ACKNOWLEDGMENTS

Acknowledgments

The Atlantic Provinces Education Foundation and the P.E.I. Department of Education and Early Childhood Development express their indebtedness to members of regional biology committees for their professional expertise and insights in developing this regional Biology 521A curriculum guide. In addition, the local biology committee and pilot teachers who contributed comments and suggestions are to be commended for their commitment to developing exemplary science programs.

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The Prince Edward Island Department of Education and Early Childhood Development would also like to thank The Department of Education of Newfoundland and Labrador for their additional contributions to the units and materials provided in the appendix of this curriculum guide.
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Foreword


This guide is intended to provide teachers with an overview of the outcomes framework for Biology 521A. It also includes some suggestions to assist teachers in designing learning experiences and assessment tasks.
Introduction

Background

The curriculum described in *Foundation for the Atlantic Canada Science Curriculum* and in *Biology 521A* was planned and developed collaboratively by regional committees. The process for developing the common science curriculum for Atlantic Canada involved regional consultation with the stakeholders in the education system in each Atlantic province. The Atlantic Canada science curriculum is consistent with the science framework described in the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*.

Aim

The aim of science education in the Atlantic provinces is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment.
Program Design and Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include:

- creating a classroom environment to support the learning and teaching of science;
- designing effective learning experiences that help students achieve designated outcomes;
- stimulating and managing classroom discourse in support of student learning;
- learning about and then using students’ motivations, interests, abilities, and learning styles to improve learning and teaching;
- assessing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions;
- selecting teaching strategies from a wide repertoire.

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs through actively constructing one’s own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students’ disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.
Communicating in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways to learning. Students, at all grade levels, should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information by using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students better record, organize, and understand information from a variety of sources. The process of creating webs, maps, charts, tables, graphs, drawing, and diagrams to represent data and results helps students learn, and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. It is through opportunities to talk and write about the concepts they need to learn that students come to better understand both the concepts and related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.
The Three Processes of Scientific Literacy

Inquiry
Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

Problem Solving
The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making
The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.
Meeting the Needs of All Learners

*Foundation for the Atlantic Canada Science Curriculum* stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware of, and make adaptations to accommodate, the diverse range of learners in their classes. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit them to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching; they must also actively address cultural and gender stereotyping (e.g., about who is interested in and who can succeed in science and mathematics). Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally underrepresented in science, and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students’ needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.
Science for EAL Learners

The Prince Edward Island science curriculum is committed to the principle that learners of English as an additional language (EAL) should be full participants in all aspects of science education. English deficiencies and cultural differences must not be barriers to full participation. All students should study a comprehensive science curriculum with high-quality instruction and co-ordinated assessment.

To this end,

- schools should provide EAL learners with support in their dominant language and English language while learning science;
- teachers, counsellors, and other professionals should consider the English-language proficiency level of EAL learners as well as their prior course work in science;
- the science proficiency level of EAL learners should be solely based on their prior academic record and not on other factors;
- science teaching, curriculum, and assessment strategies should be based on best practices and build on the prior knowledge and experiences of students and on their cultural heritage;
- the importance of science and the nature of the science program should be communicated with appropriate language support to both students and parents;
- to verify that barriers have been removed, educators should monitor enrolment and achievement data to determine whether EAL learners have gained access to, and are succeeding in, science courses.

Education for Sustainable Development

Education for sustainable development (ESD) involves incorporating the key themes of sustainable development - such as poverty alleviation, human rights, health, environmental protection, and climate change - into the education system. ESD is a complex and evolving concept and requires learning about these key themes from a social, cultural, environmental, and economic perspective, and exploring how those factors are interrelated and interdependent.

With this in mind, it is important that all teachers, including science teachers, attempt to incorporate these key themes in their subject areas. One tool that can be used is the searchable on-line database Resources for Rethinking, found at http://r4r.ca/en. It provides teachers with access to materials that integrate ecological, social, and economic spheres through active, relevant, interdisciplinary learning.
**Assessment and Evaluation**

The terms *assessment* and *evaluation* are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in the Atlantic region use these terms for the processes described below.

**Assessment** is the systematic process of gathering information on student learning.

**Evaluation** is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

The Atlantic Canada science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities/skills/actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

**Assessment Techniques**

Assessment techniques should match the style of learning and instruction employed. Several options are suggested in this curriculum guide from which teachers may choose, depending on the curriculum outcomes, class, and school/district policies. It is important that students know the purpose of an assessment, along with the method and the marking scheme being used. In order that formative assessment support learning, the results, when reported to students, should indicate the improvements expected.
**Observation (formal or informal)**

This technique provides a way of gathering information fairly quickly while a lesson is in progress. When used formally, the student(s) should be made aware of the observation and the criteria being assessed. Informally, it could be a frequent, but brief, check on a given criterion. Observation may offer information about the participation level of a student for a given task, use of a piece of equipment, or application of a given process. The results may be recorded in the form of checklists, rating scales, or brief written notes. It is important to plan in order that specific criteria are identified, suitable recording forms are ready, and that all students are observed in a reasonable period time.

**Performance**

This curriculum encourages learning through active participation. Many of the curriculum outcomes found in the guide promote skills and their application. There is a balance between scientific processes and content. In order that students appreciate the importance of skill development, it is important that assessment provide feedback on the various skills. These may be the correct manner in which to use a piece of equipment, an experimental technique, the ability to interpret and follow instructions, or to research, organize and present information. Assessing performance is most often achieved through observing the process.

**Journal**

Although not assessed in a formal manner, journals provide an opportunity for students to express thoughts and ideas in a reflective way. By recording feelings, perceptions of success, and responses to new concepts, a student may be helped to identify his or her most effective learning style.

Knowing how to learn in an effective way is powerful information. Journal entries also give indicators of developing attitudes to science concepts, processes, and skills, and how these may be applied in the context of society. Self-assessment, through a journal, permits a student to consider strengths and weaknesses, attitudes, interests, and new ideas. Developing patterns may help in career decisions and choices of further study.

**Interview**

This curriculum promotes understanding and applying scientific concepts. Interviewing a student allows the teacher to confirm that learning has taken place beyond simply factual recall. Discussion allows a student to display an ability to use information and clarify understanding. Interviews may be brief discussions between teacher and student, or they may be more extensive and include student, parent, and teacher. Such conferences allow a student to be proactive in displaying understanding. It is helpful for students to know which criteria will be used to assess formal interviews. The assessment technique provides an opportunity for students whose verbal presentation skills are stronger than their written skills.
Assessment Techniques  Continued...

Paper and Pencil (assignment or test)

These techniques can be formative or summative. Several curriculum outcomes call for displaying ideas, data, conclusions, and the results of practical or literature research. These can be in written form for display or for direct teacher assessment. Whether it is a part of learning, or a final statement, students should know the expectations for the exercise and the rubric by which it will be assessed. Written assignments and tests can be used to assess knowledge, understanding, and application concepts. They are less successful assessing skills, processes, and attitudes. The purpose of the assessment should determine what form of paper and pencil exercise is used.

Presentation

The curriculum includes outcomes that require students to analyze and interpret information; to identify relationships between science, technology, society, and environment; to be able to work in teams; and to communicate information. Although it can be time consuming, these activities are best displayed and assessed through presentations. These can be given orally, in written/pictorial form, by project summary, or by using electronic systems such as video or computer software. Whatever the level of complexity or format used, it is important to consider the curriculum outcomes as a guide to assessing the presentation. The outcomes indicate the process, concepts, and context for which and about which a presentation is made.

Portfolio

Portfolios offer another option for assessing student progress in meeting curriculum outcomes over a more extended period of time. This form of assessment allows the student to be central in the process. Decisions about the portfolio and its contents can be made by the student. What is placed in the portfolio, the criteria for selection, how the portfolio is used, how and where it is stored, and how it is evaluated are some of the questions to consider when planning to collect and display student work in this way. The portfolio should provide a long-term record of growth in learning and skills. This record of growth is important for individual reflection and self-assessment, but it is also important to share with others. For many students it is exciting to review a portfolio and see the record of development over time.
Curriculum Outcomes Framework

Overview

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian Common Framework of Science Learning Outcomes K to 12. The diagram below provides the blueprint of the outcomes framework.

Outcomes Framework

FIGURE 1

Essential Graduation Learnings

A Vision for Scientific Literacy in Atlantic Canada

Four General Curriculum Outcomes

STSE
Nature of science and technology
Relationship between science and technology
Social and environmental contexts of science and technology

SKILLS
Initiating and planning
Performing and recording
Analysing and interpreting
Communication and teamwork

KNOWLEDGE
Life science
Physical science
Earth and space science

ATTITUDES
Appreciation of science
Interest in science
Science inquiry
Collaboration
Stewardship
Safety

Key-Stage Curriculum Outcomes

Specific Curriculum Outcomes
Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries and to be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. The essential graduation learnings are the following:

Aesthetic Expression
Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship
Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication
Graduates will be able to use the listening, viewing, speaking, reading, and writing modes of language(s) as well as mathematical and scientific concepts and symbols to think, learn, and communicate effectively.

Personal Development
Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Problem Solving
Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, mathematical, and scientific concepts.

Technological Competence
Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.
The general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students’ scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science. The key-stage curriculum outcomes are from the Common Framework for Science Learning Outcomes K to 12.

Specific curriculum outcome statements describe what students are expected to know and be able to do at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings. Specific curriculum outcomes are organized in units for each grade level.
Attitude Outcomes

It is expected that the Atlantic Canada science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the Elaborations—Strategies for Learning and Teaching sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students’ growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcomes statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcome statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

The following pages present the attitude outcomes from the pan-Canadian Common Framework of Science Learning Outcomes K to 12 for the end of grade 12.
Common Framework of Science Learning Outcomes K to 12
Attitude Outcome Statements

By the end of grade 12, it is expected that students will be encouraged to

<table>
<thead>
<tr>
<th>Appreciation of Science</th>
<th>Interest in Science</th>
<th>Scientific Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not</td>
<td>439 show a continuing and more informed curiosity and interest in science and science-related issues</td>
<td>442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations</td>
</tr>
<tr>
<td>437 appreciate that the applications of science and technology can raise ethical dilemmas</td>
<td>440 acquire, with interest and confidence, additional science knowledge and skills using a variety of resources and methods, including formal research</td>
<td>443 use factual information and rational explanations when analysing and evaluating</td>
</tr>
<tr>
<td>438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds</td>
<td>441 consider further studies and careers in science- and explore where further science- and technology-related fields</td>
<td>444 value the processes for drawing conclusions</td>
</tr>
</tbody>
</table>

Evident when students, for example,

- consider the social and cultural contexts in which a theory developed
- use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on STSE issues
- recognize the usefulness of being skilled in mathematics and problem solving
- recognize how scientific problem solving and the development of new technologies are related
- recognize the contribution of science and technology to the progress of civilizations
- carefully research and openly discuss ethical dilemmas associated with the applications of science and technology
- show support for the development of information technologies and science as they relate to human needs
- recognize that western approaches to science are not the only ways of viewing the universe
- consider the research of both men and women

- conduct research to answer their own questions
- recognize that part-time jobs require science- and technology-related knowledge and skills
- maintain interest in or pursue further studies in science
- recognize the importance of making connections between various science disciplines
- explore and use a variety of methods and resources to increase their own knowledge and skills
- are interested in science and technology topics not directly related to their formal studies
- explore where further science- and technology-related studies can be pursued
- are critical and constructive when considering new theories and techniques
- use scientific vocabulary and principles in everyday discussions
- readily investigate STSE issues

Evident when students, for example,

- insist on evidence before accepting a new idea or explanation
- ask questions and conduct research to confirm and extend their understanding
- criticize arguments based on the faulty, incomplete, or misleading use of numbers
- recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen
- expend the effort and time needed to make valid inferences
- critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation
- critically assess their opinion of the value of science and its applications
- criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist
- insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged
- seek new models, explanations, and theories when confronted with discrepant events or evidence
Common Framework of Science Learning Outcomes K to 12
Attitude Outcome Statements (continued)

By the end of grade 12, it is expected that students will be encouraged to

<table>
<thead>
<tr>
<th>Collaboration</th>
<th>Stewardship</th>
<th>Safety in Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas</td>
<td>446 have a sense of personal and shared responsibility for maintaining a sustainable environment</td>
<td>449 show concern for safety and accept the need for rules and regulations</td>
</tr>
<tr>
<td>Evident when students, for example, • willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics • assume a variety of roles within a group, as required • accept responsibility for any task that helps the group complete an activity • give the same attention and energy to the group’s product as they would to a personal assignment • are attentive when others speak • are capable of suspending personal views when evaluating suggestions made by a group • seek the points of view of others and consider diverse perspectives • accept constructive criticism when sharing their ideas or points of view • criticize the ideas of their peers without criticizing the persons • evaluate the ideas of others objectively • encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making • contribute to peaceful conflict resolution encourage the use of a variety of communication strategies during group work • share the responsibility for errors made or difficulties encountered by the group</td>
<td>447 project the personal, social, and environmental consequences of proposed action</td>
<td>450 be aware of the direct and indirect consequences of their actions</td>
</tr>
<tr>
<td>Evident when students, for example, • willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation • assume part of the collective responsibility for the impact of humans on the environment • participate in civic activities related to the preservation and judicious use of the environment and its resources • encourage their peers or members of their community to participate in a project related to sustainability • consider all perspectives when addressing issues, weighing scientific, technological, and ecological factors • participate in social and political systems that influence environmental policy in their community • examine/recognize both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans • willingly promote actions that are not injurious to the environment • make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations • are critical-minded regarding the short- and long-term consequences of sustainability</td>
<td>448 want to take action for maintaining a sustainable environment</td>
<td>449 show concern for safety and accept the need for rules and regulations</td>
</tr>
<tr>
<td>449 show concern for safety and accept the need for rules and regulations</td>
<td>450 be aware of the direct and indirect consequences of their actions</td>
<td>449 show concern for safety and accept the need for rules and regulations</td>
</tr>
<tr>
<td>451 be aware of the direct and indirect consequences of their actions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Common Framework of Science Learning Outcomes K to 12
Stewardship Safety in Science
Curriculum Guide Organization

Specific curriculum outcomes are organized in units for each grade level. Each unit is organized by topic. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes. Suggested times for each topic are also provided. Although Biology 521A is 110 hours in duration, the cumulative topic instructional time allocated is 92 hours, or 46 hours per term. The remaining 9 hours each term allows for summative assessment considerations.

The order in which the units of a grade appear in the guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the semester. That is, one unit may introduce a concept that is then extended in a subsequent unit. Likewise, one unit may focus on a skill or context that will be built upon later in the semester.

Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world. The intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful and socially and culturally relevant contexts.

Unit Organization

Each unit begins with a two-page synopsis. On the first page, introductory paragraphs provide a unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills addressed in other grades so teachers will understand how the unit fits with the students’ progress through the complete science program.

The second page of the two-page overview provides a table of the outcomes from the *Common Framework of Science Learning Outcomes K to 12* that the unit will address. The numbering system used is the one in the pan-Canadian document as follows:

- **100s**—Science-Technology-Society-Environment (STSE) outcomes
- **200s**—Skills outcomes
- **300s**—Knowledge outcomes
- **400s**—Attitude outcomes (see pages 16-18)

These code numbers appear in brackets after each specific curriculum outcome (SCO).

Within each unit, the pan-Canadian outcomes are written in the context of Prince Edward Island’s Biology 521A curriculum.
The Four-Column Spread

All units have a two-page layout of four columns as illustrated below. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

Two-Page, Four-Column Spread

<table>
<thead>
<tr>
<th>Page One</th>
<th>Page Two</th>
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<tbody>
<tr>
<td><strong>Topic</strong></td>
<td><strong>Elaborations—Strategies for Learning and Teaching</strong></td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td>Students will be expected to</td>
</tr>
<tr>
<td></td>
<td>• Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)</td>
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<td></td>
<td>• Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)</td>
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</table>
Column One: Outcomes

The first column provides the specific curriculum outcomes. These are based on the pan-Canadian Common Framework of Science Learning Outcomes K to 12. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appear(s) in parentheses after the outcome. Some STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column One and Column Two define what students are expected to learn, and be able to do.

Column Two:
Elaborations—Strategies for Learning and Teaching

The second column may include elaborations of outcomes listed in column one, and describes learning environments and experiences that will support students’ learning.

The strategies in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

Column Three:
Tasks for Instruction and/or Assessment

The third column provides suggestions for ways that students’ achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journal, interview, paper and pencil, presentation, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

Some STSE, Skills, and Knowledge outcomes that appear after the assessment item may not appear in the first column. Although these outcomes are not the key outcome(s) for this section, the assessment item provides an opportunity to address these outcomes in a different context.

Column Four:
Resources/Notes

This column provides an opportunity for teachers to make note of useful resources.
Matter and Energy for Life (~13 Classes)

Introduction

Biology is the study of life. However, the study of the science of life is far from simple. It is complex because living things are complex and diverse. Living things are much more than a mere set of chemical reactions or physical machines. They are composed of individual units called cells, considered to be the basic units of structure and function and the smallest independent units capable of displaying the characteristics of life. In this unit, the historical development of cell theory and the role of the microscope in the advancement of biological knowledge will be discussed. As they study cell structures and their functions, students will gain an appreciation for the complexity of life at the cellular level of organization, and for the delicacy of interactions between components at this level.

Focus and Context

In its consideration of the cell as the fundamental unit of life, the focus of this unit is on scientific inquiry. This involves primarily an emphasis on observation and inquiry. Sections within this unit ask students to consider structures, processes, and interactions within cells, and to gain familiarity with basic laboratory techniques.

Science Curriculum Links

This preliminary discussion of cells builds upon clusters of information that have preceded it in the student’s earlier study of the science curriculum. Characteristics and needs of living things and their dependence on the environment are first introduced in a general format in grade one. This base is built upon in grade 3 with discussion of the interaction of plants with the environment. Students in elementary grades begin to become familiar with the use of magnifying tools to observe microorganisms. By the end of grade 8, students have been introduced to plant and animal cells as living systems exhibiting the characteristics of life. In addition, structural and functional relationships between cells, tissues, organs, and body systems, and their relationship to the functioning of the human organism as a whole, have been investigated.
## Curriculum Outcomes

<table>
<thead>
<tr>
<th>STSE</th>
<th>Skills</th>
<th>Knowledge</th>
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<tbody>
<tr>
<td><strong>Students will be expected to</strong></td>
<td><strong>Students will be expected to</strong></td>
<td><strong>Students will be expected to</strong></td>
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<tr>
<td><strong>Nature of Science and Technology</strong></td>
<td><strong>Initiating and Planning</strong></td>
<td><strong>314-5 explain the cell theory</strong></td>
</tr>
<tr>
<td>114-1 explain how a paradigm shift can change scientific world views</td>
<td>212-7 formulate operational definitions of major variables</td>
<td><strong>314-6 describe cell organelles visible with the light and electron microscopes</strong></td>
</tr>
<tr>
<td>114-2 explain the role of evidence, theories, and paradigms in the development of scientific knowledge</td>
<td><strong>Performing and Recording</strong></td>
<td><strong>314-7 compare and contrast different types of prokaryotic and eukaryotic cells</strong></td>
</tr>
<tr>
<td>114-5 describe the importance of peer review in the development of scientific knowledge</td>
<td>213-2 carry out procedures controlling the major variables and adapting or extending procedures where required</td>
<td><strong>314-8 describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion</strong></td>
</tr>
<tr>
<td>114-9 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions</td>
<td>213-3 use instruments effectively and accurately for collecting data</td>
<td><strong>314-9 compare and contrast matter and energy transformations associated with the processes of photosynthesis and aerobic respiration</strong></td>
</tr>
<tr>
<td>115-5 analyse why and how a particular technology was developed and improved over time</td>
<td>213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data</td>
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<tr>
<td><strong>Relationships between Science and Technology</strong></td>
<td><strong>Analysing and Interpreting</strong></td>
<td></td>
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<tr>
<td>116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology</td>
<td>214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots</td>
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<tr>
<td>116-6 describe and evaluate the design of technological solutions and the way they function, using scientific principles</td>
<td>214-11 provide a statement that addresses the problem or answers the question investigated in the light of the link between data and the conclusion</td>
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<tr>
<td><strong>Communication and Teamwork</strong></td>
<td><strong>215-6 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise</strong></td>
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Historical Development of the Cell Theory

Outcomes

Students will be expected to

- explain the cell theory (314-5)
  - define biogenesis and abiogenesis
  - develop a list of characteristics that differentiate living and non-living things
- describe how the contributions of scientists led to a better understanding of biogenesis and abiogenesis (114-1, 114-2, 114-5, 114-9)
  (i) Aristotle
  (ii) Redi
  (iii) Needham
  (iv) Spallanzani
  (v) Pasteur

- analyse and describe how scientific understanding was revised as a result of the invention of the microscope (116-2)
  - explain how the invention of the microscope permitted scientists to discover the existence of cells
  - explain the contributions of
    (i) Hooke
    (ii) Leeuwenhoek
- describe how the contributions of scientists led to the progressive development of the cell theory (114-1, 114-2, 114-5, 114-9)
  (i) Brown
  (ii) Schleiden
  (iii) Schwann
  (iv) Braun
  (v) Virchow
  (vi) Pasteur

Elaborations—Strategies for Learning and Teaching

It is important that students understand the concepts of biogenesis and abiogenesis and to be able to identify characteristics that distinguish living from non-living things before discussing the experiments of scientists who fuelled this debate. It is also important to recognize that the debate over biogenesis and abiogenesis contributed to the development of cell theory and resulted in a significant paradigm shift.

The concepts of biogenesis and spontaneous generation could be approached historically through investigation of the contributions of philosophers such as Aristotle, and scientists such as Redi, Needham, Spallanzani, and Pasteur. Sketches of their experimental setups are useful visual representations and are valuable to students’ understanding of the progression in cell theory development. Questions such as, How did the scientists’ equipment evolve? and What are the strengths and weaknesses of their research? could be pursued.

This historical approach can be used to illustrate the development and functioning of the scientific method. The theory of spontaneous generation (abiogenesis) was based on conclusions drawn from faulty or misinterpreted observations and lack of experimental control. This concept was discredited, and the theory of biogenesis was supported by the use of controlled experiments.

Students should understand that the development of the microscope and the development of the cell theory were directly related.

The accomplishments of the early cell biologists paved the way for study. Emphasis should be placed on the way this scientific knowledge developed. As each scientist worked, he/she built on previous knowledge, modified present techniques, and changed the way science viewed the origins of life (i.e., a paradigm shift occurred).

To put these developments into a historical perspective, students could be asked in groups to create a time line to chronicle the development of this theory.
## Historical Development of the Cell Theory

### Suggested Assessment Strategies

**Presentation**

- Collect information on the researcher assigned to you or your group and prepare a brief oral presentation to be given to the class. Create index cards, providing in point form the individual’s name, the time frame in which he or she worked, and his/her main contributions to the development of the cell theory. Presentations could be made in chronological order and the index cards affixed to the time line prepared at the front of the class. (114-1, 114-2, 114-5, 114-9, 116-2, 314-5)

- Debate the characteristics that separate living from non-living things. Examples should be provided. (314-5)

**Paper and Pencil**

- Using the statements on cell theory, identify the research and scientist that contributed to each particular cell theory statement. Organize statements and researchers in chronological order. (314-5, 114-5)

- Debate biogenesis and abiogenesis. (114-1, 114-2, 114-5, 114-9, 116-2, 314-5)

### Resources

- MHR *Biology*, pp. 6, 11
- MHR *Biology*, pp. 102-104
- MHR *Biology*, pp. 7-11
- MHR *Biology*, pp. 10-11
- ThinkingLab: “Spontaneous Generation and the Cell Theory” MHR *Biology*, p. 7
Introduction to the Microscope

Outcomes

Students will be expected to

- select and use apparatus and materials safely (213-8)
  - identify the microscope as an important tool for biological research

- use instruments effectively and accurately for collecting data (213-3)
  - identify microscope parts and their functions
  - demonstrate general care, focussing techniques, and safety concerns
  - prepare, stain, and observe a wet mount of a specimen

- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)

- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)

Elaborations—Strategies for Learning and Teaching

The laboratory outcomes (213-3, 213-5, 213-8, 215-6) can be addressed by completing Investigation A “Caring for and Using a Microscope,” AND Mini Lab: “Observing Stained Cells.”

Teachers should note that this lab will take at least two to three class periods.

Students should develop the techniques and skills required to use a microscope efficiently. Students will arrive in Biology 521A with varying levels of competency in the use of the microscope, and accommodations will need to be made for this.

Hands-on activities are useful for students to become acquainted with the proper use of the instrument (its parts and their functions), and with specimen preparation. Students will require practice with focussing techniques, and they should be made aware of the proper care and cleaning of the microscope, and of safety concerns. If both a compound microscope and dissecting (stereo) microscope are available, a look at the contrasts and different uses for these two instruments would be valuable.

Teachers should demonstrate the proper preparation and staining of a temporary, or wet mount slide, in order to minimize air bubbles and distractions to viewing.

It is important for students to realize that the image they view under the microscope may not be exactly as the cell always appears, because the procedures and material (stains) used to prepare specimens may alter their appearance, and the microscope yields a two-dimensional view of a three-dimensional object. A good activity might be for students to look at pond water, as this would demonstrate whether they fully comprehend the proper use of the microscope. The importance of the contrast added by the staining technique could be illustrated by having students alternately view a specimen unstained, and then stained.

This microscope work complements and reinforces the concepts discussed in the previous section, and teachers may choose to align their instruction into this section. Students are presented here with the opportunity to practice and build on the knowledge from the previous section. They have been introduced to the proper techniques for slide preparation and staining, and now they have additional opportunities to use these techniques.
Introduction to the Microscope

Suggested Assessment Strategies

This section involves an emphasis on hands-on laboratory experiences.

Paper and Pencil
- Draw a freehand diagram of a specimen provided. The diagram should have a title, labels, and scale (or estimated size). (213-3, 213-5, 214-3)

Performance
- Prepare and stain a wet mount slide. (A visual scan of their product will allow an assessment of their slide preparation and focussing techniques.) (213-3, 214-3)
- Demonstrate focussing techniques (including depth of field), and describe safety concerns. (213-3, 214-3, 213-8)
- Sketch on a piece of paper a tiny lower case “e.” It must be small enough that the entire letter can be seen under the low power of the microscope. Prepare a wet mount, position the slide on the stage in its normal orientation, observe, and sketch the image of the letter as viewed through the microscope. Prepare a summary statement describing how the microscope influences the orientation of all images produced. (213-5, 214-3, 213-8)
- Given a variety of samples of fibres (e.g., linen, wool, cotton, silk, nylon), prepare wet mounts, examine, and sketch the resulting images. Develop a crime scene scenario using one or a number of these fibres. Exchange your scenario with another group (to be solved). Alternatively, a number of hair samples might be considered for use. (213-5, 213-8)

Journal
- Explain proper care and use of a microscope. (213-3)
- Explain how a specimen is found on a microscope when it is first mounted and when it is lost. (213-3)

Resources

Core lab. #1
Investigation 1A: “Caring for and Using a Microscope,” MHR Biology, pp. 15-19

Mini Lab: “Observing Stained Cells,” MHR Biology, p. 24

Appendix E: “How to Make a Biological Drawing,” MHR Biology, p. 742

Appendix B: “Units of Measure,” MHR Biology, p. 739

BLM 1-1 “Using a Microscope”
Introduction to the Microscope  

**Outcomes**

*Students will be expected to*

- compile and display, using line diagrams and/or digital imagery, evidence and information collected through the use of the microscope (214-3)
  - draw a biological drawing which includes the concept of field of view and calculation of specimen size
- formulate operational definitions of major variables (212-7)

- analyse why microscope technology continued to develop and improve over time (115-5)

- describe and evaluate the design of microscope technologies and the way they function (compound, scanning electron, and transmission microscopes) (116-6)

**Elaborations—Strategies for Learning and Teaching**

Ideally, each student should be assigned his or her own microscope. The specimens utilized for the activities involving line diagrams should have distinct colour and contrast and be easy for the students to distinguish. A brief introduction to the concept of field of view and the estimation of specimen size is useful to help students maintain the proper perspective on what they are viewing through the microscope.

Students should create operational definitions and differentiate between, depth of field and field of view.

Opportunity exists here to link the use of the electron microscope in biology with the physical sciences and with the basic technology of the microscope. Students can research the development of the light and/or electron microscopes and their application in the development of cell theory and scientific knowledge of cellular detail. As with any technology, the microscope and its use have advanced over time - magnification, resolution, imaging, and preparation of specimens have improved. The driving force behind microscope technology is the desire by scientists to view smaller and smaller specimens.

Students should compare different microscopes in terms of illumination, magnification, and specimen preparation.

In Biology 521A, it is appropriate to make students aware of the career opportunities that exist in various areas of biology, and this outcome could provide opportunities to do so. Students may consider cytology, or laboratory technology, or a speciality in electron microscopy as career options.
Introduction to the Microscope  continued...

Suggested Assessment Strategies

Portfolio

- Compile a collection of biological drawings and examples of electron micrographs (or other microscope images) of various organelles and organisms. (214-3, 116-6)

Performance

- Using the Internet, or any other source, research careers involving microscopy. (116-6)

Paper and Pencil

- Create biological drawings using prepared slides. (214-3)
- Using a chart, compare/contrast the light and electron microscopes. Details to consider include illumination, magnification, specimen preparation, and resolution. (116-6, 115-5)

Journal

- Describe field of view and depth of view, and how magnification is calculated. (212-7, 213-3, 214-3)

Resources

Investigation 1A: “Caring for and Using a Microscope,” MHR Biology, pp. 15-19.

Appendix E: “How to make a Biological Drawing,” MHR Biology, p. 742

BLM 1-2: “The Resolving Power of Light and Electrons”

MHR Biology, pp. 20-22
# Interaction of Cell Structures

## Outcomes

*Students will be expected to*

- compare and contrast different types of prokaryotic and eukaryotic cell (314-7)
  - describe the structural differences between prokaryotic and eukaryotic cells
  - observe features of prokaryotic and eukaryotic cells using microscope technology

- describe the appearance of cell organelles visible with the light and electron microscopes (314-6)
  - examine and compare images of cell structure generated by both the light and electron microscopes
  - describe the role of the following cellular structures:
    1. cell membrane
    2. cytoplasm
    3. nucleus
    4. nucleolus
    5. endoplasmic reticulum
    6. ribosome
    7. mitochondria
    8. chloroplast
    9. vacuole
    10. vesicle
    11. Golgi apparatus
    12. microtubules/filaments
    13. cilia
    14. lysosome
    15. peroxisomes
    16. flagella
    17. cell wall
  - compare plant and animal cells in terms of types of organelles present

## Elaborations—Strategies for Learning and Teaching

Specimens can be selected that illustrate prokaryotic features (e.g., cyanobacteria, *lactobacillus* in yogurt). Eukaryotic examples can be selected from prepared slides that will illustrate their characteristics. A variety of structures are visible with the light microscopes that will be used by the students. Examples include, but are not limited to, chloroplasts in leaf stomata; leucoplasts in unripe bananas; nuclei in yeast; nuclei, vacuoles, and cell walls in onion epithelium. A variety of specimens should be examined to illustrate to students that not all cells are identical despite the similarity of cellular structures. Use of a video microscope is extremely useful in illustrating the structure of cells in a larger group setting.

Micrographs produced by both transmission electron microscopes and scanning electron microscopes could be made available for student examination. These will illustrate details of some cell structures that cannot be distinguished by students in a laboratory setting. Textbooks and Web sites are a good source for these resources.

Physical models, charts of cells, and Internet Web sites graphically illustrate structures of cells and distinguish features predominant in plant or animal cells.

Comparing the working of a cell’s organelles to a functioning city (town, school, etc.) could be an effective strategy for emphasizing the role of each organelle and how they work together.
Interaction of Cell Structures

Suggested Assessment Strategies

Presentation

- Design an organism (unicellular) with specific characteristics. Identify the organelles present and the relative quantity of each. Present your unicellular organism to the class with an explanation of its attributes and related composition. (314-6, 314-8)

Paper and Pencil

- Individually or in groups of two, prepare a chart to contrast some of the elements studied in this section. Suggestions may include:
  - plant versus animal cells
  - eukaryotic versus prokaryotic cells
  - light microscope versus scanning electron microscope
  - light microscope versus transmission electron microscope
  - scanning electron microscope versus transmission electron microscope. (314-6, 314-7)

- Complete a chart for a eukaryotic cell containing the following headings: organelle name, structure, function, plant or animal. (314-6, 314-7, 314-8)

Resources

MHR Biology, p. 23
Investigation 1A: “Caring for and Using a Microscope,” MHR Biology, pp. 15-19

Core Lab #2
Mini Lab: “Observing Stained Cells,” MHR Biology, p. 24

MHR Biology, pp. 24-33
Images can be found throughout chapters 1 and 2 of MHR Biology

MHR Biology, pp. 24-33

MHR Biology, pp. 24-33
BLM 3-2: “The Energy Organelles”

Comparison of diagrams on pages 25 and 32 of the textbook can aid in highlighting these differences. Note: The ribosome on figure 1.11, p. 25, is incorrect.
Interaction of Cell Structures  continued...

Outcomes

Students will be expected to

- describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion (314-8)

- explain how materials are able to move into and out of cells through a selectively permeable membrane. Include passive transport (osmosis, diffusion, and facilitated diffusion) and active transport (exocytosis and endocytosis, pinocytosis, and phagocytosis)

- define the terms hypotonic, hypertonic, and isotonic

- describe the effects of osmosis on cells with and without cell walls

Elaborations—Strategies for Learning and Teaching

The processes of osmosis and diffusion can be easily illustrated in the classroom by setting up an experiment in which concentration gradients exist. One example involves soaking an egg in vinegar overnight for the purpose of removing the cell while maintaining the membrane intact. The egg should be dried (with a towel), massed, and then placed in each of the following solutions for periods of eight minutes: pure distilled water; distilled water with 5% salt; distilled water with 10% salt; and distilled water with 20% salt. The egg must be dried and massed after 8 minutes in each of the solutions. The students can then tabulate and explain the results.

Creation of a model cell by students is an effective method, as well, to show passive, yet selective, transport through a membrane. Dialysis tubing or a sandwich bag can be utilized to represent the cell membrane. Example: starch, sugar and water inside the cell; iodine and water outside.

Students can explore the concept of osmosis and the influence of hypotonic, hypertonic and isotonic solutions by discussing how foods are preserved (sugar and salt); why plants may be adversely affected by too much fertilizer; why vegetables are sprayed with water at the local grocers; and how intravenous fluids are used in medical situations.

A good way to illustrate the effects of osmosis on cells with and without cell walls is by inflating a balloon versus inflating a balloon inside a closed shoe box.

Several laboratory investigations exist that illustrate the effect of osmosis on the cell. Pages 34 and 35 of this guide identify activities that partially address outcome 314-8.

Teachers may wish to address outcome 314-3 (curriculum guide, p.64) prior to outcome 314-8. Outcome 314-3 relates to structure and function of important biochemical compounds (carbohydrates, lipids, and proteins) which are addressed in Section 2.1, pp. 42-46 of McGraw-Hill Ryerson Biology.
Interaction of Cell Structures  *continued*...

**Suggested Assessment Strategies**

**Performance**
- Design and carry out a controlled experiment, using an egg as a model cell and salt solutions (varying concentrations) to test hypotheses concerning osmosis and diffusion. (213-2, 213-5, 314-8)

**Presentation**
- Observe demonstrations prepared on osmosis and/or diffusion and explain observations made based upon understanding of these concepts. (213-5, 214-3)
- Investigate one topic related to osmosis and diffusion (hypertonic, hypotonic and isotonic solutions), individually or in groups. You may also select an original topic approved by the teacher. Record your findings and be prepared to present them to the class. Suggested topics include
  - food preservation
  - wilting of plants (plasmolysis of onion cells)
  - effects of too much fertilizer on plants
  - why IVs must contain isotonic solutions
  - difficulties that must be dealt with as fish (salmon) move from fresh to salt water, or vice versa. (314-8, 213-5, 214-3, 215-6)

**Journal**
- If a cell membrane were completely permeable, how would this affect the cell? (314-8)

**Resources**

- MHR *Biology*, pp. 50-64
- BLM 2-2: “Illustrating Concentration Gradients”
- BLM 2-1: “Osmosis in a Living Potato Cell”
Interaction of Cell Structures (continued)

Outcomes

Students will be expected to

- carry out procedures controlling major variables and adapting or extending procedures where required (213-2)
  - perform an experiment to illustrate why cells are limited in their size (the relationship between surface area and volume)
  - investigate the relationship between membrane surface area and cell size, and summarize findings
- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion (214-11)

Elaborations—Strategies for Learning and Teaching

The laboratory outcomes (213-2, 213-3, 213-5, 213-8, 214-3, 214-11, 215-6) and, in part, outcome 314-8 can be addressed by completing Investigation 2B: Osmosis in a Model Cell (Note: Exploring Further question #6, p. 57, is an important part of this lab) and Investigation 2A: “The Limits of Cell Size.” As an alternative to “The Limits of Cell Size,” students may construct cells from cubes of potato and immerse them in a potassium permanganate solution. Data collected from the lab should be organized in an appropriate format for discussion and display. Surface area and volume of a sphere can be studied mathematically.

**Surface Area to Cell Size**

<table>
<thead>
<tr>
<th>Radius of Sphere</th>
<th>Surface Area $4\pi r^2$</th>
<th>Volume $\frac{4}{3} \pi r^3$</th>
<th>Surface/Volume Ratio</th>
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Students could be asked to turn in a laboratory write-up, answer questions based on the relationships seen through the laboratory work, or discuss additional potential difficulties that cells may experience as they increase in size.

Students can suggest and/or design an experiment that was suggested by their work. This can be evaluated for completeness, originality, and logical thought processes.
Interaction of Cell Structures  continued...

Suggested Assessment Strategies

Performance

• Perform a laboratory activity to investigate the relationship between cell surface area and cell size, and complete the evaluation requirement as indicated. (213-2, 213-3, 213-5, 214-3, 215-6, 214-11)

(Once the experiments have been designed and intentions stated, an opportunity exists for assessing how the students actually perform the intended activity. The following points should be considered:

– Is their plan adequate?
– Is the plan followed?
– Are experimental techniques utilized properly and safely?
– Are unexpected events dealt with effectively?)

Presentation

• Present your experimental findings to your teacher and/or entire class group. Explain the rationale behind the experiment and be prepared to answer questions on the data collected. Questions you should think about include the following: Did any questions arise during the course of this experiment that might lead to further investigations? If so, what were they? Are there any ways that the experimental design you followed could have been improved? If so, how? (214-3, 214-11)

Journal

• Why are the cells of an elephant not larger than those of a cat? (213-2, 314-8)

Resources

Core lab #3  Investigation 2A: “The Limits of Cell Size,” MHR Biology, pp. 54-55
Investigation 2B: “Osmosis in a Model Cell,” MHR Biology, pp. 56-57
BLM 2-1: “Osmosis in a Living Potato Cell”
Photosynthesis and Respiration

Outcomes

Students will be expected to

- compare and contrast matter and energy transformations associated with the processes of photosynthesis and aerobic respiration (314-9)

  - explain the importance of the processes of photosynthesis and aerobic respiration for individual organisms

  - demonstrate, using equations and the carbon cycle, that photosynthesis and aerobic respiration are complementary processes

  - explain the importance of the processes of photosynthesis and aerobic respiration on a global basis

  - define ADP and ATP and briefly describe how they are involved in energy storage and energy transfer.

  \[(ADP + P + \text{Energy} \leftrightarrow ATP)\]

Elaborations—Strategies for Learning and Teaching

The emphasis of this outcome (314-9) is the difference between aerobic processes and photosynthetic processes. It is not intended for students to investigate biochemical processes (such as Krebs Cycle, glycolysis, electron transport chain, and so on) or light and dark reactions associated with plant growth.

Teachers should explain that photosynthetic organisms, using light as an energy source, remove \(\text{CO}_2\), water, and other materials from their environment in order to assemble more complex organic compounds and release, as a by-product, oxygen gas. They should also explain that respiration is a chemical process utilized by all organisms to extract energy from organic molecules. These organic substances are broken down into the components of \(\text{CO}_2\) and water, and the energy released is utilized by the organism for its own purposes, or released into the environment.

An analysis of the role of photosynthesis as the biological basis of the primary industries of agriculture, forestry, and the fisheries would be appropriate. This may lead into a subsequent discussion of how the human population has an effect upon these processes through the release of specific chemical compounds into the environment, intentionally or unintentionally, and the impacts this may have. Students may also suggest ways that humans are manipulating these natural processes of photosynthesis and respiration directly through their activities (such as selective breeding to increase productivity), and the potential ramifications of these activities.

Laboratory experiments can be performed to help students investigate the two basic and critical processes of photosynthesis and respiration. The consumption of \(\text{CO}_2\) by a water plant during the process of photosynthesis can be visually illustrated using a methylene blue solution. (Methylene blue changes to yellow in an acidic solution, such as when \(\text{CO}_2\) is added; conversely, it reverses to blue when \(\text{CO}_2\) is removed.) Students may design and/or perform an experiment that demonstrates the production of starch by leaves during photosynthesis. Students could be asked to design and/or perform a chromatography experiment to demonstrate that plant leaves contain a range of pigments involved in the process of photosynthesis.

Students should be aware that some microorganisms are capable of metabolizing without the presence of oxygen (anaerobic respiration), and that these organisms are used in fermentation. Connections should also be made between muscle fatigue and oxygen deprivation with respect to anaerobic respiration.
### Suggested Assessment Strategies

#### Performance

- Discuss plans for an experimental design, including how your group intends to proceed, measure variables, and record data. Demonstrate understanding of the task at hand (development of a hypothesis and a workable plan), clarity of thought, and logical creativity. Possibilities for investigations may include:
  - production of sugars by plant leaves;
  - effects of temperature, light, and sugar concentration on gas production by yeast;
  - variety of pigments found in the leaves of plants;
  - respiration in germinating plant seeds compared to boiled seeds. (213-2, 213-5, 214-3, 215-6, 314-9)

(For assessment purposes, teachers should consider whether students follow their design, use correct techniques, work safely, and troubleshoot as required.)

#### Presentation

- Present to the class the results and conclusions of your experiment. Be prepared to explain your experimental design and why you made certain decisions during the planning and implementation. Based on your lab experience, design an additional experiment to answer a question that arose from your previous data.

(This could be evaluated for completeness, originality, and logical thought.) (213-2, 214-3, 215-6, 314-9)

#### Paper and Pencil

- Prepare a demonstration to illustrate the consumption of CO\(_2\) or production of O\(_2\) by a water plant found in a local pond/stream or pet store, or a demonstration to monitor production of O\(_2\) bubbles versus light intensity. Record your observations and explanations. (213-2, 214-3, 314-9)

---

### Resources

- **MHR Biology, pp. 73, 82-84, 86-88, 90**
- **MHR Biology, pp. 82, 73**
- **MHR Biology, pp. 86, 87**
- **MHR Biology, pp. 86-88, 90**
Biodiversity (~24 Classes)

Introduction

Millions of living things have been recently classified, with more constantly being identified. Scientific opinion suggests that the total number of species in existence may be anywhere from ten to thirty million. Dealing with a system as large and widespread as this requires a taxonomic organizational structure to allow scientists and students to investigate the types and characteristics of these living things. This unit introduces Linnaeus’ classification system as a basis for this study.

Organisms exhibit a huge range of diversity, yet maintain a number of basic things in common. All living things are therefore unique, in this, their unity and diversity. An appreciation for this paradox is encouraged as students are given the opportunity to experience an array of organisms through a logical survey of the taxonomic categories of life, and to investigate their anatomy, physiology, and life cycles.

Focus and Context

This unit on biodiversity emphasizes scientific inquiry and observation. There are ample opportunities for students to sample and gain an appreciation for the diversity and complexity of life on Earth through their investigation of the classification of these living things.

Science Curriculum Links

Students begin looking at different examples of living things early in the primary grades. In the elementary grades, the concept and importance of classification systems and the diversity of living things are discussed. At this level students compare characteristics of common mammals, birds, reptiles, fishes, and arthropods. The intermediate grades provide an explanation as to how biological classification can take into account the diversity of life on Earth. In Science 421A students add another variable to the concept of biodiversity when they are given the opportunity to discuss how biodiversity contributes not only to the variety within an ecosystem, but also to its sustainability.
## Curriculum Outcomes

<table>
<thead>
<tr>
<th>STSE</th>
<th>Skills</th>
<th>Knowledge</th>
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<tbody>
<tr>
<td><strong>Nature of Science and Technology</strong></td>
<td><strong>Students will be expected to</strong></td>
<td><strong>Students will be expected to</strong></td>
</tr>
<tr>
<td>115-7 explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced</td>
<td><strong>Performing and Recording</strong></td>
<td>313-1 analyse and explain the life cycle of a representative organism from each kingdom, including a representative virus</td>
</tr>
<tr>
<td><strong>Relationships between Science and Technology</strong></td>
<td><strong>116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology</strong></td>
<td>316-5 use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy</td>
</tr>
<tr>
<td><strong>118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives</strong></td>
<td><strong>213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data</strong></td>
<td>316-6 describe the anatomy and physiology of a representative organism from each kingdom, including a representative virus</td>
</tr>
<tr>
<td><strong>213-6 use library and electronic research tools to collect information on a given topic</strong></td>
<td><strong>Analysing and Interpreting</strong></td>
<td><strong>214-1 describe and apply classification systems and nomenclatures used in the sciences</strong></td>
</tr>
<tr>
<td><strong>214-2 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies</strong></td>
<td><strong>214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flowcharts, tables, graphs, and scatter plots</strong></td>
<td><strong>214-17 identify new questions or problems that arise from what was learned</strong></td>
</tr>
<tr>
<td><strong>Communication and Teamwork</strong></td>
<td><strong>215-6 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise</strong></td>
<td><strong>215-6 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise</strong></td>
</tr>
</tbody>
</table>
### Classifying Living Things

**Outcomes**

*Students will be expected to*

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
  
  - explain how scientific classification systems have developed

- describe and apply classification systems and nomenclatures used in the biological sciences (214-1)
  
  - list and describe the eight major categories of the classification system
    - domain
    - kingdom
    - phylum
    - class
    - order
    - family
    - genus
    - species
  
  - explain the advantages of binomial nomenclature

- demonstrate how to use a taxonomic key to group and identify an organism

**Elaborations—Strategies for Learning and Teaching**

This section provides a structural framework for the subsequent study of living things.

Students could research some of the newer techniques involved in the classification of organisms, and compare these techniques with the methods utilized by early scientists such as Aristotle or Linnaeus.

Use of a biological classification key to identify organisms (e.g., microorganisms, weeds, insects, leaves) increases students’ understanding of the complexities of taxonomy. Microslide sets allow students to work their way through a biological key. As well, other examples of keys are commercially available. Students may design their own keys, which could be used by others in the class to identify specific items or organisms.

It must be recognized that in addition to these classifications, subcategories (superclass, suborder) exist, adding further layers of complexity to this system.

The binomial nomenclature system is a standardized, accepted way of naming organisms. Furthermore, similar organisms have similar names. For example, *Canis lupus* (wolf) is similar to *Canis latrans* (coyote). The first word is the genus and the second word is the specific epithet (an adjective used to describe the genus).
## Classifying Living Things

### Tasks for Instruction and/or Assessment

**Laboratory Activities**
- Visit a locally accessible ecosystem and observe its organisms. Develop a grouping system for what you observe, and provide a rationale for your system of biological organization. (214-2, 316-5)

**Paper and Pencil**
- Using the sheets of animalcules (imaginary critters, e.g., various candy, nuts and bolts) provided, prepare an efficient biological classification key that could be used to identify five of these imaginary creatures. (214-2)
- Using sample organisms provided by your teacher, develop a simple classification key suitable for their identification. Upon its completion, exchange this key with that of a classmate and use it to identify one of the organisms. Discuss with this classmate any strengths or weaknesses noticed in each other’s work. (115-7, 214-2, 316-5)
- Write a short research paper on the contribution of Linnaeus to the classification of living things. (214-1)
- Develop a dichotomous key to classify your classmates into distinct categories. (214-2, 214-3, 316-5)

### Resources

- MHR Biology, pp. 104-109, 104-105, 108
- BLM 4-2: “What is a Swizzle?”
- MHR Biology, pp. 108-109
Classifying Living Things  *continued...*  

### Outcomes

*Students will be expected to:*

- compile and organize data to facilitate interpretation of the data (213-5)
- compile and display evidence and information in a variety of formats (214-3)
- work co-operatively to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- use organisms found in a local or regional ecosystem to demonstrate an understanding of the fundamental principles of taxonomy (316-5)
- identify new questions or problems that arise from what was learned (214-17)
- identify limitations of a biological classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
  - examine the common names of some species of organisms and show the inadequacies and language problems associated with this method of identification
- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
- analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)
- construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6)

### Elaborations—Strategies for Learning and Teaching

The laboratory outcomes (213-5, 214-1, 214-3, 214-17, 215-6) and, in part, outcome 316-5 are addressed by completing Investigation 4A: “Creating A Dichotomous Key.” The intent of this lab is to expose students to classification based on observable characteristics, rather than to identify specific anatomical characteristics of beetles.

Students can be provided with, or research, examples of organisms in which the classification based on physical attributes categorizes the organisms differently as compared to classification based on DNA evidence.

The use of common or local names for a species can be confusing. For example, bakeapple (*Rubus chamaemrus*), is also called cloudberry.

The STSE component “Modern Classification Technologies” (Appendix B) targets, in whole or in part, specific curriculum outcomes 115-7, 116-2, 118-6, 214-17, 316-5. Teachers should note that students are only expected to have a basic understanding of the process of DNA amplification. They are not expected to know the step-by-step process as presented in figure 2 of the STSE module.
Classifying Living Things  continued...

Tasks for Instruction and/or Assessment

Presentation

• Present the results of your research on modern classification techniques to your class. You can use any appropriate format (oral, poster, or computer presentation). (115-7, 116-2, 213-6)

• Select one of the organisms you observed and investigate its classification utilizing Linnaeus’ system. Use a visual format to share this classification with other class members. (Teachers should ensure that a wide variety of organisms are included so students can choose different organisms.) (214-1, 316-5)

Performance

• Collect samples of local flora and fauna (e.g., insects, flowers, trees) and use appropriate field guides and dichotomous keys to classify. This collection should be made at an appropriate time when weather conditions are favourable. (316-5)

Resources

Core Lab #4  Investigation 4A: “Creating a Dichotomous Key” MHR Biology, pp. 110-111

MHR Biology, p. 112

Appendix B: “Modern Classification Techniques”
Classifying Living Things  continued...

Outcomes

Students will be expected to

- use library and electronic research tools to collect information on modern techniques used in the classification process (213-6)

- identify new questions or problems that arise from what was learned (214-17)
  - recognize the difficulties inherent in the categorization of some organisms into distinct groups and identify the limitations of a five-kingdom system that led to the six-kingdom system

- describe how classification systems improved as a result of the development of modern techniques (116-2)

- identify limitations of a biological classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
  - explain why a virus does not fit neatly into the existing classification system

Elaborations—Strategies for Learning and Teaching

Students should briefly explain modern techniques used in the classification process, including

(i) radioactive dating
(ii) biochemical information (DNA/protein comparisons)
(iii) structural information
(iv) comparative embryology
(v) cellular structure
(vi) behaviour.

Examples of difficulties in classifying organisms and a discussion of how decisions were made could be introduced (e.g., Limulus—horseshoe crab, members of the Protista kingdom). These examples can be used to remind students that no classification system is etched in stone, and that one of the advantages of Linnaeus’ system is its adaptability. Recently, the Linnaeus system has changed as new knowledge about bacteria has been discovered. The adaptability of Linnaeus’ system is evident in its change from a five-kingdom to a six-kingdom system. Students should also be aware that different interpretations can lead to defining additional kingdoms.

Through the use of modern techniques, organisms once thought to be closely related have been found to be unrelated, and vice versa. For example, Echinodermata (e.g., sea stars, sea urchins) are more closely related to the chordates than to any invertebrate.

Teachers should be aware that viruses, according to the McGraw-Hill Ryerson Biology text, are not classified in any kingdom of living things because, by definition, they are not organisms. They lack many of the characteristics of living things. They have no cellular structure (i.e., no cytoplasm, organelles, or cell membrane) and they are not able to grow, respire, or reproduce independently.

Students should be aware that a virus’ ability to induce reproduction of its nuclear material qualifies them as organisms under some definitions. It may be timely to address, in part, outcome 313-1 by having students analyse and explain the life cycle of the T4 virus.
### Classifying Living Things  *continued...*

#### Tasks for Instruction and/or Assessment

**Performance**
- Debate whether or not a virus is alive.  (214-2, 316-6, 214-17)

**Presentation**
- Research information regarding the Dinosaur-Bird debate (Thinking Lab: “The Dinosaur-Bird Debate”) and present your findings to the class.  (214-17, 213-6, 116-2)
- Create a presentation on one of the major phyla or classes within the animal kingdom, using electronic and/or other research. (Teachers should ensure that a good variety of organisms are selected within the class.)  (316-6, 214-17)

#### Resources

- MHR *Biology*, pp. 113-116
- MHR *Biology*, pp. 104-107
- MHR *Biology*, pp. 117-120
- MHR *Biology*, pp. 122-126
Diversity among Living Things

Outcomes

Students will be expected to

• describe the anatomy and physiology of viruses and organisms from each kingdom (316-6)

  – identify the general characteristics (cell type, cell wall, nutrition, body form, nervous system, reproduction, locomotion) that distinguish the members of the six recognized kingdoms (Bacteria, Archaea, Protista, Fungi, Plantae, Animalia) from each other.

  – identify examples of members of each of the kingdoms

• analyse and explain the life cycle of a representative organism from each kingdom, including a representative virus (313-1)

  (i) Virus - T4 (Lytic Cycle)
  (ii) Bacteria/Archaea - E. coli
  (iii) Protista - Plasmodium
  (iv) Fungi - Rhizopus
  (v) Plantae - Fern
  (vi) Animalia - Frog

Elaborations—Strategies for Learning and Teaching

Students should demonstrate an understanding that the six recognized kingdoms of living things represent a diversity of organisms exhibiting extensive variety in terms of form and function.

*Teachers should note that this section is intended to provide students with a brief overview of biodiversity. For consistency and clarity, Appendix A provides teachers with tables that illustrate content and required depth of treatment.*

An effort should be made to use organisms that are easily available and/or indigenous to the local area. Teachers may consider the following as examples of organisms that may help illustrate some of the characteristics of each kingdom:

Lactobacillus in yogurt, pond water organisms, yeast, mushrooms, mosses, flowers, grasshoppers, earthworms, sea stars, trout, frogs, and pigs. A variety of tools/techniques - including wet mounts, prepared slides, classification sets, models, specimens, dissections, computer simulations, etc. - may provide hands-on activities to reinforce students’ learning. Commercial charts are also available that summarize the anatomy, physiology, and life cycles of many organisms.

See appendix A, table 1, Kingdoms. Note: viruses do not fit readily into the McGraw-Hill Ryerson text classifications of living things; therefore, they are not included in the kingdoms table.

The student tables presented in the appendices could be treated as resource-based learning activities whereby students access resources outside the textbook to develop their knowledge. Information presented in the appendices represents core content.

The life cycles of the organisms identified in the delineations may be studied at an appropriate time (within the study of a particular kingdom) rather than as a completely separate section. Teachers may wish to consider integrating SCO 316-6 at this time for organizational purposes.

The examples given are not necessarily representative of every member of each kingdom. In fact, students should now begin to realize how difficult it is to select one representative organism for each kingdom.

Since Bacteria and Archaea have very similar life cycles, it is unnecessary to study both. E. coli is an example of Bacteria and is a good representative of both.

As enrichment, teachers may choose to discuss the retrovirus (HIV) which has a more complex life cycle.
Diversity among Living Things

Tasks for Instruction and/or Assessment

Presentation

- Select, with the teacher's guidance, a virus, or a member of one of the groups of organisms that were discussed. For example, research a virus - its anatomy, physiology, and life cycle. Present the information on this organism to the rest of the class in the form of a model and/or poster and a brief oral report. Include any new or surprising pieces of information that you collect, and indicate where this organism might be found. (313-1, 316-6)

Paper and Pencil

- For each of the six kingdoms, identify the general characteristics (cell type, cell wall, nutrition, body form, nervous system, reproduction, locomotion) that distinguish the members of the kingdoms (Bacteria, Archaea, Protista, Fungi, Plantae, Animalia) from each other. This can be compiled in the form of a chart (see appendix A, table 1). (316-6)
- Identify examples of members of each of the six kingdoms (316-6)
- Certain organisms have not changed greatly over time (e.g., sharks, crocodiles, turtles). Students could determine what features have allowed them to remain relatively unchanged. (316-6)

Resources

- MHR Biology, Chapters 4-6 (throughout)
- MHR Biology, pp. 164-167
- Chapters 4-6 (throughout)
- “Table #1: Kingdoms Worksheet,” Appendix A
- BLM 4-3: “The Six Kingdoms”
- BLM 5-1: “Make Your Own Yogurt”
- BLM 5-2: “Cell Growth”
- BLM 5-4: “Unscrambling Micro-Organism Terms”

- MHR Biology, pp. 123, 134, 146
- MHR Biology, pp. 154, 173, 193
Diversity among Living Things  continued...

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be expected to</td>
<td>It is not the intention of this outcome to have students recognize or describe the phyla of the major Protista groups.</td>
</tr>
<tr>
<td>describe the anatomy and physiology of viruses and organisms from each kingdom (316-6)</td>
<td>Students should describe the general characteristics (cell wall, motility, nutrition, mode of reproduction) that differentiate the Protista groups (Protozoa, Algae, Slime and Water Moulds). Although students should have a general appreciation for these characteristics that contribute to the diversity of the three major groups, they should also appreciate the plant-like, animal-like, and fungus-like attributes of these major groups as well.</td>
</tr>
<tr>
<td>– describe the differences that exist between Protista groups (Protozoa, Algae, Slime and Water Moulds)</td>
<td>The laboratory outcomes (213-5, 214-3, 214-17, 316-5) are addressed by completing Investigation 5A: “Sampling Pond Organisms.” Pond samples can be collected. This is an excellent opportunity for students to practice their microscopy skills in a relevant context, select an appropriate format to compile and display data, identify the biodiversity that exists in a local ecosystem, and work co-operatively with their peers to plan and problem solve.</td>
</tr>
<tr>
<td>• compile and organize data to facilitate interpretation of the data (213-5)</td>
<td></td>
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<tr>
<td>• compile and display evidence and information in a variety of formats (214-3)</td>
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<td>• work co-operatively to develop and carry out a plan, and troubleshoot problems as they arise (215-6)</td>
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<tr>
<td>• use organisms found in a local or regional ecosystem to demonstrate an understanding of the fundamental principles of taxonomy (316-5)</td>
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</tbody>
</table>
Diversity among Living Things  continued...

Tasks for Instruction and/or Assessment

Performance

- Collect samples of local pond water and use microscopy techniques to identify as many organisms as possible. (213-5, 214-3, 214-17, 316-5, 316-6)

Paper and Pencil

- List the three major groups of the kingdom Protista. For each group, identify
  - mode of nutrition
  - presence/absence of cell walls
  - motility
  - mode of reproduction.
- Given a list of terms and/or descriptions related to the characteristics of the three major Protista groups, complete a concept map. (213-5, 214-3, 316-6)
- Explain why slime and water moulds may be difficult to classify.

Resources

MHR Biology, pp. 140, 147, 150-151
BLM 5-4: “Unscrambling Micro-Organism Terms”

Core Lab #5 Investigation 5A: “Sampling Pond Organisms,” MHR Biology, pp. 142-143
### Outcomes

*Students will be expected to*

- describe the anatomy and physiology of viruses and organisms from each kingdom (316-6)
  - describe the differences that exist between nonvascular and vascular plants

- explain why angiosperms are the most diverse plant group

- describe distinguishing characteristics of the invertebrate phyla

- explain why arthropods are the most successful phylum of animals

- describe distinguishing characteristics of the vertebrate classes

### Elaborations—Strategies for Learning and Teaching

For consistency and clarity, appendix A provides teachers with tables that illustrate content and required depth of treatment.

See appendix A, table 2, Plants.

As it is impossible to include a complete summary of the plant phyla, our focus will be on the comparison of non-vascular and vascular plants.

To explain the diversity of angiosperms, discussion should include mention of these key factors: 1) the assistance of animals, wind, and water in pollination; 2) the presence of structures in plants specific to attracting certain animal pollinators whom the plants supply with food; 3) the ways in which seeds are protected; 4) the functions of fruits and specialized structures in seed dispersal; and 5) the presence of specialized tissues in plants to help them survive heat, cold, and drought.

Discussion of the invertebrate phyla should be limited to the following characteristics:

- lack of internal skeletal structures
- both asexual and sexual reproduction (larval stages predominant in many life cycles)
- body cavity development, including acoelomate form (flatworm) and coelomate form (earthworm)
- adult body symmetries, including asymmetrical (sponges), radial (jelly fish), and bilateral (earthworm)

In discussing the diversity of arthropods, reference can be made to insects which biologically are the most successful class of arthropods. *Note the variety of characteristics contributing to the success of insects, including adaptations for feeding, reproduction, and movement. Small body size, a short life cycle, social behaviour, and adaptations in appearance should be mentioned.*

Discussion of the vertebrate classes should be limited to the following features: endoskeleton, respiration, circulation, and reproduction.
Diversity among Living Things  *continued*...

### Tasks for Instruction and/or Assessment

#### Performance

- Observe vascular transport by placing celery stalks or a fern in food colouring. Wet mounts could also be made to observe the vascular tissue. (316-6)
- Observe how food colouring travels through the vascular tissue of carnations by viewing the edges of the petals, prior to and after placing flowers in coloured water. (316-6)

#### Paper and Pencil / Presentation

- Identify and describe the characteristics of angiosperms that contribute to their diversity. These characteristics and descriptions could be presented on a poster, Web page, slideshow, or concept map (Inspiration software). (316-6)
- Identify and describe the characteristics of anthropods that contribute to their biological success. (316-6)
- Describe the advantages of an organism having a jointed external skeleton. (316-6)

#### Journal

- Design an animal and describe the characteristics that would contribute to its biological successes and its limitations. (316-6)

- Why is biodiversity necessary to the health and sustainability of an ecosystem? (118-6, 214-17, 316-6)

### Resources

<table>
<thead>
<tr>
<th>“Table #2: Plants Worksheet,” Appendix A</th>
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<tbody>
<tr>
<td>MHR <em>Biology</em>, pp. 169-181</td>
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<tr>
<td>BLM 6-1: “Key to the Evergreens”</td>
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<tr>
<td>MHR <em>Biology</em>, pp. 174-179 and 181</td>
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<tr>
<td>BLM 6-3: &quot;Plant Reproduction&quot;</td>
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<tr>
<td>MHR <em>Biology</em>, pp. 182-186</td>
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<tr>
<td>MHR <em>Biology</em>, pp. 186-188</td>
</tr>
<tr>
<td>MHR <em>Biology</em>, pp. 190-194</td>
</tr>
<tr>
<td>BLM 6-4: “Fish and Temperature Regulation”</td>
</tr>
</tbody>
</table>
Maintaining Dynamic Equilibrium I
(~32 Classes)

Introduction

Cells, tissues, organs, organ systems, and ultimately organisms must maintain a biological balance despite changing external conditions. Homeostasis is the state of internal balance so critical to existence. It represents a dynamic equilibrium displaying constant interactions and checks and balances both within organisms and between organisms and their environment. There are a variety of systems within living things responsible for the maintenance of this delicate balance. This unit will identify and introduce the role of those animal systems, including the circulatory, respiratory, digestive, excretory, and immune systems. The vital links that exist between them will be investigated.

Focus and Context

This unit has its primary focus on decision making, as social and environmental issues are considered. This STSE component contributes to the development of scientific literacy and a sense of global citizenship. In addition, there are numerous opportunities for problem solving and scientific inquiry incorporated into the discussion of the circulatory, respiratory, digestive, excretory, and immune systems.

Science Curriculum Links

Biology students have studied the components of body systems at a number of different levels. Students in grade 2 are introduced to the importance of maintaining a healthy lifestyle. When they reach grade 5, they begin to discuss the roles of specific body systems in growth and reproduction. The major components of the structure and functions of the digestive, excretory, respiratory, circulatory, and nervous systems are introduced. The contributions of the skeletal, muscular, and nervous systems to movement are also integrated into their study. In addition, body defences against infection and nutritional requirements for health are discussed. When students reach grade 8, they begin to consider the basic factors that affect the functioning and efficiency of the human respiratory, circulatory, digestive, excretory, and immune systems, and are encouraged to discover and describe examples of the interdependence of various systems of the human body. These activities provide a good introduction to the role of systems in the maintenance of homeostasis, discussed in more detail here. A cross-curricular link exists between the life sciences and physical sciences in the discussion of dynamic equilibrium incorporated into the study of chemistry and physics.
## Curriculum Outcomes

<table>
<thead>
<tr>
<th>STSE</th>
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<td><strong>Students will be expected to</strong></td>
</tr>
<tr>
<td><strong>Nature of Science and Technology</strong></td>
<td><strong>Initiating and Planning</strong></td>
<td>314-1 identify chemical elements and compounds that are commonly found in living systems</td>
</tr>
<tr>
<td>115-5 analyse why and how a particular technology was developed and improved over time</td>
<td>212-6 design an experiment and identify specific variables</td>
<td>314-2 identify the role of some compounds, such as water and glucose, commonly found in living systems</td>
</tr>
<tr>
<td><strong>Relationships between Science and Technology</strong></td>
<td><strong>Performing and Recording</strong></td>
<td>314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, and lipids</td>
</tr>
<tr>
<td>116-4 analyse and describe examples where technologies were developed based on scientific understanding</td>
<td>213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data</td>
<td>317-1 explain how different plant and animal systems help maintain homeostasis</td>
</tr>
<tr>
<td>116-7 analyse natural and technological systems to interpret and explain their structure and dynamics</td>
<td><strong>Analysing and Interpreting</strong></td>
<td>317-3 explain the importance of nutrition and fitness to the maintenance of homeostasis</td>
</tr>
<tr>
<td><strong>Social and Environmental Contexts of Science and Technology</strong></td>
<td>214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flowcharts, tables, graphs, and scatter plots</td>
<td>317-4 identify in general terms the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism</td>
</tr>
<tr>
<td>117-4 debate the merits of funding specific scientific or technological endeavours and not others</td>
<td>214-15 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan</td>
<td>317-6 predict the impact of environmental factors such as allergens on homeostasis within an organism</td>
</tr>
<tr>
<td></td>
<td>215-4 identify multiple perspectives that influence a science-related decision or issue</td>
<td></td>
</tr>
</tbody>
</table>
### Homeostasis

#### Outcomes

Students will be expected to

- explain the concept of homeostasis and its critical nature to living things (317-1)
  - define homeostasis including the concept of dynamic equilibrium
- explain the importance of temperature regulation in maintaining homeostasis (317-3)
  - define homeotherm and poikilotherm
  - describe how homeotherms maintain a dynamic equilibrium
- discuss mechanisms of temperature control, behavioural and physiological

#### Elaborations—Strategies for Learning and Teaching

In this section, students should be given the opportunity to study a variety of factors that affect the homeostasis of an organism. Through this, they will begin to appreciate the complexity of the mechanisms involved in the maintenance of homeostasis. For an illustration of how human systems interact to maintain homeostasis, refer to MHR *Biology*, p. 301.

Teachers might establish a scenario that could be used to show the interdependence of body systems and their importance in the maintenance of homeostasis. Students could brainstorm responses to the questions, What happens to your body as you run? Why? Answers generated by students may include increased heart rate; breathing more quickly and deeply; thirst; feeling sweaty, hot, and tired; or sore muscles. Students should suggest why the body would respond in each of these ways, and what body systems would be involved. For example, they might say that an increased heart rate (circulatory system) increases the distribution of $O_2$/ $CO_2$ (respiratory system) and sugar (digestive system) to and from the tissues.

Temperature regulation is only one of a number of the body’s homeostatic mechanisms. Investigating the importance of temperature regulation is a good introduction to the body’s feedback mechanisms.

Some organisms incorporate behaviours to help control temperature. For example, lions move to shady areas during midday sun, and desert animals are primarily nocturnal.

Physiologically, temperature control can be accomplished through the responses of the circulatory system. Vasoconstriction and vasodilation can assist in this.
## Homeostasis

### Suggested Assessment Strategies

#### Paper and Pencil
- In a group, consider the following questions and prepare a concept map to illustrate the interaction between the reactions produced and the body systems involved in the maintenance of homeostasis. What happens to your body when you are frightened? What happens to your body when you have a cold? Or the flu? (317-3, 317-1, 215-6)

#### Journal
- When a person is sick, he/she often feels tired. How is this tiredness feeling related to the maintenance of homeostasis? (317-1, 317-4)

#### Presentation
- Using an analogy (e.g., a furnace), explain how your body maintains temperature. Present and explain your analogy to the class. (317-3)

### Resources
- **MHR Biology, pp. 300-301**
- **MHR Biology, p. 300**
- **MHR Biology, pp. 300-303**
Circulatory System

Outcomes

Students will be expected to

• explain how the human circulatory system helps maintain homeostasis (317-1)
  – explain the need for a transport system
  – explain how the circulatory system contributes to the maintenance of dynamic equilibrium through its role in the transport of heat energy and matter
  – describe the structure of an artery, vein, and capillary, and relate these structures to their functions in blood circulation

– identify the main components of blood and explain the role of each
  (i) erythrocytes
  (ii) leukocytes
  (iii) platelets
  (iv) plasma

– identify the main components of the human heart and explain the role of each
  (i) atria
  (ii) ventricles
  (iii) valves (bicuspid, tricuspid, semilunar)
  (iv) aorta
  (v) pulmonary vein
  (vi) pulmonary artery
  (vii) septum

– trace the flow of blood through the heart and describe the pulmonary and systemic pathways

– explain how the SA node and AV node control the heartbeat

– explain lymphatic circulation and its purpose

Elaborations—Strategies for Learning and Teaching

All organisms have some mechanism to circulate materials and dispose of wastes. Larger organisms require specialized transport systems in order to ensure that all cells have access to materials required for survival and removal of wastes.

Students could observe within a laboratory situation differences in the physical structure of an artery, vein, and capillary by studying prepared microscope slides. Effects of external factors (temperature, caffeine) on peripheral blood flow can be investigated using liquid crystal thermometers.

Within the laboratory setting, students could use the microscope to examine prepared slides of human blood and to observe the contrasting morphologies and relative abundance of the cellular components (red and white blood cells).

Teachers should note that the clotting process should be addressed while discussing the role of platelets.

Students could use models, dissections, or computer simulations. They could also identify the structures of the heart through the use of drawings or photographs.

Students should be aware that the left AV valve is the bicuspid valve (two sections), and the right AV valve is the tricuspid valve (three sections). The reason for the structural difference is the blood pressure differentials.

During this process students should have the opportunity to observe and appreciate how various structures control the direction of blood flow through a heart. Observation of a heart (by using preserved specimens, models, or computer simulations) will help students clarify how the structure of the heart allows it to function as a mechanical pump. Students could discuss the mechanics and sounds of the heartbeat in relation to this role.
Circulatory System

**Suggested Assessment Strategies**

*Paper and Pencil*

- Sketch the cellular components of blood, label any visible structures, and identify and label the different types of leucocytes. (317-1, 214-3)
- Observe prepared slides of arteries, veins, and capillaries. (317-1, 213-5)
- From prepared slides, sketch diagrams of cross sections of arteries, veins, and capillaries, and compare these cross sections with those of diseased blood vessels. (317-1, 214-3)
- Sketch a diagram of the human heart and use colored arrows to indicate oxygenated/deoxygenated blood flow. (317-1, 213-5)
- Create an animation of the blood flow through the heart. In your animation, describe the major structures of the heart, and their functions. (317-1)
- The lymphatic system is often referred to as an accessory circulatory system. Briefly explain how the lymphatic system works in conjunction with the circulatory system. (317-1, 213-5)
- Using a chart, compare the circulatory and lymphatic systems (vessels, role, fluid, fluid flow). (317-1, 213-5)

**Resources**

- MHR *Biology*, pp. 304-305
- MHR *Biology*, pp. 305-307
- MHR *Biology*, pp. 308-312
- MHR *Biology*, pp. 314-315
- BLM 9-1: "Know the Pathway of Circulation"
- MHR *Biology*, pp. 320, 315
- BLM 9-1: "Know the Pathway of Circulation"
- MHR *Biology*, pp. 315-316
- MHR *Biology*, pp. 322-323
### Outcomes

**Students will be expected to**
- carry out an experiment to relate blood pressure and physical activity and identify the specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5, 214-3)
- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- identify the impact of circulatory diseases on the homeostasis of an organism (317-4)
  - describe disorders linked to the circulatory system and their effect on the homeostasis of the system and the organism as a whole
    (i) hypertension
    (ii) atherosclerosis
    (iii) arteriosclerosis
- analyse why and how technology related to the treatment of circulatory disorders was developed and improved over time (115-5)
  - describe the progress from bypass surgery to modern techniques
    (i) shunts
    (ii) angioplasty
    (iii) clot-busting drugs
- identify multiple perspectives that influence a science-related decision or issue (215-4)

### Elaborations—Strategies for Learning and Teaching


Students could measure their own blood pressure (systolic and diastolic pressures) and investigate the role of posture, exercise, or other activities on blood pressure. All group or class data can be organized and displayed in graph or table form. Similarly, students can measure heart rate prior to, and after, exercise. Students could measure the length of time it takes for heart rate to return to the relaxation levels after varying amounts of activity. Individual and class data can be recorded, plotted, and analysed.

Specific diseases of the circulatory system should be discussed or researched, along with the capability of technology to diagnose, treat, or cure the problem (e.g., angioplasty, clot-busting drugs). Students may research, assess, and debate the role that lifestyle choices play in the development of these disorders, and the importance of promoting continued physical fitness.

Students could investigate other disorders related to the circulatory system—varicose veins, heart murmur, aneurysm, blood clots, leukemia, pulmonary edema (congestive heart failure) — in order to analyse why and how technology related to the treatment of disorders was developed and improved over time.

Teachers may want to engage students in a case study related to the circulatory system (e.g., heart transplant) so they can identify multiple perspectives that influence a science-related decision or issue. “Innovation: heart transplant” from the *Organ & Tissue Donation and Transplantation Resource* could be used to address this outcome, and also address, in part, outcome 115-5.
Circulatory System continued...

Suggested Assessment Strategies

Performance

- Perform an available lab activity designed to illustrate some aspect of a transport/circulatory system. Possibilities include measurement of blood pressure and heart rates, dissection of available specimens to observe the heart and circulatory systems, and observation of the effects of external factors on peripheral blood flow. (212-6, 213-5, 214-3)

Assessment would depend on the nature and depth of the activities selected. Many of these activities involve collection of data that can be tabulated and graphed. Enrichment may be provided by allowing students the opportunity to design their own investigations in response to questions that these activities may generate. For example, students may study the heart rate/blood pressure of a smoker versus a non-smoker, or an athlete versus a non-athlete.

(Teachers should ensure that students are aware that interpretation of statistical data from small sample sizes may not reflect the true nature of the general population.)

Presentation

- Research and present, in a variety of formats, information about disorders linked to the circulatory system, and modern methods of diagnosis and treatment. (317-1, 317-3, 214-3)

- Research and prepare questions related to a topic being presented by a guest speaker. Working in groups, review and revise questions. Following the presentation prepare a brief summary of the answers given to your questions.

Assessment may be based on a student summary of the guest’s talk and/or answers provided to one of their questions. Guest speakers could include individuals knowledgeable in circulatory pathologies — community resources such as physicians; spokespersons for relevant organizations (e.g., Heart and Stroke Foundation); sufferers of circulatory disorders; or transplant recipients. (213-5, 115-5, 214-3)

Journal

- Why do some doctors recommend that heart patients take one tablet of ASA (Aspirin™) a day? (115-5)

Resources

Core Lab #6: Investigation 9B: “The Effect of Stress on Blood Pressure,” MHR Biology, pp. 324-325

OR

Core Lab. #6: Investigation 9A “The Heart Rate of Daphnia” MHR Biology, pp. 324-325

BLM 9-3: “The Heart Rate of Daphnia”

BLM 9-2: “How Much Blood Does Your Heart Pump Per Minute”

MHR Biology, pp. 326-328

Organ & Tissue Donation and Transplantation Resource CD-ROM
Respiratory System

Outcomes

Students will be expected to

- explain how the human respiratory system helps maintain homeostasis (317-1)
  - explain the need for a respiratory surface in humans
  - identify and state the function of
    (i) nasal cavity
    (ii) epiglottis
    (iii) trachea
    (iv) bronchi
    (v) bronchioles
    (vi) alveoli
    (vii) diaphragm

- carry out an experiment to collect data on respiratory function and identify the specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments, to facilitate interpretation of a completed respiratory activity (213-5)
- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)

Elaborations—Strategies for Learning and Teaching

Students should be reminded that humans require a respiratory surface for gas exchange and for the provision of O₂ for respiration at the cellular level.

The respiratory surface must be moist, thin-walled, and large enough for efficient gas exchange. Students should realize that moisture is required to allow gases to dissolve and allow cross-membrane transport. A large surface area aids in efficiency and accounts for the advantage of the mammalian lung.

Students should investigate the mechanics of inhalation/exhalation and the regulation of the breathing cycle. They may construct a model to illustrate the functioning of the diaphragm in respiration. A popular design involves the use of a bell jar, with balloons to represent lungs and a membrane for the diaphragm.

The laboratory outcomes (212-6, 213-5, 215-6) can be addressed by completing Investigation 10A: “Measuring Respiratory Volumes.”

There are many short activities that students could undertake during their investigation of the respiratory system. Students could design and/or perform experiments to investigate the mechanics of breathing. These might include measurement of lung volume and vital capacity using a spirometer, and measurement of breathing rates at different times of rest or activity.

Both individual and class data can be compiled and organized in tabular and graphic form by hand or by using available technology. Comparisons can be made of lung functions by using different groups of individuals in the class depending upon class demographics (e.g., smokers and non-smokers, athletes and non-athletes, asthmatics and non-asthmatics, asthmatics before and after using an inhaler) and correlating with gender and mass. Students should be aware that correlation does not imply causation.
Respiratory System

Suggested Assessment Strategies

Paper and Pencil

- Sketch the respiratory tract and identify the path of air through the tract. (317-1, 213-5)

Journal

- Explain why it is advantageous for humans to inhale through their noses. (317-1)

Performance

- Perform an activity designed to illustrate an aspect of the respiratory system. Activities might include
  - measurement of lung volume and vital capacity using a spirometer
  - measurement of breathing rates under different conditions
  - dissection of available specimens to observe the systems of respiration
  - investigation of air quality indices
  - development of a model illustrating effect of the diaphragm. (212-6, 213-5, 215-6, 317-1)

Assessment would depend on the nature and depth of the activities selected. Many of these activities involve collection of data that can be tabulated and graphed. Enrichment may be provided by allowing students the opportunity to design their own investigations in response to questions that these activities may generate. For example, students may compare the vital capacities of a smoker and a non-smoker; an athlete and a non-athlete; an asthmatic and a non-asthmatic; a male and a female.

(Teachers should ensure that students are aware that interpretation of statistical data from small sample sizes may not reflect the true nature of the general population.)

Resources

BLM 10-1 and 10-2: “The Human Respiratory System”

MHR Biology, pp. 334-337

MHR Biology, pp. 338-339

Core Lab #7 Investigation 10A: “Respiratory Volumes,” MHR Biology, pp. 340-341

BLM 10-3: “Air Pressure and Diffusion of Gases”

BLM 10-4: “Measuring Respiratory Volume Observation Sheet”

BLM 10-5: “Interpreting the Concentrations of Gases in Inhaled and Exhaled Air”
Respiratory System *continued...*

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
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<tbody>
<tr>
<td>Students will be expected to</td>
<td>Specific pathologies of the respiratory system created by respiratory disorders should be discussed or researched, along with the capability of technology to diagnose, treat, or cure the problem.</td>
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<tr>
<td>• identify how respiratory diseases affect the homeostasis of an organism (317-4)</td>
<td>Students may choose to investigate respiratory disorders such as lung cancer, pneumonia, asthma, bronchitis, and emphysema. Students may discuss other environmental concerns related to respiratory difficulties and clean air, including the scent-free policy that exists within many public buildings, sick building syndrome, and smog.</td>
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<tr>
<td>• predict the impact of environmental factors such as allergens on homeostasis within an organism (317-6)</td>
<td>Students could investigate the existence of air quality indices, what they measure, and the units used. Records of these can be obtained for local areas over periods of time and the data graphed or presented in tabular form. Students can hypothesize reasons for varying air quality indices (correlation with weather, environmental events) and the effects on individuals with respiratory difficulties when these indices register high readings.</td>
</tr>
<tr>
<td>– identify the impact of environmental factors on the respiratory system of an asthmatic (i) cigarette smoke (ii) allergens (dust, mould, food) (iii) petrochemical fumes, perfumes</td>
<td>Students could be asked to assess and debate or discuss the effects of legal and over-the-counter drugs on the functioning of the respiratory system, including but not exclusive to nicotine, codeine, and prescription medicines. Students might be asked to investigate provincial and community standards on smoking in public places, and on tobacco advertising. Debates/discussions may involve a discussion of the rights of the smoker versus the non-smoker; the issue of exposure to second hand smoke; why smoking remains an issue among youth, particularly among young women; whether high schools should provide a smoking areas for their students. Alternate approaches to stopping smoking can be investigated (e.g., nicotine gum, patches, acupuncture, hypnotism) and their relative effectiveness compared.</td>
</tr>
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</table>
Respiratory System  continued...

Suggested Assessment Strategies

Presentation

• In a debate, present the results of research and argue against other stakeholders concerning issues such as Should smoking be allowed in public places? Should tobacco companies be permitted to sponsor sporting events? Should tobacco advertising be permitted? In some provinces, young people cannot purchase cigarettes until the age of 19, yet it is not illegal to smoke at a younger age. Is this hypocritical? Should schools provide their students with smoking areas? Sectors of society that will be considered may include lung cancer victims, executives from a tobacco company, students, smokers, and/or clean air activists. (Teachers could assess the participation of selected students on the bases of preparation of the argument and thoroughness of the research.) (117-4, 116-4, 213-5, 215-4, 215-6)

• Research and prepare questions related to a topic being presented by a guest speaker. Working in groups, review and revise questions. Following the presentation, prepare a brief summary of the answers given to your questions.

Assessment may be based on a student summary of the guest’s talk and/or answers provided to one of their questions. Guest speakers could include individuals knowledgeable in respiratory pathologies - community resources such as physicians; spokespersons for relevant organizations (e.g., Lung Association, Canadian Cancer Society); or sufferers of respiratory disorders. (116-4, 117-4, 215-4, 215-6, 214-3, 317-6, 317-1)

Journal

• The incidence of respiratory ailments (e.g. bronchitis) is much greater in urban than in rural environments. What factors might be responsible for this difference? (317-6)

Resources

MHR Biology, p 344-348

MHR Biology, pp 346-348
## Digestive System

### Outcomes

*Students will be expected to*

- identify chemical elements and compounds that are commonly found in living systems (314-1)
  - identify the six basic nutrients (carbohydrates, lipids, proteins, vitamins, minerals, and water) and determine the sources of each of these nutrients

- identify the role of some compounds involved in digestion (314-2)
  - identify the role of the six basic nutrients
  - identify the role of fibre
  - identify the general role of enzymes and secretions, and the role of these substances pertaining to the digestive system

- identify and describe the structure and function of the important biochemical compounds, carbohydrates, proteins, and lipids (314-3)
  - explain the role of hydrolysis and dehydration reactions within the digestive process
  - discuss the basic structural units of carbohydrates, lipids, and proteins
  - discuss the basic structure of carbohydrates, lipids, and proteins
  - identify the end products of digestion for carbohydrates, lipids, and proteins

### Elaborations—Strategies for Learning and Teaching

Outcomes 314-1 and 314-2 describe both the identification of the chemicals (nutrients and enzymes) involved in digestion, and their role in the digestive processes. Alternative approaches are to identify all the chemicals first, then describe their role in the digestive process, or to investigate each individually.

Students should identify the roles of the six basic nutrients. Although fibre is not considered one of the six nutrient because it has no nutritional value, it plays an important role in digestion. Without fibre, the food that we ingest would have little bulk, making it increasingly difficult for peristalsis to occur.

As an introduction to the various biochemical compounds, teachers may provide students with a list of biochemical names or product labels and ask students to identify those that are familiar and describe what they know about the functioning of the compounds identified.

*To understand this component of the biology course, it is sufficient for students to simply recognize that the large molecules of carbohydrates, proteins, and lipids consist of basic smaller components that are the product of digestion.*

Hydrolysis is the breaking apart of larger biochemical molecules by the addition of the parts of a water molecule, $\text{H}^+$ and $\text{OH}^-$. Dehydration synthesis or condensation reactions refers to the removal of a water molecule during the joining of two molecules, such as amino acids or sugars. It is not the intention that students discuss these reactions in detail (e.g., polysaccharide - hydrolysis - disaccharide - hydrolysis - monosaccharide). It may be useful to refer to section 2.1, “The Molecular Basis of Life,” in the student text (pp. 42-47).
Digestive System

Suggested Assessment Strategies

Performance

- To reinforce learning of the steps in the digestive process, imagine that you are eating a meal containing starches, proteins, and fats. Think about what happens to each of these food molecules as they pass through your digestive tract.

  Teachers could choose one student to begin the process by naming the first digestive compartment (the mouth) and describing what happens to one of the food molecules in that location (i.e., chunks of protein are chewed by the teeth). They might then ask the next student to describe what happens to another type of food molecule in that same location (e.g., starch is hydrolysed by amylase). Continue around the room, naming compartments and processes until the end of the digestive tract is reached. (314-2)

- Perform an available lab activity that illustrates an aspect of the digestive system. These may include utilizing qualitative and/or quantitative tests to detect the presence within food of organic substances such as carbohydrates, lipids, and proteins. (314-1, 314-3)

Presentation

- Design a Web page that illustrates the utilization of the six basic nutrients. (314-2, 214-3)

Paper and Pencil

- Create and complete a table involving the six basic nutrients, their roles, and the sources of each (314-1, 314-2)

- Given a variety of product labels, identify those substances that are familiar and describe what you know about the functioning of the substances identified. (314-3)

Resources

- MHR Biology, pp. 354-358
- BLM 11-1: “Nutrients”

- MHR Biology, pp. 355, 363-365, 42-46
**Outcomes**

*Students will be expected to*

- explain how the human digestive system helps maintain homeostasis (317-1)
  - describe the purpose and functioning of the digestive system
  - define mechanical and chemical digestion and explain the relationship between them
  - identify the major organs and glands of digestion and describe their roles in the digestive process
    (i) salivary glands
    (ii) stomach
    (iii) liver
    (iv) pancreas
    (v) gall bladder
    (vi) small intestine
    (vii) large intestine
  - trace the pathway of food through the human digestive tract and explain the efficiency of its structure
    (i) teeth
    (ii) taste buds
    (iii) tongue
    (iv) mucous lining
    (v) sphincters
    (vi) villi

**Elaborations—Strategies for Learning and Teaching**

Students should be aware that the purpose of digestion is to convert large molecules into smaller ones capable of being utilized by the cell.

It is important to have students distinguish between the digestive organs (e.g., stomach, small intestine, oral cavity) through which food travels, and the accessory digestive organs that assist with digestion via secretions (e.g., liver, pancreas, salivary glands).

The chart provided in appendix A represents the minimum level of student understanding.

Students should be provided with the opportunity to observe the principal features of the digestive system by utilizing models, computer simulations, or dissection, and to identify these structures through the use of drawings or photographs.

Teachers could relate the function of intestinal villi to active transport. In active transport, materials are carried across the cell membrane. Intestinal villi increase surface area for absorption of amino acids, sugars, and peptides from the intestines into the blood vessels. Fats are transported to the liver.
Digestive System  *continued*...

**Suggested Assessment Strategies**

**Performance**
- Perform an available lab activity that illustrates an aspect of the digestive system. The activity may include the dissection of available specimens to observe the systems of digestion. (213-5, 317-1)

**Journal**
- Individuals who have had much or even all of their digestive systems damaged or diseased can still survive. How is this possible? (317-1)
- After having surgery to remove the gall bladder, how would a patient have to modify his/her diet? (317-1)
- Food does not pass through the liver, gall bladder, or pancreas. Why are these organs considered to be part of “Team Digestion”? (317-1)

**Resources**

- MHR *Biology*, p. 354
- MHR *Biology*, p. 359
- “Table 3: Digestion Worksheet,” Appendix A
- BLM 11-3: “Digestive Time Line”
- BLM 11-4: “The Pancreas”
- MHR *Biology*, pp. 365, 368
- MHR *Biology*, pp. 359-362
Digested System  

**Outcomes**

*Students will be expected to*

- carry out an experiment to investigate the effect of specified variables on the effectiveness of an enzyme (212-6)

- compile and organize data, using appropriate formats and data treatments, to facilitate interpretation of the data from a completed digestive activity (213-5)

- describe disorders and the treatment of disorders linked to organs of the digestive system and their effect on the homeostasis of the system and the organism as a whole (317-4)
  
  (i) ulcers
  
  (ii) gall stones
  
  (iii) ileitis/colitis

**Elaborations—Strategies for Learning and Teaching**


Experiments using qualitative and/or quantitative tests can be performed to detect the presence in food of organic molecules, such as carbohydrates, lipids, and proteins. Calorimetry experiments can be designed and/or performed to determine in a quantitative fashion the potential energy found in carbohydrate or lipid food materials. Data can be recorded and displayed, and food categories compared.

Students could perform laboratory activities to demonstrate the action of digestive enzymes on animal or plant tissue (e.g., egg white) or a prepared solution (e.g., starch). They could design and/or perform experiments to investigate the influence of enzyme concentration, temperature, and pH on the activity of these enzymes. They could also design an experiment to investigate the relative effectiveness of commercially advertised antacid products. (Teachers should be aware that students’ saliva should not be collected for investigations.)

The specific pathologies of the digestive system created by digestive disorders should be discussed or researched along with the capability of technology to diagnose, treat, or cure the problems. Students may describe other conditions related to digestive function, such as cancer, Crohn’s disease, or celiac disease. Students could be asked to assess and debate or discuss the effects of legal and over-the-counter drugs on the functioning of the digestive system, including but not limited to alcohol, codeine, and prescription medicines. Students could be asked to debate or discuss the question of whether society can, or should, play a more proactive role in promoting the improvement of diets and the prevention of diseases, or a more reactive role in the treatment of these diseases.
Digestive System  continued...

Suggested Assessment Strategies

**Paper and Pencil**
- Working in groups, gather nutritional information about a minimum of three fast food/restaurant menus. Some possible sources of this information would be from the restaurants themselves, dieticians, or the Internet. Design what you think is the healthiest “takeout” meal plan possible for three days. How does the plan compare to the recommendations in Canada’s Food Guide? (213-5, 314-1, 314-2, 314-3)

**Performance**
- Perform available lab activities that illustrate some aspects of the digestive system. These may include tests for the action of digestive enzymes on animal or plant tissue. (Enrichment may be provided by allowing students the opportunity to design their own investigations in response to questions that these activities may generate. For example, students may investigate what would be the optimal temperature or pH for activity of a given enzyme.) (212-6, 213-5, 314-1, 314-2, 314-3, 317-1)

**Presentation**
- Research and prepare questions related to a topic being presented by a guest speaker. Working in groups, review and revise questions. Following the presentation, prepare a brief summary of the answers given to your questions.

Assessment may be based on a student summary of the guest’s talk and/or answers provided to one of their questions. Guest speakers could include individuals knowledgeable in digestive system pathologies, such as physicians; spokespersons from relevant organizations (e.g., Ileitis and Colitis Association, Canadian Liver Association); or sufferers of digestion related disorders (e.g., anorexia nervosa). Students could research and prepare questions related to the topic being presented by the guest speaker. Working in groups, these questions should be reviewed and revised, and questions should be selected to be asked during the presentation. Following this presentation, students might be asked to prepare a brief summary. (317-4)

**Resources**

Core Lab #8 Investigation 11A: “What’s Here? Testing Macromolecules,” MHR Biology, pp. 356-357

MHR Biology, pp. 368-373
Digestive System  continued...

Outcomes

Students will be expected to

• explain the importance of fitness and nutrition in maintaining homeostasis (317-3)

• propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15)
  – investigate the value of vitamins, minerals and herbal supplements in support of a healthy lifestyle

• identify multiple perspectives that influence a science-related decision or issue (215-4)
  – evaluate how nutritional deficiency (e.g., starvation diets, bulimia, anorexia nervosa) can adversely affect the dynamic equilibrium
  – discuss whether the images portrayed through the media and advertising promote positive self image and a healthy lifestyle for men and women

Elaborations—Strategies for Learning and Teaching

Students could investigate the terms “healthy nutrition” and “fitness.” They could suggest what parts of their bodies or what body systems are involved in the achievement of health and fitness. For example they may suggest that a balanced diet is important and propose a connection with the digestive system to break down the food, the circulatory system to distribute nutrients, etc. This provides another opportunity to have students establish the interrelationships between systems within the body as they work to maintain homeostasis.

Many individuals routinely consume various vitamins, minerals, and herbal supplements in their search for a healthy lifestyle. Students could research and investigate the origins of these herbal medicines, and the claims made by their manufacturers (e.g., echinacea, St. John’s Wort, gingko biloba, garlic, etc.) and any scientific basis or data that exists for these assumptions.

The media inundates the public with information on fad diets. Students could be asked to investigate the physiological basis of these diets (e.g., high protein, high carbohydrate, low fat), their safety, and their effectiveness. They may include more drastic weight loss measures that involve anatomical operations such as stomach stapling or removal of a portion of the small intestine.

For enrichment, students could also choose to

• research and debate the safety and necessity of food additives, food irradiation, and other technologies used to improve the shelf life or the attractiveness of food products;
• examine the relative value of the use of processed versus non-processed foods;
• examine the use of pesticides on food crops;
• examine the necessity of techniques used only to make food more visually appealing to the consumer;
• discuss the question of where our food comes from;
• examine the potential of the inadvertent introduction of foreign organisms to an ecosystem through the importation of food.
Digestive System  continued...

Suggested Assessment Strategies

Presentation

- Research and collect information on alternate diets that are currently proposed or advertised in the media, surgical approaches to deal with the problem of obesity, and the potential health effects of these. Information could be presented to the class as a whole. You might select a herbal health supplement and investigate the health claims that the manufacturers of these products make. Alternately, you might investigate the health benefits and sources of vitamins and minerals within the diet. The information will be presented to the class as a whole and you will subsequently place the information on a poster board designed to collate the essential elements of the class information for classroom or school display. You could select a disorder requiring dietary restrictions, such as lactose or gluten intolerance, and investigate its prevalence and causes, and the methods employed to control the symptoms. (215-4, 317-1, 317-3)

- Research and present the effects of legal drugs, illegal drugs, over-the-counter, and prescription drugs on the functioning of the digestive and respiratory systems.
  (Groups could be assigned different categories of drugs, and the resulting presentations will thereby provide an overview of this topic. Assessment would be based upon thoroughness of research and accuracy of information presented.) (215-4, 317-1)

Resources

MHR Biology, pp. 370-371
BLM 11-2: “Fitness”

MHR Biology, pp. 372-373
## Excretory System

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations—Strategies for Learning and Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Students will be expected to*</td>
<td>Excretory systems maintain homeostasis with respect to water, salt, and metabolite concentrations within the blood.</td>
</tr>
<tr>
<td>• explain how the excretory system helps maintain homeostasis (317-1)</td>
<td>Students may oversimplify the excretory system by thinking it is all about the kidney (which removes metabolic wastes). Several other organs involved in the excretory system are often overlooked. The lungs (which remove CO₂), the skin (which removes heat), and the liver (which removes metabolic wastes and creates bile and urea) are vital organs that play a major role in the excretory system. Students should investigate their role in maintaining homeostasis.</td>
</tr>
<tr>
<td>– explain how the following act as organs of excretion (i) lungs (ii) skin (iii) liver (iv) kidney</td>
<td>Students should be provided with the opportunity to observe the principal features of the human excretory system, utilizing models, dissection, or computer simulations, and to identify those structures through the use of drawings or photographs. Diagrams or charts could be used to illustrate the structure of the nephron and to emphasize its role as the working unit of the kidney. Microscopic analysis of a kidney cortex section could provide some visual confirmation of the structural components of the kidney.</td>
</tr>
<tr>
<td>– explain the role of the kidney as an excretory organ in removing metabolic wastes from the body</td>
<td>Students will recognize the kidney’s structure as including the cortex, medulla, and pelvis, and will understand the filtration and reabsorption functions of the nephron. Students could perform experiments to investigate simulated urine composition, perform data analysis, and summarize the role of the kidney in homeostatic regulation of pH, water, and ionic substances.</td>
</tr>
<tr>
<td>– identify and describe the main structures of the human urinary system, including kidney, ureter, bladder, and urethra</td>
<td>The specific diseases of the excretory system caused by excretory disorders could be discussed or researched along with the capability of technology to diagnose, treat, or cure the problems. Students may discuss other disorders related to kidney function, including diabetes and nephritis. Teachers could discuss the effects of lifestyle on the homeostasis of the excretory system and have students hypothesize why consumption of alcohol induces more trips to the washroom than does the consumption of water alone.</td>
</tr>
<tr>
<td>– identify and describe the internal structure and function of the kidney, including the cortex, medulla, and pelvis</td>
<td></td>
</tr>
<tr>
<td>– identify and describe the function of the glomerulus</td>
<td></td>
</tr>
<tr>
<td>– identify and explain the function of the parts of a nephron (i) Bowman’s capsule (ii) loop of Henle (iii) tubules-proximal and distal (iv) collecting duct</td>
<td></td>
</tr>
<tr>
<td>• describe disorders linked to the excretory system and their effect on the homeostasis of the system and the organism as a whole (317-4) (i) kidney stones (ii) kidney infections (iii) bladder infections</td>
<td></td>
</tr>
</tbody>
</table>
Excretory System

Suggested Assessment Strategies

Performance

• Perform available lab activities related to the excretory system, such as a microscopic examination of a kidney cortex, an investigation using simulated urine, or a dissection of available specimens. (213-5, 317-1)

   Enrichment may be provided by allowing students to design their own investigations in response to questions that these activities may generate.

Presentation

• Research and prepare questions related to a topic being presented by a guest speaker. Working in groups, review and revise questions. Following the presentation, prepare a brief summary of the answers given to your questions.

   Assessment may be based on a student summary of the guest’s talk and/or answers provided to one of their questions. Guest speakers could include individuals knowledgeable in endocrine system pathologies, such as physicians; spokespersons from relevant organizations (e.g. Kidney Foundation); or sufferers of excretory disorders (e.g., dialysis patients, transplant recipients). (317-1, 317-4, 213-5, 214-3)

Paper and Pencil

• Sketch a longitudinal section of the kidney and label the cortex, medulla, pelvis, renal artery, and renal vein. (213-5)

Journal

• What effect on your lifestyle would a non-functioning bladder have? (317-1)

Resources

MHR Biology, p. 374 and throughout section 11.3

MHR Biology, p. 374

MHR Biology, pp. 374-378

BLM 11-6: “Nephron Structure and Function”

MHR Biology, pp. 379-381
### Outcomes

*Students will be expected to*

- analyse and describe examples where technologies were developed over time, based on scientific understanding, to treat renal failure (116-4, 115-5)
  - briefly explain how the technology of dialysis works

- analyse natural and technological systems to interpret and explain their structure and dynamics (116-7)
  - compare the human kidney system with that of kidney dialysis technology
  - briefly explain why dialysis is a temporary measure for treating kidney disease

- debate the merits of funding kidney transplant therapy versus improvements in dialysis technology (117-4)

- identify multiple perspectives that influence a science-related decision or issue (215-4)

### Elaborations—Strategies for Learning and Teaching

The STSE component “Kidney and Urologic Diseases” (Appendix B) incorporates a broad range of Biology 521A outcomes. More specifically, it targets (in whole or in part) outcomes 115-5, 116-4, 116-7, 117-4, 215-4, and 317-4.

The discussion of dialysis should be limited to the fundamental aspects of how kidney dialysis functions. Kidney dialysis is the process whereby blood is removed from the body, harmful metabolic waste products are removed from the blood by the processes of osmosis and diffusion, and the processed blood is returned to the body. This process has limitations.

Kidney shutdown or renal failure may result from a variety of conditions and can lead to many deleterious effects, including abnormal concentrations of salt and water, altered pH, and general deterioration of homeostasis. Ideally, dialysis is a temporary measure used to replace normal kidney functioning until the kidneys begin to function again on their own, or in more serious cases, until a transplant becomes available.

Students could consider the implications of the utilization of other species as potential donors. They could, in groups, propose guidelines for selecting the most appropriate expenditures. They could then debate and defend their choices. Much of the success of transplants recently is due to research performed on, and in the creation of, immunosuppressant drugs. Students could be provided with background information from the *Organ & Tissue Donation and Transplantation Resource (One Life... Many Gifts CD-ROM)*. This may be an excellent opportunity to engage students in the activity, group case study “Transplant Assessment: Kidney”.

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**Excretory System continued...**
Excretory System  continued...

Suggested Assessment Strategies

Presentation

- Research a topic in preparation for a debate. The format of this debate would require you to display the results of your research and argue against other stakeholders concerning issues such as selection procedure for organ transplant recipients, ethics of the sale of human organs (developing countries), or ethics of organ transplants across species. (115-5, 117-4, 214-3, 213-5)

Paper and Pencil

- Research information about kidney dialysis. Why is it used? What type of person is a dialysis candidate? What different methods are available? What complications are possible? (116-7)

Journal

- What concerns would you expect a potential kidney donor to have? (117-4)

Resources

Appendix B: “Kidney and Urologic Diseases”


MHR Biology, pp. 377-379

MHR Biology, pp. 377-381

Organ & Tissue Donation and Transplantation Resource

One Life... Many Gifts CD-ROM
Immune System

Outcomes

Students will be expected to

• explain how the immune system helps to maintain homeostasis (317-1)
  – explain the “lines” immune response
    (i) 1st line of defence (physical and chemical barriers)
    (ii) 2nd line of defence (inflammatory response)
    (iii) 3rd line of defence (immune response)
  – explain the role of white blood cells in the defence process including phagocytes and lymphocytes
  – explain the mechanism of acquired immunity including passive (breast milk) and active (actual exposure, vaccines)
  – explain how autoimmune disorders cause diseases such as rheumatoid arthritis

• analyse why and how a particular technology was developed and improved over time (115-5)
• analyse and describe examples where technologies were developed based on scientific understanding (116-4)
• debate the merits of funding specific scientific or technological endeavors and not others (117-4)

Elaborations—Strategies for Learning and Teaching

A study of the non-specific first line defenses should include both physical and chemical barriers such as skin, sweat, and stomach acids. The inflammatory response and phagocytes as second line defenders should be explained. The third line of defence, involving specific immunity (which includes the immune response involving T cells, B cells, and antibody production), should be summarized. A visual display (chart or sketch) of the role of each of these in the body’s defence system may help students grasp the basics of these concepts. Their discussion may be expanded to include the role of the lymphatic system within the immune response. Students can expand their study by investigating how vaccines make use of the workings of the immune system in order to be effective, and by studying the requirements, interest and financial resources society has to support the prevention of the spread of disease-causing organisms such as HIV, Staphylococcus, and smallpox. Some herbal supplements (e.g., echinacea) claim that they boost the immune system. Students may investigate these claims by examining the antioxidant (chemical altering of free radicals) nature of Vitamins E, C, and beta-carotene, and the relevance of these to the health of the human population (e.g., link with cancer and cardiovascular disease).

The STSE component “Hodgkin’s Disease” (Appendix B) incorporates a broad range of Biology 521A outcomes. More specifically, it targets (in whole or in part) outcomes 115-5, 116-4, 117-4, and 317-1.
Immune System

Suggested Assessment Strategies

Presentation

- Select a herbal supplement or vitamin and investigate its effect on the functioning of the immune system. Include both natural and synthetic sources of these products, and prepare a poster for display. (115-5, 116-4, 213-5, 317-1)

- Research different technologies used for the treatment of Hodgkin's disease and analyse why and how these technologies have improved over time. Debate the merits of funding technological endeavours related to the treatment of Hodgkin's disease. (115-5, 116-4, 117-4, 317-1)

Resources

MHR Biology, pp. 382-385
Appendix B: “Hodgkin’s Disease”

MHR Biology, p. 386
Immune System *continued*…

**Outcomes**

*Students will be expected to*

- predict the impact of environmental factors on homeostasis within an organism (317-6)

- explain the meaning of antigen (allergen) and antibody, and their role in an allergic reaction

**Elaborations—Strategies for Learning and Teaching**

Students should be aware that a properly functioning immune system is essential for health and well-being, and recognize the consequences that result when the immune system does not function properly. They should also be aware of the sequence of general physiological events that result in an allergic reaction, and identify the resulting symptoms. The typical symptoms of runny nose, swollen eyes, sneezing, coughing, and rash are caused by a release of highly active substances, including histamine, from body cells at the site of the immune reaction (production of special antibodies against the allergen). Histamine induces an inflammatory reaction, as it does whenever there is an injury or infection. Students should be able to describe how allergic responses affect the maintenance of homeostasis within an organism. This may be accomplished through consideration of the following questions: How would the body have responded to the presence of an allergen (pollen) in a non-allergic or non-sensitive individual? and How does the body respond in an allergic individual?

Students could investigate and compare respiratory allergies (such as hay fever) with food allergies. It is important to understand how and why some allergies are severe enough to be life threatening (anaphylaxis), and to understand the significance of the accurate labelling of commercial food products. Students could investigate the prevalence of use and the effectiveness of over-the-counter antihistamines and decongestants and allergy shots to control allergies. The methods by which these medications relieve the symptoms can be investigated.
Immune System continued...

Suggested Assessment Strategies

Presentation

- Investigate the natural response of the body to a bacterial infection or a viral disease such as a cold or flu. Investigate the mechanism of a selected auto-immune disease, (e.g., rheumatoid arthritis, myasthenia gravis, multiple sclerosis, rheumatic fever, systemic lupus erythematosus (lupus), thyroiditis). You would be expected to present to the class the symptoms of the disorder. (Assessment would be based on thoroughness and accuracy of information. Alternately, this activity could become a research activity where work is passed in for written assessment.) (317-1, 317-3, 317-4)

Paper and Pencil

- Prepare and conduct a survey on the prevalence and variety of allergies within the school population, and the remedies used to alleviate symptoms. Data would be tabulated, graphed by hand or by utilizing available technology, and presented via a bulletin board display to the school population in general. (213-5, 214-15, 317-1, 317-6)

Resources

MHR Biology, pp. 382, 386
BLM 11-7: “Players in the Immune Response”
Interactions among Living Things
(~5 Classes)

Introduction
During a discussion of human ecology (the relationship between the human population and the environment), students will build on their understanding of the basics of ecology and ecosystems and certain principles of population dynamics. It is important that they understand the many interrelationships affecting human population growth and dynamics, along with the issues facing global population growth, particularly the subsequent and continuous pressure being placed on the natural resources of the globe.

Focus and Context
In this section, a variety of curriculum outcomes are met through the integration and discussion of a number of societal and sustainability issues. Therefore, the focus is on decision making and STSE issues. There does remain, however, opportunity for observation and inquiry.

Science Curriculum Links
This unit, “Interactions among Living Things,” connects with other clusters in the science curriculum primarily at the elementary and intermediate levels, and in Science 421A. Previous to this, primary students learned how humans and other living things depend on their environment. They expand on this knowledge by describing features of environments that support the health and growth of animals. The major focus in elementary grades is on habitat and community, including the identification of regional and local habitats and examination of how the removal of plant or animal populations would affect the remainder of the community. The life science portion of the curriculum in the intermediate grades concentrates on interactions within ecosystems; an introduction to biotic and abiotic factors; the flow of energy within an ecosystem through producers, consumers, and decomposers; and ecological succession. Science 421A builds on this background with its more in-depth look at the sustainability of ecosystems; a discussion of characteristics and responses of ecosystems; the cycling of matter through biotic and abiotic components; and an introduction to ways in which natural populations are kept in equilibrium in relation to the availability of resources. By the time students arrive in Biology 521A, they have a broad background with which to pursue their study of interactions among living things.
## Curriculum Outcomes

<table>
<thead>
<tr>
<th>STSE</th>
<th>Skills</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students will be expected to</strong></td>
<td><strong>Students will be expected to</strong></td>
<td><strong>Students will be expected to</strong></td>
</tr>
<tr>
<td><strong>Contexts of Science and Technology</strong></td>
<td><strong>Performing and Recording</strong></td>
<td>318-8 describe population growth and explain factors that influence population growth</td>
</tr>
<tr>
<td>118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability</td>
<td>213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data</td>
<td>318-10 evaluate Earth’s carrying capacity, considering human population growth and its demands on natural resources</td>
</tr>
<tr>
<td></td>
<td>213-6 use library and electronic research tools to collect information on a given topic</td>
<td></td>
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<td></td>
<td><strong>Analysing and Interpreting</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flowcharts, tables, graphs, and scatter plots</td>
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</tr>
<tr>
<td></td>
<td>214-7 compare theoretical and empirical values and account for discrepancies</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Communication and Teamwork</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>215-6 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise</td>
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</tr>
</tbody>
</table>
Population Change

Outcomes

Students will be expected to

• describe population growth and explain factors that influence it (318-8)
  – describe how population growth is dependent upon the difference between natality and mortality rates and a balance between emigration and immigration
  – distinguish between density independent and dependent factors
  – explain how biotic potential, environmental resistance, and carrying capacity interact in population dynamics

• compare theoretical and empirical population values and account for discrepancies (214-7)
  – examine and label the sections of an S-shaped (logistic) and J-shaped (exponential) growth curve
    (i) lag
    (ii) exponential
    (iii) equilibrium
  – compare how J and S curves describe the general population growth patterns observed in animal populations
  – explain the predator-prey cycle with respect to population growth curves

Elaborations—Strategies for Learning and Teaching

Students can take an example of a local or regional endangered species and review the determinants of population: natality, mortality, emigration, and immigration. Students can then brainstorm factors that affect human natality and mortality. This exploration may lead to the following question for discussion: Why should we be concerned about the Earth's carrying capacity for the human population?

Students should analyse and describe the limiting factors that regulate population size within ecosystems. Some of these are competition, environmental quality, disease, parasitism, predation, and stress.

The concept of environmental quality can include the availability of food, shelter, and water, and the climate. Students can design and/or perform an experiment to demonstrate the effect of environmental factors on human growth.

Students should recognize that the shape of the “S” in the S-shaped curve varies depending on the growth strategy of the species (many offspring with little parental investment, few offspring with much parental investment).

Students should recognize that there is no equilibrium section in a J-shaped curve. The J-shaped curve generally exists in a manipulated situation.
Population Change

Suggested Assessment Strategies

*Paper and Pencil / Presentation*

- Investigate a threatened or endangered species and prepare a visual display on this organism (try to find a local species). Your report should include a diagram, estimated current population, reasons for endangerment, suggested interventions necessary to alleviate the problem, and any difficulties there may be with their implementation. Prepare a bulletin board display for observation by the entire school, and ensure that the work is of display quality.

  (Assessment will be based on accuracy of information collected, and its presentation.) (213-5, 213-6, 214-3, 318-8)

- Given demographic data from various regions of the world, work in groups to produce graphs that show different population growth patterns. (213-5, 214-3, 214-7, 215-6, 318-8)

**Resources**

- MHR Biology, pp. 225-226
- MHR Biology, pp. 233-244
- MHR Biology, pp. 243-244, 226
- MHR Biology, pp. 225-232
- BLM 7-4: “Population Growth”
- MHR Biology, pp. 237
## Outcomes

*Students will be expected to*

- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- gather and examine information on the limiting factors that work to influence population growth (213-6)
- compile and display evidence and information in a variety of formats (214-3)
- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)

- describe population growth and explain factors that influence population growth (318-8)
  - analyse and describe the factors that regulate human population size

## Elaborations—Strategies for Learning and Teaching

The laboratory outcomes (213-5, 213-6, 214-3, 215-6) can be addressed by completing Investigation 7A: “Sampling Hare Populations.”

During class discussions, students should easily generate a list of limiting factors that affect the human population. Limiting factors such as space, war, disease, and poverty reflect competition within the human population dynamic. These limiting factors should be explained by further research using the textbook or other resources.

This delineation can be examined while addressing outcome 318-10 on p.86.
Population Change  continued...

Suggested Assessment Strategies

Paper and Pencil / Presentation

- Research trends in population growth in Prince Edward Island or other Atlantic provinces. (213-5, 213-6, 214-3, 215-6, 318-8)

- Research population growth patterns of introduced species in our province (e.g., purple loosestrife, green crab, oyster thief, clubbed tunicate, skunk, raccoon, rainbow trout, Hungarian partridge, sharp-tailed grouse). Your research should explain why these populations have exploded since their introduction. (213-5, 213-6, 214-3, 215-6, 318-8)

Resources

Core Lab #11
Investigation 7A: “Sampling Hare Populations,” MHR Biology, pp. 238-239

MHR Biology, pp. 256-257 and throughout sections 8.1, 8.2, and 8.3
Global Resources

Outcomes

Students will be expected to

- evaluate Earth’s carrying capacity, considering human population growth and its demands on natural resources (318-10)
  - determine the current growth rate of the human population, and the projected growth rate
  - investigate the demands that will be placed upon Earth’s natural resources by future population growth
  - explain how technological developments have raised, and continue to raise, the carrying capacity of Earth

- propose courses of action on the social issue of global population control, taking into account an array of perspectives, including that of sustainability (118-10)

Elaborations — Strategies for Learning and Teaching

The previous section leads into a preliminary discussion of human population growth and issues related to this growth. Graphs may be found in resource materials (library, electronic, population or government agencies) or constructed from data tables that illustrate the historical growth of human population based on estimated data. Students can be asked to project that graph line into the future as an exercise of prediction and extrapolation. This would lead to a discussion of linear or exponential growth, and doubling time. Students can investigate the population growth rates of developing and developed countries and relate these to elements such as standard of living, education level of the population, and level of health care. They may discuss why population is stabilizing in developed countries but still increasing at a rapid rate in the developing world.

Students may, in turn, discuss and identify what social and environmental factors need to be considered and controlled locally, regionally, and globally to create a sustainable human growth pattern for Earth. This may lead to the following questions: What population size do you believe would allow the world’s people to maintain a good quality of life? What needs to be done to attain this? Students may debate and justify their responses.

Early human population was low due to limiting environmental factors such as disease and food shortages. With the advancement of civilization (development of agriculture, advances in medicine, etc.) the carrying capacity increased and rapid growth of the human population occurred.

Students may choose to research and debate the ethics of human population control methods as practised within various areas of our globe (e.g., China’s one child per family rule). Students may then discuss how improved infrastructure, education of women, use of advanced technologies, and changed lifestyles may help a population meet its energy/material needs.
Global Resources

Suggested Assessment Strategies

Paper and Pencil

- Select a country for which to gather demographic data, including total population, population density, natality, mortality, life expectancy, annual income, immigration, emigration, standard of living, availability of education, and health care. Report your findings to the class, and be prepared to participate in a discussion. Add your information, in abbreviated form, to a global map prepared by members of the class. This would serve to illustrate in a dramatic fashion some of the population issues that exist within the world today. (Organizations such as CIDA have produced both maps and brochures that outline this information.) Be sure that countries selected include a range of both developing and developed countries and represent all areas of the globe. Assessment can be based on presentation of information collected and observation of participation by students within the subsequent discussion. (118-10, 213-5, 318-8, 318-10)

Journal

- It can be argued that some third world regions have reached their carrying capacity. What factors do you think have contributed to this? How would other countries help increase their carrying capacity? (213-5, 214-3, 318-8, 318-10)

Performance

- Divided into two opposing class groups, debate the pros and cons of a topic related to population control. Topics may include mandatory birth control, one child per family, or mandatory enforcement of the Kyoto regulations. (118-10, 213-5, 215-6)

Presentation

- Working in groups, select a country and research its population dynamics. Determine the stage of the Demographic Transition Model that this country is in. Present your findings to the class. (213-6, 213-5, 215-6, 318-10)

Resources

- MHR Biology, pp. 256-273
- MHR Biology, pp. 256-257
- BLM 8-1: “Investigating Human Population Growth”
- BLM 8-2: “Sports and Population Growth”
- MHR Biology, pp. 263-267
- MHR Biology, pp. 256-263
- BLM 8.3: “Ecotourism”

Teachers may refer to the Geography 521A (Global Studies) resources for additional information on Earth’s population.
Appendix A

Supplementary Tables
## Table 1: Kingdom Worksheet

<table>
<thead>
<tr>
<th>Kingdom Type</th>
<th>Bacteria</th>
<th>Archaea</th>
<th>Protista</th>
<th>Fungi</th>
<th>Plantae</th>
<th>Animalia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Type</td>
<td>prokaryotic</td>
<td>prokaryotic</td>
<td>eukaryotic</td>
<td>eukaryotic</td>
<td>eukaryotic</td>
<td>eukaryotic</td>
</tr>
<tr>
<td>Cell Wall</td>
<td>often present, contains peptidoglycan</td>
<td>present, does not contain peptidoglycan</td>
<td>exists in some, composition will vary</td>
<td>usually composed of chitin</td>
<td>composed of cellulose</td>
<td>none</td>
</tr>
<tr>
<td>Body Form</td>
<td>unicellular, some are colonial</td>
<td>unicellular, some are colonial</td>
<td>unicellular, colonial, and some simple multicellular</td>
<td>most are multicellular</td>
<td>multicellular</td>
<td>multicellular</td>
</tr>
<tr>
<td>Nutrition</td>
<td>photosynthesis, chemosynthesis, and absorption (heterotrophs)</td>
<td>heterotrophs, some heterotrophs (ingestion and absorption, and some both)</td>
<td>heterotrophs (absorption, or secretion of enzymes that digest food outside of itself)</td>
<td>photosynthesis</td>
<td>ingestion</td>
<td></td>
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<tr>
<td>Nervous System</td>
<td>absent</td>
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<td>absent</td>
<td>absent</td>
<td>absent</td>
<td>present</td>
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<tr>
<td>Reproduction</td>
<td>asexual</td>
<td>asexual</td>
<td>asexual and sexual</td>
<td>asexual and sexual</td>
<td>asexual and sexual</td>
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<tr>
<td>Locomotion</td>
<td>present in some</td>
<td>present in some</td>
<td>present in some</td>
<td>none</td>
<td>none</td>
<td>distinct at some point in the life cycle</td>
</tr>
<tr>
<td>Examples</td>
<td>bacteria, cyanobacteria</td>
<td>methanogens, extreme thermophiles, extreme halophiles (organisms that live in harsh environments such as salt lakes, hot springs, and animal guts)</td>
<td>algae, protozoa</td>
<td>mushrooms, yeast, bread moulds</td>
<td>mosses, ferns, conifers, flowering plants</td>
<td>sponges, jellyfish, starfish, lobsters, worms, birds, mammals</td>
</tr>
</tbody>
</table>
Table 1: Kingdom Worksheet

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## Table 2: Plants Worksheet

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<tr>
<th>Characteristics</th>
<th>Nonvascular</th>
<th>Vascular Spore Producing</th>
<th>Vascular Seed Producing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular vs. nonvascular</td>
<td></td>
<td>Ferns and fern allies</td>
<td>Gymnosperms</td>
</tr>
<tr>
<td>structure</td>
<td>lack true roots, stems,</td>
<td>vascular tissue provides</td>
<td>vascular tissue provides</td>
</tr>
<tr>
<td></td>
<td>and leaves</td>
<td>support and aids in</td>
<td>support and aids in</td>
</tr>
<tr>
<td></td>
<td>small in size</td>
<td>transport</td>
<td>transport</td>
</tr>
<tr>
<td></td>
<td>transport through</td>
<td>possess true roots,</td>
<td>possess true roots,</td>
</tr>
<tr>
<td></td>
<td>diffusion</td>
<td>stems, and leaves</td>
<td>stems, and leaves</td>
</tr>
<tr>
<td></td>
<td>no internal support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependency on water</td>
<td>yes, for movement of</td>
<td>yes, for movement of</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>sperm</td>
<td>sperm</td>
<td>no</td>
</tr>
<tr>
<td>Dominant generation</td>
<td>gametophyte</td>
<td>sporophyte</td>
<td>sporophyte</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>sporophyte</td>
</tr>
<tr>
<td>Reproduction</td>
<td>depends on water for</td>
<td>depends on water for</td>
<td>wind and insects are</td>
</tr>
<tr>
<td></td>
<td>movement of sperm to egg</td>
<td>movement of sperm to egg</td>
<td>used to move sperm to</td>
</tr>
<tr>
<td></td>
<td>no protection of egg</td>
<td>no protection of egg</td>
<td>egg</td>
</tr>
<tr>
<td>Examples</td>
<td>mosses, liverworts,</td>
<td>ferns, whisk ferns,</td>
<td>deciduous trees,</td>
</tr>
<tr>
<td></td>
<td>and hornworts</td>
<td>club mosses, borsetails</td>
<td>beaths, roses, peas,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>magnolias, dandelions</td>
</tr>
</tbody>
</table>
# Table 2: Plants Worksheet

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Bryophyta</th>
<th>Spore Producing</th>
<th>Tracheophyta Seed Producing</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ferns and fern allies</td>
<td>Gymnosperms</td>
</tr>
<tr>
<td>Vascular vs nonvascular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependency on water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organ</td>
<td>Associated Glands</td>
<td>Chemical Digestion (Enzyme Action)</td>
<td>Mechanical Digestion</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Mouth</td>
<td>salivary glands</td>
<td>salivary amylase breaks starch into maltose</td>
<td>teeth and tongue</td>
</tr>
<tr>
<td>Stomach</td>
<td>gastric glands and pyloric glands</td>
<td>pepsin breaks proteins into shorter polypeptides</td>
<td>peristalsis 3 times a minute</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>liver and gall bladder</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pancreas</td>
<td>proteases (trypsin and chymotrypsin) further break down polypeptides from the stomach into shorter polypeptides</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>erepsins break down simple polypeptides into amino acids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>intestinal glands</td>
<td>lipase breaks down fats into fatty acid and glycerol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pancreatic amylase breaks down starch into maltose</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>peptidases break simpler polypeptides into amino acids</td>
<td>peristalsis occurs regularly to mix food and enzymes and so push food against the intestinal wall for absorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lipase breaks down fats into fatty acids and glycerol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>maltase breaks maltose into simple sugars</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>sucrase breaks sucrose into simple sugars</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>lactase breaks lactose into simple sugars</td>
<td></td>
</tr>
<tr>
<td>Large Intestine</td>
<td>mucous glands</td>
<td>none</td>
<td>none, any muscular action is for the movement of food water is reabsorbed</td>
</tr>
</tbody>
</table>
Table 3: Digestion Worksheet

<table>
<thead>
<tr>
<th>Organ</th>
<th>Associated Glands</th>
<th>Chemical Digestion (Enzyme Action)</th>
<th>Mechanical Digestion</th>
<th>Other Secretions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Intestine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Intestine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

STSE

Science-Technology-Society and the Environment
Modern Classification Technologies

Outcomes

1. Explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced. (115-7)

2. Analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology. (116-2)

3. Construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives. (118-6)

4. Identify new questions or problems that arise from what was learned. (214-17)

5. Use organisms found in a local or regional ecosystem to demonstrate an understanding of the fundamental principles of taxonomy. (316-5)

Introduction

New and modern classification techniques have provide important diagnostic tools in the classification of organisms. The unique chemical nature of DNA can be used to identify individual organisms and/or to classify organisms. It provides a tool that can confirm relationships between individuals and also provides a means to identify a species using only the smallest fragment of biological material. All multicellular organisms have this unique fingerprint. There are many possible applications of DNA analysis. Relationships and identifications using DNA evidence are widely used in court rooms to convict perpetrators of crimes as well as to acquit those who might be wrongly convicted. Through a mapping of the unique chemical nature of the DNA molecule, biologists can obtain valuable information to further enhance their work. As methods of DNA analysis become more refined and utilized, the science of classification is improved. The following examples illustrate some of the possibilities of these techniques and how they help science.

Fish Forensics

While on a normal patrol of the Flemish Cap a Canadian Coast Guard helicopter spots a foreign trawler. When the pilot radios in the location and name of the vessel, she finds that the vessel has a quota for pollock, yet the area where the vessel is sighted is far from the grounds on which pollock would be caught. Yielding to her suspicions, the pilot has a support vessel pursue the trawler and detain it.

Imagine that you are the DFO (Department of Fisheries and Oceans) scientist assigned to the case. You have strong reason to believe that the fish caught by the trawler is Atlantic cod, yet the crew maintains that the filleted and salted fish are pollock. How could you possibly prove that the fish is Atlantic cod? Visually examining the flesh of the fish which has been filleted, iced, and/or salted would not aid in the identification because of the similarity of pollock and cod in appearance, texture, colour, and smell. The answer lies in using DNA analysis.
The species of fish that has been caught, and processed can be difficult to determine. Questions may arise as to the origin of a commercial fish product, for example -whether the catch in a boat's hold has been properly reported, or whether the label on a commercial product is accurate. Although physical identification is difficult or impossible once skin and scales are gone, the fish DNA survives processing in sufficient quantities to provide a reliable test.

In the test shown above, the identity of four salt-cured fish was questioned. DNA from each was amplified (copied), sequenced (coded), and compared to a DNA data base of known cod, pollock, and hake species. The analysis produce a "family tree" which showed that each fish came from a different commercial species: Atlantic pollock, or *Pollachius virens* (Fish 4); Atlantic cod, or *Gadus morhua* (Fish 3); Pacific cod, or *Gadus macrocephalus* (Fish 2); and Alaska cod, or *Gadus chalcogrammus* (Fish 1). Similar tests can be used to differentiate many species of fish. If a sample of fish is found to contain similar DNA to a known species, then it can be concluded that the sample would be from the same species.

Even though the trivial names Atlantic Pollock, Alaskan Pollock would indicate a close relationship between 1 and 4. The DNA similarities indicate a close relationship between 1 and 3.

In order to compare genetic material, the actual sequence of bases must be determined in each sample. This analysis can be done through the use of gel electrophoresis. When the actual sequence of nitrogenous bases is determined, a direct comparison can be made not only between species, but also between individuals. The closer the sequences are to each other, the more closely related are the individuals.

The samples taken are often small, and therefore the amount of viable genetic material is often limited. To overcome this problem it is necessary to amplify or copy the DNA material. Older technologies (recombinant technologies) were capable of doing this, but it was time consuming. The modern means of amplifying and copying DNA is known as Polymerase Chain Reaction (PCR). PCR can amplify DNA of any origin (virus, bacteria, plant, or human) hundreds of millions of times in a matter of hours, a task that would have required several days with recombinant technology. PCR is especially valuable because the reaction is highly specific, easily automated, and capable of amplifying minute amounts of sample. For these reasons, PCR has had a major impact on clinical medicine, genetic disease diagnostics, forensic science, and evolutionary biology. A diagrammatic representation of the PCR process is found in figure 2.
The Fortune Bay "Sea Monster"

In the summer of 2001 there was a fascinating story that came from the small outport town of St. Bernard's. Washed up on shore was an unknown creature that local residents and scientists could not visually identify. Reports were issued that described the large creature as having fur. The description of a large marine creature with fur started many rumours of a washed up “sea monster.” A picture of the “sea monster” is found at the end of this section. Genetic testing using PCR, and subsequent sequencing revealed that the “sea monster” was in fact a badly decomposed sperm whale. As for the fur, it was actually badly decomposed fatty tissue. The following is a news release that was issued shortly after the DNA analysis was completed.
St. John’s, Newfoundland, 16 August 2001 - DNA testing has identified the “sea monster” that washed ashore at St. Bernard’s, Fortune Bay, as the remnant of a sperm whale (Physeter catodon).

Based on material provided by Dr. Garry Stenson, of the Department of Fisheries and Oceans in St. John’s, scientists at the Genetics, Evolution, and Molecular Systematics Laboratory in the Department of Biology at Memorial University of Newfoundland (Dr. Steve Carr, Dr. Dawn Marshall, Ms. Kim Johnstone, and Ms. Lori Pynn) performed a forensic DNA test to determine species origin. The analysis compared the DNA sequence of the creature’s NADH2 gene (a specific genetic marker) with that of homologous DNA from a variety of large marine species, including sharks and whales. Comparison with this database gave an almost perfect match with a sperm whale. The few observed differences are consistent with ordinary genetic variation expected among individuals within species. The test involves a “DNA xeroxing” procedure called the polymerase chain reaction, which generates a large number of copies from a single original gene. The sequence of the gene can then be determined on an automated DNA sequencer. This type of DNA test is particularly useful in cases like the sea monster, which involve material in a poor state of preservation or of questionable origin. The identification was done as part of an ongoing collaboration between DFO and Memorial scientists to study the genetics and genomics of marine organisms.

**Figure 3**: The Fortune Bay “sea monster”

The DNA analysis technique described in the article is identical to the one used in our hypothetical case of foreign over-fishing. Careful examination of a minimal amount of genetic material enables scientists to identify organisms that otherwise would be impossible to identify.

**Stock Structure in Atlantic Cod**

DNA classification techniques can also be used to help make important commercial fish management decisions. Setting inshore and offshore quotas is very difficult when it is unknown whether fish migrate between these two regions. This could be more easily determined if the fish could be examined to check for distinct breeding units. And knowing whether the fish move between the regions would have a significant impact on quotas set by DFO.

The existence of distinct breeding units, with different DNA, indicate that fish migrate. This would mean that quotas for inshore cod are high, while offshore stocks are still very low. Many inshore fisherman argue that the inshore fishery should be reopened on a commercial basis. DFO
scientists are hesitant about this because they see a possibility of the inshore fish being used to replenish the depleted offshore stocks.

The Genetics, Evolution, and Molecular Systematics Laboratory at Memorial University has pioneered the application of DNA analysis techniques to study the natural populations of marine organisms. In particular, direct analysis of DNA sequences via the polymerase chain reaction (PCR) technology has been developed as a tool to investigate several fishery management questions. One in particular is whether distinct breeding units exist in the inshore and offshore regions.

**Conclusion**

The science of classification has progressed greatly with the development of new DNA analysis technologies. These technologies have empowered biologists with an ability to gather much information about individual organisms and their relationships to other species, using small amounts of genetic material. Identification and subsequent classification of organisms reveals evolutionary links between known and unknown species. For example, evolutionary links between humans are being uncovered by the Human Genome Project. Methods and technologies that help scientists classify and organize information enhance our ability to understand the world around us and improve science.

**Questions**

1. How could information gathered through genetic analysis be applied to fisheries management as it pertains to setting quotas in various fishing zones?

2. During a routine check on an offshore trawler, DFO officials discover a large supply of what they believe to be frozen cod fillets. The crew has no licence for the species but maintain that the fish is pollock for which they had a quota. Discuss how the situation could be resolved.

3. What is the significance to the inshore fishery of the province if it can be determined that the offshore and inshore populations of cod are genetically distinct?

4. There have been suggestions by some that the Beothuk Indians were amalgamated into the population of early Newfoundland and Labrador. How could the techniques of molecular (DNA) classification be used to confirm or deny this suggestion? Would the conclusions reached by this method be valid?

5. Area quota systems are used to effectively manage big game populations. This involves managing each area as a separate stock. How could the science of DNA classification be used to more effectively define the boundaries that determine the areas? Why would this be (or not be) practical?

**References**

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http://www.mun.ca/biology/scarr/Bio2900.htm

http://www.mun.ca/biology/scarr/WSN_talk.htm

http://www.ornl.gov/hgmis/publicat/primer/pcr.html

Kidney and Urologic Diseases

Outcomes
1. Analyse why and how a particular technology was developed and improved over time. (115-5)
2. Compare human kidney systems and kidney dialysis systems to interpret and explain their structure and dynamics. (116-7)
3. Debate the merits of funding research into organ transplant therapy. (117-4)
4. Identify multiple perspectives that influence a science-related decision or issue. (215-4)
5. Identify, in general terms the impact of kidney disease on the homeostasis within an organism. (317-4)
6. Describe disorders linked to the excretory system and their effect on the homeostasis of the system and the organism as a whole. (317-4)
7. Analyse and describe kidney dialysis and kidney transplant as ways of applying scientific understanding to the treatment of renal failure. (116-4)

Introduction

Every year thousands of Canadians are diagnosed with some form of renal disease. Kidney disease usually progresses silently, often destroying most of the kidney function before causing any symptoms. For this reason, people at risk of developing kidney disease should be evaluated regularly. For many of those afflicted, the necessity of maintaining a homoeostatic balance within their bodies forces them to undergo a procedure known as kidney dialysis. Unfortunately for many, kidney dialysis is a temporary solution, and eventually they will need a kidney transplant.

This STSE module will explore the impact of renal disease on the human system and describe the seriousness of this situation for people so afflicted. The number of Canadians over 65 with kidney failure has more than doubled in the last decade (according to the Canadian Institute for Health Information). From 1990 to the end of 1999, the number of people who developed kidney failure and needed dialysis or a transplant soared by 132%. During that same period, new cases in all age groups across Canada rose by 73%. Due to this dramatic increase, this disease and its treatments are becoming a serious concern for all Canadians.

The treatment of kidney disease has come a long way over the past 30 years.
• Thirty years ago - anyone suffering from kidney failure had little hope of survival, and thousands of Canadians suffered from disorders such as kidney stones and bladder cancer.
• Twenty years ago - dialysis patients spent up to 36 hours per week connected to a machine, and half of kidney transplants were successful.
• Ten years ago - new dialysis treatments reduced patient time by 12 hours per week.

In the future, genetic discoveries may help prevent some forms of hereditary kidney disease. Kidney transplants may become 100% successful! Dialysis and transplantation may no longer be necessary because more effective treatments for kidney disease could be discovered.
Why are the kidneys important?

The kidneys are important because of their three essential functions:

1. Kidneys regulate water. The body must contain the right amount of water. The kidneys remove excess water from the body or retain water when the body needs more.

2. Kidneys remove wastes. Many chemicals in the blood and body must be kept at the correct concentration for the body to function properly.

3. Kidneys produce hormones. Hormones circulate in the bloodstream and regulate functions such as blood pressure, the making of red blood cells, and the uptake of calcium from the small intestine.

The kidneys are designed and placed within the body so that they can effectively remove the by-products of metabolism (see Figure 1).

Warning Signs of Kidney Disease

Sometimes even people with serious kidney disease may not have any symptoms. That is why blood or urine tests are necessary to check for kidney problems. Possible symptoms include:

- passing less urine, or difficulty passing urine;
- puffiness of the eyes, hands, and feet;
- passage of cloudy or tea-colored urine;
- persistent generalized itching;
- frequently passing urine at night;
- hypertension.

A medical assessment, however, is required to determine kidney problems.

Treatments for Kidney Disease

1. Diet Control

A diet for people with kidney disease helps make up for what poorly functioning kidneys are unable to do. When the kidneys are damaged, they cannot filter the blood; therefore substances can build up to harmful levels. This build up can damage other organs of the body and cause problems. Changing a person’s diet may minimize this toxic build up. This diet should limit:

1. protein, a nutrient containing nitrogen;
2. fluid;
3. potassium, a nutrient important for muscle functioning;
4. sodium, a part of salt;
5. phosphorus, a mineral.
Unfortunately, it is not easy to design a diet for someone with kidney disease. People with kidney disease are at risk for vitamin deficiencies and anemia, and their bodies may not be able to make muscle tissue and bones as usual. The extra fluid and sodium present in the blood stream can lead to high blood pressure. Hormonal changes due to the lack of filtration by the kidneys can cause cholesterol and other fats in the blood to become high. A diet for kidney disease, therefore, is very personalized. The degree to which each nutrient needs to be restricted varies from individual to individual. A registered dietitian is needed to instruct the patient on his or her specific diet. Frequent blood tests are necessary to show which nutrients need to be limited.

The diet must include the minimum amount of protein needed to provide the essential amino acids needed by the body. The amount of protein needed depends on the person’s weight. Protein by-products are filtered by healthy kidneys for toxic substances. Usually, people with kidney disease are advised to get their protein from animal sources, since animal proteins contain all of the essential amino acids. This allows those with kidney disease to eat a small amount of protein but still get all of their essential amino acids.

The allowable amount of sodium for a person with kidney disease is usually 1,000 to 3,000 milligrams daily. This usually means limiting table salt, as well as processed, canned, and convenience foods. Fruits, vegetables, and dairy products are also limited because they are high in potassium. Restricting the amount of meat and milk helps to control the amount of phosphorus, saturated fat, and cholesterol in the diet. Due to diet restrictions, people with kidney disease must include a lot of starch to provide enough calories to prevent weight loss, and take supplements of vitamins (iron and calcium). This level of dietary control is difficult to maintain.

2. Kidney Dialysis

Dialysis is a procedure that cleans and filters the blood when the kidneys are not functioning properly. It is a treatment for people in the later stage of chronic renal insufficiency (kidney failure). Sometimes dialysis is a temporary treatment. However, when the loss of kidney function is permanent (as in end-stage kidney failure), the patient must continue to have dialysis on a regular basis. This treatment cleans the blood and removes wastes and excess water from the body. Dialysis keeps some people with kidney failure alive. The only other treatment for kidney failure is a kidney transplant.

There are two types of dialysis: hemodialysis and peritoneal dialysis. In hemodialysis, the blood is passed through an artificial kidney machine. Peritoneal dialysis uses a filtration process similar to hemodialysis, but the blood is filtered inside the body rather than in a machine. Both types of dialysis require surgery to prepare the person’s body.

Hemodialysis

Hemodialysis means "cleaning the blood"—and that is exactly what this treatment does. Blood is circulated through a machine which contains a dialyzer (also called an artificial kidney). An illustration of the machine is found below (see Figure 4). The dialyzer has two spaces separated by a thin membrane. Blood passes on one side of the membrane and dialysis fluid passes on the other. The wastes and excess water pass from the blood through the membrane into the dialysis fluid, which is then discarded. The cleaned blood is returned to the patient’s bloodstream.

Figure 4: Hemodialysis Machine

The patient can be attached to the dialysis machine in different ways. The most common method of providing permanent access to the bloodstream for hemodialysis is through an internal fistula in the patient’s arm. This involves having an artery and a vein connected surgically. When they are joined, the...
stronger blood flow from the artery causes the vein to become larger. Needles can be inserted into the enlarged vein to connect the patient to the dialysis machine.

Inserting an **internal graft** is another way to provide access to the bloodstream. In this procedure an artery is surgically connected to a vein with a short piece of special tubing placed under the skin. Needles can be then inserted in this graft.

Each hemodialysis treatment normally takes three to five hours, and usually three treatments a week at a dialysis centre are required. Only a small amount of the blood is out of the body at one time. Therefore the blood must circulate through the machine many times before it is cleaned.

**Peritoneal Dialysis**

The inside of the abdomen is called the peritoneal cavity and it is lined with a thin membrane called the peritoneum. This membrane surrounds the intestines and other internal organs. Peritoneal dialysis is also called **continuous peritoneal dialysis** (CPD). In CPD the patient always has dialysis fluid in the peritoneal cavity, so the blood is constantly being cleaned. The fluid is changed at regular intervals throughout the day by using a catheter (see Figure 5).

![Peritoneal Cavity with Catheter Insertion](image)

Excess water and wastes pass from the blood through the peritoneum into the dialysis fluid. This fluid is then drained from the body and discarded. In most cases this treatment can be performed at home or at work without assistance.

A tube called a **catheter**, made of soft, nonirritating plastic, is inserted in the patient’s abdomen below the navel, and stays there as long as the patient is using this type of dialysis. The catheter may be inserted using local anesthetic, or in the operating room, depending on what is best for the patient. The dialysis fluid flows into, and is drained out of, the peritoneal cavity through this special tube.

Peritoneal dialysis is not painful; however, care must be taken to avoid infection. This type of dialysis is done at home, and after each time the equipment is used, it must be carefully cleaned. Whatever type of dialysis is used, repeated sessions are usually needed for survival.

Until the body adjusts to the procedure, people often feel tired, weak, and even confused after dialysis.

### 3. Kidney Transplants

A kidney transplant is a surgical procedure in which a healthy, donated kidney is transplanted into the patient’s body. A successful transplant will allow the patient to return to a healthier lifestyle and will free them from dialysis treatments.

**Who is a candidate for the procedure?**

Transplant is the treatment of choice for people with chronic renal insufficiency who are considered suitable candidates.

There are a few conditions that would rule out a transplant entirely. These include

1. cancer within the past five years, as the risk of developing complications following the transplant increase dramatically;
2. infections such as tuberculosis or osteomyelitis, (an infection of the bones), which weaken the person’s immune system and may complicate the acceptance of the donated organ;
3. severe heart, lung, or liver problems, as the person would be unable to physically handle the procedure.

Once a person is deemed suitable as a transplant
candidate, a donor must be found. The best situation is for the donor kidney to come from a living family member, as the likelihood of a genetic match is much greater, and the likelihood of rejection is therefore considerably less.

There are two types of kidney transplants: a living donor transplant and a cadaveric transplant.

**Living Donor Transplant**

In a living donor transplant, a kidney from a donor, usually a blood relative, is transplanted into the patient’s body. The donor’s blood group and tissue type must be compatible with the patient’s, and extensive medical tests would be done to determine the health of the donor. People who donate a kidney can live a normal life with one kidney, and there are few risks to healthy donors. For this type of transplant, there is a shorter waiting period and the transplant operation is planned at a time convenient for both patient and donor. Living donor transplants have a 90% - 95% success rate. That means that after one year, 90 to 95 of every 100 transplanted kidneys are still working.

**Cadaveric Transplant**

In a cadaveric transplant a healthy kidney from someone who has died suddenly is transplanted into the patient’s body. Before a cadaveric donor’s organs can be transplanted, a series of medical tests determine whether the organs are healthy. In addition, the family of the donor must consent to organ donation.

After the patient has a series of tests, he/she is put on a transplant waiting list until a compatible kidney is found. The length of time patients wait is hard to predict because it depends on how hard they are to match and how many kidneys become available. Unfortunately, the waiting time for a cadaveric organ transplant is getting longer. Cadaveric transplants have an 80% - 85% success rate.

**What happens during transplant?**

The kidney transplant operation usually takes two to four hours. The new kidney and ureter (the tube through which the urine flows into the bladder) are placed in the lower abdomen near the groin, as illustrated in figure 3. They are surgically attached to the blood vessels and bladder. The old kidneys are not removed unless they are so large there is no room for the new kidney, or they are chronically infected.

**Figure 3: Location Transplanted Kidney**

**What happens right after the procedure?**

Recipients of new organs need to take drugs to suppress their immune systems and prevent their bodies from rejecting the new kidneys. These are started either immediately before, or during the transplant procedure. Even with many precautions and a healthy donor kidney, some complications are possible. These may include

1. infection, which happens in roughly 25% of transplant recipients;
2. problems with the blood vessel connections between the donor kidney and the recipient’s pelvic vessels;
3. a clot in the blood supply to the kidney, which may result in the death of the kidney;
4. narrowing of the artery within the kidney (called transplant renal artery stenosis), which limits blood flow to the kidney and makes it difficult to keep blood pressure under control. (usually, the narrowed segment can be expanded using angioplasty - a small balloon that is inflated in the narrow section);
5. leaky ureter connections to the bladder, which can be treated by inserting a stent (a very thin, straw-like tube that provides a kind of scaffolding around which tissues can heal);

6. kidney rejection - the body’s normal immune response to the new kidney, which can usually be prevented by using drugs to suppress the immune system.

Kidney transplantation usually has very positive results. Recipients live longer, healthier lives than is possible with dialysis treatments. There is a short-term risk of death associated with the surgery, but this risk is outweighed by the long-term effects of continuous dialysis. Depending on the source and quality of the donor kidney, 80% - 95% of the time there is a successful outcome for a kidney transplant, and it can last an average of 8 to 25 years.

Outcomes for living kidney donors are excellent. The risk of death from kidney donation is less than 4 in 10,000, and there are almost no long-term risks. Living kidney donors do not need to undergo any special medical testing, maintain any special diet, or take any medications as a result of kidney donation.

**Conclusion**

The impact of renal disease on both the patient and their families is great. The treatments - dialysis, transplant, or diet modification - can greatly affect the way that the afflicted person is able to carry out his or her daily life. Diet modification would be the least intrusive, however, it is usually only successful in the early stages of kidney disease. Dialysis provides a short term measure of treatment for more severe kidney problems, but over time may not be sufficient to treat the condition. Kidney transplantation, the third and most invasive treatment, is major surgery and, as with all major surgeries, there are possible complications. At present, there is research being conducted into which method of treating kidney disease is most effective. This cost money. With a limited pool of research dollars available, the question arises, where should the money be spent?

**Questions**

1. Define the following terms:
   (i) Peritoneal cavity
   (ii) Hemodialysis
   (iii) Catheter
   (iv) Peritoneal dialysis
   (v) Stent

2. Describe some of the problems commonly associated with kidney dialysis and kidney transplant.

3. With a limited pool of research dollars available for medical research, where should the money be primarily spent? Support your answer.

4. Why is it so important that a kidney patient control his/her diet?

5. In a recent episode of a popular TV drama series, a mother suffering from kidney disease had her daughter artificially inseminated so as to bear a child that would provide a donor kidney. The daughter was inseminated through the use of her father’s sperm. Does this means of acquiring a donor kidney constitute a viable option - medically and ethically? Explain.

**References**

- http://www.cihi.ca/
- http://www.kidney.ca/index-eng.html
- http://www.rein.ca/
Hodgkin’s Disease

**Outcomes**

1. Analyse why and how a particular technology was developed and improved over time. (115-5)
2. Analyse and describe examples where technologies were developed based on scientific understanding. (116-4)
3. Debate the merits of funding specific scientific or technological endeavours and not others. (117-4)
4. Explain how different plant and animal systems help maintain homeostasis. (317-1)
5. Identify in general terms the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism. (317-4)

**Introduction**

There are many things that influence the ways that living organisms are able to effectively cope with changes in the environment. Using various feedback mechanisms, organisms are able to respond to changes, although there are situations that arise that make this maintenance difficult. One such difficulty is the development of disease. The following STSE module will outline the impact that one type of cancer, Hodgkin’s disease, has on the body’s ability to maintain its dynamic balance.

**What Is Cancer?**

One of the most frightening diagnoses that a person can be give by a physician is cancer. Cancer is not just one disease, but rather a group of diseases. All forms of cancer cause cells in the body to change and grow out of control. Most types of cancer cells form a lump or mass called a **tumour**. Cells from the tumour can break away and travel to other parts of the body, where they can continue to grow. This spreading process is called **metastasis**. If cancer spreads, it is still named after the part of the body where it started. For example, if breast cancer spreads to the lungs, it is called breast cancer, not lung cancer.

Tumours which are cancerous are referred to as **malignant**, while those tumours that are not cancerous are referred to as **benign**. Benign tumours are usually not a threat to life as they lack the ability to metastasize and interfere with surrounding tissue.

Not all cancers form tumours. A few cancers, such as blood cancers (leukemia), interfere with the production of cells throughout the system. Other examples of this type of cancer include cancers of the lymphatic system, such as Hodgkin’s and non-Hodgkin’s lymphoma.

One in three Canadians will be diagnosed with cancer in his/her lifetime. Cancer is now the second leading cause of death in Canada and, given current trends, its incidence is expected to increase by 70% by the year 2015. The good news is that, with improved screening tests, availability of comprehensive information, and better treatments, more than half of all people with cancer will survive the disease.

**What Is Hodgkin’s Disease?**

In Canada it is difficult to hear the term Hodgkin’s disease without thinking of one of the greatest hockey players in the world - Mario Lemieux. He has proved that a diagnosis of a cancer is nowhere near as devastating as it once was. He was treated for Hodgkin’s disease and returned to a productive career as one of the NHL’s elite players.

Hodgkin’s disease (also called Hodgkin’s lymphoma) is a type of cancer that starts in lymphatic tissue. Lymphatic tissue includes the lymph nodes and other organs that are part of the body’s system that forms blood and protects against germs. Lymph nodes are small, bean-shaped organs found in many places throughout the body. The
lymph nodes make and store white blood cells that fight infection. Lymph vessels - narrow tubes similar to blood vessels - connect the lymph nodes and carry a clear fluid that contains the white blood cells. The lymphatic system also includes the spleen, bone marrow, and thymus.

Due to the presence of lymphatic tissue in many parts of the body, Hodgkin’s disease can start almost anywhere, and can spread through the lymphatic vessels. If it gets into the blood vessels, it can potentially spread to almost any place in the body.

Hodgkin’s disease is named after Dr. Thomas Hodgkin, who first recognized it in 1832. Hodgkin’s disease is identifiable through the presence of what are known as Reed-Sternberg cells. The following figure shows what these cells look like.

The nodules contain numerous cells (mostly lymphocytes) and two distinct types of malignant cells. One of these malignant cells, the Reed-Sternberg cell, is large and frequently binuclear or multinuclear (containing more than one nucleus).

Figure 1: Reed Sternberg Cell as identified through the arrow.

Prevalence of Hodgkin’s Disease?

The National Cancer Institute of Canada reported that in 2001 there were 810 new cases of Hodgkin’s disease in this country, and that 120 of these patients succumbed to the disease. Both children and adults can get Hodgkin’s disease, but it is most commonly found in two age groups: early adulthood (ages 15-40), and late adulthood (after age 55). Due to improved treatment, death rates have decreased by over half since the early 1970s. Today the death-to-case Ratio is listed at 0.15 for all patients.

The 1-year relative survival rate after treatment is 93%; the 5-year and 10-year rates are 82% and 72% respectively. At 15 years, the overall survival rate is 63%. It should be noted that these survival rates are based on treatment regimens that were in place 15 years ago. The survival rate refers to the percentage of people with Hodgkin’s disease who live at least that many years after cancer is diagnosed.

What Causes Hodgkin’s Disease? Can It Be Prevented?

A risk factor is anything that increases a person’s chance of getting a disease such as cancer. Different cancers have different risk factors. Scientists have identified a few risk factors for Hodgkin’s disease. These include a past history of mononucleosis, and a reduced immune system (as with people who have had organ transplants, or those with AIDS). If one has one or more risk factors for Hodgkin’s disease, it is impossible to know how much each risk factor contributed to the cause of the cancer. Unlike many other types of cancer, Hodgkin’s disease does not seem to be caused by problems with a person’s genes, his/her diet, or environmental factors. Since the cause(s) of Hodgkin’s disease are unknown, it is not possible at this time to list preventive measures.
How Is Hodgkin’s Disease Diagnosed?

Symptoms of Hodgkin’s Disease

There are no early screening tests for Hodgkin’s disease, and often people with the disease have no symptoms. One symptom of the disease may be enlarged, painless lymph nodes. In most people, however, especially children, enlarged lymph nodes are caused by an infection or other illness and not by cancer. In the case of a person who has lymph nodes over an inch in size, and no recent history of infection, Hodgkin’s disease may be suspected.

Hodgkin’s disease causes the lymphatic tissue to become enlarged and press on nearby structures. The swelling of lymph nodes inside the chest creates pressure on the windpipe, which can result in coughing or shortness of breath. Other symptoms include fever, drenching night sweats, or weight loss. Many of these symptoms resemble what one would expect to see if one were suffering from a common flu or cold. The key to detection is that persons having these symptoms, especially if they persist, should seek medical advice.

Tests to Diagnose Hodgkin’s Disease

If a person potentially has Hodgkin’s disease, certain information must be gathered. The first step would be to get a complete medical history. A thorough physical exam would determine whether there is an infection. During the exam, the doctor will pay particular attention to the lymph nodes. Since it is common for people, especially children, to have swollen lymph nodes, the doctor will probably prescribe antibiotics initially to see if the lymph nodes shrink. If they do not, more testing is required.

The only way to conclusively determine whether a person has Hodgkin’s disease is to perform a biopsy (examine a tissue sample under the microscope). Some biopsies involve cutting through the skin to remove an entire node or a small part of a large tumour. In another type, the doctor uses a thin needle to remove a small amount of fluid and tiny bits of tissue from the tumour. A doctor with special training in blood and lymphoid tissue disease examines all biopsy samples under a microscope and looks for the Reed-Sternberg cells. Sometimes the first biopsy does not provide a definite answer and more biopsies are needed.

What Are the Stages of Hodgkin’s Disease?

Staging is the process of determining how far the cancer has spread. This is very important because the treatment and the outlook for recovery depend on the stage of the cancer. The staging system for Hodgkin’s disease is called the Ann Arbor Staging Classification. This system has four stages, labeled I through IV. In general, the lower the number, the less the cancer has spread. A higher number, such as in Stage IV, means a more serious cancer.

Clinical staging consists of taking the patient’s medical history, doing a physical exam, and then doing several kinds of imaging studies. Imaging studies such as CT (computed tomography) and MRI (magnetic resonance imaging) are used to create detailed pictures that show the size and shape of lumps or tumours that might be cancerous.

For many people, the results of the clinical staging will determine the plan for treatment. Other cases, however, require pathological staging. In this process, a laparotomy is performed to check inside the abdomen for any organs that contain cancer. Small pieces of tissue are removed and looked at under a microscope to see if Hodgkin’s disease is present.

How Is Hodgkin’s Disease Treated?

After Hodgkin’s disease is staged, the doctor will discuss treatment choices with the patient. It is important to take time and think about all the treatment choices. The two main methods of treating Hodgkin’s disease are chemotherapy and radiation therapy. These treatments are used independently or together, depending on a number of factors. If the disease is isolated to one specific area (Stage 1), often only radiation therapy is used. If the disease is spread over multiple areas, then chemotherapy is used. Combinations of these treatments would be determined by the examining
specialist.

Chemotherapy

Chemotherapy is the use of drugs to kill cancer cells. Usually the drugs are given orally or intravenously, and subsequently enter the bloodstream and are carried throughout the body. Drug cocktails are often given, with each drug capable of acting on certain characteristics of the cancer cells. Combining drugs produces a more effective treatment. The drug cocktails work to interfere with the cell’s ability to reproduce. Therefore the cancer cells live out their normal course of life and die. Without the ability to reproduce, the cancer cells are unable to spread, and if the drugs are effective, the cancer will be eliminated from the person’s body.

Unfortunately the drugs that kill cancer cells also damage normal cells - especially those that rapidly reproduce such as the blood cells (red blood cells, white blood cells, platelets, etc.), epithelial tissue, hair follicles, and reproductive cells. The side effects caused by this damage depend on the type and dose of drugs used and the length of time they are taken, but they can include hair loss, mouth sores, increased chance of infection, easy bruising or bleeding, fatigue, loss of appetite, nausea, and vomiting. These side effects are temporary and go away after treatment is finished. If the patient has severe side effects, the cancer care team can suggest ways to ease their impact. For example, drugs can be given to prevent or reduce nausea and vomiting.

Some patients, however, are at risk of developing more severe long-term side effects, even after chemotherapy is finished. These can affect a person’s heart, lungs, growth, and ability to reproduce. There is also a risk of developing a secondary type of cancer. The risk of these long-term effects have greatly diminished as treatment programs have improved.

Radiation Therapy (Radiotherapy)

Unlike chemotherapy, radiation therapy involves a very localized attack on a diseased area. The chemotherapy provides a systemic approach, whereas the radiotherapy involves a direct attack.

When radiation therapy is given, it usually involves a focussed beam of x-rays, from a machine outside the body, known as external beam radiation. In Canada, radiotherapy is given by a machine called a linear accelerator. It converts household electrical current to 6,000,000 - 21,000,000 electron volts and converts it to X-rays. The x-rays are then refined to a single energy and are focussed on a specific target. The beam can be changed in size and shape (but not intensity) to tailor the treatment for any one person. The duration of the treatment determines the total dose that is delivered.

Radiation therapy can produce some serious side effects, including damage to nearby healthy tissue, skin changes (similar to sunburn), tiredness, upset stomach, and loose bowels. To reduce the risk of side effects, technicians are careful to deliver exactly the dose needed in an accurate beam hitting only the cancer.

Bone Marrow Transplantation

Sometimes Hodgkin’s disease stops responding to the standard treatments of chemotherapy and radiation therapy. In these cases, bone marrow transplants might be performed.

In one procedure, the patient’s own bone marrow is removed and stored. Then very high doses of chemotherapy (with or without radiation therapy) are given to the patient to kill the cancer. These high doses will also destroy bone marrow. After the treatment, the stored marrow is transplanted back to the patient through a vein. The bone marrow cells enter the bloodstream and return to the bone, replacing the marrow and making new red and white blood cells.

In another type of procedure, called peripheral blood stem cell transplant (PBSCT), a machine removes the patient’s blood a little at a time. Only the stem cells (immature cells from which all blood cells develop) are removed. These are stored to be reintroduced at a later date. The rest of the blood is returned to the body. This process usually takes a few hours. The stem cells are frozen until they are returned to the patient after treatment is finished.
Conclusion

The treatment of Hodgkin’s disease, as with all cancers, has improved greatly over time. The diagnosis of the cancer is not as devastating as it once was, as there have been considerable improvements in all aspects of the treatment of the disease. Presently the likelihood of a complete cure for those afflicted with Hodgkin’s disease is greater than 80%. With further research this statistic will undoubtedly improve.

Questions

1. What are the symptoms of a person diagnosed with Hodgkin’s disease? How are these symptoms related to other body systems?
2. Explain the reasons for chemotherapy causing side effects for the patient, such as hair loss.
3. Why would a bone marrow transplant provide a course of treatment for a patient afflicted with Hodgkin’s disease?
4. Children tend to have an even higher success rate in dealing with this disease? Why would this be so?
5. Define the following terms:
   (i) Malignant and benign tumours
   (ii) Metastasis
   (iii) Biopsy
   (iv) Staging
   (v) Chemotherapy
   (vi) Radiotherapy

Extension/Research

1. When a patient is undergoing chemotherapy, blood tests are regularly conducted. One of the blood components that is closely monitored is the neutrophil count. What is the role of the neutrophils? Why would treatment be delayed if the neutrophil count drops?
2. If you had a million dollars to donate to cancer research, on which treatment (chemotherapy, radiation, or bone marrow transplantation) would you want the money spent? Why?

References

http://www.umm.edu/cancer-info/
http://www3.cancer.org/
http://www.cfl.org/
http://www.lymphomainfo.net/
http://www.hc-sc.gc.ca/hpb/lcdc/bc/stats.html

3. Hodgkin’s disease was one of the first cancers that was described. Some of the early treatments used a noxious chemical called nitrogen mustard. Why was this used, and what were the potential side effects of using this chemical?
Appendix C

Instructional Planning
Transparency Correlations
INSTRUCTIONAL PLAN
Biology 521A

Term 1 (~37 Classes)

### Matter and Energy for Life (~13 Classes)

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Note: Brackets denote text pages located outside of the identified text sections that may be of assistance in addressing specific curriculum outcomes.
### INSTRUCTIONAL PLAN continued

**Biology 521A**

**Term 2 (~37 Classes)**

#### Maintaining Dynamic Equilibrium I (~32 Classes)

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<td></td>
<td></td>
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Note: Brackets denote text pages located outside of the identified text sections that may be of assistance in addressing specific curriculum outcomes.
## CORRELATIONS

McGraw-Hill Ryerson *Biology* text - Transparencies Set *Biology 7th Ed.*

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Appendix D

Dissection Policy
P.E.I. Department of Education and Early Childhood Development
Dissection Policy

The P.E.I. Department of Education and Early Childhood Development supports each teacher's decision to use animal dissection as a pedagogical practice to assist with the teaching and learning of specific curriculum outcomes.

The practice of dissection is supported by the National Science Teachers Association (NSTA) as articulated in their position statement regarding the responsible use of live animals and dissection in the science classroom.

NSTA supports each teacher's decision to use animal dissection activities that help students:
- develop skills of observation and comparison;
- discover the shared and unique structures and processes of specific organisms; and
- develop a greater appreciation for the complexity of life.

NSTA recognizes science educators as professionals. As such, they are in the best position to determine when to use—or not use—dissection activities. NSTA encourages teachers to be sensitive to students’ views regarding animal dissection, and to be aware of students’ beliefs and their right to make an informed decision about their participation. (NSTA, 2008)

The PEI Department of Education and Early Childhood Development agrees with the aforementioned NSTA position.

Should a student wish not to participate in a dissection activity for moral, religious, or other acceptable reasons, then a meaningful alternative to the dissection activity must be provided for the student.

Students are to be informed, at the beginning of any course potentially involving the practice of animal dissection, of their right to choose to not dissect animals.

Students who opt to engage in a meaningful alternative to dissection are responsible for completing the form titled Alternative to Dissection. This form must be completed and returned within the specified time communicated by the teacher at the beginning of the course. This form requires students to articulate the reason(s) why they wish not to engage in the practice of dissection. The Alternative to Dissection form further serves to confirm students’ acknowledgment that they agree to engage in a meaningful alternative to dissection. The Alternative to Dissection form must be signed by the student, the teacher, and a parent/guardian.

Reference:

## ALTERNATIVE TO DISSECTION
(Student form)

This form provides students with the opportunity to articulate their reason(s) to not engage in the practice of dissection.

This form further serves to have students acknowledge their participation in a meaningful alternative to dissection.

<table>
<thead>
<tr>
<th>Student Name:</th>
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<tbody>
<tr>
<td>Course:</td>
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<tr>
<td>Teacher:</td>
<td>__________________</td>
</tr>
<tr>
<td>Date:</td>
<td>__________________</td>
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</tbody>
</table>

Please identify your reason(s) for not wanting to engage in the practice of dissection by selecting one (or more) of the following options:

- [ ] Moral
- [ ] Religious
- [ ] Other; please specify __________________

Based on the selection(s) identified above, please explain the reason(s) for not wanting to engage in the practice of dissection.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Briefly describe the provided alternative to dissection which you have agreed to perform.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(Student Signature) __________________
(Teacher Signature) __________________
(Parent/Guardian Signature) __________________

Date: _________ Date: _________ Date: _________

ATLANTIC CANADA CURRICULUM: PRINCE EDWARD ISLAND BIOLOGY 521A