact your local municipal governments about where drinking water is obtained for the community and what is done to it before it is consumed and how much is used. To get some idea about how the community views clean water devise a simple questionnaire to discover what the general public understands by the term "clean water". Create models of the matter cycles which are specific to the regions you are studying. Is the nitrogen cycle in a salt water marsh identical to the nitrogen cycle on the drylands?

Sources of information include local resource people such as extension agrologists, and employees of municipal water departments. Saskatchewan

Environment, Saskatchewan Water Corporation, and Environment Canada are other possible sources.

Objectives

- 1.10 Discuss the following cycles and attempt to illustrate their interrelationships: water, carbon dioxide-oxygen, nitrogen.
- 2.3 Describe how the human community is dependent on soil, water, and air.
- 2.5 Describe how the human community in which one lives is dependent on, and influenced by, the climate.

- NUM To strengthen students' knowledge and understanding of how to compute, measure, estimate, and interpret numerical data, when to apply these skills and techniques, and why these processes apply to the study of populations.
- CCT To develop an understanding of how knowledge is created, evaluated, refined and changed within biology.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of biology.
- CCT To promote intuitive, imaginative thought and ability to evaluate ideas, processes, experiences and objects in the context of the study of the environment.

Factors: A7, A9, C5, C7, D3, D5

Part 3: The Study

In order to carry out the study, it may be useful to distribute the class time allotted for this part over the course of one or two months. This will give students time to arrange for and carry out field research, find print and non-print resources, and reflect on their study. One way to do this would be to schedule one or two class periods per week to be used by the students to do their research. The expectation is that students would use at least as much time outside of class as they use in class to complete their research. The unit **Diversity of Life** would be an excellent unit to integrate with work on Part 3. There is potential for much of the study within that unit to strongly support this study of ecosystems.

Since Part 3 involves implementation of the plan created in part 2, there are no specific activities listed for this part. The objectives and the factors listed with the **Descriptions of categories for research** are the objectives and factors for this component of the unit.

Evaluation should consist of anecdotal records gleaned from discussing the projects with the groups, observation checklists which monitor the groups' progress, and self- and peer evaluation by the students. An example of a checklist which might be used is found on page 50 of this guide. Another checklist which will be useful is found on page 75 of *Student Evaluation: A Teacher Handbook*. Chapter 4 of that document has advice and ideas about the use of anecdotal records, observational checklists, and self- and peer-evaluation by students.

Part 4: Preparing for Reporting

Writing the group summaries, final exam questions, and allowing preparation time for the presentations in part 5 are the focus of this part.

Student groups are required to:

- ! Write one group summary of approximately 1-2 pages which highlights their research findings. It is important that this summary be checked by the teacher and be typed in its final form by the students, to be duplicated for all class members.
- ! Prepare final exam questions which may become part of the final comprehensive exam on this unit. Spend some time discussing exam question options such as matching items, multiple choice items, short answer items, and extended written responses. Discuss with students some of the important principles of exam question construction. Students should provide a suggested answer or a marking key with each of their questions.
- ! Prepare and practice their 10 minute presentation. Encourage them to make use of a variety of methods of presentation: Audio or video tapes, slides, posters, short oral presentations, handout sheets, or concept maps or webs. Discuss with them the importance of concrete representations of abstract ideas. Discuss the value of different modes of presentation to accommodate various styles of learning and to keep a high interest level among the audience during the presentation.

Objectives

- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of ecology.
- CCT To promote intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and the objects in the context of the study of the environment.
- IL To support the development of a positive disposition to lifelong learning. (IL)

Factors: A1, A3, A5, A7, A9, B16, C2, C4, C6, C9, C12, C15, C19, C21, F1, F3, F4, F8, G2, G6

Assessment: In writing a summary and in formulating examination questions, students will be forced to evaluate what they have discovered and its relevance to the overall picture they are creating of the Saskatchewan environment. Writing about this process in their journal or notebook would be one way to have them reflect on the reflection process which they have used in this part of the unit. The written summary containing the highlights of their research and their exam questions may be marked as written assignments. You might consider taking 10 to 15 minutes and discussing with students the criteria for judging oral presentations. From criteria discussed during this session, you or the class as a whole might create a checklist to be used to help assign a grade to the group presentations in Part 5.

Part 5: Describing the ecosystems

Activity 4 (2 hours)

Each group will present their view of what they have learned, in order to elaborate on the summary they have prepared for the class. Ask students to look for interdependencies between the area being presented and their own area.

Objectives

- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of ecology.
- CCT To promote intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and the objects in the context of the study of the environment.

Factors: A1, A9, B5, C2, D3, D7, E4, F5, G8

Assessment: If a presentation evaluation checklist was created during part 4, this should be used during the student presentations, either by the teacher, students or both. If none was prepared, the evaluation might be done by asking each class member to list one aspect of the presentation which was well done. These comments could form the basis of an anecdotal record to include in the student or group portfolios. The "Holistic Rating Scale for an Oral Presentation" on page 92 of *Student Evaluation: A Teacher Handbook* might be useful for grading the presentations.

Activity 5 (2 hours)

Ask each group to draw a new concept map of the ecology of Saskatchewan. Ask them to concentrate on charting the interdependencies among the categories which were discussed by each group. Have them compare their initial concept maps/webs with the one they have produced during this activity.

Through a class discussion of their ideas, create a class concept map. Use the blackboard during the initial stages of development. Transfer the refined version of the map/web to a large poster to display in the classroom. Each group should be able to identify where ideas which they discovered or contributed have become part of the class 'knowledge' about ecosystems and about Saskatchewan.

Objectives

Virtually all the objectives which have been developed during this unit, and which are outlined with the **Descriptions of the categories for research** in Part 2 may be reinforced here.

Factors: A9, B16, C19, D4, F5, G8

Assessment: Concept mapping/webbing is an excellent self-evaluation technique. When it is done in a group, it becomes a good exercise in communications and consensus making.

Part 6: Saskatchewan, and the global context

This part provides a chance for students to use information about their ecosystem and additional research to gain a global perspective on the state of the environment.

Activity 6 (1-2 hours)

How have agriculture, urbanization, and industrialization affected the ecology of Saskatchewan? We live in this environment. How do our lives affect our local ecosystem? How are our lives affected by what is around us? Use these questions to open a class discussion. What is going on that's positive? If we want to decide what is positive, what point of view shall we take? What are the concerns and issues about the environment? List highlights of the discussion on the board. Use "Edge of Home" from *Project WILD* (page 177) if you need something to focus this discussion.

Listing terms such as these may provide cues for student discussion during this activity, if that is necessary: renewable resource, nonrenewable resource, crop rotation, zero tillage, erosion, shelterbelt, irrigation, watershed, acid deposition, biodegradable, insecticide, biological magnification, biological control, nuclear waste, mine tailings, Canada Land Inventory, photochemical reaction, temperature inversion, fallout.

Are Saskatchewan's concerns and issues identical to those which would be identified by a class in Alberta or Manitoba? Compare the points arising from the initial discussion to regional, national, and global environmental issues. How are we (as Saskatchewan residents) a part of the larger scale problems? How can we be part of a solution? This second phase of the discussion will generate some more issues and concerns which can be listed on the board.

Objectives

- 1.9 Investigate the interrelationship of agriculture and the environment.
- 5.4 Discuss the carrying capacity of the planet Earth for the human population.

PSVS To support students in coming to a better understanding of the personal, moral, social and cultural aspects of the study of life.

CCT To promote intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and the objects in the context of the study of the environment.

IL To support the development of a positive disposition to life-long learning. (IL)

Factors: A3, A9, B5, B12, B14, B16, B24, B25, B26, B29, C1, C6, C9, C13, C15, C19, D3, D4, D5, D7, D9, D11, F1, F5, F7, G3, G5

Assessment: Through discussion with the students, you will be able to judge how their awareness and understanding of environmental issues has developed since the first activity of this unit. Their comments and ideas should be noted for use when revising this unit for its next use.

Activity 7 (4 hours)

Participating responsibly in decisions involving environmental management is dependent on having information which is valid and reliable. The class should be divided into pairs. Each pair should pick one issue identified during Activity 6 or from others that have been identified by you. They should find reading materials which focus on the issues they have selected. The gathering of this material is a long-term project. Consult with a teacher-librarian in your school at the start of the school year (or before).

Start creating files on each of these topics immediately. Sources of information for the files can be excerpts from existing vertical files, magazines, newspaper articles, and newsletters. The files may contain also references to other available sources of information such as videotapes, encyclopedia yearbooks, periodical indexes, books, and interviews with people in the community.

Ask them to keep reading notes on file cards. For each article read or source examined, one card with a citation of the source and a series of phrases which highlight the main ideas should be prepared.

Objectives

3.3 Investigate the role of humans in creating and sustaining conditions which alter the rate of ecological change.

TL To develop an understanding that technology both shapes and is shaped by society.

IL To support the development of a positive disposition to life-long learning. (IL)

CCT To develop an understanding of how knowledge is created, evaluated, refined, and changed within biology.

Factors: A2, A8, B20, B31, B32, C10, C21, D5, D7, F4, F7, G4, G9

Assessment: You may be able to make judgements about students' attitudes and values by observing their behaviour. Such behaviour can be noted on anecdotal records. Students may decide to join the Saskatchewan Natural History Society or the Saskatchewan Environmental Society in an effort to be directly involved with strategies for saving the environment. This would be a sign of their attitude. The reading notes may be marked according to criteria which are known to the students. Marks could be given for a complete citation, for clear, unambiguous notes, for number of articles found, or for pertinent notes to the Saskatchewan situation.

Activity 8 (1 hour)

Share what was discovered during Activity 7. A poster, short essay, concept map, cartoons, bumper stickers, or an emblem and slogan for a t-shirt all could be ways of expressing this. See *Project WILD* activity "Cartoons and Bumper Stickers" (page 268) for some ideas.

Objectives

COM To enable students to understand and use the vocabulary, structures, and forms of expression which characterize the study of ecology.

Factors: A7, B15, B16, B21, C2, D4, E4, F4, G4

Assessment: In addition to being a self-evaluation exercise of synthesis and communication, the products can be assessed on the basis of criteria developed during a discussion between the teacher and the class or between the teacher and the creator of each work.

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- Saskatchewan soils maps are available from Saskatchewan Soil Survey Office, College of Agriculture, University of Saskatchewan, Saskatoon S7N 0W0

Introduction

The attainment of understanding and appreciation by the students of the factors of the Dimensions of Scientific Literacy is the first, and most important, objective of Biology 20. This is the focus of the K-12 science program in Saskatchewan schools. More specific to the study of biology are other objectives. Students must be encouraged to closely observe the visible world around them. They should be invited to look at how it operates on a macroscopic level and to discern the interactions which exist. Students must gain an appreciation of the complexity, the interrelatedness, and the fragility of the natural world, and an awareness of the power of the human presence on this planet. This curriculum sets the study of biology into the context of the students' lives, so that they can draw from their experience and apply to their environment what they learn in the classroom. From that base, they will be prepared to generalize what they have learned, from the systems they see to the global ecosystem.

In Biology 30 also, the factors of scientific literacy form the foundation of the Saskatchewan curriculum. Students should also be exposed to the internal world and how it functions. Students should be given experiences which allow them to see the connections between the external, macroscopic world and the internal, microscopic world. They should develop an understanding of homeostasis in living systems, and recognize the similarity in the homeostasis of our global system.

In both Biology 20 and Biology 30, emphasis should be placed on concrete experiences for the students. These may take many forms. Students should certainly spend a portion of time out of doors, investigating and examining the ecosystem in which they live. Manipulations of equipment, personal investigations into a variety of systems, visiting sites which illustrate the principles which are discussed in class or which encourage students to launch investigations of their own, are examples of ways in which the students may become directly involved in the study of biology. The use of video recordings may take students vicariously to a place where they are not able to go, and may be used to illustrate principles which are difficult to express in other media. A general guideline is that approximately 30% of the time allotted to the study of biology should be spent in investigative activities. Some of these activities should be relatively long-term investigation of phenomena. The time spent on these activities

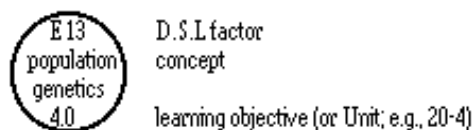
should be reflected in the evaluation scheme.

Concept Webs

The guide has been constructed using concept webs, a type of map, to assist the user in visualizing some of the major concepts (patterns in ideas). The unit webs illustrate concept interrelationships, correlate foundational and specific learning objectives, and map a number of the factors of Scientific Literacy.

Formal concept maps are hierarchic and begin with the broadest idea at the top of the page with other ideas clustered beneath. These ideas are joined by lines indicating those which are most closely associated to each other, moving from the most general idea to the most specific as would be seen in an example from a standard biological classification system. Webbing demonstrates connections which are not necessarily hierarchic but are significant because they reveal broad interrelationships. The following pattern will be used:

Example:



Each concept web has been limited to one page per unit. Brevity prevents the use of a great many linking words (the, as, with, leads to, begins with) which are often beneficial to the reader for better understanding. If a web is on a single page, it will expedite the reader's ability to obtain an overall picture.

The concept web in Figure 5 provides an overview for Biology 20 and 30. There is no one best way to start biology, but the start and finish suggested complete a type of survey of the circle of life.

The person using this guide will likely discover that they can change not only some of the headings but they can simplify a web or make more complex webs depending on their interests and background experience. These webs are a guide to activate the individual's own creativity and to provide direction for individuals who may need help on some specific occasion.

Teachers should copy the web(s) and superimpose other connections to suit their styles: other factors of scientific literacy; other objectives; CELs; reference to activities; instructional methods; assessment techniques; the Adaptive Dimension; integration with other areas of study.

These webs should not necessarily be copied for sharing with students. **Students and teachers need to be encouraged to construct their own meaningful webs.** Webs could be drawn as unit organizers or as answers for pre- or post-assessments.

Unit Overview

Note: each Secondary Level credit equals 100 hours of instruction.

Science K-10 courses are required prerequisites to Biology 20/30. Biology 20 is not a prerequisite for Biology 30.

Biology 20 Core Units	Minimum Time
1. Introduction	7 hours
2. Ecological Organization	25 hours
3. Diversity of Life	25 hours
4. Agricultural Botany of Saskatchewan	15 hours
* Various Options	Remaining Time (28 hours)
Biology 30 Core Units	Minimum Time
1. Chemical Basis of Life	10 hours
2. Cell Structure and Function	10 hours
3. Genetics	20 hours
4. Animal Systems	20 hours
5. Evolution	15 hours
* Various Options	Remaining Time (25 hours)

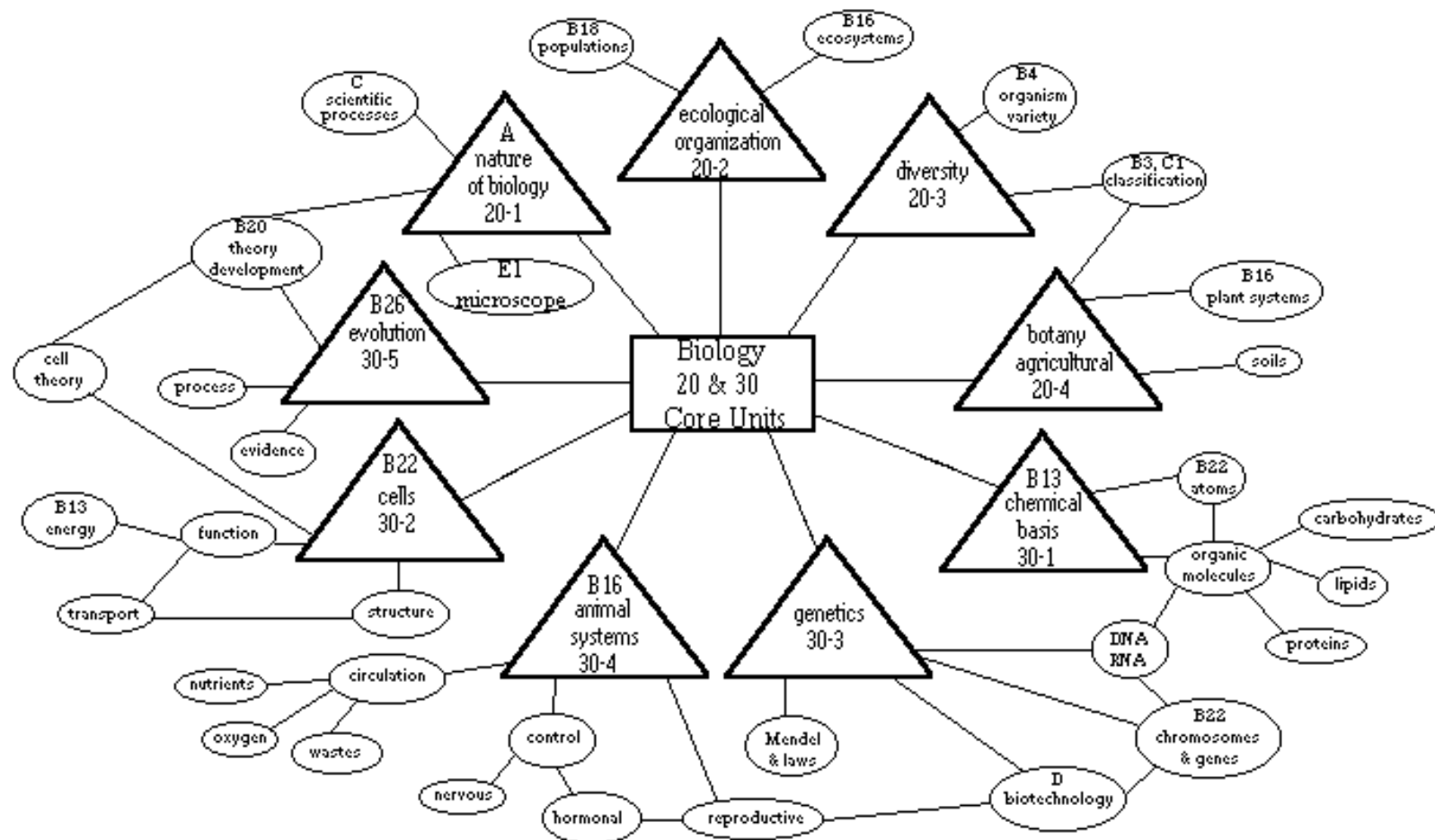
* **Biology 20 Optional Units** (remaining available time)

- ! expand one or two of the Core Units
- ! utilize **Science Challenge** ideas (see the Life Science section in Science 10)
- ! assign student independent study projects
- ! create a unit using the **Unit Planning Guide**

* **Biology 30 Optional Units** (remaining available time)

- ! expand one or two of the Core Units
- ! utilize **Science Challenge** ideas (see the Life Science section in Science 10)
- ! assign student independent study projects
- ! create a unit using the **Unit Planning Guide**
- ! do an ecology reprise) impact of humankind on the environment; explore the concept of sustainable development

Figure 5. Concept Web Overview of Biology
 Note: many other connections are added through unit webs.



Biology 20 Units

Unit 1

Introduction to Biology (7 hours)

Unit Overview

This unit is meant to establish a rationale for the teaching of biology, create an excitement for the study of biology, and set the context in which biology is viewed. To accomplish this last objective, the cell theory and the evolutionary theory are introduced. These two theories have had great impact on the structure of the discipline of biology, and can act as organizers for the study of biology in grades 11 and 12. The meaning of the term 'theory' in science should be discussed.

A **theory** is an understanding of the world which has the possibility of being altered as new information modifies the individual's perception of the world. Illustrate the sequential nature of theory development beginning with primary observations that lead to a clearly defined **problem** that can be studied by creating a number of clearly defined **hypotheses**. A logical **procedure** should emerge followed by **structured observations** and then **interpretations**. Finally have students realize that by following many confirmed trials of an experiment a hypothesis may result in a change to a current theory which in turn may help modify the scientific law.

It is not intended that all the suggested activities given be used in this unit. **The goal is to use a wide variety of activities.** Teachers can select and adapt those which best suit their students' capabilities and interests, the facilities and resources in the school, and the time available.

Conceptual Development

grade 3

- ! the concept of theory (Dimension B20 factor) may be introduced

grade 4

- ! introduction to cells
- ! some Earth history; fossils

grade 6

- ! the concept of fundamental entities (Dimension B22 factor) should have been introduced
- ! animal adaptations for survival (optional)

grade 7

- ! adaptations of organisms to land changes

grade 8

- ! geological history of Saskatchewan; effects on life
- ! fossil evidence
- ! rate of environmental change

grade 10

- ! cell studies (suggested)

See Figure 6.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Microscopy, theory, cell theory, natural selection, evolutionary theory.

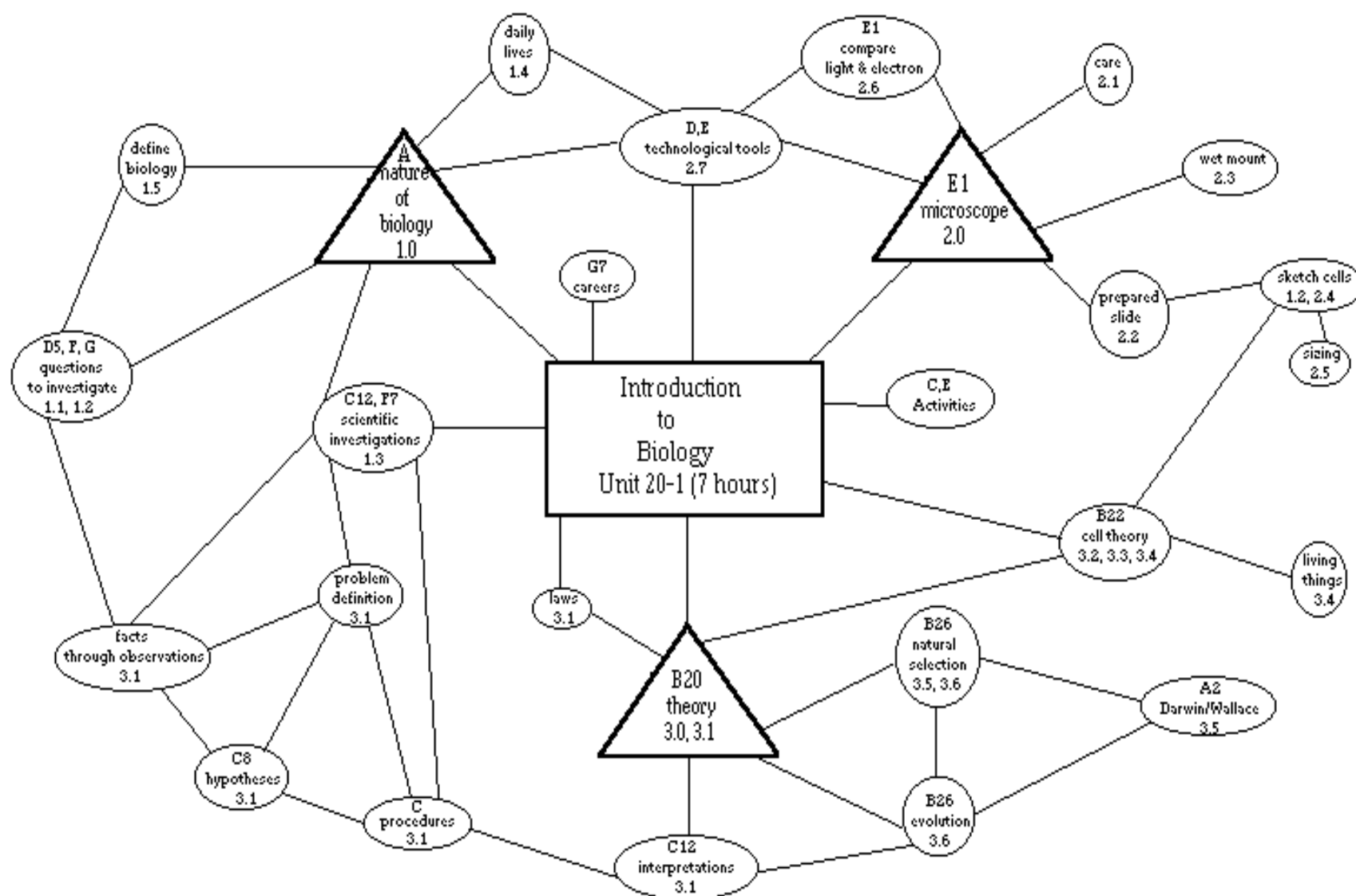
Safety Concerns

Any use of cells from human or other living sources must be treated with care. Human cheek epithelial cells and human blood cells must be handled with care so that students do not have contact with the body fluids of others. Living bacteria should be handled with appropriate technique, as should samples from the protist and fungi kingdoms. Consult a reference text if information is needed.

Science-Technology-Society-Environment (S T S E) Focus

- ! biology is multidisciplinary (consider connections).
- ! biology impacts our daily lives.

Figure 6. Biology 20 - Core Unit One



Note: see pages 81-82 for an explanation about webs.

Factors of Scientific Literacy Which Should be Emphasized

- A6 probabilistic
- A7 unique
- A8 tentative
- A9 human-culture related
- B20 theory
- B22 fundamental entities
- B26 evolution
- C8 hypothesizing
- C9 inferring
- C12 interpreting data
- D5 public understanding gap
- D7 variable positions
- E1 using magnifying instruments
- E2 using natural environments
- E13 using quantitative relationships
- F7 demand for verification
- F8 consideration of premises
- G8 explanation preference
- G9 valuing contributors

Common Essential Learnings Foundational Objectives to Emphasize

- CCT To develop an understanding of how knowledge is created, evaluated, refined and changed within biology.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of biology.
- IL To develop students' abilities to access knowledge.

Biology Foundational and Learning Objectives

1. Understand the nature of the study of biology.
 - 1.1 Examine the types of questions which biologists investigate.
 - 1.2 Exhibit a curiosity about life and the conditions which support life.
 - 1.3 Appreciate the nature of scientific investigations and the findings of science.
 - 1.4 Recognize the relationship between what is studied in biology and daily life.

1.5 Define the term biology.

2. Use a microscope to examine cells.

- 2.1 Develop proper techniques for handling and care of a microscope.
- 2.2 View prepared slides.
- 2.3 Prepare wet-mount slides.
- 2.4 Sketch what is seen in the field of view.
- 2.5 Estimate sizes of objects observed.
- 2.6 Compare the images produced by light microscopes and electron microscopes.
- 2.7 Discuss examples of how the microscope has altered what we know.

3. Explain the importance of theory in biology.

- 3.1 Outline the key aspects of a scientific theory. (See the Unit Overview and web.)
- 3.2 Discuss the development of the cell theory.
- 3.3 Recognize the link between the development of cell theory and the technology available to study cells.
- 3.4 Realize the significance of cell theory in establishing the relatedness of all living organisms.
- 3.5 Examine the principles of natural selection as identified by Darwin and Wallace.
- 3.6 Explain how natural selection is the basis of the theory of evolution.
- 3.7 Describe how a theory might change using an example(s).

Assessment Techniques

- ! Review pages 15 - 19.
- ! Use ***Student Evaluation: A Teacher Handbook***
- ! Consult key resource supports.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. Introduction to biology.

This activity is one which allows the student to explore the breadth of biology utilizing the skill of brainstorming and the opportunity to practice co-operative group work. The activity should take about 3 1/2 days.

Objectives: 1.1, 1.3, 1.4, 1.5, CCT, COM, IL

Factors: A7, D5, D7, G9

Assessment: Written Assignments

Instructional Strategies

The breadth of biology can be studied by considering a variety of categories. In groups of 3, (facilitator, recorder, and reporter) use the **brainstorming** technique to carry out a number of tasks.

- a) Define the term biology.
- b) List places or activities in Canadian society where an understanding of biology may be utilized for fun, benefit, profit or interest.
- c) Using key resources identify the areas in the text where the items in b would be located. You may discover that some of the items from part b cannot be found in the exact wording that you chose.
- d) Students should construct a list of local sources where one can find biological information. This might include expert individuals, magazines, newspapers, etc.
- e) Each person should go to the library or elsewhere, with teacher permission, to collect examples of information which: 1) contain clear and concise explanation, and 2) have appropriate documentation about the many diverse topics associated with biology and where a knowledge of biology would be useful. At some point you will be expected to share the information with the two other people in your group. (Career information might be gathered at the same time.)
- f) Back in class the students should do the following:
 - ! The three individuals in the group should share the information that they collected.
 - ! Each person should write a 2-3 page report entitled "**One View of the Breadth of Biology**". This report should demonstrate the breadth of biology as seen by the members of the group. There does not need to be any documentation for this 2-3 page summary. **The teacher will, at random, collect one of the 3 reports and allocate a mark that will be shared equally by all group members.** (Oral reports or other methods might be used.)

Evaluation Strategies

Evaluation for the report: 1/2 mark for each situation where a knowledge of biology would be useful in other areas of society. Maximum - 10 marks. Each 1/2 mark item should be accompanied by a concrete example, each for an additional 1/2 mark. Total for the exercise - 20.

2. Cell theory activity.

Students will have an opportunity to practice microscope skills, hypothesizing, writing skills, co-operative group work skills and to see how one may begin to develop ideas leading to a theory.

Objectives: 1.3, 2.1, 2.2, 2.3, 2.4, 2.25, 2.6, 3.1, 3.2, 3.6, 3.7, CCT

Factors: B20, C8, C9, C12, E1, E13, F7, F8

Assessment: Laboratory Reports

Instructional Strategies

Organize the students into groups of four with various responsibilities, such as: **Leader**- makes sure the objectives are interpreted and completed; **Equipment person**- obtains the materials/equipment and returns them; **Researcher**- conducts and oversees the procedures; **Recorder**- keeps a written record of all important information as indicated by the group. All people should agree on the written material because all people are responsible for the reporting. (Rotate roles periodically.)

General steps:

- ! organize the groups with responsibilities as indicated above
- ! obtain a list of people in each group
- ! students pick up plant and/or animal samples) make their own slide or get a prepared slide.

Specific Steps:

- a) Define the problem. **Do cells have some common characteristics?**
The students are to develop a theory about what a cell is and then be able to predict what they might see if they were to look at a yet unseen cell.
- b) Set up a hypothesis before each slide is viewed to guess what will be seen. Hypotheses: What do I think I will see? Write as: **if** "I do the following", **then** "I expect to get the following results".

-
- c) Record the information.
Record what you see; size some distinguishable part; draw the parts and label with your own labels.
- d) Interpretations.
How do the slides compare? (similarities and differences).
On the basis of the hypotheses what have I learned?
Set up a chart which has one column with the **hypotheses** and a second column indicating what was learned.

Evaluation Strategies

- ! Give students 5 marks for each complete drawing with its labels and sizing features. Also allow 2 marks for each section of the chart in part d which relates to a slide.
 - ! Finally, give the students 5 marks for showing the relationship between what they have learned and the cell theory statements. You should look for specific factual bits of information that they have learned from their hypotheses and what components they were not able to discover.
3. Discuss Redi's and Pasteur's investigation of spontaneous generation and biogenesis. Consider the concepts of controlled experiments, identifying variables, and determining cause-and-effect relationships.
 4. Generate a list of the characteristics of living organisms. Relate these to the characteristics the students observe in the living organisms around them.
 5. Discuss the distinction between living and non-living things. What non-living things have characteristics which are similar to, or which imitate, those of living organisms?
 6. To introduce the nature of biology to the students, organize a guided and structured field trip to a site of exceptional interest, such as a coulee, sand dune area, slough, creek, river valley, wooded area, or lake. The purpose of the trip is to introduce students to the diversity and the complexity of the systems which surround them. The approach should require the students to make detailed observations and assessments of what they see. A sample worksheet is in Appendix E.

7. Discuss the nature of science, laying a foundation for this eventual outcome:

"Students of biology should acquire not only an intellectual and esthetic appreciation for the complexities of living things and their interrelationships in nature, but also for the ways in which new knowledge is gained and tested, old errors eliminated, and an even closer approximation of the truth obtained."

-H. Bentley Glass, BSCS, 1960.

8. View and discuss the film *The First Inch*, or some other exemplary film or video.
9. Prepare a hay infusion, and observe the organisms which develop in it. Methyl cellulose may be added to the wet mount to slow the motion of the protozoans.
10. Ask students to search through magazines to find examples of images produced by light microscopes and by electron microscopes. If they can be removed from the magazine, mount them as a collage, composite, or series on a bulletin board.
11. Collect some household chemicals, foods, and articles which are found around most houses. Discuss how biology may be associated with them.
12. Have students consider two categories: What potential attributes contribute to someone being a successful human being? and what attributes are required to be a successful scientist? Brainstorming and research may be used. (It should be stressed that one can be successful in one role, but not the other and that diversity is one of the special qualities of humans which should be appreciated.)
13. Using current news sources, list examples of biological research. Ask students to write a short story about how the future might be based on the research.
14. How can a teacher encourage gender equity in the natural sciences?

-
15. Review and reflect upon "Native Problems in Biology Classes" ***American Biology Teacher***, March 1989. Does this article apply to the Aboriginal peoples of Saskatchewan? Why or why not? How could one find out for sure?

(Invite an Elder to discuss this with the class. See Appendix A and B.)

16. When dealing with objectives 1.1 and 1.3:

- ! Consider areas such as medicine, agriculture, environment, and such processes as classification and designing experiments.
- ! Consider examples such as detailed measurement, reproducibility of experiments, long term historic value of information, crop production values, breeding programs between North American cattle breeds and European, tentative change, control of insect pests, human-culture related science, and the current problems associated with finding a control for a virus which has the capacity to mutate quickly.

Unit 2

Ecological Organization (25 hours)

Unit Overview

This unit is designed to give students an opportunity to examine closely populations and ecosystems within Saskatchewan. During the course of this inspection, students will see how Saskatchewan is a part of the larger global ecosystem, and how diverse the life, and life-support system, in the province really is. Points to be stressed are that the quality soil, air, and water provide the basis for healthy life and that human action has a disproportionately large effect on populations and ecosystems. They will also consider how life in Saskatchewan has changed in the past, consider the changes which are taking place now, and those which may come in the future.

The general philosophy of this unit is expressed by J. Stan Rowe in a chapter titled "The Importance of Conserving Systems" from the book *Endangered Spaces* edited by Monte Hummel. There needs to be a balance struck between looking at the organisms and looking at the sphere in which they live.

...the widespread opinion (is) that the entities of prime importance on Earth are people, other animals, and plants, rather than the globe's miraculous life-filled skin. Species attract far more attention than the earth-surface spaces which envelop them, even though over the long haul the species were born from the earth-circling fertile space that continues to provide for their support, sustenance, or renewal. Endangered species elicit torrents of public concern; endangered spaces are routinely desecrated and destroyed with scarcely a murmur of public disapproval. The priority is wrong, and from this profound error the whole world suffers. (page 229)

The qualitative factors which influence populations and the quantitative determination of a population are major topics. Some of the factors which influence the growth and ultimate size of a population may have been discussed during Middle Level Science and Social Studies classes, but for the

for the first time.

Teachers are encouraged to use the spaces surrounding the school and further afield, so that these studies are done within the contexts of the students' lives. As much as is possible, students should be given the chance to be outdoors to make first-hand observation of the phenomena studied in this unit. Consult **Out to Learn!**

Conceptual Development

grade 1

- ! needs of animals; habitats
- ! how are animals adapted to their environment

grade 2

- ! how plant and animal needs are met
- ! relationships between living organisms and their environment
- ! effects of weather

grade 3

- ! food chains and webs
- ! agriculture and soil

grade 5

- ! recognition of nonliving elements of the environment essential to life
- ! human impact on the environment
- ! communities and ecosystems (optional)

grade 6

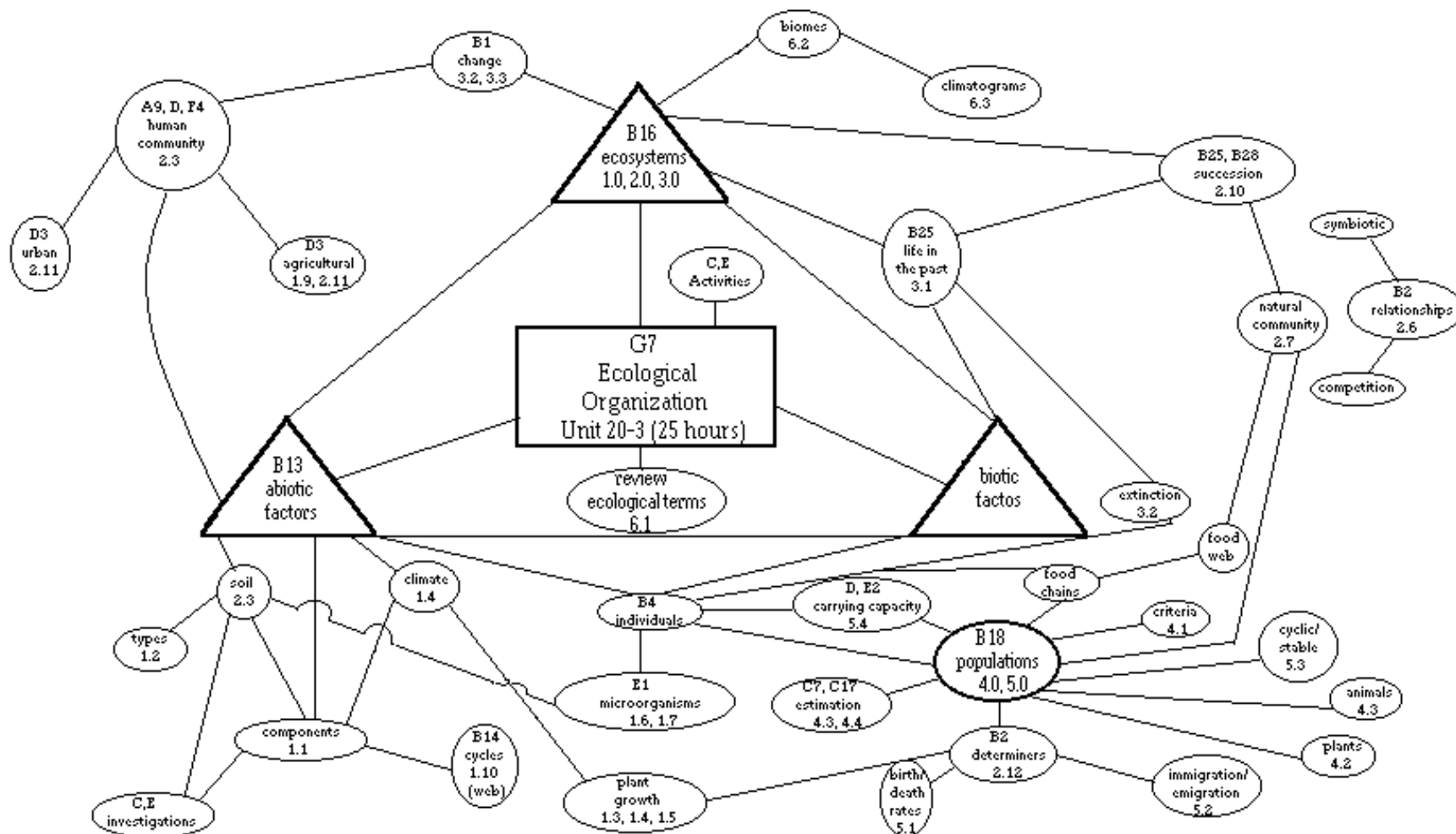
- ! interactions among living things and the environment which surrounds them (how ecosystems work)
- ! populations
- ! climate change (optional)

grade 7

- ! essential characteristics of life
- ! how organisms adapt
- ! nutrient cycles
- ! impact of humans
- ! role of microorganisms (optional)

most part, students will be considering these topics

Figure 7. Biology 20 – Core Unit Two



Note: see pages 81-82 for an explanation about webs

- ! potash
- ! impact of consumer products; life in space (optional)

grade 9

- ! diversity of ecological regions of Saskatchewan
- ! human activity effects on landscape
- ! risks and benefits and the natural environment

grade 10

- ! water quality (suggested); Greenhouse Effect; and uranium (optional)

See Figure 7.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Soil, soil health, climate, ecosystem, niche, interdependence, communities, succession, extinction, habitat, fossil record, population, sampling, species, population cycles, stable population, carrying capacity

Webbing highlights

By using scientific processes (Unit 20-1) students can learn to analyze various ecological problems and begin to understand the complexity of major issues.

Science-Technology-Society-Environment (S T S E) Focus

- ! wild game management
- ! sustainable agriculture
- ! habitat destruction
- ! pesticide (insecticide, herbicide, etc.) use

Factors of Scientific Literacy Which Should be Emphasized

- A3 holistic
- A4 replicable
- A6 probabilistic

- A7 unique
- A9 human/culture related
- B1 change

- B2 interaction
- B3 orderliness
- B4 organism
- B5 perception
- B8 quantification
- B11 predictability
- B12 conservation
- B15 model
- B16 system
- B18 population
- B19 probability
- B20 theory
- B21 accuracy
- B22 fundamental entities
- B24 scale
- B26 evolution
- B28 equilibrium
- B29 gradient
- C1 classifying
- C5 measuring
- C7 using numbers
- C8 hypothesizing
- C10 predicting
- C12 interpreting data
- C13 formulating models
- C14 problem solving
- C15 analyzing
- C17 using mathematics
- C19 consensus making
- C20 defining operationally
- D3 impact of science and technology
- D4 science, technology, and the environment
- D5 public understanding gap
- D7 variable positions
- D8 limitations of science and technology
- D9 social influence on science and technology
- D10 technology controlled by society
- D11 science, technology and other realms
- E1 using magnifying instruments
- E2 using natural environments
- E4 using audio visual aids
- E7 manipulative ability
- F3 search for data and their meaning
- F4 valuing natural environments
- F5 respect for logic
- F6 consideration of consequence
- F7 demand for verification
- F8 consideration of premises
- G5 avocation
- G6 response preference

Common Essential Learnings Foundational Objectives

- NUM To strengthen students' knowledge and understanding of how to compute, measure, estimate and interpret numerical data, when to apply these skills and techniques, and why these processes apply to the study of populations.
- CCT To develop an understanding of how knowledge is created, evaluated, refined, and changed within biology.
- CCT To promote intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and objects in the context of the study of the environment.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of ecology.
- IL To support the development of a positive disposition to life-long learning.
- PSVS To support students in coming to a better understanding of the personal, moral, social, and cultural aspects of the study of life.
- TL To develop an understanding that technology both shapes society and is shaped by society.

Biology Foundational and Learning Objectives

1. Explain how the interactions among the soil, climate, and living organisms produce the ecosystems which can be observed.

- 1.1 Identify the components of soil.
- 1.2 Describe the soil types of Saskatchewan.
- 1.3 Determine how soil characteristics influence plant growth.
- 1.4 Describe how climatic variations in Saskatchewan influence plant growth.
- 1.5 Investigate variations in plant growth on slopes.
- 1.6 Identify some soil microorganisms.
- 1.7 Discuss the importance of soil microorganisms.

- 1.8 Appreciate that the soil and the climate are

the keys to life in Saskatchewan, and on this planet.

- 1.9 Investigate the interrelationship of agriculture and the environment.
- 1.10 Discuss the following cycles and attempt to illustrate their interrelationship: water, carbon dioxide-oxygen, nitrogen.

2. Analyze a variety of ecosystems.

- 2.1 Understand the concept of niche and habitat.
- 2.2 Identify the biotic and abiotic components and interactions in the ecosystems observed.
- 2.3 Describe how the human community is dependent on the soil, water, and air.
- 2.4 Formulate some food chains and webs involving the human community.
- 2.5 Describe how the human community in which one lives is dependent on, and influenced by, the climate.
- 2.6 Identify both symbiotic and competitive relationships among organisms within a community.
- 2.7 Investigate a natural community in the neighbourhood of the school.
- 2.8 Compare the similarities and differences between the natural community and the constructed/human community.
- 2.9 Compare communities which have other soil types or other climate types.
- 2.10 Discuss succession in communities.
- 2.11 Identify how human activity, e.g. agriculture and urbanization, has altered succession or changed its rate.
- 2.12 Indicate some determiners of succession.

3. Describe life in past ecosystems.

- 3.1 Examine the evidence of life in the past.
- 3.2 Debate change and extinction theories.
- 3.3 Investigate the role of humans in creating and sustaining conditions which alter the rate of ecological change.

4. Explain how populations are counted.

- 4.1 Recall the criteria which define a population.
- 4.2 Identify some populations of plants or animals in the local area.
- 4.3 Describe methods of estimation by sampling.
- 4.4 Estimate some populations using one or more methods.

5. Analyze population changes.

- 5.1 Identify factors which influence reproduction rates and death rates.
- 5.2 Recognize factors which affect immigration and emigration.
- 5.3 Compare cyclic populations and stable populations.
- 5.4 Discuss the carrying capacity of planet Earth for the human population.

6. Recognize ecological sequencing.

- 6.1 Identify the sequencing present in the following terms: biosphere, biome, ecosystem, community, and population.
- 6.2 Review several examples of biomes by discussing some of their major kinds of plants.
- 6.3 Draw a climatogram and discuss temperature and moisture as major determiners of a specific ecological area.

Assessment Techniques

- ! Use ***Student Evaluation: A Teacher Handbook***.
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. Studying an ecological problem.

This activity reinforces the precise use of ecological concepts and the integration of the information learned in this unit. You will be assigned an ecosystem to study. An ecological problem should be chosen such as an oil spill, community garbage disposal, pesticide run off, monoculture agriculture, forest cutting and management techniques, or soil conservation. Preparation to study consists of three parts which should be followed in sequence.

Objectives: 1.0, 1.8, 2.1, 1.3, 2.11, 4.1, 5.1, 6.1, 6.2, CCT's, COM, IL

Factors: A3, A7, B2, B3, B15, B18, B22, F8, G6

Assessment: Rating Scales; Self- and Peer-Assessments

Instructional Strategies

Note: each group will set up the potential analysis on their own except for the section on consultation.

! Preparation

Locate some general information about the ecosystem (biome). It should include where it is located, what the climate may be like, what the terrain (hills, valleys, mountains, etc.) is like and the kinds of living organisms there. This does not have to be a detailed description but rather an outline so that one can make a presentation to other people.

! Consultation

You are to consult with your own group and three other outside people who you do not work with during this project. The purpose of the meeting is to broaden your thinking to arrive at some consensus as to **what should be studied** when one does an impact analysis of the area and the **potential destruction** that may have occurred or might occur. Assume that you are doing this study to **make suggestions to a government about potential disasters that could occur and what you could do to contain the damage or to create a situation where there is more harmony between the environment and the needs of the people.**

! Analysis Format

With the information from the **preparation** and the final set of ideas from the **consultation**, the student group is now ready to construct a concept web to illustrate what they have learned.

Steps to follow:

- a) Begin the concept web with the term **impact analysis**.
- b) sketch the ecosystem information from the preparation listing the key ideas and how they are related.
- c) Add the **what should be studied**, potential destruction, damage containment and harmony to the concept web along with the connections that should be made to the ecosystem. Students should be reminded that the concept web is a valuable visual account of pertinent

ideas and especially shows the kinds of connections which might not be demonstrated by any other means.

d) Finally, as a group write a recommendation.

! **Prepare a list of items that should be studied or considered.**

! **Give examples of why each item may be important.**

! **Suggest possible damages to the area.**

! **Finally, suggest how in the opinion of the group and based on the concept web there can best be harmony between all participants and the environment.**

2. Environmental impact.

This activity provides an opportunity to process information about the impact of the human population on the environment.

Objectives: A1.4, A1.6, A1.8, 1.9, 2.7, 5.4

Factors: B1, B2, C1, C7, C10, D3, D4, D8, F3, F4, F6, CCT, NUM, PSVS, TL

Assessment: Rating Scales; Self- and Peer-Assessments

Instructional Strategies

a) Form co-operative teams of six students each.

! Two individuals will attempt to discover the ways that society has attempted to regulate and protect their environment and thus to protect ourselves: public health regulations, waste treatment plants, garbage disposal, hospitals, immunization, etc. How does a treatment plant work or how do we dispose of garbage?

! A second group should attempt to discover the various scientific ways that we have for detecting environmental hazards.

! The third group should make a list of all the synthetic products that make their way into our environment: medicines, plastics, food additives, dyes, etc.

b) Have students construct a series of posters which illustrate what has been learned.

c) In addition, students could be asked to illustrate the impact of any of their categories on the ecosystem by suggesting where each of

the three categories impacts on the ecosystem.

This could be a summary with no marks assigned.

Evaluation Strategies

Prepare a **poster** (on an 8.5 by 11 sheet) or if they wish, prepare a record cover jacket, an emblem for a T- shirt, etc., which will reflect the student's concern about their chosen environmental problem. Have the poster reflect thoughts and underlying feelings from the information gained.

The finished product should include:

! **a definite theme illustrating the knowledge about the topic;**

! **appropriate utilization of space and perception; and,**

! **aesthetic balance to reflect their critical and creative thinking.**

Evaluation (Five marks for each item):

! impact - dominant idea presented

! organization - clarity and content

! creativity - different artistic methods employed

! students will evaluate two other posters on the above three criteria. The students will be assigned the other posters by the teacher.

Use the following chart for student assessment

Student Name	Categories			
	Impact	Organization	Creativity	Total
1.				
2.				

3. The slide-tape series *Landscapes of Saskatchewan* provides a contextual setting for the study of the ecology of Saskatchewan. Since the topography influences the type of succession which occurs, a full study of the ecosystem requires an understanding of the origin of the landscapes. The following objectives, based on the first section of that series, could be used to create an introduction to this unit.

! Describe the effect of the last glacial period on the soil and water resources of Saskatchewan.

- Recognize glacial and proglacial landforms.
- Describe how glacial and proglacial landforms were created.
- Examine the surface drainage patterns of the province.
- Identify topography produced by surface drainage.
- Identify sources of ground water and surface water in Saskatchewan.

! How did the Indian peoples cope within the ecosystems at the time of the last glacier?

4. Ask each student lab group to collect soil samples from various locations. Describe the collection site, the method of collection, the depth from which the sample was taken, the exposure of the site, type of vegetation, amount of ground cover, and other features.

Each sample can then be analyzed in the lab for characteristics such as pH, texture, particle size, organic content, amount of soluble material, living animals and remains of animals, and the presence of algae and bacteria.

Groups can then prepare a summary sheet of each analysis, for distribution to other groups so that the analyses of all the groups in the class

can be compared. Using the class data, groups can search for generalizations which can be made.

5. Ask each lab group to generate food chains and a food web, using the foods which have been eaten by the members of the class over a three day period. These webs could be presented to the class as a whole, either in an oral presentation with handouts, or as a large poster for the bulletin board.
6. Together in a class discussion, identify the organisms -- plant, animal, fungus, protist, and moneran -- which inhabit the area in which your school is located. Identify the niche of each organism. Compare the list generated with a list of those organisms which would have existed in the same area 200 years ago. Discuss the changes which have occurred. Predict what changes may occur under various scenarios, e.g., greenhouse effect raises the average temperature by 5 °C, with more precipitation than now.
7. Study the population of a yeast culture, over a ten to fourteen day period.
8. Each lab group could design and conduct a population study for plants or animals in a particular area. The study could be a one-time study, or be longitudinal. One example might be to study the population distribution and characteristics of the dandelions in a lawn over a four week period in May. Do yearly comparisons.
9. Natural communities are dynamic systems which change constantly through time. Have students interview older members of the community or certain organizations that have information about change over the last 50 years. Construct a series of maps of specific areas to illustrate the ecological changes that have occurred over the 50 year period. Try to identify the human

influences that have contributed to these changes. Videos, stories, legends, and posters may be used for sharing.

10. On a piece of cardboard or plywood have students create several models of the geological history of the earth at different times in the history of Saskatchewan. Include the mountains, seas, rivers, glaciers, plains, etc. Indicate the dominant life forms of the day and the climate on a key chart beside the model.

11. Have students collect recent articles about "Ecology" from newspapers, magazines etc. during the time interval that this unit is being taught. These should be collected in a student journal/folder and be referenced) source, date, page. If the article has to be summarized because it cannot be taken out of a source, then please do the summary in point form.

At the conclusion of this unit have the students do this follow-up:

- ! Prepare a concept map/web of what has been collected.
- ! Write a one page summary of what was learned using the concept web as a guide.
- ! Redraw the web using someone else's raw data. Then the two students should share their findings:
 - What is common and different between their results (concept webs and summaries) using the same initial information?
- ! These results should be shared with the class to indicate the spectrum of information interpretation that there is in society.

12. Investigate the "Global Village) Greening the Park" project at LaLoche, Saskatchewan.

13. Create a natural plant mini-ecosystem in your school yard. See the **Science Teacher**, December, 1991 issue for ideas.

14. Use the September-October, 1989 issue of **Equinox** plus data from Ducks Unlimited and other organizations to study the "Duck Dilemma" in Saskatchewan. Population graphs and interpretations are valuable.

In conjunction with this or separately, investigate the North American Waterfowl Management Plan (NAWMD).

15. Use **Project WILD** materials to explore the concept of the ecozone(s) in Saskatchewan.
16. Have students investigate and report on "Biosphere 2"! Start with newspaper articles.
17. In small groups, have students read and discuss the perspectives of the Inuit hunter and the biologist in "Two Ways of Knowing", from the **Caribou News**, August 1989. See Appendix A.
18. Students raised in traditional Indian ways may believe that abiotic/non-living natural objects have spirits. How does this concept impact upon your perspective of respect for the environment? (Perhaps you could invite an Elder in to discuss this with the class.)
19. Was the "Greenhouse Effect" unit covered in the new grade 10 Science course or will you integrate it here? See Objective 3.3.
20. After the arrival of Christopher Columbus, what factors contributed to the decline of North American Aboriginal populations? The Europeans originally saw North America as a wilderness area) untouched by human hands. Was it untouched? How might this be related to the concept of carrying capacity? (See **American Indian Ecology**.)
21. What biological arguments are part of the Nunavut land settlement?
22. Discuss the hypothesis that some Aboriginal cultures caused profound ecological damage. See **International Wildlife** (July-August, 1989) and **Discover** (December, 1988).
23. Inquire into allelochemicals such as rotenoids, natural insecticides.
24. The ecological 3R's are Reduce and Reuse listed before Recycle. What are the implications of the 3R's for the environment? What enrichment or extra-curricular projects can your students pursue?
25. Which of the "Twelve Principles of Indian Philosophy" have an ecological focus? (Consult **The Sacred Tree** or see the Native Studies Curriculum).
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26. The Development Unit of **Native Studies 20** contains a section on the Environment and case studies dealing with ecological problems involving Indian and Métis peoples. Use this as a reference for student inquiry or as a team teaching approach.
 27. Pesticides and insecticides have an impact on the community. Have students conduct interviews with individuals that may have the information. With insightful interviewing, students will begin to learn about the potential positive and negative impacts of these chemicals.
 28. Students could conduct a survey of the community to collect information about the various alternative ways that may exist to utilize the land which is available within the community.
 29. The Saskatchewan Research Council, Saskatoon is involved on a project with the Cigar Lake Uranium mine. Two kinds of lichens (**Cladina stellaris** and **C. mitis**) are being studied as living monitors of airborne chemical and radioactive elements. Revegetation is also being studied. Inquire!
 30. Contact the Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706 for a copy of "Bottle Biology" - hands on biology projects with plastic containers investigating ecosystem interactions, population dynamics, biodegradation, and experimental design.
 31. Contact the Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706 for information on "Fast Plants" for projects dealing with **Brassica rapa** tropisms, seed germination, life cycle, growth, and genetic studies.
 32. Contact the Devonian Botanic Garden, University of Alberta, Edmonton, AB, T6G 2E1 for information regarding student involvement in a Wildflower Survey. Fifteen species of plants are studied in their natural habitat. Their flowering dates contribute to **phenology**. The data can be used in climate studies, forestry, satellite sensing, and human health.
-

Unit 3

The Diversity of Life

(25 hours)

Unit Overview

During this unit, the student should have a chance to observe a wide variety of organisms. These may be observed living in their natural habitats or in the classroom, or as preserved specimens.

The unit is structured so that the diversity of life in Saskatchewan is highlighted, and the comparisons can be made from the diversity of life in this province to that in the rest of the world. Several examples of organisms from each of the kingdoms should be studied in detail. An attempt to study the phylogeny of all life is not intended in this unit, and should not be attempted.

The science of taxonomy is considered in this unit. Its importance in the identification of species, and in communication of information about organisms should be stressed.

The unit can be integrated with Unit 20-2, **Ecological Organization**, which looks at the study of ecology in the context of the diversity of habitat and life in Saskatchewan.

Conceptual Development

grade 1

- ! characteristics of plants and animals
- ! animals around us and their needs
- ! classification of objects

grade 2

- ! adaptations of organisms to habitat
- ! dinosaurs; ocean life (optional)

grade 3

- ! food webs

grade 4

- ! fossils
- ! characteristics and interrelationships of vertebrates and invertebrates; classification of animals; plant diversity (optional)

grade 6

- ! how ecosystems work

grade 7

- ! characteristics of living and nonliving
- ! microorganisms (optional)

grade 9

- ! diversity of living things; classification systems (optional)

See Figure 8.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Classification systems, dichotomous keys, binomial nomenclature, niches of unicellular organisms, eukaryotic organization, vascularization in plants, behaviour.

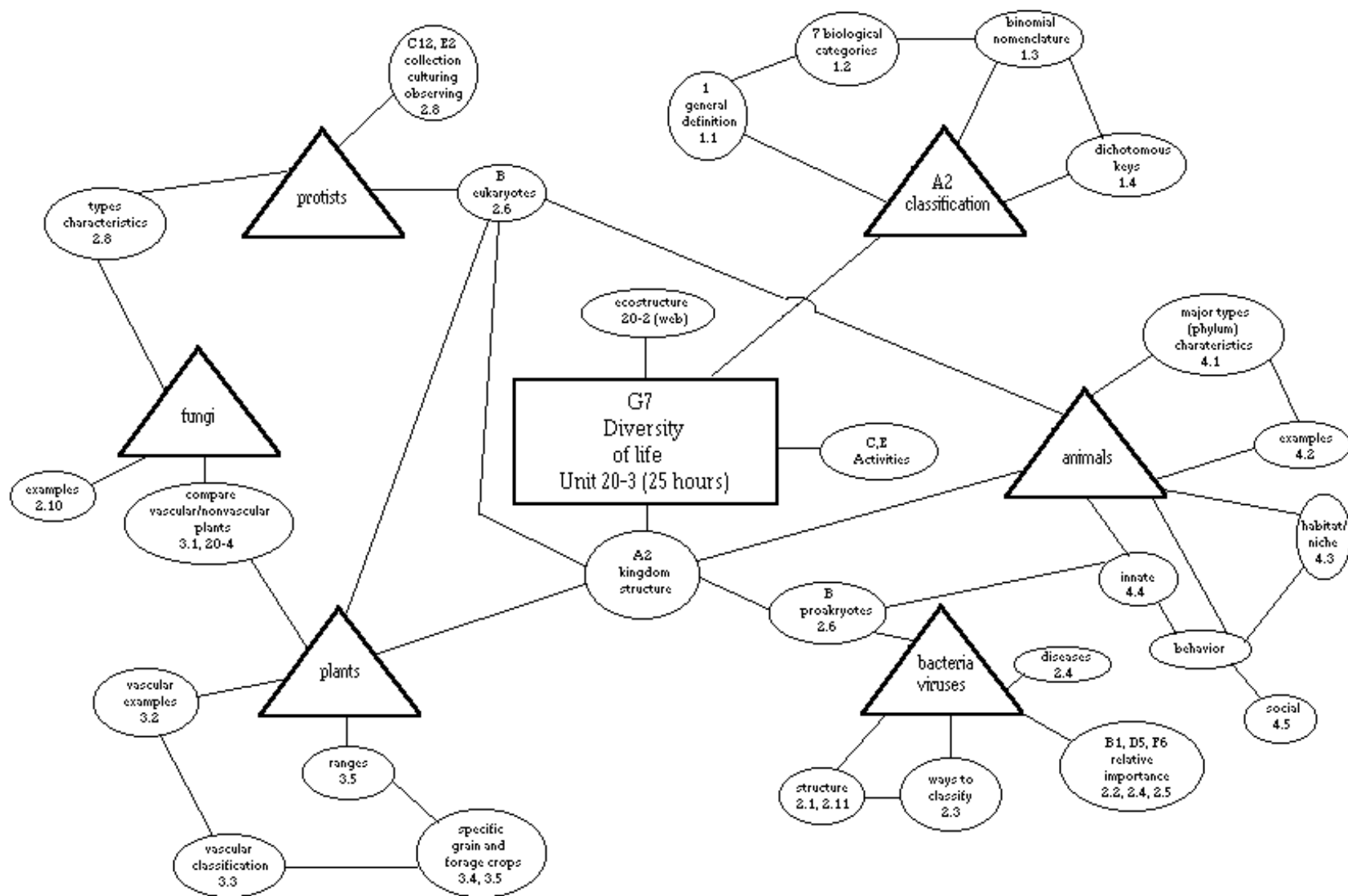
Webbing Highlights

This unit offers an opportunity to study the individual organism but there is an opportunity to see how organisms relate to each other and an integrated ecostructure.

Science-Technology-Society-Environment (S T S E) Focus

- ! introduction of foreign organisms for pest control
- ! agricultural research and new varieties
- ! habitat change
- ! evolution of pathogens

Figure 8. Biology 20 – Core Unit Three



Factors of Scientific Literacy Which Should be Emphasized

A2 historic
A7 unique
A8 tentative
B2 interaction
B4 organism
B11 predictability
B13 energy-matter
B14 cycle
B16 system
B18 population
B26 evolution
C1 classifying
C3 observing and describing
C9 inferring
C12 interpreting data
C15 analyzing
C21 synthesizing
D2 scientists and technologists are human
D7 variable positions
E2 using natural environments
F3 search for data and their meaning
F5 respect for logic
G3 continuous learner
G5 avocation
G7 vocation

Common Essential Learnings Foundational Objectives

CCT To develop an understanding of how knowledge is created, evaluated, refined, and changed within biology.

COM To use a wide range of possibilities for developing students' knowledge of the major concepts within biology.

IL To support the development of a positive disposition to life-long learning.

PSVS To develop compassionate, empathetic and fair-minded students who can make positive contributions to society as individuals and as members of groups.

Biology Foundational and Learning Objectives

1. Describe the principles of classification.

- 1.1 Discuss everyday examples of classification. (Then discuss the value of having a biological classification and some of the unique problems that might manifest themselves.)
- 1.2 Compare several different ways organisms are grouped into kingdoms. (It would be useful to have the students see the historical development of the 5 kingdom structure from a 2 kingdom structure.)
- 1.3 Understand the system of binomial nomenclature. (Discuss the 7 major classification units which include Kingdom, Phylum, Class, Order, Family, Genus, and Species and their associated relationships.)
- 1.4 Use dichotomous keys to help identify organisms. (One could demonstrate that a key locates actual organisms just as binomial nomenclature and the species level identifies actual organisms.)

2. Recognize the role of monera, protists, and fungi in the ecosystem.

- 2.1 Describe viral structure and activity.
- 2.2 Identify some viral diseases prevalent in plants, animals, and humans in Saskatchewan.
- 2.3 Discuss the various ways bacteria are classified.
- 2.4 Describe some diseases caused by bacteria which affect organisms living in Saskatchewan.
- 2.5 Identify some valuable roles played in the ecosystem by bacteria.
- 2.6 Distinguish between prokaryotes and eukaryotes.
- 2.7 Describe how the protist kingdom is classified.
- 2.8 Collect, culture, and observe a variety of protists.
- 2.9 Describe the general characteristics of fungi.
- 2.10 Collect and observe some samples of fungi.
- 2.11 Identify the basic structural features of bacteria.

3. Describe the diversity of plants.

- 3.1 Compare nonvascular and vascular plants.
- 3.2 Identify, describe, and collect some examples of nonvascular and vascular plants.
- 3.3 Discuss the ways that vascular plants are classified.
- 3.4 Describe grain crops and forage crops grown in Saskatchewan. (Correlate with Unit 20-4.)
- 3.5 Chart the ranges of representative plants of Saskatchewan.

4. Recognize the diversity of animals.

- 4.1 Describe the characteristics of the major animal phyla. (It is suggested that the teacher consider a mollusk such as a clam or snail, an annelid such as an earthworm, an arthropod such as an insect or spider, and one or more of the chordates, as time allows, which would include a mammal.)
- 4.2 Identify members of each phylum which contains animals native to Saskatchewan.
- 4.3 Describe the habitat and niche of animals native to Saskatchewan.
- 4.4 Contrast innate behaviour in animals with learned behaviour.
- 4.5 Describe social behaviour in animals.

Assessment Techniques

- ! Use ***Student Evaluation: A Teacher Handbook***
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. Newspaper story.

The student has the opportunity to do some group work, practice research and organizational skills as well as obtain some general information about the animal kingdom. Could this be a dual assignment with an English class?

Objectives: 2.3, 2.9, 2.11, 3.3, 4.1, COM., IL, PSVS

Factors: A2, B4, B11, B18, C1, C3, C12, D7, F3

Assessment: Reports; Self- and Peer-Assessments

Instructional Strategies

You are a reporter from a distant planet here to write about the newly discovered animal kingdom.

Working in groups of no more than three people prepare a three part newspaper story. The story will appear on three separate days in your local paper, and each story should attempt to have a theme and lead the reader to want to read the rest of the story. Use an appropriate headline for each that tells about the discovery of the animal kingdom. The information should tell the reader about when the animals developed, how they developed, where they developed, special features and finally where they may be going in their development. Each day's story should be no more than one page. In summary, the story of the development of the animal kingdom should be done in a sequence of three pages progressing from one day to the next.

Evaluation Strategies

The student's mark will be a combination.

- ! Information - 30 marks; 10 per story
- ! Organization (sequencing of information in each story) 3 marks per story for a total of 9
- ! Appropriate opening and closing paragraphs for each story; 5 marks per story for a total of 15
- ! Overall total=54

- 2. Classification. Students will review the concept of classification and study examples of classification usage in biology.

Objectives: 1.1, 1.4, CCT, COM

Factors: A8, B4, B11, C1, C3, C12, C15

Assessment: Laboratory Reports; Self- and Peer-Assessments

Instructional Strategies

- a) What are the important components of any classification system? The teacher should discuss general ideas about a dichotomous key.

- b) There are 30 organisms on the side bench. The students pick any 10 organisms and then create a dichotomous key that could be used to identify the 10 organisms. These should be features like: four legs, feathers, leaves, etc.

! Set up your key on **one page with no answers on that page**. Leave a blank where each of the 10 answers should go so that someone else could write in the answers. Put your name at the top of the page. This should be a dichotomous key.

ALL ORGANISMS

LEGS

NO LEGS

Organism A?

- ! Have a second page as an answer key for the dichotomous key that the student designed, such as the example below.

NAME: _____

choices	number
A	21
B	10
etc.	

Note: All organisms have visible characteristics. Separate the organisms on the basis of the visible characteristics and keep separating them until you have only one organism in each category. **This means that if you start with 10 organisms in a group then you will end with 10 organisms in 10 separate categories.** Make sure that you identify the specific characteristics for separating the organisms.

Evaluation Strategies

Students should turn in their finished dichotomous keys along with the answer key with the names of the organisms. The dichotomous keys will then be turned back to other students to see if they can identify the 10 organisms. All students are to answer the following questions and then turn in the student dichotomous key and the answers to the questions. When the student tries to use the other student key remember they will fill in their answers in the **blank spaces** and then check the answers with the real key set up by the originator of the key. The student trying the

key should make the corrections under their answers.

Questions to answer when the key is finished.

- ! What difficulties did I have with the key?
- ! What are the positive points about the key?
- ! What kinds of improvements might be made to this key? (If I was going to redo the key, I would...)
- ! Read what the key resource says about **classification and then record the significant information in point form**. Remember that significant information is any information that adds to the basic knowledge of how a classification system works and how it has become refined over long periods of time.

3. Have the students each bring a shoe to put into a pile. Warn them that if they forget to bring one, they will have to remove one of the ones they are wearing. Create a dichotomous key by sorting the shoes according to physical characteristics decided by consensus. Each characteristic should divide the group of shoes in the pile into two groups. Record the characteristics on a dichotomous key form. Continue identifying characteristics until each shoe is alone, or with other identical shoes. Then bring out some shoes which you have brought (from home or from the lost and found box in the school) and see how well they fit into the key produced. Modify the key if necessary and relate this exercise to the classification of organisms. Some questions to ask are: what happens if someone discovers a new organism? and what happens to the system if we had selected different characteristics to separate the piles?
4. Produce a list of Latin or Greek prefixes, suffixes, and root words. Define each and then give your students a list of fictitious animals to 'translate'. e.g. dactylo and phyta give dactylophyta or finger-plant, or platy and cephalus give platycephalus or flat-brain.
5. Collect a variety of mushrooms native to the area. Write descriptions of them and make spore prints. Use the key in a mushroom handbook to identify the samples.
6. Grow some bread mold cultures (*Rhizopus*) and examine them with hand lenses or with dissection microscopes.

-
7. Gather some samples of lichens and observe using hand lenses or dissection microscopes.
 8. Collect and describe some examples of nonvascular and vascular plants. Use keys to identify them.
 9. Ask the students to construct concept maps/webs to probe their understanding of the Kingdoms of life. Pages T89-92 of the Teacher's Edition for *Biological Science: An Ecological Approach* (Seventh Edition) has a description of the use of concept mapping in biology classes.
 10. Collect resource material and encourage students to research the programs being undertaken to preserve the foundational gene pool of plant species.
 11. Interview farmers or veterinarians in the surrounding area to discover the kinds of animal diseases that are prevalent, how they are transmitted, their associated costs and what can be done to control them.
 12. Interview an Extension Agrologist in the area to discover the new kinds of crops that have been introduced to the area and what may be available in the near future. Discuss with the expert how the new crop may have been developed.
 13. Have students collect recent articles about the diversity of living organisms such as organism extinction, exotic breeds, etc. from newspapers, magazines, etc. during the time interval that this unit is being taught. These should be collected in a student journal/folder and be referenced) source, date, page. If the article has to be summarized because it cannot be taken out of a source, then please do the summary in point form. See Activity 11 page 100 for a suggested follow-up.
 14. Culture and study various micro-organisms: for example, ***Micrococcus Luteus*** bacteria; ***Penicillium***, ***Aspargillus***, ***Newrospora*** or bread molds grown on potato-dextrose agar plates.
 15. Did/do other human cultures use diversity classification systems? Why were these systems adopted (or not adopted) by the scientific community?
 16. Instead of collecting plant specimens use photographs (or video) and collect data about plant species. See the ***American Biology Teacher***, February 1990.
 17. Do the investigation(s) "Medicinal and Poisonous Plants of the Holiday Season". See the ***American Biology Teacher***, November/December, 1987.
 18. Study the effects of new kinds of organisms. Make a study of your individual area and attempt to determine which organisms may be new to the area over the last 50 years and which ones no longer are found in the area. One could also contact the Canadian Wildlife Service to discover which organisms may have become extinct in your area and which ones are on the endangered species list. How has human culture had an effect on the changes in the kinds of organisms in your area and the province as a whole?
-

Unit 4

Agricultural Botany of Saskatchewan (15 hours)

Unit Overview

Three major plant systems -- reproduction, transport, and growth control -- are considered in this unit, in the context of the agricultural botany of Saskatchewan. In addition, the interrelatedness of agriculture and the Saskatchewan environment is investigated. (The term agriculture is used broadly to refer to crop and livestock production, horticulture, forestry, aquaculture and their associated industries.) Agriculture is a major disruptive human activity to the Saskatchewan environment and an important segment of this province's economy. Food production is necessary for our survival therefore knowledge of the processes associated with agriculture is of critical importance. The focus of this unit could be established by a in-depth study of the biogeography of the local region. Human and print resources can be obtained from Saskatchewan Agriculture and Food, the Saskatchewan Soil Conservation Association, Agriculture Canada, College of Agriculture - University of Saskatchewan, Saskatchewan Environment, Ducks Unlimited, etc.

Conceptual Development

grade 1

- ! characteristics (structures) and basic needs of plants

grade 2

- ! conditions important for optimum plant growth and reproduction
- ! role of agriculture

grade 3

- ! adaptive nature of plant structures (optional)

grade 4

- ! diversity of plant species (optional)

grade 5

- ! functions of specialized plant tissues and organs
- ! the place of agriculture in Saskatchewan

grade 7

- ! effects of the glaciers and weathering on the land
- ! effects of agriculture on the environment
- ! soil characteristics
- ! how plants are adapted to the Saskatchewan environment

grade 8

- ! potash and petroleum
- ! factors influencing plant growth; effects of agriculture (optional)

grade 9

- ! human activity affects the landscape

grade 10

- ! water quality (suggested)
- ! food additives and human nutrition (optional)

See Figure 9.

Note: A pre-test to determine the entry level of the students may be appropriate.

Key Concepts

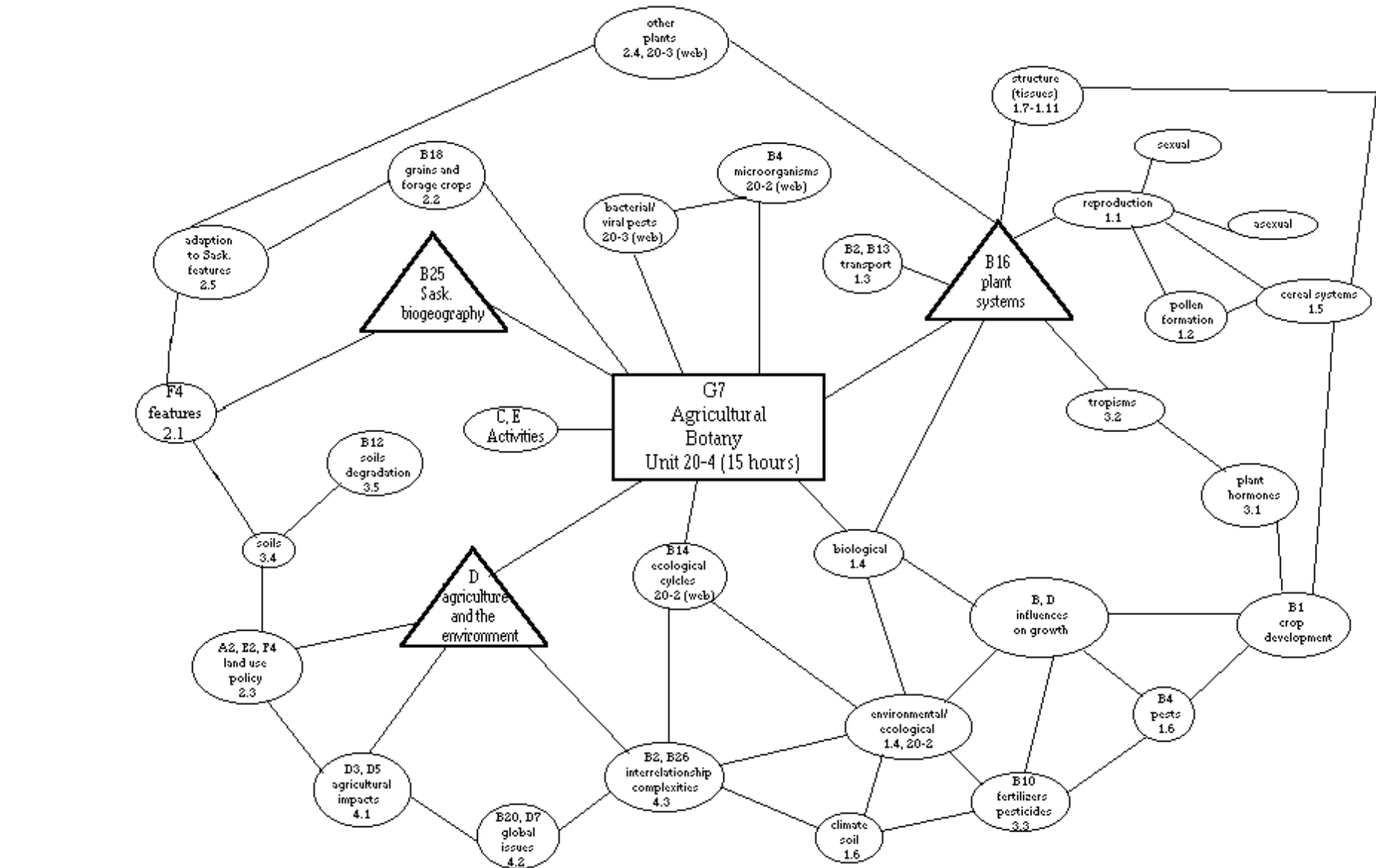
Plant reproduction, transport of solutions, plant tissues, hormonal control of growth, interrelatedness of agriculture and the environment, biogeography.

Webbing highlights

Relate agriculture to the ecological cycles (Unit 20-2). Do a study of the impact of agriculture on the environment and soil microorganisms (20-2). Review the information about bacteria and viruses (20-3) and relate this to agriculture.

Science-Technology-Society-Environment (S T S E) Focus

- ! biological control of pests
- ! land use policies



Note: see pages 81-82 for an explanation about webs.

Factors of Scientific Literacy Which Should be Emphasized

- A2 historic
- B1 change
- B4 organism
- B12 conservation
- B18 population
- B20 theory
- C6 questioning
- C8 hypothesizing
- C12 interpreting data
- C14 problem solving
- C15 analyzing
- C20 defining operationally
- D5 public understanding gap
- D7 variable positions
- E2 using natural environments
- E4 using audio visual aids
- E7 manipulative ability
- F4 valuing natural environments
- F6 consideration of consequence
- F7 demand for verification
- G7 vocation
- G8 explanation preference

Common Essential Learnings Foundational Objectives

- CCT To promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences, and objects within the context of the study of ecosystems.
- COM To use a wide range of possibilities for developing students' knowledge of the major concepts within biology.
- IL To develop students' abilities to meet their own learning needs.
- PSVS To support students in coming to a better understanding of the personal, moral, social, and cultural aspects of the study of life.

Biology Foundational and Learning Objectives

1. Recognize the various biological processes associated with plant systems.

- 1.1 Compare sexual and asexual reproduction in angiosperms.
- 1.2 Describe the processes of pollen production, fertilization and seed formation of plants.
- 1.3 Describe the means by which solutions are transported through plants.
- 1.4 Investigate the environmental and biological influences on growth.
- 1.5 Describe the major plant systems of various cereal, oilseed, pulse, forage, or native crops.
- 1.6 Identify the effects of climate and pest on different stages of crop development.
- 1.7 Review the three major structures of a plant which include the root, stem and leaf along with their locations and functions.

Note: Objective 1.8 should be seen as a general organizer and is not intended to be used to rigorously cover great detail on plant tissues.

- 1.8 Identify four broad tissue areas found in a plant which include meristematic, protective, vascular and fundamental.

- ! meristematic: frequent mitotic division for growth which includes cambium.
- ! protective: epidermis and cuticle.
- ! vascular: conducts water and minerals (xylem and phloem).
- ! fundamental tissue: three functions which include food storage, food production and support. (Examples include sclerenchyma, collenchyma and parenchyma. If you use these terms, discuss the Greek/Latin origins and help students make these connections.)

2. Appreciate the relation of Saskatchewan's biogeographical regions and agricultural activity.

- 2.1 Identify the characteristics of all the biogeographical regions of Saskatchewan.
- 2.2 Compare kinds of grain and forage crops.
- 2.3 Discuss the reasons and issues associated with various land uses and crop diversity.
- 2.4 Identify various species of trees, shrubs, plants and grasses of Saskatchewan.
- 2.5 Compare such plant characteristics as reproduction and growth patterns as they relate to the Saskatchewan environment.

3. Describe the internal and external influences on plant growth.

- 3.1 Describe the function and effect of cytokinins, auxins, and gibberelins.
- 3.2 Contrast tropisms with responses due to changes in turgor pressure.
- 3.3 Investigate how plants respond to chemicals such as fertilizers and herbicides.
- 3.4 Examine the effect on soil of the application of fertilizers and biofertilizers.
- 3.5 Identify the impact and examples of soil degradation.

4. Recognize the interconnectedness of agriculture and the environment.

- 4.1 Describe the impact of agriculture on the local environment.
- 4.2 Identify local and global issues associated with agriculture.
- 4.3 Appreciate the complexity of issues such as soil degradation, world hunger and environmental concerns.

Assessment Techniques

- ! Use ***Student Evaluation: A Teacher Handbook***.
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources ***Information Bulletin***.

1. Rangeland management.

This activity will be one which allows students to review some ecological ideas, identify some Saskatchewan plants, practice interviewing techniques, and analyze student collected field data.

Note: This activity is contingent upon having a resource called ***Managing Saskatchewan Rangelands*** which can be obtained from Saskatchewan Agriculture. (Check your Rural Service Centre.)

Objectives: 1.4, 1.5, 1.6, 2.1, 2.4, 2.5, 3.5, 4.1, CCT, COM, IL, PSVS

Factors: B1, B12, B18, C6, C8, C12, C14, C15, C20, D7, E2, F4, F6, F7.

Assessment: Major project; Reports

Instructional Strategies

The overall activity will require planning and organization in three areas. The students need background review of several areas which include **grazing history**, some **ecological terms**, a look at where they are in the **natural vegetation zones**, a quick survey of **range plants**, **principles of grazing** and finally a review of some **sampling techniques** and consideration of the kinds of data to be collected.

Information for parts a to c below can be given by the teacher or the students can be asked to prepare instructional materials to be shared with the other students.

- a) The **grazing history** provides the students with a historical background to the area of grassland management.
- b) The **ecological terms** are useful to illustrate the correct kinds of relationships that students should be trying to understand.
- c) Identify the correct **natural vegetation zone** for the specified area.
- d) Do a survey of **range plants** using the coloured plates and the example of the key. This will allow students to identify plant types in the field.
- e) Provide information about the **principles and concepts** associated with grazing.
- f) There are many **sampling techniques (found in the evaluation section)** and these should be discussed. This is the section where the students can be divided into various groupings depending upon the tasks to be accomplished. The plan is to have students collect different kinds of information and make class presentations to obtain a complete picture. This group approach is how most scientists work.

Small groups could conduct these activities.

- ! One group could interview a farmer or farmers who may use a common pasture. Collect general information about the numbers and kinds of animals grazing, how long they graze, costs to the farmer, etc.

- ! One or more groups can identify the different kinds of plants in the grazing area as well as the relative abundance of each.
- ! Some students can take soil samples at different places and add this information to the kinds and numbers of plants present.
- ! Another activity would be to collect information on the kinds and numbers of living organisms at these different soil sites.
- ! Sketch the topographic features of the pasture area and set up a key to identify all natural and constructed features. List all physical improvements made to the property.

Design a land use strategy for the local area. Identify soil degradation problems, social and economic impacts, wildlife habitat, and uses of the water resources. This would be an excellent opportunity to reinforce STSE connection.

Discuss the science and technology associated with agricultural practises. Brainstorm for social, economic, cultural and environmental impacts.

Evaluation strategies

Have all students turn in a paper summarizing what they have learned from all the various student groups about rangeland management. This can be given whatever value the teacher desires. See the group evaluation form (next page).

2. Compare samples of the various kinds of grains produced in Saskatchewan. These are generally classified as cereals, oilseed, pulse, and forage.
Cereal: barley, oats, rye, wheat, wild rice.
Oilseed: canola, flax, mustard, rapeseed, sunflower.
Pulse: field pea, dry bean, lentil.
Forage: grasses (bluegrasses, brome grass, canarygrass, fescues, ryegrasses, timothy, wheatgrasses) and legumes (alfalfa, clovers, sainfoin, trefoil).

Soak some seeds and dissect, to observe the embryo and the cotyledon(s). Germinate samples of the seeds to compare the rates and times of germination, and the rate of development of primary root and stem. Maintain some of the germinated seed to maturity (80 to 130 days). A student project might be to grow or collect mature plants, which could then be dry mounted and displayed with a sample of the seed.

3. Radishes, beans, or some other species which grows quickly could be used to replicate Von Helmont's experiment. Each group could be given a statement of the problem -- to determine what part of the mass of a plant comes from the soil in which it grows. The group's task would be to design a procedure which would provide an answer. The teacher with each group, or the class as a whole could discuss the proposals and refine them.
4. As a class project, brainstorm various methods and sites of application of gibberelic acid to growing plants. Design procedures to test the effects of the proposals. Assign each lab group one or more of the procedures which have been designed by the class. When each group has concluded its investigation, pool the reports of the results into a large report, with one copy distributed to each class member.
5. Invite a regional agronomist or regional soil biologist to discuss the adaptation of grain and forage plants to the soils of Saskatchewan in general and to your specific region.
6. Grow trays of wheat to the shot blade stage. Place one tray in a freezer for several hours. Compare the immediate effect and the long-term effects with a control tray. Simulate other weather conditions such as drought, excessive heat, hail (marbles dropped on plants?).
7. Identify the various trees, shrubs, and plants in vicinity of the school. Look for effects of environmental changes e.g. loss of wetland habitats, increase or decrease of specific plant populations.
8. Investigate various programs from organizations such as the Prairie Farm Rehabilitation Administration or Ducks Unlimited. Many sites across the province can be accessed by classes.
9. Have students prepare displays using appropriate media. Possible topics are:
 - ! soil profile(s)
 - ! how is soil formed?
 - ! how is soil "destroyed"?
 - ! soil samples under the microscope.

Group Evaluation Form

Scale: 1 is the least and 5 is the most. Circle your best estimate along the scale.

Questions

1) Were all of the members involved in the activity?

1 2 3 4 5 _____

2) Did all the areas of the assignment receive attention?

1 2 3 4 5 _____

3) Overall, did the students appear to understand what they were presenting?

1 2 3 4 5 _____

4) Was I able to clearly hear the presentation?

1 2 3 4 5 _____

5) The information was clearly stated so that I was able to understand what was being said?

1 2 3 4 5 _____

6) Props/aids were used to help with the explanations.

1 2 3 4 5 _____

Total = _____

Take the total and divide by 3 to find the potential mark.

Total = /3 = _____

-
10. Have students collect recent articles about agriculture from newspapers, magazines, etc. during the time interval that this unit is being taught. These should be collected in a student journal/folder and be referenced) source, date, page. If the article has to be summarized because it cannot be taken out of a source, then please do the summary in point form. See Activity 11 page 100 for a suggested follow-up.
 11. Many foods enjoyed worldwide come from plants cultured by North American Aboriginal peoples. Trace the selection and development of some examples: corn, potatoes, beans, tomatoes, peppers, various members of the squash family, tapioca, wild rice, many types of berries, etc. (See **Indian Givers** by Jack Weatherford.)
 12. Obtain plant and flower samples from florists or gardens. Have students dissect, sketch, and display various types.
 13. Research the wild rice or saskatoon plant industry in Saskatchewan.
 14. Research reports may be prepared and shared on the medicinal and other uses of some of Saskatchewan's native plants.
 15. Compare and contrast organic farming to other farming techniques.
 16. What is ethnobotany? Can this term be applied to the agricultural scene?
 17. Do a study of pest control using insecticides and herbicides. Contact someone who has information about biological control of pests.
 18. What are the land use policies that are pertinent to your area?
 19. The Science Council of Canada investigated how science and technology can best be managed to achieve an agricultural system that is economically and environmentally sustainable. Study **It's Everybody's Business** and **Sustainable Farming: Possibilities 1990-2020**.

Optional Plans

Biology 20 Optional Units (remaining available time)

- ! expand one or two of the Core Units.
- ! utilize a **Science Challenge** (see the Life Science section in Science 10).
- ! assign student independent study projects.
- ! create a unit using the **Unit Planning Guide**.

Biology 30 Units

Unit 1

The Chemical Basis of Life (10 hours)

Unit Overview

This unit highlights the basic chemistry which the student needs to understand the complex biochemical processes which occur in the cells and in the organs of organisms. The major biochemical processes) polymerization, enzyme catalysis and inhibition, DNA replication, and the transcription of RNA are described.

The teacher should check the entry level of the students to determine the extent to which the basic chemistry of bonds and bond energies should be discussed. Activities 2, 3, and 4 should be done or other comparable activities should be used in their place. These activities demonstrate the chemistry of bands and band energies.

Conceptual Development

grade 1

- ! air and water are essential for life

grade 3

- ! states of matter

grade 4

- ! energy from food
- ! sources of food (optional)

grade 5

- ! physical and chemical properties of matter
- ! particle theory of matter
- ! resources (air, water, soil)

grade 6

- ! elements and use of symbols
- ! chemical reactions
- ! acids and bases

grade 7

- ! biomass energy (optional)

grade 8

- ! abiotic factors affecting life
- ! solutions

grade 9

- ! nutrients and foods

grade 10

- ! chemical changes and reactions; elementary chemistry (suggested)
- ! food energy (optional)

See Figure 10.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Bond energy, catalysis, inhibition, molecular structure.

Webbing Highlights

- ! Relate the chemicals found in our bodies to all living organisms (Unit 20-3).
- ! See also the production of food-chemicals by the agricultural industry (20-4).
- ! Do experiments on chemical change relating this to the scientific process (20-1 and grade 10).

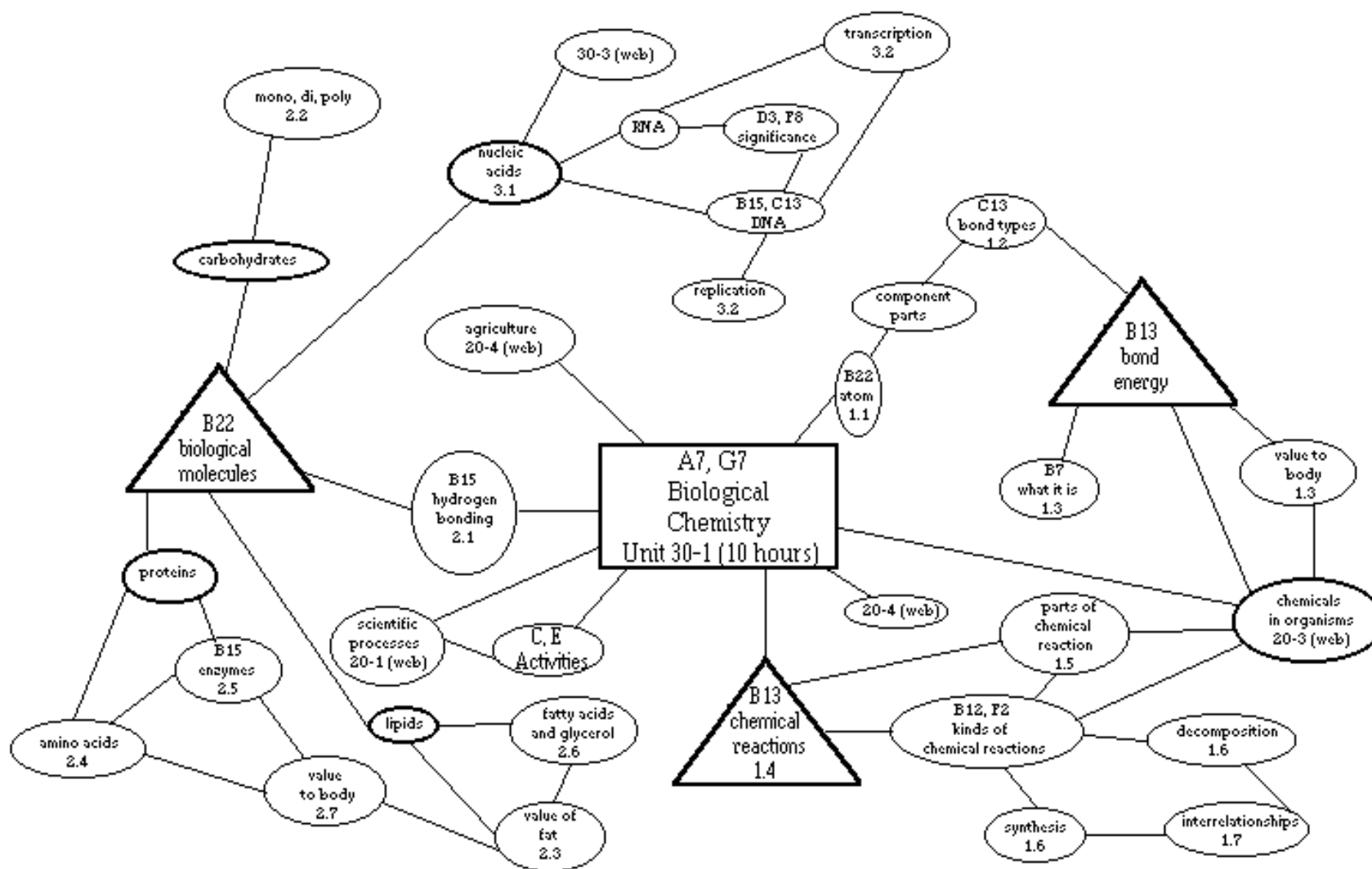
Science-Technology-Society- Environment (S T S E) Focus

- ! cancer research
- ! synthetic foods
- ! enzymatic chemistry

Safety Concerns

Normal laboratory safety procedures should be followed. Review the safety section in this Guide and in the *Science Program Overview and Connections K-12* document. Students must be reminded to never taste any materials that are being used in the laboratory.

Figure 10. Biology 30 – Core Unit One



Note: see pages 81-82 for an explanation about webs.

If tasting is required as a part of an activity, there should be clear guidelines established about how the tasting is done, and under what conditions it takes place.

Factors of Scientific Literacy Which Should be Emphasized

- A1 public/private
- A7 unique
- A8 tentative
- B7 force
- B11 predictability
- B13 energy-matter
- B15 model
- B22 fundamental entities
- B33 entropy
- C13 formulating models
- C15 analyzing
- D1 science and technology
- D3 impact of science and technology
- E7 manipulative ability
- F2 questioning
- F5 respect for logic
- F8 consideration of premises
- G6 response preference
- G8 explanation preference

Common Essential Learnings Foundational Objectives

- CCT To develop an understanding of how knowledge is created, evaluated, refined, and changed within biology.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of science.
- IL To develop students' abilities to access knowledge.

Biology Foundational and Learning Objectives

1. Appreciate the basic principles of chemistry which are involved in life processes.

- 1.1 Recognize that organisms are made of atoms.

- 1.2 Realize the relationship between the electron structure of atoms and the type of bond which forms.
- 1.3 Understand the relationship between chemical bonds and stored energy.
- 1.4 Recognize the importance and ongoing nature of various chemical reactions in the body.
- 1.5 Discuss a chemical reaction) the reactants, products and energy either required or produced.
- 1.6 Illustrate with examples the similarities and differences between synthesis and decomposition reactions.
- 1.7 Describe some relationships which exist between synthesis and decomposition reactions in relation to the functioning of the body ie., dynamic balance (homeostasis).

2. Investigate the properties of carbohydrates, lipids, and proteins.

- 2.1 Explain how carbon-based molecules interact with each other through hydrogen bonding.
- 2.2 Compare mono-, di-, and polysaccharides and then provide examples of their usefulness to a living system.
- 2.3 Describe the relationship between fatty acids and fats by providing examples to illustrate when they are useful to a living system.
- 2.4 Describe the relationship between amino acids and proteins with reference to the peptide bond.
- 2.5 Discuss enzymes using a series of key words which should be included in a concept web with the heading of proteins. (The key words are substrate, enzyme) substrate complex, lock and key, catalyst, factors affecting enzyme activity [temperature; relative concentration of substrate], enzymes, and coenzymes.)
- 2.6 Indicate the component parts of a fat molecule.
- 2.7 Recognize the value of proteins by using examples from the human body.

3. Describe the structure of nucleic acids.

- 3.1 Describe the similarities and differences in the structure of DNA and RNA.
- 3.2 Describe the processes of replication and transcription.

Assessment Techniques

- ! Use **Student Evaluation: A Teacher Handbook**.
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources **Information Bulletin**.

1. Basic body compounds.

This activity allows students an opportunity to practice some laboratory techniques and to also learn something about the identification of three categories of basic materials that are required the body.

Objectives: 2.0

Factors: B11, C15, E7, COM

Assessment: Short-Answer Quiz/Test;
Laboratory Report

Instructional Strategies

- Use the chart below as a guide:
- Place students in pairs and assign tasks such as equipment manager and recorder.
- Remind students about general safety procedures when working with chemicals in a laboratory.

d) Conduct these tests. Discuss the results.

! starch test

Boil a mixture of a small amount of starch and water until the mixture in the test tube is clear. When the solution is cold add a few drops of iodine. A dark blue colour indicates the presence of starch.

! glucose test

Place a test tube containing a small amount of Benedicts solution and glucose in a water bath. Glucose is present when after a series of colour changes there is a final red precipitate of copper oxide.

! protein test

The biuret test indicates the presence of 2 or more peptide linkages by producing a final violet colour. To an unknown mixture of dilute protein (example, egg albumin) add 5 ml of dilute sodium hydroxide (warn students that this is caustic); then add 5 ml of dilute copper sulfate.

! fat test

Dissolve 2 drops of cooking oil in 10 ml of ethanol. Pour the oil and ethanol into 5 ml of water. There should be a cloudy emulsion indicating the presence of a fat.

- Test a variety of foods for the presence of simple sugars, starch, protein, and fat. (Consider comparing traditional foods of Aboriginal peoples to a modern diet.)

Evaluation strategy

The students should turn in their lab sheets and write a short quiz on how to test for various compounds.

Kinds of Compounds	Results
Carbohydrates - Glucose Test	
- Starch Test	
Protein Test	
Fat Test	

-
2. Have student lab groups construct models of specific organic chemicals from molecular model kits. If each group does a different molecule (or several), a class set of representative models can be produced quickly. Each group might be asked to prepare a description of the chemical and its function for presentation to the class. Molecules that could be assigned are glucose, fructose, sucrose, lactose, alanine, phenylalanine, butanoic acid, any triglyceride, any dipeptide, and so on. Posters, animation, role plays, videos, etc. may be used here, too.
 3. For each lab group, prepare four gelatin plates, by pouring hot gelatin into a Petri dish, and cooling. On one plate, place a cube of freshly cut pineapple, and on another a cube of freshly cut apple. The third and fourth plates should get a cube of canned pineapple and a pinch of meat tenderizer containing papain, respectively. The effect of each on the gelatin over the course of ten to fifteen minutes, and then at the next class period, should be recorded. Why is papain used in some beauty products?
 4. Ask each group to add to a 13 x 100 mm test tube containing 3 mL of 3% hydrogen peroxide, a small cube of freshly cut turnip. To another test tube, add a similar sized cube of freshly cut potato. Compare the reactions in the two test tubes. Sense the temperature. What other foods can be found which act similarly to the turnip? to the potato?
 5. Have students make a list of the foods that they consume for one week under the heading of carbohydrates, fats and proteins. Have students attempt to decide which foods have been processed and in what way they have been processed. Finally, attempt to decide which foods could be processed less or not at all. (Be aware of the topic of anorexics and/or bulemics.)
 6. Invite a guest speaker to discuss the nutritional effects of certain favourite things we eat.
 7. Brainstorm a list of foods students eat. Have students investigate two foods:
 - ! What are the ingredients?
 - ! Classify the ingredients as nutrients (type): preservatives, colouring agents, taste enhancers, etc.
 - ! What are alternative, healthier foods?
 8. Try Activity 11 page 100 for this unit.
 9. Was topic C-2 "Food Additives and Human Nutrition" covered in the new grade 10 Science course? Use certain objectives or review what was covered(?).
 10. Compare historical and contemporary diets in relation to fats and cholesterol levels.
 11. Act out replication and transcription (objective 3.2) or use some other type of simulation. See Activity 11 in Unit 30-3.
 12. Do a study of heart disease and relate that to harmful fatty acids.
 13. What kind of research is being done with nucleic acids? What is the impact of this research on society?
-

Unit 2

Cell Structure and Function (10 hours)

Unit Overview

This unit covers both the characteristics and the functioning of plant and animal cells, and looks at how we have come to our current understanding of those fundamental entities. The material on the metabolism of glucose and the steps in the Calvin cycle of photosynthesis should be understood by the general principles of the reactions involved, and not as a series of equations for chemical reactions which must be memorized. Ensure that the terms 'light reactions' and 'dark reactions' do not acquire connotations of 'day reactions' and 'night reactions'. Energization cycle and Calvin cycle are alternate terms.

Safety: The proper handling of any human cells or tissues must be emphasized at all times.

Conceptual Development

grade 2

! food

grade 4

! types of cells; cell organization in multicellular organisms

grade 7

! microorganisms (optional)

grade 9

! importance of air (optional)

grade 10

! cell structure; body system(s); disease (optional)

See Figure 11.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Eukaryotic cell structure, cell respiration, functions of organelles, diffusion, active transport, photosynthesis.

Webbing Highlights

- ! Conduct experiments about cells using the experimental process (20-1).
- ! Relate photosynthesis to the cycles in Unit 20-2 and the ideas about the interrelationships in ecosystems (20-2).
- ! Consider the chemical structure of the cell (30-1).

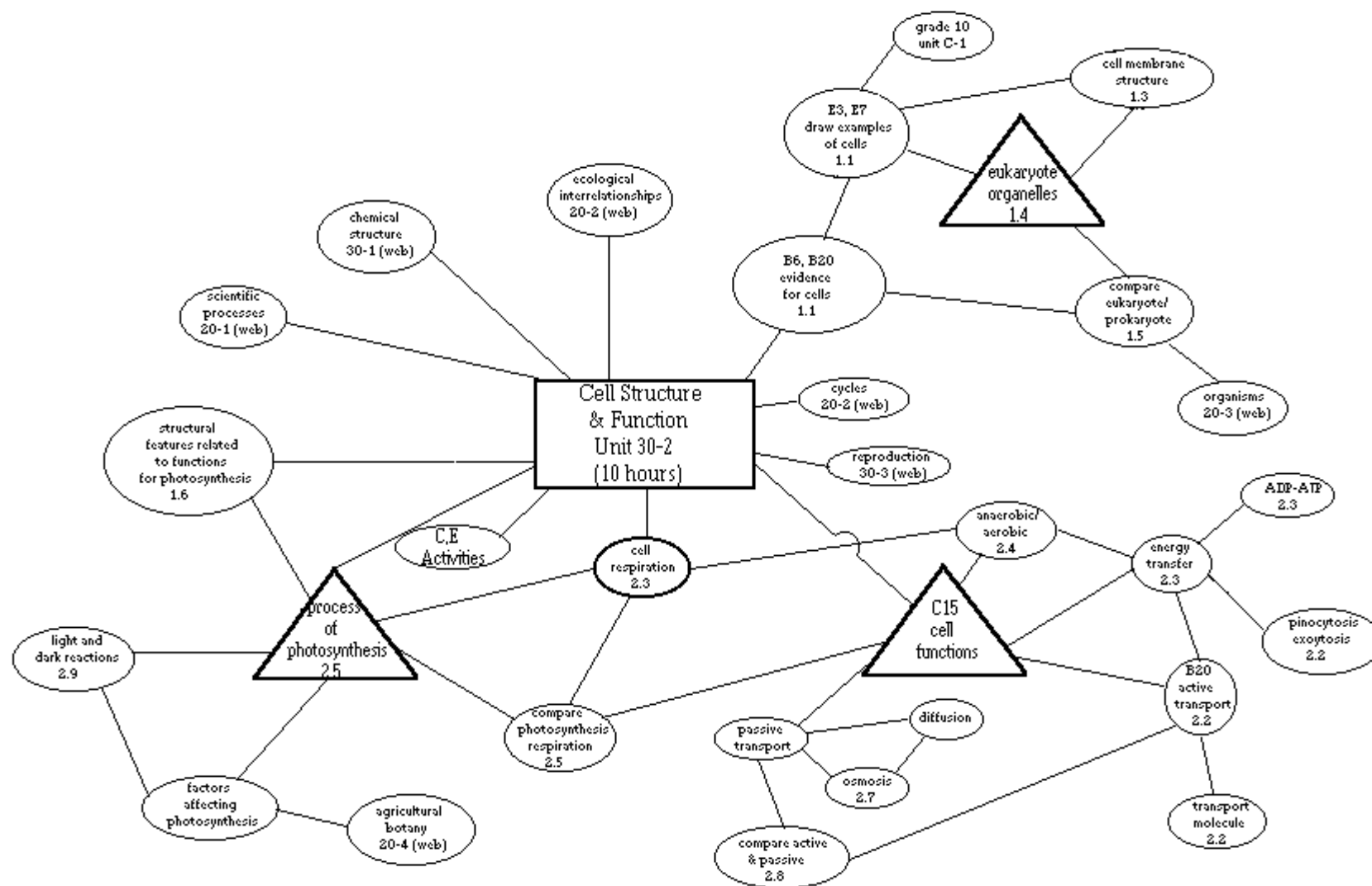
Science-Technology-Society-Environment (S T S E) Focus

- ! technologies for cell study
- ! medical and agricultural breakthroughs

Factors of Scientific Literacy Which Should be Emphasized

- A2 historic
- A3 holistic
- A4 replicable
- A8 tentative
- B1 change
- B6 symmetry
- B10 cause-effect
- B12 conservation
- B13 energy-matter
- B14 cycle
- B20 theory
- B22 fundamental entities
- B26 evolution
- B31 significance
- B32 validation
- C8 hypothesizing
- C9 inferring
- C10 predicting
- C11 controlling variables
- C12 interpreting data
- C15 analyzing
- C16 designing experiments
- C19 consensus making
- C20 defining operationally
- D5 public understanding gap
- E3 using equipment safely

Figure 11. Biology 30 – Core Unit Two



Note:
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- E7 manipulative ability
- F5 respect for logic
- F7 demand for verification
- G8 explanation preference
- G9 valuing contributors

Common Essential Learning Foundational Objectives

- CCT To promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences, and objects within the context of the study of ecosystems.
- COM To use a wide range of possibilities for developing students' knowledge of the major concepts within biology.
- IL To develop students' abilities to meet their own learning needs.
- IL To support the development of a positive disposition to life-long learning.
- TL To develop an understanding that technology both shapes society and is shaped by society.

Biology Foundational and Learning Objectives

1. **Describe the structures and functions of cell components.**
 - 1.1 Review evidence for the existence of cells.
 - 1.2 Observe, sketch, and describe a representative sampling of plant and animal cells.
 - 1.3 Describe the structure of a cell membrane.
 - 1.4 Describe the functions of the organelles found in eukaryotic cells.
 - 1.5 Contrast the structure of prokaryotic and eukaryotic cells.
2. **Explain how the processes of diffusion, active transport, photosynthesis, and respiration are accomplished in a cell.**
 - 2.1 Identify the factors which influence the rate and direction of diffusion.

- 2.2 Examine the mechanisms of active transport by identifying and explaining the two processes. (Process one involves the expenditure of energy where a carrier molecule takes a substance from one side of a membrane to the other side of the membrane. Process two involves the inpocketing of material by a membrane -- pinocytosis and exocytosis.)
- 2.3 Recognize how the ATP-ADP system, and the NAD-NADH system, transfer energy within a cell.
- 2.4 Compare aerobic and anaerobic metabolism.
- 2.5 Describe the processes involved in photosynthesis and then compare the process of photosynthesis with respiration.
- 2.6 Examine how the structure of the leaf is adapted for the processes involved in photosynthesis.
- 2.7 Identify how osmosis is related to diffusion and the value of osmosis to living organisms.
- 2.8 Compare the similarities and differences between active and passive transport.
- 2.9 Indicate the importance of the light and dark reactions in the process of photosynthesis.

Assessment Techniques

- ! Use ***Student Evaluation: A Teacher Handbook***
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. A Voyage Through A Living Cell

Introduce this activity to the students before the unit is started so they understand that the final class exercise is to make a presentation trying to combine all of the ideas into one comprehensive picture.

Objectives: 1.2, 1.4, 2.1, 2.2, 2.4, 2.7, 2.8, COM, IL

Factors: A3, B1, B12, B13, B14, C9, C10, C12, C15, C19, F5, G8

Assessment: Rating Scale; Self-and Peer-Assessment; Essay

Instructional Strategies

In groups of approximately 5-7 prepare a presentation for the rest of the class. The title of your presentation is **A Voyage Through A Living Cell**. Your presentation can be no more than 20 minutes and must include everyone in the group.

In the presentation the student should attempt to clearly point out the **parts of the cell** and **identifying features**. Different kinds of cells with some size variations should be studied. There are a number of **dynamic processes** which are useful in the transport of materials throughout the cell. The students should attempt to illustrate the different mechanisms by the use of very simple props or descriptions which involve all the individuals in the group.

Then there is the complex area of **energy production** and energy use. It is essential that the students attempt to clearly indicate the potential sources of energy such as carbohydrates, fats, and proteins. In the section about energy it is up to the teacher's discretion how far beyond the basic definitions of the energy terms the student should progress. Be prepared to define anabolism and catabolism, metabolic rate, respiration, homeostasis, glycolysis, krebs cycle, electron transfer and how aerobic and anaerobic respiration support each other in the body. ATP should be discussed in terms of its component parts and how it is formed in cells of the body. There should also be an attempt to show how respiration and photosynthesis are related.

Finally, the most important key to the whole exercise is that the presentation should not be just a reading of definitions but rather a story which is factually correct but yet reasonably engaging so that people will be able to learn something about the dynamic cell and also be entertained at the same time. A videotape production could be tried.

You will likely need a co-ordinator and individuals in charge of various aspects of the content. There may be some individuals who will make props, etc., but your first step is to organize and establish some commitment to the task at hand.

Evaluation Strategy

Use the same strategies as Activity 1 in Unit 20-4.

2. **Review the microscope work done in Biology 20.** Ask students to observe and sketch a variety of slides, both prepared by themselves and commercially prepared. The lower epidermis of geranium leaves is not difficult to prepare and has large, easily recognizable guard cells. Have the students practice staining techniques.
 3. Supply each lab group with a 30 cm length of dialysis tubing. Diffusion through a semi-permeable membrane can be shown by placing a tube filled with a starch and sugar solution in a beaker of distilled water. After 3 minutes, and again after 45 minutes, each group should test the distilled water for the presence of sugar and starch. The apparatus may be left and the water tested again at the start of the next class.
 4. The effect of osmosis can be demonstrated by placing 5 mm thick slices of freshly cut potato in beakers of distilled water, isotonic (1.5% salt) solution, and saturated salt solution. After 15 minutes to a half hour, the slices from each beaker can be compared to each other, and with slices stored for that period of time in a plastic bag. Carrot slices may be used in place of the potato slices. Encourage students to test this effect on other fresh foods, and over different time periods.
 5. To test the production and storage of starch in leaves, assign one geranium plant to each lab group. In a class discussion, or in lab group discussion, have the students identify the factors which may influence the amount of starch production. Ask the students to design procedures to determine whether the factor is influential. Some designs may be completed using only one plant, while other designs may require cooperation between groups to supply enough plants to complete the procedure. Each group will be responsible for summarizing the hypotheses, procedure, and analysis of the results of their experiment, and for presenting these to the members of the other groups.
 6. Have students prepare reports about careers that relate to the study of cells such as cytology, histology, biochemistry, and cell physiology. Encourage students to find and interview such people.
-

-
7. Make a list of the various kinds of cells and attempt to illustrate, where possible, the following ideas.
 - ! What is the unique adaptation or niche of each cell?
 - ! If certain cells work together in some way how do they support each other?
 - ! Ask students to consider whether or not cells might change in the future. If so, what are some of the possibilities?
 8. New organelles and genetic material can be introduced into cells. Investigate the types of intervention possible for humans. Should these be done? In small groups, discuss the moral and ethical implications of these practices.
 9. Try Activity 11 page 100 for this unit.
 10. Have students prepare and share reports on the causes and treatments of various forms of cancer.
 11. Role-play or simulate various cellular functions: for example, diffusion, osmosis, photosynthesis, etc.

Unit 3

Genetics (20 hours)

Unit Overview

This unit introduces the application of probability theory to Mendelian genetics. Consideration of Mendel's laws of heredity and the concept of the gene as a discrete carrier of hereditary information leads to the discussion of chromosomes, genes, and DNA. Both the technical and ethical aspects of genetic engineering and biotechnology are discussed, as is the study of population genetics.

Conceptual Development

grade 6

- ! basic principles of heredity (optional)

grade 7

- ! traits; characteristics of life

grade 9

- ! probability and risk
- ! diversity (optional)

grade 11

- ! diversity of life

See Figure 12.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Chromosomes, ethics and morality, gene pool, heredity, probability, DNA, chromosome mapping.

Webbing Highlights

- ! Relate DNA and genes to chemical structures (Unit 30-1) and to where they are found in cells (30-2).
- ! Relate genetic information to the diversity of life forms (20-3).

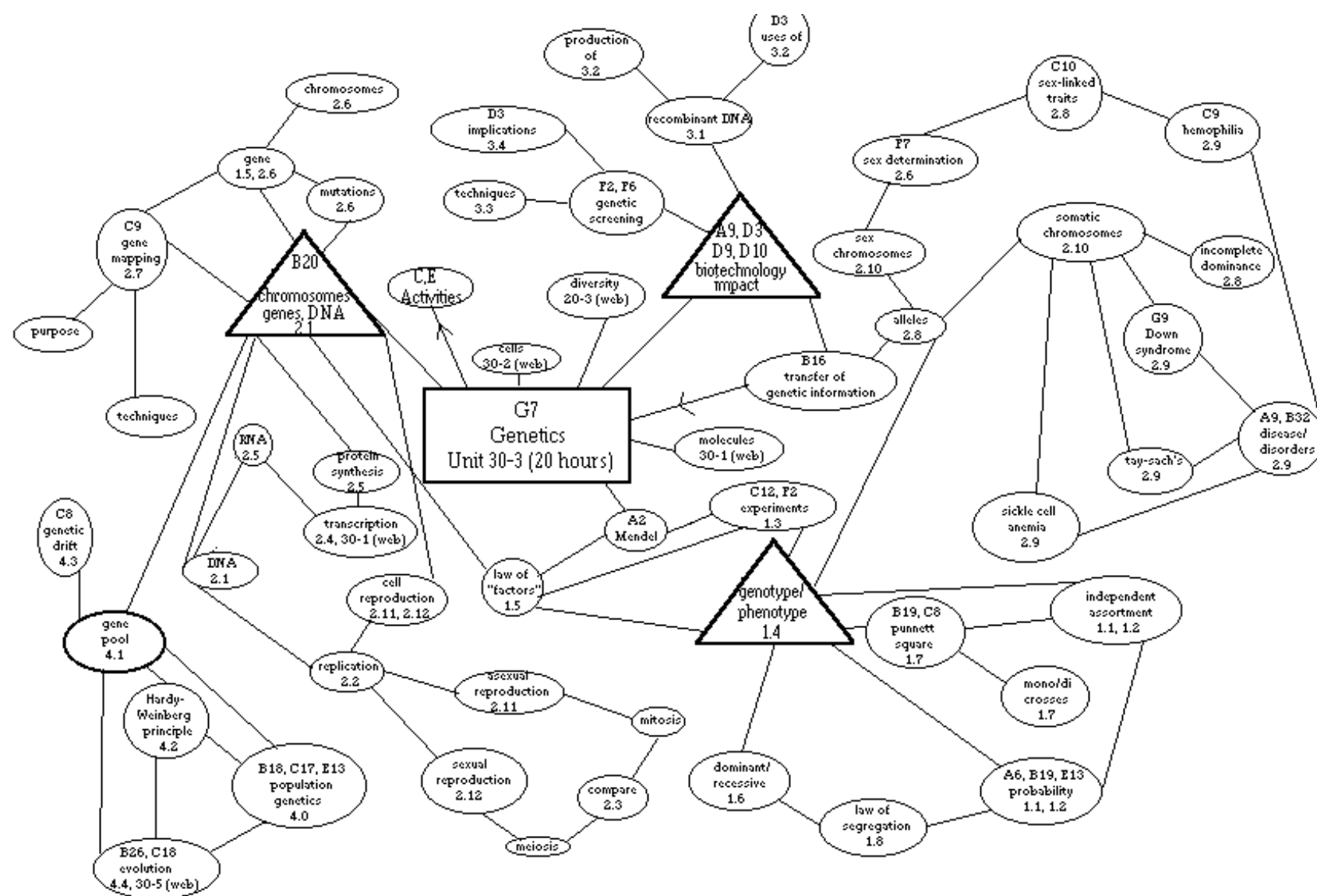
Science-Technology-Society-Environment (S T S E) Focus

- ! "creation" of new species
- ! genetic disease technologies
- ! human genome project

Factors of Scientific Literacy Which Should be Emphasize

- A1 public/private
- A2 historic
- A6 probabilistic
- A8 tentative
- A9 human/culture related
- B16 system
- B18 population
- B19 probability
- B20 theory
- B26 evolution
- B32 validation
- C8 hypothesizing
- C9 inferring
- C10 predicting
- C12 interpreting data
- C14 problem solving
- C17 using mathematics
- C18 using time-space relationships
- D2 scientists and technologists are human
- D3 impact of science and technology
- D6 resources for science and technology
- D9 social influence on science and technology
- D10 technology controlled by society
- D11 science, technology, and other realms
- E13 using quantitative relationships
- F2 questioning
- F5 respect for logic
- F6 consideration of consequence
- F7 demand for verification
- G3 continuous learner
- G7 vocation
- G9 valuing contributors

Figure 12. Biology 30 – Core Unit Three



Note: see pages 81-82 for an explanation about webs.

Common Essential Learnings Foundational Objectives

- COM To enable students to understand and use the vocabulary, structure and forms of expression which characterize the study of biology.
- TL To develop a contemporary view of technology.
- TL To develop an understanding that technology both shapes society and is shaped by society.
- IL To support the development of a positive disposition to life-long learning.
- CCT To contribute to the development of "strong sense" critical and creative thinkers.
- PSVS To develop compassionate, empathetic and fair-minded students who can make positive contributions to society as individuals and as members of groups.

Biology Foundational and Learning Objectives

1. Explain the significance of Mendel's experiments and observations, and the laws derived from them.

- 1.1 Explain the concept of independent events.
- 1.2 Understand that the probability of an independent event is not altered by the outcomes of previous events.
- 1.3 Describe Mendel's experiments and observations.
- 1.4 Describe the relationship between genotype and phenotype.
- 1.5 Use the concept of the gene to explain Mendel's laws.
- 1.6 Describe the ideas of dominant and recessive traits with examples.
- 1.7 Consider the value of the punnett square by creating examples of mono and dihybrid crosses.
- 1.8 Explain the law of segregation.

2. Discuss the relationships among chromosomes, genes, and DNA.

- 2.1 Describe how the genetic code is carried on the DNA.
- 2.2 Outline the process of replication.
- 2.3 Compare mitosis and meiosis.
- 2.4 Describe the process of transcription.
- 2.5 Describe the functions of mRNA, tRNA, amino acids, and ribosomes in protein synthesis.
- 2.6 Describe the causes and effects of both chromosome and gene mutations.
- 2.7 Consider the purposes and techniques of gene mapping.
- 2.8 Examine incomplete dominance, alleles, sex determination, and sex-linked traits in the context of human genetics.
- 2.9 Discuss several human genetic disorders such as hemophilia, sickle-cell anemia, Down's syndrome, and Tay-Sach's disease.
- 2.10 Discuss the similarities and differences between sex chromosomes and somatic chromosomes.
- 2.11 Using examples from living organisms discuss the importance of asexual and sexual reproduction to their growth and survival.

3. Delineate the impact of biotechnology on our society.

- 3.1 Describe the basic processes involved in the production of recombinant DNA.
- 3.2 Discuss examples of current uses of recombinant DNA technology in the agricultural and pharmaceutical industries.
- 3.3 Discuss the techniques of genetic screening.
- 3.4 Consider the implications of genetic screening of adults, children, and fetuses.

4. Discuss the application of population genetics to the study of evolution.

- 4.1 Describe the concepts of the deme and the gene pool.
- 4.2 Consider the Hardy-Weinberg principle.
- 4.3 Describe the factors which influence genetic drift.
- 4.4 Consider the relevance of the gene pool and the idea of mutations to the concept of evolution which will be studied later in unit 5.

Assessment Techniques

- ! Use **Student Evaluation: A Teacher Handbook**.
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. Student checked traits.

This activity can be used to introduce the ideas expressed in objectives 1.1, 1.2, 1.4, 1.5 and 1.6. This also provides students an opportunity to practice observation and recording techniques while working in a small group environment. Additional traits can be studied.

Objectives: 1.1, 1.4, 1.6, 1.7, CCT, COM, PSVS

Factors: C9, C10, C12, C17, E13, F6, F7

Assessment: WA - Laboratory Report; Short-Answer Quiz/Test

Teacher Chart

Trait	Dominant Factor	Recessive Factor	Identification
Tongue Rolling	roll tongue (genotype) (Rr or RR)	rr	Tongue can be bent into a U shape
Attachment of the ear lobe	attached (FF or Ff)	ff	Free ear lobe part of ear hangs below attached part
Cheek indentations	DD or Dd	dd	Dimples or depressions in the cheeks
Second toe length	SS or Ss	ss	Second toe longer

Instructional Strategies

Student Procedure

- a) Tell the students how to recognize the traits but do not tell them if it is dominant or recessive.
- b) Set up a chart with the students for recording the information.
- c) Have the students work in pairs where one will record while the other observes.
 - ! Do at least half the class.
 - ! The teams should add to the above total at least 10 more individuals from the school.
 - ! Finally, ask the students in each group to do their family members and add this to their total.
- d) At the next class period discuss **dominance** and **recessive** traits and have the students, in their groups set up a chart (dominant and recessive) and decide which traits are dominant and which are recessive. Do not assess the information yet.

- e) Introduce the ideas of **genotype** and **phenotype**. Have students in their teams set up a chart and record the genotype and phenotype for each of the traits.
- f) Discuss the **punnett square** and then have the student pairs draw out punnett squares for at least 2 of the traits.
- g) It is possible to discuss **population sampling** and the kinds of information that the class obtained as small groups, as a large class group and how this relates to the percentages in a punnett square of each of the traits.

Evaluation Strategy

Have student teams turn in charts d, e, and f and allocate 8 marks for each activity.

2. You could bring in an animal breeder and/or have students collect pedigrees from cattle, horse, sheep or dog breeders. There are also other possibilities. How has their work affected the balance of the traits present in various kinds of animals?

-
3. Trace a family tree for a number of traits. (Be sensitive to cultural or ethnic concerns regarding diseases or extended family adoptions, etc.)
 4. Collect immigration and emigration information of various ethnic groups from the Provincial Government to see how various genes in the gene pool may be changing.
 5. Contact pharmacists, extension agrologists, etc. to discover if there are new developments like genetically engineered drugs or crops.
 6. Have students perform some of the classic investigations dealing with:
 - ! probability
 - ! mitosis and meiosis
 - ! aspects of DNA
 - ! human pedigrees
 7. How might the field of genetics be applied to improving the economy of your local community and the Province of Saskatchewan. It is important that you discuss the specific genetics you would apply and what kind of jobs that this would generate.
 8. When large extinctions occur on the earth, such as with the loss of the dinosaurs, what is the genetic impact?
 9. Try Activity 11 page 100 for this unit.
 10. Investigate the ancestry of bread wheats (or other crops) developed on the prairies. Check with Agriculture Saskatchewan or Canada.
 11. Use the "DNA Investigations" simulation from the December, 1991 issue of the **Science Teacher**.
 12. Cross red-eyed female fruit flies with white-eyed Males. Cross $F_1 \times F_1$. Analyze the results. (Reflect on the CEL and DSL connections.)
 13. Much of this unit could be done using **Mapping Our Genes: The Human Genome Project**. Use cooperative learning methods to analyze 10 case studies of human genetic disorders. Many genetic concepts and principles will be covered. Use outreach: invite disabled people in to speak or have students visit clinics.
 14. In the traditional Haida culture there were two large family groups (phratries) called the Ravens and the Eagles. Members of the same phratry were forbidden to marry. Why do you think this practice was established? How? What genetic advantages and disadvantages does this have?
 15. How did the introduction of pathogens to New World Aboriginal peoples shift the genetic composition of populations?
 16. Have student do research on new species of organisms that are created in a lab and used either in medicine or agriculture.
 17. How has genetics changed our current ecosystems? How will they change in the future?
-

Unit 4

Animal Systems (20 hours)

Unit Overview

A comparative look at transport, control, and reproductive systems in the Animal Kingdom, concentrating on the human body, is the focus of this unit. The role of the blood circulatory system is the most important element considered under the heading of transport systems. Control over the actions and functions of organisms exerted by the nervous system and the endocrine system are important aspects of the section on control systems. Finally, there is a comparison of asexual and sexual reproduction, and a detailed consideration of human reproduction and reproduction technologies.

Teachers should review with Health and Home Economics teachers what has been covered at the Middle and Secondary Levels.

Concept Development

grade 1

- ! body features; animal motion; senses

grade 4

- ! skin as an organ
- ! nutrition and digestion, senses, brain (optional)

grade 5

- ! human breathing and circulation (optional)

grade 6

- ! human life cycle, human body control systems (nervous and endocrine) (optional)
- ! animal adaptations (optional)

grade 7

- ! animal structure and designs

grade 10

- ! human nutrition, food additives (optional)

See Figure 13.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Active transport, blood circulation system, immune system, nervous systems, biofeedback

Webbing Highlights

- ! Use ecological ideas (20-2) to illustrate the co-ordinated activities of the human body.
- ! Relate the development of organisms to the diversity of life (Unit 20-3).
- ! Link to cell structure as in the neuron and endocrine cells (30-2).
- ! Review cell processes in the body as they relate to a functioning human body.

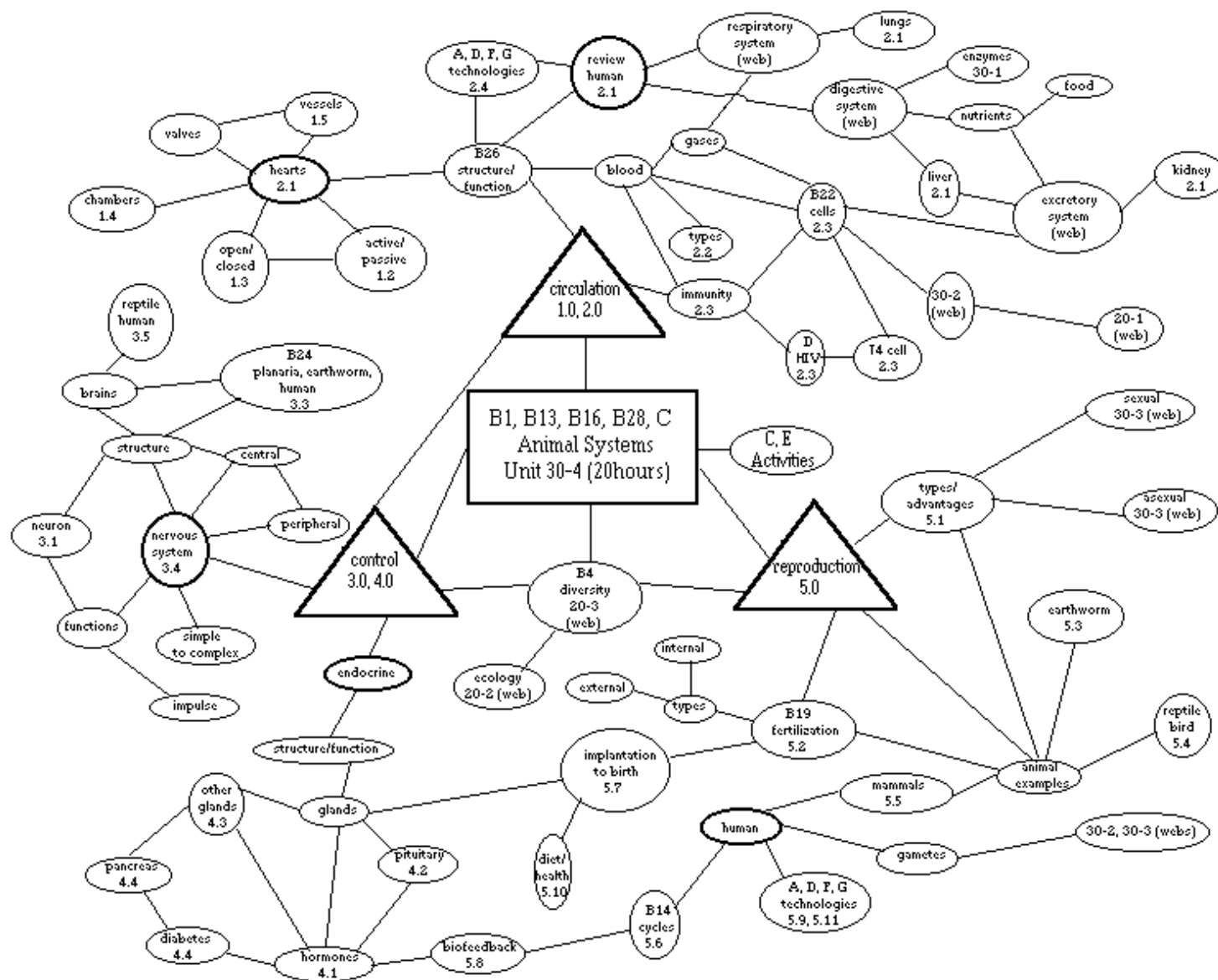
Science-Technology-Society-Environment (S T S E) Focus

- ! new reproductive technologies.
 - ! ways to sustain and maintain life where artificial means have to be applied.
 - ! diets and healthy living.
 - ! methods of delivering medical care.
- Correlate the above with other areas of study; eg. health, social studies, home economics.

Factors of Scientific Literacy Which Should be Emphasized:

- A3 holistic
- A4 replicable
- A5 empirical
- A9 human/culture related
- B10 cause-effect
- B14 cycle
- B15 model
- B16 system
- B26 evolution
- B28 equilibrium
- B29 gradient
- B33 entropy
- C6 questioning
- C9 inferring
- C12 interpreting data
- C13 formulating models
- C21 synthesizing
- D7 variable positions

Figure 13. Biology 30 - Core Unit Four



Note: see pages 81-82 for an explanation about webs.

-
- D8 limitations of science and technology
 - D11 science, technology, and other realms
 - E4 using audio visual aids
 - E7 manipulative ability
 - F1 longing to know and understand
 - F6 consideration of consequence
 - F8 consideration of premises
 - G3 continuous learner
 - G5 avocation
 - G6 response preference
 - G7 vocation
 - G8 explanation preference
 - G9 valuing contributors

Common Essential Learnings Foundational Objectives

- CCT To promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences, and objects within the context of the study of biological systems.
- COM To enable students to understand and use the vocabulary, structure and forms of expression which characterize the study of biology.
- IL To develop students' abilities to meet their own learning needs.
- PSVS To support students in coming to a better understanding of the personal, moral, social, and cultural aspects of the study of life.
- TL To develop students' appreciation of the value and limitations of technology within society.
- TL To provide opportunities for students' active involvement in decision-making related to technological developments.

Biology Foundational and Learning Objectives

1. Describe how nutrients and oxygen are moved to the body cells.

- 1.1 Review the principles of diffusion and active transport.

- 1.2 Contrast passive transport systems, as in the cnidaria, with active transport systems, such as the human blood circulation system.
- 1.3 Compare open circulation systems, as in the grasshopper, with the closed systems of vertebrates.
- 1.4 Compare the efficiencies of hearts with one, two, three, and four chambers.
- 1.5 Describe the blood circulation pattern and vessels in the mammalian systems.

2. Explain the functioning of the human circulation system.

- 2.1 Describe the functions of the heart, lungs, kidneys, and liver in the circulation system.
- 2.2 Describe the ABO and Rh typing systems for human blood.
- 2.3 Consider the role of the blood in the immune system and the effect of the human immunodeficiency virus on the T4 cells of the blood.
- 2.4 Research the use of artificial hearts, heart transplants, the and circulation machines used during open-heart surgery.
- 2.5 Discuss respiration by relating the activity to the physical structure like the lungs and blood and the cells fed by the blood.

3. Describe the functions and functioning of nervous systems.

- 3.1 Describe the structure of a neuron.
- 3.2 Explain how neurons transmit impulses within and between themselves.
- 3.3 Compare the complexity of nervous systems in the planaria, earthworm, and human.
- 3.4 Contrast the functions of the central nervous system and the peripheral nervous system in humans.
- 3.5 Compare the structure of the brains of reptiles and humans.

4. Explain how the human endocrine system influences body development and maintenance.

- 4.1 Describe the general structure of hormones.
- 4.2 Describe the influence of the pituitary gland on body processes and on other glands.
- 4.3 Discuss the relationship between insulin and the body's control of blood sugar levels in the two forms of diabetes.
- 4.4 Outline the functions of hormones produced by several other glands.

5. Compare reproductive strategies among animal phyla.

- 5.1 Contrast the advantages and disadvantages of asexual reproduction with those of sexual reproduction.
- 5.2 Compare external fertilization with internal fertilization.
- 5.3 Describe fertilization in the earthworm.
- 5.4 Compare the amniotic egg of reptiles and birds with the structures which form in the uterus of a pregnant mammal.
- 5.5 Describe the production of semen in humans.
- 5.6 Describe the human female reproductive cycle from ovulation to either menstruation or implantation.
- 5.7 Trace the major developmental events from implantation of a fertilized egg to the birth of a human baby.
- 5.8 Identify the biofeedback mechanisms which are important in the regulation of the female reproductive cycle.
- 5.9 Describe how the use of the hormones found in birth control pills alters the reproductive cycle.
- 5.10 Discuss the relationship between the diet and health of the mother and the development of the fetus.
- 5.11 Investigate some technologies related to reproduction, such as **in vitro** fertilization, use of fertility drugs, birth control, amniocentesis, genetic screening of prospective parents, sperm banks, etc.

Assessment Techniques

- ! Use **Student Evaluation: A Teacher Handbook**.
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. The role playing exercise.

The students should develop an awareness of at least 4 body systems and their functions, see the interrelationships that exist among the systems, and work on group co-operation skills.

Objectives: 1.5, 2.1, 3.4, 4.1, COM, IL

Factors: B16, B28, C9, C12, F6, G6

Assessment: Major Project and Report;
Short-Answer Quiz/Test

Instructional Strategies

- a) The teacher will assign the body systems, as few or as many as they think are valuable to the situation, such as circulatory, nervous, and endocrine systems.

Note: The overall plan should be to have students work in small groups to gather information in step b and then to work together as a complete organism in step c under the direction of the teacher.

- b) small group work

- ! Set out a list of the major functions of the assigned system. Remember that **key identifying words** are very useful to create an understanding.
- ! Try to establish where the system may be found in the body and the parts closely associated during daily activities.
- ! List some of the unique structural features of the system and where possible provide some examples of sizes of the features.

- c) large group work

- ! The students should assign one member from each smaller group to a spokesperson role so that there is someone who will respond when appropriate.

Example procedure

The teacher presents a question such as: what is the involvement of the systems studied to the action of **lifting an arm from your side to a spot above your head?**

The smaller groups will consider their contributions individually and then communicate this to their spokesperson who will in turn meet with the spokesperson from the other groups. They will then formulate an answer to be communicated to the teacher.

Evaluation Strategies

- ! Provide 5 marks for each part of b for a total of 15 marks.

! The following should be done once the students have practised answering several questions. As a **memory** exercise have the students try to explain the roles of the various systems and where possible indicate something unique about each system in terms of the structures.

Assign 5 marks for each system role and 2 marks for mentioning at least 2 unique structural features.

2. Dissect and study one vertebrate, preferably a fetal pig. Note: if dissections are morally or philosophically objectionable, arrange for an alternate assignment; for example, computer simulated or video dissections and a report.
3. Study the kinds of changes in the human body as an individual ages.
4. What are some of the new techniques in reproductive technology? A second part of this could be -- should they be included on medical care plans?
5. Do a study of a current technology such as an artificial heart or kidney and describe how it works. Alternately, build models.
6. Try to describe how a dog or cat might behave in the world if it had the capacities of a human brain.
7. Construct a series of record jackets, T-shirt pictures, etc. that would clearly illustrate open and closed circulatory systems or possibly do one on the evolutionary development of the brain.
8. Have students design and build various structures of the body and then using their models describe: how that structure functions; what it looks like; what chemical structures are found in the body of the structure; and, how it might interconnect with its adjacent structures?
9. Have students make models of at least 4 kinds of body structures that have changed over time, illustrate what those changes are, and discuss what advantages or disadvantages have occurred as a result of the changes; e.g., heart.
10. Try Activity 11 page 100 for this unit.
11. Investigate the "Animal Rights" controversy.
12. If acceptable, use carcasses and organs from

trapped animals to study anatomy.

13. Snare rabbits as a class project. Perform dissections. Do research on tanning or using all of the animal. If possible, enlist the aid of an Elder.
14. Explore the meaning of this Cheyenne statement: "It takes more than the semen of conception to raise a child." (from **American Indian Ecology**, a grade 10 science resource.) What are the roles of males and females in conception and in raising a child?
15. Contrast traditional methods of birth control with modern methods. What are the future methods being considered?
16. Research the development of artificial organs: e.g., hearts, kidneys, pancreas, etc.

Unit 5

Evolution (15 hours)

Unit Overview

This unit is a consideration of evidence of evolution, the development of evolutionary theory, and of the mechanisms by which evolution proceeds. This unit completes a circle to Biology 20, and provides opportunities for many connections in learning.

Concept Development

grade 4

- ! some Earth history
- ! fossils

grade 6

- ! animal adaptations for survival (optional)

grade 7

- ! adaptations of organisms to land changes

grade 8

- ! geological history of Saskatchewan; effects on life
- ! fossil evidence
- ! rate of environmental change

See Figure 14.

Note: A pre-assessment to determine the entry level of the students may be appropriate.

Key Concepts

Genetic variation, Hardy-Weinberg principle, natural selection, phytogenetic development, punctuated equilibrium, speciation by isolation, uniformitarianism.

Webbing Highlights

- ! genetics and the process of science and change (20-1)
- ! ecological organization and change (20-2)
- ! diversity of life and evolution (20-3)
- ! changing agriculture and changes in the kinds of

- organisms (20-4)
- ! mutations (30-3)
- ! gene mapping (30-3)
- ! biotechnological impacts
- ! population genetics (30-3)
- ! changing animal systems and evolution (30-4).

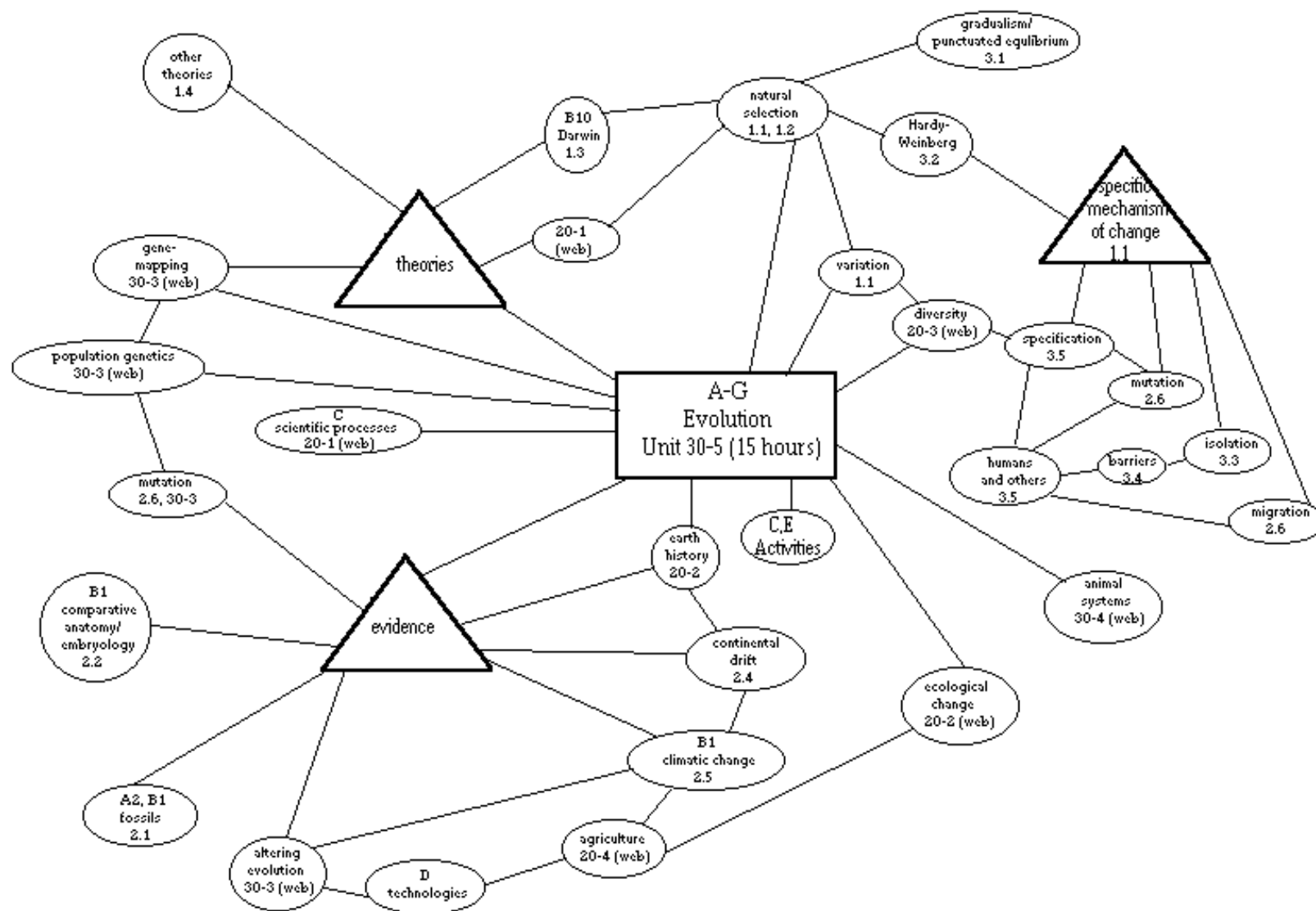
Science-Technology-Society-Environment (S T S E) Focus

- ! effect of climate change -- global warming
- ! the long term effects of manipulated change of organisms
- ! the development of new species
- ! the linkages among organisms -- chemical closeness
- ! gene transfer
- ! protection of anthropological and archaeological finds and what they tell us about the present and the past
- ! effect of current environmental problems on human biology

Factors of Scientific Literacy Which Should be Emphasized

- A2 historic
- A3 holistic
- A7 unique
- A8 tentative
- A9 human/culture related
- B1 change
- B2 interaction
- B10 cause-effect
- B18 population
- B20 theory
- B26 evolution
- B29 gradient
- C1 classifying
- C6 questioning
- C8 hypothesizing
- C9 inferring
- C13 formulating models
- C18 using time-space relationships
- C21 synthesizing
- D7 variable positions
- D11 science, technology, and other realms
- E2 using natural environments
- E4 using audio visual aids
- F3 search for data and their meaning
- F5 respect for logic
- F8 consideration of premises

Figure 14. Biology 30 – Core Unit Five



Note: see pages 81-82 for an explanation about webs.

-
- G5 avocation
G6 response preference

Common Essential Learnings Foundational Objectives

- CCT To develop an understanding of how knowledge is created, evaluated, refined, and changed within biology.
- COM To enable students to understand and use the vocabulary, structures and forms of expression which characterize the study of science.
- IL To support the development of a positive disposition to life-long learning.
- PSVS To support students in treating themselves and others with respect.

Biology Foundational and Learning Objectives

1. **Explain how the evolutionary theory unifies biology.**
 - 1.1 Describe how individual variations are produced.
 - 1.2 Discuss the action of natural selection on individuals, populations, and species.
 - 1.3 Explain how Darwin's observations led to his inferences about evolution.
 - 1.4 Compare the development of theories of evolutionary change (some examples - Lamarck, De Vries, Weisman).
2. **Recognize evidence of evolution.**
 - 2.1 Discuss the use of the fossil record in the creation of lines of phylogeny.
 - 2.2 Examine data from comparative anatomy and comparative embryology.
 - 2.3 Describe instances of evolution documented in earth history.
 - 2.4 Discuss the theory of continental drift and how that might have contributed to the changing variety of organisms that exist today. Where possible consider examples.
 - 2.5 Examine broad climatic changes during the earth's history (ice ages, melting of the ice caps) and consider how these changes may have contributed to the changing organisms.

- 2.6 Examine the effects of migration and mutations on evolutionary change.

3. Discuss how evolution proceeds.

- 3.1 Compare gradualism and punctuated equilibrium.
- 3.2 Discuss the implications of the Hardy-Weinberg principle.
- 3.3 Describe the role of isolation in speciation.
- 3.4 Identify both pre-mating and post-mating barriers to recombination and reproduction.
- 3.5 Consider the speciation and development of humans.

Assessment Techniques

- ! Use ***Student Evaluation: A Student Handbook***
- ! Consult key resource supports.
- ! Review pages 15-19.

Suggested Activities and Inquiries

Note: Many activities have been identified in the key resources *Information Bulletin*.

1. Change over time.

It is important for students to realize that the process of change in organisms occurs not only in the long term, which is very difficult for any of us to comprehend, but that organisms change in the short term as well.

Objectives: A1.1, A1.2, A1.3, CCT, COM

Factors: B1, C6, C9, C18, F3

Assessment: Reports

Instructional Strategies

- a) With students in small groups (2 to 4) initiate discussion on two ideas:

- ! **manipulated change** (from the unit on genetics consider how organisms are changed by gene and chromosome manipulation)
- ! **natural change** (changes within a population such as the increase in height and weight of North American males and females over the last 50 years).

Students should have a recorder set up a series of charts for individual examples.

organism	characteristic	degree of future
	change	change prediction

manipulated
change

natural
change

Since time is a factor, you may want students to work only with the information that they can generate in the classroom or you may wish to give them one or more class periods to collect data before they present their information to the class.

- b) Students could illustrate the information in poster format or they could simply provide examples as their groups are asked to contribute.

Evaluation Strategies

Use the information from above to prepare a **poster** (on an 8.5 by 11 sheet) or if they wish prepare a record cover jacket, picture for a T- shirt, etc., which will reflect the **student's understanding of the topic**. The finished product should include:

- ! Definite illustration of the theme of change.
- ! Utilization of space and perception.
- ! Aesthetic balance to reflect their creative thinking.

Evaluation (**Five** marks for each of the following)

- ! impact - dominant idea present.
- ! organization (clarity and content).
- ! creativity - different artistic methods employed.
- ! students will evaluate two other posters on the same basis as above. The teacher will assign the other posters to students.

Use the following chart for student evaluation.

Student Name	Categories			
	Impact	Organization	Creativity	Total
1				
2				

2. Ask an **animal breeder** to come into the school and discuss her or his breeding program in terms of the kinds of changes that are desired.
3. Ask students to pick organisms that have homologous structures, draw those structures, and discuss the similarities and differences that they can observe.
4. Prepare a chart on the eyes of birds, mammals, insects, and the octopus. Include the most impressive adaptations and the disadvantages.
5. If one were to find a fossil organism, what can one learn about the fossil's past? Include ideas about the size, lifestyle, intelligence, climatic conditions, etc. What kinds of information is not revealed by the fossil?
6. Do a survey of early humanoid organisms and prepare a series of posters depicting their physical features, habitat, and niche.

-
7. Reconstruct a campsite for early humans that would illustrate that they were hunters and gathers as well as living in social groups.
 8. Explain how a fossil Pleisiosaurus could be found in central Saskatchewan. Was this a dinosaur or a crocodile?
 9. Try Activity 11 page 100 for this unit.
 10. Inquire into the "beefalo" story.
 11. Consult ***American Indian Ecology*** (Grade 10 Science reference) to expand on the concept of extinction.
 12. As far as Saskatchewan Education is concerned, "Special Creation" is a religious concept in contrast to evolution, a scientific concept. Any special student essays on this topic should contrast these ways of knowing.
 13. Have students prepare a short report on an animal which has undergone de-evolution such as the buffalo. (See ***The First Albertans.***)

Optional Plans

Biology 30 Optional Units (remaining available time)

- ! expand one or two of the Core Units.
- ! utilize a **Science Challenge** (see the Life Science section in Science 10).
- ! assign student independent study projects.
- ! create a unit using the **Unit Planning Guide**.
- ! do an ecology reprise) impact of humankind on the environment; explore the concept of sustainable development. (The Economics Unit of ***Native Studies 30*** contains a section on the Environment and Case Studies dealing with ecology-economy problems concerning Indian and Métis peoples. Use a reference, student inquiry, or team teaching approach.)

Appendix A

"Two Ways of Knowing"

People of different cultures tend to acquire knowledge about the world in which they live in different ways. The reason is that their *purpose* for acquiring such knowledge is very different. This fact, which may seem obvious, helps explain why two persons - an Inuit hunter born and raised in Eskimo Point and a biologist born and raised in Toronto, say - can look at the same thing and not see it the same way at all.

For example, both the hunter and the biologist may know a great deal about caribou. But what they know may appear contradictory (and sometimes is) because what the hunter and the scientist want or need to learn about caribou are not the same. So, in many cases, one kind of knowledge is not simply better or worse than another - it is different. More than that, the hunter and the scientist do not "learn" in the same way. A little more background will help make this point clear.

Over countless generations, what people such as Inuit, Chipewyans, Crees or Europeans (who became the main non-natives in North America) learned about their part of the world enabled them to survive there. In this way, the many different people in the world have come to know their own regions intimately. This collective knowledge, derived from their own living experiences, affects how they see and interpret their surroundings.

The scientists who explain the "cultural" differences among people in this way (as well as those who study animals) see and interpret their surroundings according to European-derived traditions of learning. Their "way of knowing" is based on science. This scientific approach is so alien to traditional Inuit and Indian attitudes that it is little wonder that biologists and native people often have difficulty understanding one another when they are discussing caribou.

To a native hunter, who has to learn about caribou in order to hunt them, the biologist's methods often seem ineffective or aimed at acquiring useless information. The hunter needs to know, for example, how to hunt caribou at different seasons of the year, how hunting on cold clear days is different from hunting when a light storm masks the sounds of walking or the smell of the hunter, how to tell the sex and health of individual animals

from great distances. He must be able to predict where the caribou are likely to be days in advance, whether they are migrating or not. The hunter has not taken a course at a university to learn such things. And, while he does learn by practice, he doesn't learn by experimenting in the way a scientist does.

The native hunter, taught such things by his elders since he was a boy accepts them as facts. He does not question this basic knowledge. In the past, his survival and that of his family depended on his learning and performing his tasks well. Thus the native hunter has grown up learning about caribou by participating in the use of that knowledge, and he is expected to pass on that knowledge to his children.

The biologist, on the other hand was raised in a culture where students are taught to question knowledge. In this culture, he is taught basic principles or rules about the relationships of various things and is expected to take those and use them to learn more. Yet even the basic principles are not utterly beyond questioning. In this system, it makes sense to ask a question and suggest ways to answer it if only to see where the exercise leads. It is a kind of mental exploration. And, the survival at stake is that of the biologist's reputation and possibly his job, but not his life.

It is easy to see how these different approaches to knowledge cause misunderstanding. Each person, the hunter and the biologist, learns "facts" about caribou, but learns what is important to his own way of life. In a certain sense, the hunter learns from the inside and the biologist from the outside. An Inuit hunter learns about caribou by experience, by doing what his father has taught him to do, and a biologist applies to caribou the same basic system of learning that he would apply to learning anything.

There are some similarities. Both of these "ways of knowing" are built upon and develop over time, and both make sense in their own cultural context. Moreover, while the biologist's explanation of science may seem foreign to an Inuit hunter, concepts of organizing knowledge should not. For example, Inuit have their own ways of categorizing animals and the relationships between them.

An example will show that while the biologist's approach produces results, it is often not the only useful way to learn about caribou. In the 1960s and 1970s, there was growing concern among biologists because the Kaminuriak herd appeared to be declining. Many native hunters said there was no problem and that the caribou would come back, that they were merely somewhere else. In late 1981, Inuit at Repulse Bay were saying that Kaminuriak caribou were showing up in the vicinity of Wager Bay. Biologists, because they had not actually seen Kaminuriak caribou moving north-eastward and had seen no signs to suggest that they were, doubted that it could be so.

But Repulse Bay people were adamant, saying that many caribou in their area were not the same as the animals they were used to - they looked different and they *tasted* different. This did not qualify as scientific information, so biologists tended to reject the idea. Since calving ground surveys in recent years have shown much greater numbers of Kaminuriak caribou, biologists have had to reconsider what Inuit had been saying. And some may be willing to admit that, to some degree at least, the Repulse Bay people had been right.

Caribou News. Vol. 9, No. 2, August 1989.
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Appendix B

The Invitation of Elders

All cultures are enriched by certain valuable and unique individuals. Such individuals possess a wide range of knowledge--knowledge that once shared, can expand students' insight beyond the perspectives of the teacher and classroom resources.

Indian and Métis Elders in particular, are integral to the revival, maintenance, and preservation of Aboriginal cultures. Elder participation in support of curricular objectives develops the positive identity of Indian and Métis students and enhances self-esteem. All students may acquire a heightened awareness and sensitivity that inevitably promotes anti-racist education. It is important to note that the title "Elder" does not necessarily indicate age. In Aboriginal societies, one is designated an Elder after acquiring significant wisdom and experience.

When requesting guidance or assistance there is a protocol used in approaching Elders, which varies from community to community. The district chiefs' office, tribal council office, or a reserve's band council or education committee may be able to assist you. Prior to an Elder sharing knowledge, it is essential that you and your students complete the cycle of giving and receiving through an appropriate offering. This offering represents respect and appreciation for knowledge shared by an Elder. One must ascertain the nature of the offering prior to an Elder's visit as traditions differ throughout Aboriginal communities. In addition, should your school division normally offer honoraria and/or expense reimbursement to visiting instructors, it would be similarly appropriate to extend such considerations to a visiting Elder.

To initiate the process of dialogue and participation, a letter should be sent to the local band council requesting Elder participation and indicating the role the Elder would have within the program. The band council may then be able to provide the names of persons who have the recognized knowledge and skills that would meet your specific needs. It is recommended that prior consultation occur with the Elder to share expectations for learning outcomes.

Friendship Centres across the province are active at the community level and often present cultural workshops and activities in co-operation with Elders and other recognized resource people. Teachers and schools may wish to contact the following Indian Directors of Education.

Charles Fiddler
Director of Education
Meadow Lake Tribal Council
P.O. Box 1360
Meadow Lake, S0M 1V0 236-5654

Don Kondrat
Director of Education
Yorkton Tribal Administration
P.O. Box 790
Broadview, S0G 0K0 794-2170

Larry Goldade
Director of Education
Prince Albert Tribal Council
P.O. Box 1437
Prince Albert, S6V 5S9 922-4610

Stewart Boston
Director of Education
Confederation of Tribal Nations
10211 - 12th Avenue
North Battleford, S9A 3X5 445-5838

Tony Sparvier
Director of Education
Touchwood/File Hills/Qu'Appelle
Tribal Council
P.O. Box 1549
Fort Qu'Appelle, S0G 1S0 332-8200

Len Neufeld
Director of Education
Saskatoon District Tribal Council
226 Cardinal Crescent
Saskatoon, S7L 6H8 956-6130

Audrey Pewapisconias
Director of Education
Battlefords Tribal Council
691 - 109th Street
North Battleford, S9A 2C5 445-1383

Dave Adams
Director of Education
Agency Chiefs Tribal Council
P.O. Box 550
Debden, S0J 0S0 724-4555

Appendix C

NABT Guidelines for the Use of Live Animals*

Living things are the subject of biology, and their direct study is an appropriate and necessary part of biology teaching. Textbook instruction alone cannot provide students with a basic understanding of life and life processes. The National Association Biology Teachers recognizes the importance of research in understanding life processes and providing information on health, disease, medical care and agriculture.

The abuse of any living organism for experimentation or any other purpose is intolerable in any segment of society. Because biology deals specifically with living things, professional biology educators must be especially cognizant of their responsibility to present the inhumane treatment of living organisms in the name of science and research. This responsibility should extend beyond the confines of the teacher's classroom to the rest of the school and community.

The National Association of Biology teachers believes that students learn the value of living things, and the values of science, by the events they witness in the classroom. The care and concern for animals should be a paramount consideration when live animals are used in the classroom. Such teaching activities should develop in students and teachers a sense of respect and pleasure in studying the wonders of living things. NABT is committed to providing biological education and promoting humane attitudes toward animals. These guidelines should be followed when live animals are used in the classroom:

A. Biological experimentation should be consistent with a respect for life and all living things. Humane treatment and care of animals should be an integral part of any lesson that includes living animals.

B. Exercises and experiments with living things should be within the capabilities of the students involved. The biology teacher should be guided by the following conditions.

1. The lab activity should not cause the undue loss of a vertebrate's life. Bacteria, fungi, protozoans and invertebrates should be used

in activities that may require use of harmful substances or loss of an organism's life. These activities should be clearly supported by an educational rationale and should not be used when alternatives are available.

2. A student's refusal to participate in an activity (e.g., dissection or experiments involving live animals, particularly vertebrates) should be recognized and accommodated with alternative methods of learning. The teacher should work with the student to develop an alternative for obtaining the required knowledge or experience. The alternative activity should require the student to invest a comparable amount of time and effort.

C. Vertebrate animals can be used as experimental organisms in the following situations:

1. Observations of normal living patterns of wild animals in their natural habitat or in zoological parks, gardens or aquaria.
2. Observations of normal living functions such as feeding, growth, reproduction, activity cycles, etc.
3. Observations of biological phenomenon among and between species such as communication, reproductive and life strategies behavior, interrelationships of organisms, etc.

D. If live vertebrates are to be kept in the classroom the teacher should be aware of the following responsibilities:

1. The school, under the biology teacher's leadership, should develop a plan on the procurement and ultimate disposition of animals. Animals should not be captured from or released into the wild without the approval of both a responsible wildlife expert and a public health official. Domestic animals and "classroom pets" should be purchased from licensed animal suppliers. They should be healthy and free of diseases that can be transmitted to humans or to other animals.
2. Animals should be provided with sufficient space for normal behavior and postural requirements. Their environment should be free from undue stress such as noise, overcrowding and disturbance caused by students.
3. Appropriate care - including nutritious food, fresh water, clean housing, and adequate temperature and lighting for the species - should be provided daily, including weekends, holidays and long school vacations.

-
4. Teachers should be aware of any student allergies to animals.
 5. Students and teachers should immediately report to the school health nurse all scratches, bites and other injuries, including allergies or illnesses.
 6. There should always be supervised care by a teacher competent in caring for animals.
- E. Animal studies should always be carried out under the direct supervision of a biology teacher competent in animal care procedures. It is the responsibility of the teacher to ensure that the student has the necessary comprehension for the study. Students and teachers should comply with the following:

1. **Students should not be allowed to perform surgery on living vertebrate animals.** Hence, procedures requiring the administration of anesthesia and euthanasia should not be done in the classroom.
2. Experimental procedures on vertebrates should not use pathogenic microorganisms, ionizing radiation, carcinogens, drugs or chemicals at toxic levels, drugs known to produce adverse or teratogenic effects, pain causing drugs, alcohol in any form, electric shock, exercise until exhaustion, or other distressing stimuli. No experimental procedures should be attempted that would subject vertebrate animals to pain or distinct discomfort, or interfere with their health in any way.
3. Behavioral studies should use only positive reinforcement techniques.
4. Egg embryos subjected to experimental manipulation should be destroyed 72 hours before normal hatching time.
5. Exceptional original research in the biological or medical sciences involving live vertebrate animals should be carried out under the direct supervision of an animal scientist, e.g., an animal physiologist, or a veterinary or medical researcher, in an appropriate research facility. The research plan should be developed and approved by the animal scientist and reviewed by a humane society professional staff person prior to the start of the research. All professional standards of conduct should be applied as well as humane care and treatment, and concern for the safety of the animals involved in the project.
6. Students should not be allowed to take animals home to carry out experimental studies.

F. Science fair projects and displays should comply with the following:

1. The use of live animals in science fairs projects shall be in accordance with the above guidelines. In addition, no live vertebrate animals shall be used in displays for science fair exhibitions.
2. No animal or animal products from recognized endangered species should be kept and displayed.

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Appendix D

Guidelines for Responsible Use of Animals in the Classroom*

These guidelines are recommended by the National Science Teachers Association for use by science educators and students. They apply, in particular, to the use of non-human animals in instructional activities planned and/or supervised by teachers who teach science at the precollege level.

Observation and experimentation with living organisms give students unique perspectives of life processes that are not provided by other modes of instruction. Studying animals in the classroom enables students to develop skills of observation and comparison, a sense of stewardship, and an appreciation for the unity, interrelationships, and complexity of life. This study, however, requires appropriate, humane care of the organism. Teachers are expected to be knowledgeable about the proper care of organisms under study and the safety of their students.

These are the guidelines recommended by NSTA concerning the responsible use of animals in a school classroom laboratory:

- ! Acquisition and care of animals must be appropriate to the species.
- ! Student classwork and science projects involving animals must be under the supervision of a science teacher or other trained professional.
- ! Teachers sponsoring or supervising the use of animals in instructional activities) including acquisition, care, and disposition) will adhere to local, [provincial], and national laws, policies, and regulations regarding the organisms.
- ! Teachers must instruct students on safety precautions for handling live animals or animal specimens.
- ! Plans for the future care or disposition of animals at the conclusion of the study must be developed and implemented.
- ! laboratory and dissection activities must be conducted with consideration and appreciation for the organism.
- ! Laboratory and dissection activities must be conducted in a clean and organized work space with care and laboratory precision.

- ! Laboratory and dissection activities must be based on carefully planned objectives.
- ! Laboratory and dissection objectives must be appropriate to the maturity level of the student.
- ! Student views or beliefs sensitive to dissection must be considered; the teacher will respond appropriately.

- Adopted by the NSTA Board of Directors in July, 1991

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Appendix E

Field Trip to an Aspen Grove

Each group of four should have:

- ! four 1 m long pieces of string, marked every 10 cm
- ! five popsicle sticks or tongue depressors
- ! four hand lenses
- ! one plastic magnifying box
- ! one plastic grocery bag

Each group member should have a field notebook, and should record all observations made individually or as part of a group process.

1. Pick a spot along the edge of the grove so that there is a working space of three to four metres clear of any other group. Decide where the edge of the grove is, and mark that edge with one of the sticks. Moving along a straight line towards the middle of the grove, place a marker every three metres or so, to the centre of the grove or until the sticks run out.

Describe how the vegetation on the floor varies at each marker. How many species of plants can be distinguished? How thick is the trash cover? What is the composition of the trash cover? Describe the soil. Describe how the aspen trees vary near each marker. How tall are they? What other features are notable? Use the calibrated strings to make measurements.

2. What is the largest trunk diameter you can find within one metre of your line of marks. Compare the bark on that tree with the bark on a young tree which is less than 3 m tall. If the leaves are on the trees, try to determine if there is a relationship between the size of the tree and the size of the leaves it has.
3. Collect any garbage -- bottles, cans, plastic, paper, popsicle sticks or tongue depressors -- which indicates human presence in the area. Use your plastic grocery bag to bring it back to the class where it can be classified.
4. Search for some moss. Do not remove it from where it is growing. Describe the structure of the plant. Feel the texture of the plant. Describe the surroundings.

5. Look for animal life and for evidence of animal life. One good place to look for insects is in the bark of the trees. Another is under rocks or fallen logs. Lift or roll the rock or log over slowly, and then replace it after you have recorded your observations. Any insects captured in the magnifying box should be released after observation. Birds nests and animal tracks can be sketched for later identification.
6. Locate a terminal bud of a branch, at the end of a branch or twig. Compare its size, shape, and covering to the those characteristics on a lateral bud, along the side of a branch. Can you determine where the previous year's terminal bud was? (Look for three wrinkles which run around the branch.) How much did the branch grow in the past growing year?