Prince Edward Island
CANADA

Education and Early Childhood Development
English Programs

Science Curriculum

Biology

Biology 621A

CURRICULUM

2010

Prince Edward Island

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Contents

Foreword

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12*, released in October 1997, will assist in standardizing science education across the country. New science curriculum for the Atlantic Provinces is described in *Foundation for the Atlantic Canada Science Curriculum* (1998).

This guide is intended to provide teachers with an overview of the outcomes framework for Biology 621A. 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 621A* 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, drawings, 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

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

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, the method used, and the marking scheme being used. In order that formative assessment support learning, the results, when reported to students, should indicate the improvements expected.

Assessment Techniques *Continued...*

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) would 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 student's participation level, 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 all students are observed in a reasonable period of 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 their various skills (e.g., how to use a piece of equipment; apply an experimental technique; interpret and follow instructions; 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 toward science concepts, processes, and skills, and application of these 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 application of scientific concepts. Interviewing a student allows the teacher to confirm that learning has taken place beyond simple 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 pro-active 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 an activity 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 of concepts. They are less successful in 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 analyse and interpret information; to identify relationships between science, technology, society, and environment; to be able to work in teams; and to communicate information. Although the process 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 (science fair), 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.

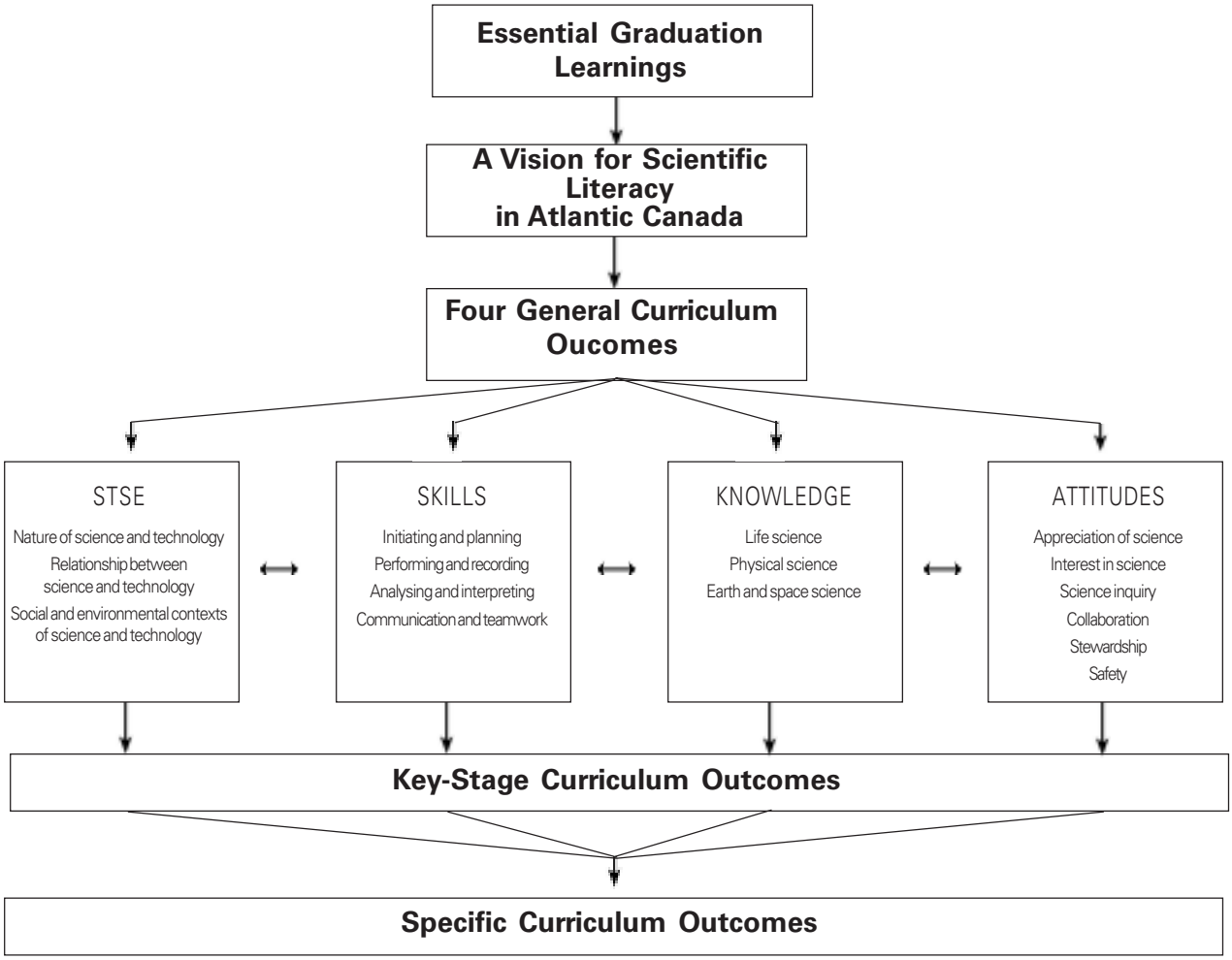
Curriculum Outcomes Framework

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 C*ommon 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

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.

General Curriculum Outcomes

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.

Science, Technology, Society, and the Environment

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.

Skills

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.

Knowledge

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.

Attitudes

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

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 Outcomes

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

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

Collaboration	Stewardship	Safety in Science
445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *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	**446** have a sense of personal and shared responsibility for maintaining a sustainable environment **447** project the personal, social, and environmental consequences of proposed action **448** want to take action for maintaining a sustainable environment *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	**449** show concern for safety and accept the need for rules and regulations **450** be aware of the direct and indirect consequences of their actions *Evident when students, for example,* • read the label on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood • criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment • consider safety a positive limiting factor in scientific and technological endeavours • carefully manipulate materials, cognizant of the risks and potential consequences of their actions • write into a laboratory procedure safety and waste-disposal concerns • evaluate the long-term impact of safety and waste disposal on the environment and the quality of life of living organisms • use safety and waste disposal as criteria for evaluating an experiment • assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place • seek assistance immediately for any first aid concerns like cuts, burns, or unusual reactions • keep the work station uncluttered, with only appropriate lab materials present

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 621A is 110 hours in duration, the cummulative 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 year. 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 year.

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 621A 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

Page One		**Page Two**	
Topic			
Outcomes	Elaborations—Strategies for Learning and Teaching	Tasks for Instruction and/or Assessment	Resources/Notes
Students will be expected to • Specific curriculum outcome based on the pan-Canadian outcomes (outcome number) • Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)	elaboration of outcome and strategies for learning and teaching elaboration of outcome and strategies for learning and teaching	*Informal/Formal Observation* *Performance* *Journal* *Interview* *Paper and Pencil* *Presentation* *Portfolio*	Provincial responsibility

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.

Maintaining Dynamic Equilibrium II *(~20 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 and this unit will identify and introduce the role of some of the nervous (electrochemical) and endocrine (chemical) systems in humans.

Focus and Context

This unit focusses primarily on decision making (STSE) 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, numerous opportunities for problem solving and scientific inquiry are incorporated into the discussion of electrochemical and chemical control systems.

Science Curriculum Links

Biology students have studied the components of body systems at a number of different levels prior to Biology 621A. Students in grade 2 are introduced to the importance of maintaining a healthy lifestyle. When they reach grade 5, students begin to discuss the role of growth and reproduction in the human system. They are introduced to the major components of the structure and function of the digestive, excretory, respiratory, circulatory, and nervous systems. The skeletal, muscular, and nervous systems and their contributions to movement are also integrated into this study. In addition, the curriculum provides an opportunity for students to discuss the body's defences against infection and the nutritional requirements for health. When students reach grade 8, they begin to consider the factors that affect the functioning and efficiency of the human respiratory, circulatory, digestive, and excretory systems, and are encouraged to discover and describe examples of the interdependence of various systems of the human body. These systems have been studied in more detail in Biology 521A. This provides a good background for the study of the role of biological systems in the maintenance of homeostasis within an organism. A cross-curricular link exists between the life sciences and physical sciences in the discussion of dynamic equilibrium incorporated into the provincial chemistry and physics curriculums.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-7 analyse natural and technological systems to interpret and explain their structure and dynamics

Social and Environmental Contexts of Science and Technology

117-11 analyse examples of Canadian contributions to science and technology

118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

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

Skills

Students will be expected to

Initiating and Planning

212-6 design an experiment and identify specific variables

Performing and Recording

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

Analysing and Interpreting

214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

Knowledge

Students will be expected to

314-2 identify the role of some compounds, such as water, glucose, and ATP, commonly found in living systems

314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids

314-4 explain the critical role of enzymes in cellular metabolism

317-1 explain how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis

317-2 analyse homeostatic phenomena to identify the feedback mechanisms involved

317-4 evaluate the impact of viral, bacterial, genetic, and environmental diseases on an organism's homeostasis

317-5 evaluate, considering ethical issues, the consequences of medical treatments such as radiation therapy, cosmetic surgery, and chemotherapy

317-7 describe how the use of prescription and nonprescription drugs can disrupt or help maintain homeostasis

Nervous System: Neurons

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain how the nervous system helps to maintain homeostasis (317-1)	The nervous system is responsible for receiving information from internal and external stimuli and quickly responding to that information. Students have explored the concept of homeostasis in Biology 521A. This concept can be reviewed with students and related to the nervous system.
– identify requirements necessary for a nervous response to occur (i) sensory receptors (skin, eye, ear) (ii) impulse transmission (neurons) (iii) interpretation and analysis of impulses (brain, spinal cord) (iv) effectors (muscles, glands)	
– describe the structure of the typical neuron and explain the function of each part (i) dendrite (ii) cell body (iii) axon (iv) axon terminal (v) Schwann cells (myelin sheath and nodes of Ranvier)	Students can observe microscopically the structure of neurons and neuromuscular junctions on prepared microscope slides in the laboratory. Teachers should note that the axon terminal is not specifically named in the textbook. The axon terminal is described as the bulblike end of the axon. Other terms for this structure may include "end brush" or "terminal ending."
– describe the function of sensory neurons, motor neurons, and interneurons	
– describe the transmission of an impulse along the length of a neuron (i) the ion distribution of the neural membrane (rest, depolarization, repolarization) (ii) threshold (iii) action potential (iv) all-or-none response	Students can be directed to various Web sites containing animations or they can animate this process using available computer animation software. Students should be able to describe the role of the sodium-potassium (Na^+/K^+) pump as it pertains to ion distributions. Discussion of action potential should also be included here.

Nervous System: Neurons

Tasks for Instruction and/or Assessment	Resources/Notes
Performance	
• Perform available laboratory activities to illustrate aspects of the nervous system. These may include microscopic examination of components of the nervous system, dissection of specimens, or observation of models in order to observe the structure of the system. (Enrichment may be provided by giving students the opportunity to design their own investigations based on questions that arise from these activities.) (317-1)	MHR *Biology,* p. 392 BLM 12-1: "The Nervous System and Homeostasis"
• Animate the transmission of an impulse along the length of a neuron using various materials (playdough, cutouts, or other materials) and animation software. (317-1)	MHR *Biology,* pp. 395-396 MHR *Biology,* pp. 402-406
	MHR *Biology,* pp. 395-396
	MHR *Biology,* pp. 402-404 MHR *Biology,* pp. 60-61
	BLM 12-2: "Action Potentials in the Neuron" BLM 12-3: "Action Potentials"

Nervous System: Neurons *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain how the nervous system helps to maintain homeostasis (317-1) **(cont'd)**	
– describe the transmission of an impulse across a synapse and the effects of neurotransmitters involved (i) acetylcholine (ii) noradrenaline (iii) glutamate (iv) GABA (v) dopamine (vi) serotonin	Students may investigate neurological and physiological explanations for the effectiveness of acupuncture and for the production of a "runner's high." Students can investigate how nerve poisons (e.g., curare, botulism, tetanus, organophosphate pesticides, nerve gas) interfere with synaptic transmission.
– define reflex arc	Students can design and/or perform experiments to investigate other physiology of reflex arcs (e.g., pupil dilation, reaction time, reflex response). This delineation can be addressed with the laboratory outcomes referenced on page 30 of this guide.
• describe the critical role of cholinesterase in nerve transmission (314-4)	Students should understand the role of cholinesterase in the breakdown of neurotransmitters across the synapse.
• identify the role of certain compounds in neuron function (oxygen, glucose, ATP, sodium and potassium ions) (314-2)	Cells within the nervous system require enormous amounts of energy to function. This energy is provided by the processing of glucose and the production of ATP within these tissues, which requires an adequate supply of carbohydrates and oxygen (Na^+/K^+ pump). ATP energy is required to operate the sodium-potassium pump which converts cellular chemical signals into electrical signals along a nerve cell and between individual nerve cells (i.e., synapse).

Nervous System: Neurons *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Performance	
• Test the reflexes of a member of your class (for example, knee jerk test or reaction time). (317-1)	
Paper and Pencil	MHR *Biology,* pp. 405-406
• Construct a flow chart that shows the path of a reflex arc. (317-1)	
• Draw a cartoon strip of ATP in action. (317-1)	MHR *Biology,* p. 406
• Perform the laboratory activities provided to illustrate some aspects of the nervous system. These may include activities to investigate reflex times; observe the behaviour of species (e.g., *Planaria*) in response to stimuli; or study the effect of the stimulant caffeine on Daphnia. (Assessment would depend on the nature and depth of the activities selected. Enrichment may be provided by allowing students the opportunity to design their own investigations based on questions that these activities may generate.) (213-5, 214-10, 215-2, 317-1)	MHR *Biology,* pp. 395-396 MHR *Biology,* pp. 397, 402

Nervous System: Structures

Outcomes

Students will be expected to

- analyse the nervous system and explain its structure and dynamics (116-7)
  - explain the basic structure and function of the central nervous system
    (i) brain
    (ii) spinal cord
  - explain how the nervous system is protected
    (i) skull
    (ii) meninges
    (iii) cerebrospinal fluid
  - explain the basic structure and function of the brain
    (i) cerebrum
    (ii) cerebellum
    (iii) medulla oblongata
    (iv) thalamus
    (v) hypothalamus
    (vi) midbrain
    (vii) pons
    (viii) corpus callosum
  - describe the basic functions of a peripheral nervous system
    (i) autonomic
    - sympathetic
    - parasympathetic
    (ii) somatic

Elaborations - Strategies for Learning and Teaching

Students should be given the opportunity to observe the principle features of the central nervous system - using models, dissected mammalian brains, or computer simulations - and to identify and label major physical structures and their functions on drawings or photos of specific organs.

Students should understand that the basic function of the cerebrum is to sort and interpret all the information from our senses. It is the part of the brain that makes humans different from animals because it is the centre of human consciousness. Students should also understand that the cerebrum can be divided into two hemispheres (left and right) or into four lobes (frontal, parietal, temporal, occipital). For this course it is not necessary for students to know the individual function of each hemisphere or lobe.

Students can prepare a chart to visually contrast the sympathetic and parasympathetic components of the autonomic nervous system in various parts of the body (e.g., heart, digestive tract, blood vessels, bladder, bronchi, eye).

Nervous System: Structures

Tasks for Instruction and/or Assessment

Presentation

- Research and prepare questions related to a topic being presented by a guest speaker (physician or public health specialist). Working in groups, review and revise questions. Following the presentation, prepare a brief summary of the answers given to your questions. (116-7)

Journal

- What happens to your body when you are faced with a stressful situation (e.g., danger, fright)? How long does it usually take for your body to return to normal? (116-7)

Performance

- Identify regions of a preserved sheep brain. (116-7, 213-5, 215-2)
- Create a model of the human brain, illustrating the basic structures and describing their associated functions. (317-1)

Paper and Pencil

- Create a concept map for the nervous system. The concept map would begin by branching the nervous system into the CNC and PNS, each of which can be further subdivided. The major features and functions should be provided, in point form, for each component identified in the map. (116-7)

Resources/Notes

MHR *Biology,* pp. 392-393

MHR *Biology,* pp. 393

MHR *Biology,* pp. 399-401

MHR *Biology,* pp. 392-394

Nervous System: Neurons *continued...*

Outcomes

Students will be expected to

- design an experiment to investigate and collect data on the nervous system (reflexes) and identify specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- identify and explain qualitatively sources of error and uncertainty in measurement and express results from this nervous system activity in a form that acknowledges the degree of uncertainty (214-10)
- select and use symbolic and linguistic modes of representation to communicate ideas and results (215-2)

Elaborations - Strategies for Learning and Teaching

The laboratory outcomes 212-6, 213-5, 214-10, and 215-2 are addressed by completing Investigation 12A: "The Nervous System and Reflex Responses" and Investigation 12B: "The Effect of Light on Pupil Size."

Students could be asked to design an experiment to measure their reaction time given a metre-stick and the formula for displacement ($d=v_it + 0.5at^2$; a = 9.81 m/s^2, t(s), d(m), v(m/s)). They would be required to create an experimental procedure and control necessary variables. Sources of error could be identified and qualitatively explained. This experiment can be performed in conjunction with "The Nervous System and Reflex Response" and "The Effect of Light on Pupil Size." Students can compare, and explain differences in, their reaction time versus reflex response time. These experiments provide an opportunity to discuss the need for the reflex arc in situations where time is an important factor. Experimental setup and the importance of controlling variables can also be addressed.

Nervous System: Neurons *continued...*

Tasks for Instruction and/or Assessment

Performance

- Design an experiment to qualitatively examine the concept of the reflex arc. (212-6, 213-5, 214-10, 215-2, 317-1)
- Design an experiment to quantitatively examine the concept of reaction time. (212-6, 213-5, 214-10, 215-2, 317-1)

Paper and Pencil

- Describe the advantage of a reflex response. (317-1)
- Compare your reaction time to reflex response time from experimental data. Draw a sketch to illustrate the pathway in the somatic and central nervous system in order to explain differences between a reflex and non-reflex response to stimuli. (213-5, 214-10, 215-2, 317-1)

Resources/Notes

Core Lab #1
Investigation 12A: "The Nervous System and Reflex Responses," MHR *Biology,* pp. 396-397

Core Lab #2
Investigation 12B: "The Effect of Light on Pupil Size," MHR *Biology*, pp.410-411

Nervous System: Disrupting Homeostasis

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to • analyse why and how technologies related to the treatment of nervous system disorders were developed and improved over time (115-5)	Students may investigate and discuss how specific technologies influence our ability to explore the human brain. Technologies may include MRI, EEG, CAT Scan, and PET Scan. Students may evaluate the consequences of damage or injury to the nervous system (e.g., stroke, spinal injury). Students may investigate the research being done on treatments for the conditions of stroke and spinal injury and the potential these have for the improvement of the lifestyle of victims of these conditions. Stem cell research could be investigated with respect to Parkinson's disease (Appendix C: "Stem Cell Research").
• describe disorders linked to the nervous system and their effect on homeostasis of the system and the organism as a whole. (317-4)	Specific pathologies of the nervous system should be discussed or researched along with the capability of technology to diagnose, treat, or cure each problem. During this discussion, students should investigate the physiological basis and causes of neurological diseases, and discuss the effectiveness and the ethics of innovative treatments (e.g., transplant of fetal brain tissue into patients as a treatment for Parkinson's). Disorders that students may be asked to investigate and describe include multiple sclerosis, Alzheimer's disease, Parkinson's disease, meningitis, and Huntington's disease. Students may be interested in other conditions related to nervous function, such as polio, stroke, Bell's palsy, ALS, Tourette syndrome, epilepsy, or mental disorders related to chemical imbalances.

Nervous System: Disrupting Homeostasis

Tasks for Instruction and/or Assessment	Resources/Notes
Presentation • Working within assigned groups, select a substance (chocolate might be an example) or procedure (e.g., acupuncture, chiropractic) that affects the nervous system. Report to the class on its physiological effects on the nervous system. (115-5)	MHR *Biology,* pp. 398-399 MHR *Biology,* pp. 404-405
• 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 a radiologist/x-ray technician or individuals knowledgeable in nervous system pathologies - community resources such as physicians; chiropractors; spokespersons from relevant organizations such as the Alzheimer Society, Parkinson Foundation, Heart and Stroke Foundation, Canadian Mental Health Association, or Multiple Sclerosis Society; sufferers of or caregivers of those who suffer from these disorders.) (115-5, 116-7, 317-4)	Appendix C: "Stem Cell Research"
• Working within assigned groups, select a nerve poison to investigate. Report to the class on the physiological effect it has on the nervous system, its source, and the historical and/or current reasons for its use. (317-4, 115-5)	MHR *Biology,* pp. 406-408

Nervous System: Disrupting Homeostasis *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• describe how the use of prescription and nonprescription drugs can disrupt or help maintain homeostasis (317-7)	Students may survey information concerning the influence of anaesthetics, prescription drugs (e.g., OxyContin, Valium, Ritalin), illegal drugs (e.g., marijuana, ecstasy, cocaine) and legalized drugs (e.g., alcohol, nicotine, caffeine) on the functioning of the nervous and endocrine systems, and their relationship to addiction theory (e.g., nicotine, OxyContin, morphine, LSD). Students may compare the relative physiological and societal impacts of chemical and drug use on adult development and fetal development. The STSE component in appendix C, "Drugs and Homeostasis," can be used to address, in whole or in part, these three outcomes, as well as 317-1, 317-4, and 115-5.
• distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot (118-8)	Students can debate the merits of using drugs for treatments of nervous disorders in light of their long-term side effects. Questions for discussion could also include the following: How does Valium affect the nervous system? (a question which can be answered by science); and How should society address the unlawful use of drugs such as OxyContin? (a question that cannot be answered by science). Students can participate in an on-line blog or discussion forum. Available software can be used to arrange a secure environment for this class blog or discussion forum. This is an excellent opportunity to have parents engage in their child's education by participating in the on-line blog or discussion forum.
• propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability. (118-10)	Students can debate the legalization of certain drugs, such as marijuana for medicinal purposes. They can propose how a person affected by multiple sclerosis may be assisted by technology. Similarly, students can propose a course of action on how technology can aid in the regeneration of nerve cells or repair a spinal cord injury.

Nervous System: Disrupting Homeostasis *continued...*

Tasks for Instruction and/or Assessment

Performance

- Participate in a debate as a means of exploring the use of drugs for the treatment of nervous disorders. (118-8, 317-7)
- Participate in a debate regarding the legalization of drugs. (118-10, 317-7)

Presentation

- Using outside sources (media, Internet, etc.), find out how drugs affect the central nervous system. Discuss findings and create a class chart that summarizes the effects of common drugs. (317-7)

Paper and Pencil

- Select a particular pharmaceutical or drug to investigate. Include the sources of the chemical, medical or non-medical uses, effects of use, and any other appropriate information. Present your information to the class. (115-5, 116-4, 118-8, 118-10, 317-7)
- Research the effects of drugs (such as codeine, heroin, caffeine) on the synapse. Compile your findings in the form of a magazine article. (317-7)

Resources/Notes

MHR *Biology,* pp. 408

Appendix C: "Drugs and Homeostasis"

http://atutor.edu.pe.ca/atutor

Nervous System: Sense Organs

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain how the eye as a sense organ helps maintain homeostasis (317-1)	The investigation of sense organs serves as a cross-curricular link with the waves/sound/light sections of high school physics. Students should observe the principal features of the mammalian eye - using models, dissected structures, or computer simulations - and identify and label major visible structures and their functions in drawings or photos of this organ.
– describe the general structure and function of the eye (i) lens (ii) iris (iii) retina (iv) cornea (v) choroid layer (vi) fovea centralis (vii) rods (viii) cones (ix) pupil (x) blind spot/optic disc (xi) optic nerve (xii) aqueous humour (xiii) vitreous humour	
– identify the structures of the eye through which light passes and explain how the amount of light entering the eye is regulated	Student activities dealing with the eye can illustrate binocular vision, dominant eye, focussing, resolution, blind spot, and retinal fatigue.
• analyse and describe examples of disorders of the eye and where technologies for the correction of visual defects were developed based on scientific understanding (116-4)	Students may research the development of new technologies for the treatment of sensory malfunctions (e.g., corneal laser surgery, extended-wear contact lenses).
– eye disorders (glaucoma, cataracts, astigmatism, myopia, hyperopia)	Students should know that myopia and hyperopia are also known as near-sightedness and far-sightedness, respectively.
– treatments for eye disorders (corneal transplant, laser surgery, corrective lenses, lens replacement)	Corneal transplant is one of the most successful transplant surgeries. The chance of rejection is low and the operation is relatively quick and cost-effective. Many people, however, suffer because too few donor cornea are available. One possible solution is for mandatory donation to be enforced. This could be a very controversial solution and should be discussed by students.

Nervous System: Sense Organs

Tasks for Instruction and/or Assessment	Resources/Notes
Laboratory Activities	MHR *Biology,* pp. 409-413
• Following the procedure outlined, dissect a sheep eye and identify the parts. Complete a table that relates the parts of the eye to their functions. (317-1)	MiniLab: "Finding Your Blind Spot," MHR *Biology,* p. 413
Journal	
• Birds of prey often have much greater visual resolution (the ability to distinguish between objects at great distances) than humans. What is it about a bird's eye that gives it this ability? (317-1)	
Performance	
• Design an experiment to investigate the effect of light intensity on pupil diameter. Show the procedure to your teacher for approval. All safety precautions and procedures must be followed. (317-1)	
• Use an eye-chart to test your vision. (317-1)	
• Design a model of the human eye. Lenses could be used to show image formation. (317-1)	
Presentation	
• Construct a chart of eye disorders (e.g., cataracts, crossed eyes, sty). Describe the disorder and the possible medical treatments. This could be done individually or in groups, with each group completing one eye disorder and the results combined to make a large class display. (116-4)	MHR *Biology,* pp. 411-413
	Core Lab #2 Investigation 12B: "The Effect of Light on Pupil Size," MHR *Biology,* pp. 410-411
	MHR *Biology,* pp. 413-414

Nervous System: Sense Organs *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain how the ear as a sense organ helps maintain homeostasis (317-1) – describe the general structure and function of the ear (i) pinna (ii) tympanic membrane (iii) ossicles (i.e., malleus, incus, stapes) (iv) eustachian tube (v) semicircular canals (vi) vestibule (vii) cochlea (viii) auditory nerve	The investigation of sense organs serves as a cross-curricular link with the waves/sound/light sections of high school physics. Students should observe the principal features of the mammalian ear - using models, dissected structures, or computer simulations - and identify and label major visible structures and their functions in drawings or photos of this organ. Students should know that the malleus, incus, and stapes are also known as the hammer, anvil, and stirrup, respectively.
– trace the pathway of sound through the ear	When the pathway is traced through the ear, the structures should be limited to only those discussed above. Students should recognize the importance of hair cells in transmission of sound through the cochlea to the auditory nerve.
• analyse and describe examples of disorders of the ear and where technologies for the correction of auditory defects were developed based on scientific understanding (116-4) – ear disorders - conduction deafness, nerve deafness – treatments for ear disorders - tympanostomy tube surgery, hearing aids	Students should research and discuss the potential negative effects of repeated exposure to loud noises (noise pollution) and the use of cochlear and digital implants.
• evaluate, considering ethical issues, the consequences of medical treatments for visual and auditory disorders (317-5) – sense of exclusion – mandatory organ donation	The ethical issues regarding the treatment of visual and auditory disorders may include a sense of loss experienced by the treated individual. These individuals may find themselves excluded from the deaf and blind communities. The long term success of laser surgery and the potential risks can be evaluated.

Nervous System: Sense Organs *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil	MHR *Biology,* pp. 414-416
• Construct a flowchart that shows the path of sound energy through the auditory system. (317-1)	
• Investigate the development of new technologies for the correction of malfunctions of the sense organs and/or the potential health effects of environmental factors such as noise pollution and extended wearing of contact lenses. Present your findings to the class. (Assessment may be based on completeness and accuracy of research as observed during the student's presentation to the class or in a written summary.) (116-4, 317-5)	
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 sensory organ pathologies - community resources such as physicians; spokespersons from relevant organizations such as the Canadian National Institute for the Blind, Eye Banks, or Canadian Association for the Deaf and Blind); corneal and cochlear transplant recipients; or persons suffering from sensory disorders.) (317-5)	MHR *Biology,* pp. 415-416
Performance	
• Devise a model of the human ear. Tuning forks or oscilloscopes (Xplorer GLX) could be used to demonstrate sound patterns. (317-5)	MHR *Biology,* p. 416

Nervous System: Sense Organs *continued...*

Outcomes

Students will be expected to

- perform an experiment to investigate and collect data on the nervous system (sense organs) and identify specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10)
- select and use appropriate symbolic and linguistic modes of representation to communicate ideas and results (215-2)

Elaborations - Strategies for Learning and Teaching

The laboratory outcomes 212-6, 213-5, 214-10, and 215-2 can be addressed by completing available laboratory activities found in the laboratory experiment titled "Sense Organs (Vision, Hearing and Equilibrium)" in appendix B.

The vision component of "Sense Organs (Vision, Hearing and Equilibrium)" will allow students to collect qualitative and quantitative data regarding various aspects of human vision, such as visual acuity, blind spot, eye dominance, field of vision, and vision near point. Similarly, the hearing and equilibrium component has students collect data and answer questions about the two critical functions of the ear, namely, hearing and equilibrium.

Nervous System: Sense Organs *continued...*

Tasks for Instruction and/or Assessment

Performance

- Perform an investigation to find information about your vision (e.g., visual acuity, blind spot, eye dominance, field of vision, vision near point). (212-6, 213-5, 214-10, 215-2)
- Perform an investigation to find information about your hearing and equilibrium (e.g., the apparent sound of a tuning fork when placed in various locations on, or near, your head; the direction one leans after having been rotated in a particular direction). (212-6, 213-5, 214-10, 215-2)

Paper and Pencil

- Describe evidence that the fluid in the semicircular canals continues to move even after rotation has stopped.(116-7, 317-1)
- Describe the manner in which the semicircular canals are able to detect changes in motion during a roller-coaster ride.(116-7, 317-1)
- Identify three occupations where good visual acuity would be necessary. Explain. (116-7, 317-1)
- It appears that an object moves when you view it with a different eye. Offer an explanation for this observation. (116-7, 317-1)
- Horses and cows have eyes on the sides of their heads. Their visual fields overlap very little. What advantage would this kind of vision have over human vision? (116-7, 317-1)

Resources/Notes

Core Lab #3
Appendix B: "Sense Organs (Vision, Hearing and Equilibrium)"

Endocrine System: Maintaining Homeostasis

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain how the endocrine system helps maintain homeostasis (317-1)	The endocrine system of animals releases chemical hormones into the blood to be circulated. These help maintain homeostasis by causing or preventing change in specific organs or tissues of the body. The endocrine system is slower in producing an effect than the nervous system; however, the effect is a more sustained. It is important for students to realize that the nervous system and endocrine system work together in a co-ordinated fashion.
– explain the difference between endocrine and exocrine gland – explain the general concept of a hormone and target cell or organ	Teachers could review the basic biochemical structure of carbohydrates, proteins, and lipids/steroids. Students should examine diagrams that illustrate the location of receptors for non-steroid hormones as compared to steroid hormones. They should recognize the importance of the solubility of steroid hormones in the cell membrane and the critical nature of the shape of non-steroid hormones. Additional hormones may also be of interest to students (e.g., antidiuretic hormone, cortisol, aldosterone).
– compare how non-steroid and steroid hormones cause changes in target cells (i) solubility in cell membrane (ii) location of receptors (iii) end result	Students should understand that the non-steroid hormones cause chain reactions in the target cells, while steroid hormones stimulate genes to produce a protein. Students should be provided with the opportunity to observe the principal features of the endocrine system - utilizing models, dissection, or computer simulations - and to identify and label those structures through the use of drawings or photographs.

Endocrine System: Maintaining Homeostasis

Tasks for Instruction and/or Assessment

Performance

- Develop a visual model or animation that illustrates enzyme function (one messenger vs. two messenger models). Your designs may range from physical models to visual animations, so be creative! (Assessment will be based on accuracy and effectiveness of the product submitted and/or presented to the class.) (317-1, 314-3)

- Perform the laboratory activities provided to illustrate some aspects of the endocrine system. These may include the following:
  - microscopic examination of pancreas to distinguish endocrine tissue from digestive enzyme producing tissue
  - test showing the effect of epinephrine on the heartbeat of Daphnia
  - observation of the metamorphosis of tadpoles
  - development of models to illustrate visually the concept of negative feedback

(Assessment of these activities would depend on the nature and depth of the activities selected. Some of them involve collection of data that may be tabulated and graphed. Enrichment may be provided by allowing students the opportunity to design their own investigations based on questions that these activities may generate.) (317-1, 213-5, 215-2)

Resources/Notes

MHR *Biology,* pp. 420-423

BLM 13-1: "Hormone Regulation of Target Cell Metabolism"

MHR *Biology,* pp. 424-426

MHR Teacher's Resource CD-ROM, "BLM 13-1"

Endocrine System: Maintaining Homeostasis *continued...*

Outcomes

Students will be expected to

- identify and describe the structure and function of important biochemical compounds, including non-steroid and steroid hormones (314-3)
  - identify hormones and their source glands, and explain their general effects on the human organism
    - (i) melatonin
    - (ii) thyroxine
    - (iii) adrenaline
    - (iv) somatotropin (HGH–human growth hormone)
    - (v) insulin
    - (vi) glucagon

Elaborations - Strategies for Learning and Teaching

Students can discuss the social, ethical, and health issues associated with hormone therapy for the treatment of humans (e.g., growth hormones, steroid use in sports, hormone use to slow the effects of aging or to minimize jet lag). This may lead to questions, such as, Should physicians provide HGH as a treatment for individuals who have normal levels of human growth hormone, yet are genetically shorter than average, simply to increase their height? Students may investigate the hormonal connection with biorhythms and seasonal affective disorder (SAD). Students may investigate the abuse among athletes of steroid hormones as they attempt to build body tissue quickly and increase their athletic ability and the long-term side effects that result. Student can use available software programs to engage in an online discussion forum to prepare for classroom debate.

Because of the volume of information and the way it is interrelated, teachers could use a series of tables to summarize information about the glands, their hormones, and their functions. An extension of this may include problems with hypersecretion and hyposecretion of a hormone, and target organs.

Students could be engaged in case studies where a variety of patient cases could be provided in which the students would have to identify the possible endocrine gland affected and the hormone involved, and decide whether the disorder is caused by hypersecretion or hyposecretion of that hormone. Alternatively, students could create a hypothetical patient who is presenting some classical symptoms of a common endrocrine disorder. Their report should provide a patient history, symptoms presented, diagnosis, treatment, and expected outcomes.

Students may research, identify, and summarize the main hormonal and nervous components of reactions to stress. They could discuss why some individuals may experience the following symptoms when they are nervous: cool hands, knots in the stomach, dilated pupils, dry mouth, and rapid heart rate.

The location and function of the principle endocrine glands will be dealt with in a later outcome.

Endocrine System: Maintaining Homeostasis *continued...*

Tasks for Instruction and/or Assessment

Presentation

- In a debate format, display the results of research and argue against other stakeholders about various issues. Should doctors prescribe HGH as a treatment for individuals who have normal levels of human growth hormone in their systems, yet are genetically shorter than average, simply as a means to increase their height? Should steroids (performance enhancing drugs) be legalized for use by all athletes? Should random drug testing of athletes be permitted, or is it an invasion of privacy? Should hormones be used within the beef industry to increase production?

  (Assess the participation of students, preparation of the argument, thoroughness of the research, and familiarity with the topic.) (314-3)

- Read the case studies listed below. Based on your knowledge of endocrine glands and hormones, you must identify the endocrine gland that may be affected, along with the hormone involved, and decide whether the problem is due to hypersecretion or hyposecretion of the hormone. (314-3, 317-1)

Case 1

A 55 year-old male has begun to notice changes in his body despite following the same daily routines. He has a constant unquenchable thirst, has lost a significant amount of weight despite an increased appetite, and has been feeling weak.

Case 2

A 17 year-old male is unable to sleep at night and is finding it difficult to concentrate in school. He has noticed that his eyes have begun to appear larger than usual, he has lost weight, and that a small lump is beginning to form on the front of his neck.

Paper and Pencil

- Select a hormone and investigate the effects of its hypersecretion and hyposecretion in the body. Prepare a visual display to illustrate this. Hormones may include HGH, aldosterone, cortisol, thyroxine, insulin, and/or glucagon. (314-3, 317-1)
- Create a chart listing all the hormones produced in the human body. The chart should list both steroid and non-steroid hormones and include source gland and general effect on the human body. (317-1, 314-3)
- You are provided with a hypothetical patient who is presenting with some classical symptoms of a common endrocrine disorder. Prepare a report which includes a patient history, symptoms, diagnosis, treatment, and expected outcomes. (317-1, 314-3)

Resources/Notes

MHR *Biology,* pp. 438, 440
MHR *Biology,* p. 432
MHR *Biology,* pp. 444-446
MHR *Biology,* pp. 428-429

MHR *Biology,* pp. 435-436

Endocrine System: Feedback Mechanisms

Outcomes

Students will be expected to

- analyse homeostatic phenomena to identify the feedback mechanisms involved (317-2)
  - describe representative positive and negative feedback loops
    - (i) hypothalamus-pituitary complex as a negative feedback control
    - (ii) oxytocin as positive feedback control
  - describe the regulation of blood sugar by controlled release of insulin and glucagon

Elaborations - Strategies for Learning and Teaching

Students should be able to use flowcharts to describe representative positive and negative feedback mechanisms in living systems. They may compare technological feedback control systems with the natural electrochemical control systems of organisms, and discuss sensitivity, response time, and effectiveness.

Within the discussion of the hypothalamus-pituitary complex, RF (releasing factor), pituitary hormones, and target tissues (e.g., TSH on thyroid) should be included. Oxytocin should be used to illustrate a positive feedback loop in a human system (e.g., when the water breaks during labour, pressure is exerted on the cervix, and an increase in uterine contractions occurs. In turn, more oxytocin is released, which then increases the contractions.).

Students should be encouraged to construct/describe an everyday occurrence of negative feedback (e.g., thermostat control) and positive feedback (e.g., microphone in front of speaker).

Students could contact the Canadian Diabetes Association or do an Internet search to obtain sample data concerning blood and/or urine composition. Data can be analysed and interpreted in order to infer the role of hormones in homeostasis. Students could perform an experiment to investigate the presence of sugar in simulated urine samples and compare the results with other urinalysis data. Using a table, students may compare the conditions of juvenile diabetes and adult-onset diabetes. Headings may include age of onset, cause, severity, and method of treatment. Students could research and present modern approaches to the detection, treatment, and control of diabetes, e.g., the onset of diabetes in relation to diet, exercise, and culture (some populations).

Endocrine System: Feedback Mechanisms

Tasks for Instruction and/or Assessment

Paper and Pencil

- Analyse and interpret the provided data on blood or urine composition. Use the data to determine the role of hormones in homeostasis. (317-2)
- Work in groups to complete a partial flowchart to illustrate hormones and feedback systems within the human body. When your chart is complete, develop a partial chart of your own design for completion by other groups within the class. (317-2, 314-3)

Journal/Presentation

- Describe an everyday example (such as a thermostat) to explain the process of negative feedback. (317-2)
- Describe an example to explain the process of positive feedback (e.g., acoustical "vocal" microphone placed in front of a speaker; additional boat speed resulting from apparent wind). (317-2)

Performance

- Develop a physical working model to illustrate visually the concept of negative and positive feedback. (317-2)
- Given the following data involving glucose levels of a normal individual (A) and a diabetic individual (B) after ingesting a glucose sample, create a line graph of blood glucose versus time and describe the trend in blood glucose level for each individual. Hypothesize the contrast in the amount of insulin being secreted in each individual. (231-5, 215-2, 317-1, 317-2)

Time (hours)	**Individual A** Blood Glucose (mg/100mL)	**Individual A** Blood Glucose (mg/100mL)
0	90	150
0.5	120	180
1.0	140	220
1.5	110	250
2.0	90	240
2.5	85	230
3.0	90	210
3.5	90	190
4	95	170

Resources/Notes

MHR *Biology,* pp. 302-303

MHR *Biology,* pp. 424, 427, 432

MHR *Biology,* p. 431

MHR *Biology,* pp. 435-438

MHR Teacher's Resource CD-ROM, "BLM 13-3"

Endocrine System: Feedback Mechanisms *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to • explain how the endocrine system helps maintain homeostasis (317-1) (**cont'd**) – identify the location and function of principal endocrine glands in the human organism (i) pituitary (ii) hypothalamus (iii) pineal (iv) thyroid (v) parathyroid (vi) adrenal (vii) pancreas (Islets of Langerhans) (viii) thymus (ix) ovaries (x) testes	It is not necessary that students know the function of all hormones associated with every gland. Students should know the general function of each gland. Specific hormones have been identified in previous outcomes and will be dealt with in outcomes contained in the following units. Using presentation or other software, students can hyperlink principal endocrine glands to a general description of their function. The hormones identified in outcome 314-3 (page 44 of this guide) can be incorporated into this activity. The individual presentations can be shared by uploading each to a common Web-site. Ovaries and testes have a dual function. For this reason they are dealt with in more detail in unit 2.
• describe disorders and treatments linked to the secretions of the endocrine system and their effect on the homeostasis of the system and the organism as a whole (317-4) (i) dwarfism (ii) giantism (iii) hyperthyroidism (iv) hypothyroidism (v) diabetes mellitus	Students should describe the possible effect on organisms of the oversecretion (hypersecretion) or undersecretion (hyposecretion) of previously identified hormones.
• analyse examples of Canadian contributions to science and technology (117-11) – analyse the role played by Frederick Banting and Charles Best in the discovery of insulin	Students should be aware of the importance of Canadian researchers Frederick Banting and Charles Best in the discovery of insulin and the control of diabetes.

Endocrine System: Feedback Mechanisms *continued...*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Prepare a short report on the role played by Canadian researchers Frederick Banting and Charles Best in the discovery of insulin. (117-11)
- Describe the importance of the appropriate level of a particular hormone and explain the side effects of hyposecretion/ hypersecretion of the hormone. Use hormones related to dwarfism/giantism, hyperthyroidism/hypothyroidism, or diabetes. (317-4, 314-3)

Performance

- Using presentation software, create a map of the principal endocrine glands with each gland hyperlinked to a page containing a description of the basic gland function and key hormones produced therein. (317-1, 314-3)

Resources/Notes

MHR *Biology,* p. 422

BLM 13-2: "Adrenal Glands and Response to Stress"

MHR *Biology,* pp. 427-435

MHR *Biology,* p. 438

MHR *Biology,* pp. 440-443

MHR *Biology,* pp. 490-493

MHR *Biology,* pp. 486-487

MHR *Biology,* p. 437

MHR *Biology,* p. 439

Endocrine System: Feedback Mechanisms *continued...*

Outcomes

Students will be expected to

- distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot (118-8)
  - debate the merits of developing and using life support technology, identifying questions that are scientific, technological, and social in nature
- propose courses of action on the social issues related to life support technologies, taking into account an array of perspectives (118-10)

Elaborations - Strategies for Learning and Teaching

Students may investigate and discuss the development and use of technologies to maintain, prolong, sustain, or terminate life; and the resulting social, moral, ethical, and legal issues.

Note: Outcomes 118-8 and 118-10 can be addressed in other units, such as the one on reproduction.

Endocrine System: Feedback Mechanisms *continued...*

Tasks for Instruction and/or Assessment

Presentation

- Discuss the scientific, technological, and social concerns that are related to temporary and permanent life-support. (118-8, 118-10)

- 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. (118-8, 118-10)

Resources/Notes

MHR *Biology,* p. 445

Reproduction and Development *(~16 Classes)*

Introduction

This unit helps students to understand the principles of how living organisms reproduce and develop at both the cellular and individual levels. The primary emphasis is placed on human systems. Students should begin to appreciate the complexity and importance of reproductive technologies and be able to discuss and analyse from a variety of perspectives the relative risks and benefits of these technologies.

Focus and Context

This unit has its primary focus on scientific inquiry and observation. However, through its review of reproduction and development, there are numerous opportunities to meet curriculum outcomes utilizing decision making (STSE). Discussions concerning the potential impacts of reproductive technologies can lead into problem-solving and technology use.

Science Curriculum Links

Students begin at the primary level to discuss life cycles of familiar animals and the changes that humans undergo as they grow, and to investigate the life cycle of some plants. At the elementary level, students begin to relate body changes to growth and development, and examine the role played by body systems in helping both humans and other organisms grow and reproduce. At the intermediate level, students are introduced to the basic processes of cell division and the differences between sexual and asexual reproduction. Although not specifically taught in the intermediate science program, the structures and functions of the human reproduction systems are covered in other curriculums, such as health.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

115-1 distinguish between scientific questions and technological problems

Relationships between Science and Technology

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

116-3 identify examples where technologies were developed based on scientific understanding

116-7 analyse natural and technological systems to interpret and explain their structure and dynamics

Social and Environmental Contexts of Science and Technology

117-4 debate the merits of funding specific scientific or technological endeavours and not others

118-4 evaluate the design of a technology and the way it functions on the basis of a variety of criteria that they have identified themselves

118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives

118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

Skills

Students will be expected to

Initiating and Planning

212-3 design an experiment, identifying and controlling major variables

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-3 use instruments effectively and accurately for collecting data

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

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Analysing and Interpreting

214-9 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information

214-18 identify and evaluate potential applications of findings

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

Knowledge

Students will be expected to

313-2 describe in detail mitosis and meiosis

313-3 analyse and describe the structure and function of female and male mammalian reproductive systems

313-4 explain the human reproductive cycles

313-5 explain current reproductive technologies for plants and animals

313-6 evaluate the use of reproductive technologies for humans

317-5 evaluate the physiological and ethical consequences of medical treatments such as radiation therapy, chemotherapy, and cosmetic surgery

Cell Division

Outcomes

Students will be expected to

- describe mitosis (313-2)
  - describe the events of interphase, mitosis, and cytokinesis (the cell cycle)
  - explain the importance of maintaining a constant number of chromosomes through the processes of cell and organism reproduction
- use instruments effectively and accurately for collecting data on the cell cycle (213-3)
  - observe, identify, and describe (using prepared slides of plant and animal cells) the events of the cell cycle
    (i) growth
    (ii) cytokinesis
    (iii) chromosome behaviour
- design an experiment, identifying and controlling major variables to observe the chromosomes during cell division (212-3)
- select appropriate instruments for collecting evidence on cell division and appropriate processes for problem solving, inquiring, and decision making (212-8)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data on cell division (213-5)

Elaborations - Strategies for Learning and Teaching

Classroom or laboratory simulations of the process of mitosis may be useful. Students may use pipe cleaners to simulate chromosomes and follow the process by preparing pipe cleaner models of chromosomes during each stage in mitosis. This process can be animated using available software. Similarly, students can be provided with a flipbook template and engaged in animating mitosis by completing the flipbook.

The laboratory outcomes 213-3, 212-3, 212-8, 213-5, and, in part, 313-2 are addressed by completing Investigation 14A: "Observing the Cell Cycle in Plant and Animal Cells." Outcome 212-3 can only be addressed by having students design an investigation as described in the *Exploring Further* section of Investigation 14A. A complementary laboratory approach would be to have the students propagate their own fast-growing plant tissue (e.g., onion root tips) and prepare their own slides for viewing by fixing, squashing, and staining the fresh tissue.

Students should be given the opportunity to observe and investigate the stages of the cell cycle and cytokinesis within both plant and animal cells through laboratory or computer simulations, diagrams, photographs, laser disc, or time lapse video technology. Stages of mitosis can be observed using prepared slides of plant cells (e.g., onion root tips) or animal cells (e.g., whitefish blastula). Some comparisons between the processes of mitosis in plant and animal cells may be made by careful examination of these prepared slides. Students may be asked to identify, sketch, and discuss what is occurring during each of the stages. Use of a video microscope display can assist the teacher in initially illustrating, as a class activity, how to distinguish between cells in each of the different stages. Videos and animations to show mitosis and meiosis are effective and are easily located.

Cell Division

Tasks for Instruction and/or Assessment

Performance

- Perform available laboratory activities to illustrate aspects of the process of cell division. These may include the examination of prepared microscope slides of animal and plant cell mitosis and cytokinesis, or growth of onion root tips and preparation of squashes to observe chromosomes. (212-8, 213-3, 313-2, 213-5)
- Design an investigation based on questions that arise from activities related to cell division. (212-3, 212-8, 213-3, 313-2, 213-5)
- Using a flip book or animation software, animate the process of interphase, mitosis, and cytokinesis. (313-2)

Paper and Pencil

- Develop a glossary of new terms related to the reproduction unit. (313-2)
- Using pipe cleaners of two colours, construct models of a pair of homologous chromosomes and follow their progress through the stages of meiosis (reduction-division). Construct one member of the pair from one colour, the second from another. Illustrate an example of crossing over and follow its transmission.

  (Assessment should be based on accuracy of models and completeness of exercise.) (215-2, 313-2)

Resources/Notes

MHR *Biology,* pp. 460-465

BLM 14-1: "The Cell Cycle"
BLM 14-2: "The Process of Mitosis"

MHR *Biology,* pp. 461-462

Core Lab #4
Investigation 14A: "Observing the Cell Cycle in Plant and Animal Cells," MHR *Biology,* pp. 466-467

Cell Division *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• evaluate the physiological and ethical consequences of radiation therapy and chemotherapy in cell division (317-5)	One significant side effect of chemotherapy and radiation is sterility (as a result of their impact on cell meiosis). Teachers may raise this issue as an introduction to the further study of meiosis. As an extension, students may research some alternative methods currently being developed for the treatment of cancer.
– describe the use and effectiveness of these treatments	
– describe positive and negative aspects of these treatments	
• describe meiosis (313-2)	
– describe the events of meiosis (reduction-division) and cytokinesis	Meiosis can be animated using available software. Similarly, students can be provided with a flipbook template and engaged in animating meiosis by completing the flipbook.
– explain the necessity of chromosome reduction during the production of sex cells	Crossing over (chiasma) in meiosis can also be illustrated through the pipe cleaner activity described on the previous page of this guide - if different pipe cleaner colours are available. This provides the student with a visual confirmation of the exchange of genetic information and its effect on randomizing gene combinations within the chromosomes.
– describe the crossing-over process and explain its role in helping randomize the gene combinations for sex cells	Teachers should note that chromosomal disorders associated with crossing over are addressed in detail in the genetics unit.
• analyse and describe the function of spermatogenesis and oogenesis (313-3)	
– examine the processes of spermatogenesis and oogenesis	To highlight the differences between spermatogenesis and oogenesis, students could develop a table or chart which summarizes gamete formation.
– analyse why there is only one functional egg produced during oogenesis	

Cell Division *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil	
• Research a method currently being developed for the treatment of cancer. Examples may include monoclonal antibodies; immunotherapy using tumour infiltrating lymphocytes; hyperthermia—utilizing heat; cryotherapy—cold, photodynamic therapy—using light; or an alternate as appropriate. Discuss the pros and cons of each method of treatment. (317-5)	MHR *Biology,* pp. 468-469
Presentation	
• Invite a guest speaker to talk about the diagnosis, treatment, and recovery from the various types of cancer. Possible speakers could include a representative from the Canadian Cancer Society, a palliative care nurse, or an oncologist. (317-5)	
• Create a moving image, using a flipchart book, slide show, video, or digital animation to show the sequence of events in cell division. Present your finished product to the class. (215-2, 313-2)	MHR *Biology,* pp. 470-475 BLM 14-3: "The Stages of Meiosis"
• 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 the importance of cell division and the effects on the homeostasis of an organism should it be disrupted - by using community resources such as physicians; or spokespersons from relevant organizations, such as the Canadian Cancer Society.)	BLM 14-4: "Homologous Chromosomes and Crossing Over"
Performance	MHR *Biology,* pp. 477-478
• Make a model and demonstrate the events of meiosis. The model should include homologous chromosomes, and dominant and recessive alleles. Illustrate the randomness of allele assortment during meiosis. Sample materials that may be used include marshmallows, pipe cleaners, Plasticine, popsicle sticks, Velcro, toothpicks, push pins, etc. (315-2, 315-3)	
• Using a flip book or animation software, animate the process of interphase, meiosis, and cytokinesis. (313-2)	
Journal	
• Select a Web-site that contains activities on meiosis and/or mitosis. Perform an activity of interest and write a brief report, including the Web address, a description of the activity, and any comments about it. (313-2)	

Cell Division *continued...*

Outcomes

Students will be expected to

- analyse and describe the function of spermatogenesis and oogenesis (313-3) (**cont'd**)
  - describe and compare the structure of sperm and egg cells
    - (i) relative sizes
    - (ii) energy reserves
    - (iii) mitochondria
    - (iv) numbers produced
    - (v) motility
    - (vi) enzyme cap (acrosome)
- identify and describe examples of technologies that were developed based on cell division. (116-3, 213-7)
    - (i) stem cell research
    - (ii) cell transplant
    - (iii) cancer treatment
    - (iv) spinal cord injury
    - (v) therapeutic cloning
    - (vi) reproductive cloning
- construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6)
- debate the merits of funding specific scientific or technological endeavours and not others (117-4)
- distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot (118-8)

Elaborations - Strategies for Learning and Teaching

The female and male mammalian reproductive systems will be addressed in greater detail later in this unit.

The STSE component "Stem Cell Research," found in appendix C, targets (in whole or in part) outcomes 116-3, 317-4, 115-5, 213-7, 118-6, and 117-4.

Students can investigate the role of biotechnology in cell growth and the potential it may hold for the regeneration of damaged tissues or parts of organisms. They may evaluate the role of cell division in the development of cancer and how knowledge of cell division might be applied to limiting cancerous growth in plants and animals. They may investigate the newer approaches to the chemical treatment of cancer, and the bases upon which they are effective.

In preparation for classroom debate regarding the merits of funding specific scientific or technological endeavours and not others, students could use available software to engage in an on-line discussion forum. They can classify questions for debate, using the following two categories: those that can be answered by science, and those that cannot be answered by science. The topic for the discussion forum can be provided to the students. Alternatively, student groups could be responsible for creating and responding to a particular discussion thread of their creation.

Cell Division *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil	
• Select an aspect of biotechnology related to cell division of interest (e.g., regeneration of lost limbs), or a type of cancer. Investigate the topic (causes, treatment, statistics), using more than one source of electronic or print information. Prepare a written summary and present the topic to the class. (Assessment should be based on accuracy and relevance of information gathered and completeness of research - based upon the written report and class presentation. Students should also be evaluated based on their responses to questions generated by the class during the discussion.) (116-2, 212-8, 213-7, 214-18, 215-2, 317-5)	MHR *Biology,* p. 478
• Create a chart to compare and contrast the structure and function of egg and sperm cells. (313-3)	MHR *Biology,* pp. 478-479
Presentation	
• Debate issues related to stem cell research (e.g., the use of embryonic tissue or amniotic fluid). (116-3, 213-7)	Appendix C: "Stem Cell Research" MHR *Biology,* pp. 628-630

Reproductive Systems: Strategies

Outcomes

Students will be expected to

- analyse natural reproductive strategies to interpret and explain their structure and dynamics (116-7)
  - distinguish between asexual and sexual reproduction
  - define various types of asexual reproduction
    (i) budding
    (ii) binary fission
    (iii) spore production
    (iv) fragmentation
    (v) parthenogensis

Elaborations - Strategies for Learning and Teaching

Investigation of the range of reproductive strategies found within the plant and animal kingdom serves to reinforce the concept of biodiversity. This information can be presented to the class in the form of charts, tables, or diagrams.

See appendix A, "Modes of Reproduction."

Students can investigate or research the strategy involved in the use of reproductive technologies with an agricultural plant (e.g., canola), an aquaculture animal (e.g., salmon), or any other appropriate example.

Reproductive Systems: Strategies

Tasks for Instruction and/or Assessment

Paper and Pencil

- Select an animal or plant reproductive strategy and present relevant information to your class in the form of charts, tables, diagrams, visual animations, or any other appropriate format. Find and present unusual or interesting reproductive strategies.

  (Assessment should be based on accuracy and relevance of information gathered and completeness of research - based upon the quality of the class presentation.) (116-7, 213-5, 213-7, 215-2)

Performance

- Observe the examples of reproductive processes provided in the laboratory. These may include prepared slides or wet mounts of budding in yeast, budding in hydra, or wet mounts of mold spores.

  (Assessment would depend on the nature of the activities selected and could range from the development of microscope diagrams to the answering of questions.) (116-7, 212-8, 213-3, 215-2, 313-2)

Resources/Notes

Appendix A: "Modes of Reproduction"

MHR *Biology,* pp. 157, 186
MHR *Biology,* p. 134
MHR *Biology,* pp. 166, 154
MHR *Biology,* pp. 186, 155

Reproductive Systems: Strategies *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• describe mitosis and meiosis within plant reproduction (313-2)	The laboratory outcomes 213-5, 215-2, and, in part, 313-2 are addressed by completing Investigation 6A: "Reproductive Structures in Flowers." Students can observe the male and female reproductive structures of angiosperms through the use of models, charts, computer simulations, or the dissection of a flower in a laboratory setting. Enrichment may be provided by allowing students the opportunity to design their own investigations based on questions that these activities may generate.
– observe, identify, and give the function of the basic structures of sexual reproduction in angiosperms (flowering plants) (i) pistil (ii) stamen (iii) pollen (iv) ovules (v) seed (vi) fruit	
– describe the process of sexual reproduction in flowering plants	The description of the process of sexual reproduction in flowering plants should be taken from the production of pollen to the production of a seed. Discussion of pollen containing (1) a generative nucleus producing two sperm nuclei, and (2) the tube nucleus producing the pollen tube should be included. The process of one sperm nucleus (n) uniting with the egg (n) to produce a diploid zygote (2n), and the other sperm nucleus (n) uniting with two haploid polar nuclei (n each) to produce a triploid endosperm (3n), should also be included.
• compile and organize data, using appropriate formats to facilitate interpretation of the data (213-5)	
• select and use appropriate symbolic and linguistic modes of representation to communicate results (215-2)	

Reproductive Systems: Strategies *continued...*

Tasks for Instruction and/or Assessment

Performance

- Perform the available laboratory activities to illustrate some aspects of the reproductive process. These may include examination of the reproductive parts of a flower, study of prepared microscope slides of ovaries and testes (egg and sperm cells), comparison of a monocot and dicot seed, and/or examination of a composite flower (daisy, dandelion).

  (Assessment would depend on the nature of the activities selected, ranging from the development of microscope diagrams to the answering of questions.) (213-5, 215-2, 313-2)

- Dissect a flower from the lily family. Draw a picture of each part, label it, and reconstruct the flower using individually drawn sketches. (313-2)

Resources/Notes

MHR *Biology,* pp. 165, 175-181

Investigation 6A: "Reproductive Structures in Flowers," MHR *Biology,* pp. 176-177

Reproductive Systems: Regulation

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• analyse and describe the structure and function of the human male reproductive system (313-3) (i) testis (ii) scrotum (iii) seminiferous tubules (iv) epididymis (v) sperm duct (vas deferens) (vi) Cowper's (bulbourethral) gland (vii) seminal vesicle (viii) prostate (ix) urethra	Students should be provided with the opportunity to observe and discuss the functions of the principal features of the male reproductive system - using models, dissections, or computer simulations - and to identify and label the major structures in drawings or photos of that organ system.
• explain the human male reproductive cycles (313-4)	Students can analyse sample data on blood hormone levels and physiological events, and infer the roles of the male sex hormones.
– identify and state the functions of the principal reproductive hormones of the human male (i) inhibin (ii) follicle stimulating hormone (FSH) (iii) luteinizing hormone (LH) (iv) testosterone	As an enrichment, students can discuss the role of steroid use in sports, and run a risk/benefit analysis. They can debate the issue of mandatory doping tests for athletes to determine the presence or absence of banned substances. They can research and develop a list of these banned substances and answer the questions, Are any of these substances found in over-the-counter medication? If so, for what purpose are they used? Canadians athletes Ben Johnson, Ross Rebliati, and Silken Laumann suffered some consequences of doping tests found to be positive for banned chemical substances. Students could be divided into groups and asked to prepare an argument in support of or against one of the following statements: – Doping tests should be mandatory for all professional and amateur athletes. – A positive doping test should result in the lifetime ban of an athlete from his/her competitive sport.
– explain the function and interactions among these hormones in maintaining the male reproductive system	Students could examine the interaction of these hormones in the form of a negative feedback loop. Negative feedback loops were addressed in outcome 317-2 (the endocrine system, feedback mechanisms).

Reproductive Systems: Regulation

Tasks for Instruction and/or Assessment

Paper and Pencil

- Trace the path of a sperm cell from where it is formed to the point of fertilization. (313-3, 313-4)
- Identify the structures of the male human reproductive system, and describe their functions. (313-3)

Resources/Notes

MHR *Biology,* pp. 486-489

NOVA Online "Life's Greatest Miracle"
http://www.pbs.org/wgbh/nova/miracle/program.html

Reproductive Systems: Regulation *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• analyse and describe the structure and function of the human female reproductive system (313-3) (i) ovary (ii) follicles (iii) oviduct (Fallopian tube) (iv) fimbriae (v) uterus (vi) endometrium (vii) cervix (viii) vagina	Students should be provided with the opportunity to observe and discuss the functions of the principal features of the female reproductive system - using models, dissections, or computer simulations - and to identify and label the major structures in drawings or photos of that organ system.
• explain the human female reproductive cycle (313-4)	Students can analyse sample data on blood hormone levels and the physiological events of a single menstrual cycle, and infer the role of the female sex hormones. By creating a diagram, students can be provided with the opportunity to illustrate the interaction of these hormones that would result from ovarian and uterine events during the menstrual cycle.
– identify and state the functions of the principal reproductive hormones of the human female (i) estrogen (ii) progesterone (iii) luteinizing hormone (LH) (iv) follicle stimulating hormone (FSH)	
– explain the function and interactions among these hormones in the menstrual cycle	Students could examine the interaction of these hormones in the form of a negative feedback loop.
– research and evaluate the uses and effects of estrogen/progesterone treatment on the health of women (including hormone therapy among menopausal women, and the use of birth control pills)	Estrogen/progesterone hormone treatment may involve the use of synthetic chemicals or herbal and natural sources found within the diet or taken as dietary supplements. Students can investigate the purposes of hormone therapy among menopausal women.

Reproductive Systems: Regulation *continued...*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Use an available case study to analyse data on blood hormone levels and physiological events during a female menstrual cycle. Investigate how the cycle is regulated using positive and negative feedback, and the roles of pituitary and ovarian hormones.

  (Assessment should be based upon the logical analysis of data and the conclusions drawn.) (313-3, 313-4)
- Identify the structures of the female human reproductive system, and describe their functions. (313-3)

Resources/Notes

MHR *Biology,* pp. 490-493

NOVA Online: "Life's Greatest Miracle"
http://www.pbs.org/wgbh/nova/miracle/program.html

BLM 15-1: "Effects of Hormones During Stages of the Menstrual Cycle"

Reproductive Systems: Regulation *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)	The laboratory outcomes 213-5, 213-7, 214-18, 215-2, and, in part, 313-4 are addressed by completing Investigation 15A: "The Menstrual Cycle," which investigates how levels of pituitary (LH, FSH) and ovarian (progesterone, estrogen) hormones affect, and are affected by, ovarian and uterine events during the menstrual cycle.
• select and integrate information from various print and electronic sources or from several parts of the same source (213-7)	
• identify and evaluate potential applications of findings (214-18)	
• select appropriate numeric, graphical, and linguistic modes of representation to communicate ideas, plans, and results (215-2)	
• explain the human reproductive cycles (313-4)	Students should be encouraged to consider not only immediate health concerns but also societal impacts (e.g., effects on future children, health care systems) of exposure to STIs..
– research and describe the potential health risks for individuals and groups associated with exposure to sexually transmitted infections (i) HIV and AIDS (ii) chlamydia (iii) hepatitis B (iv) genital herpes (v) syphilis (vi) gonorrhea	Transmission of HIV or other STIs can be simulated with the use of a base (sodium hydroxide) and an indicator (phenolphthalein). A class set of test tubes of water containing one test tube with a diluted base can be arranged. Students can swap "fluids" and the transmission can be detected later by using the indicator.

Reproductive Systems: Regulation *continued...*

Tasks for Instruction and/or Assessment

Performance

- Perform an experiment to investigate how levels of pituitary and ovarian hormones affect, and are affected by, ovarian and uterine events during the menstrual cycle. (213-5, 213-7, 214-18, 215-2, 313-3, 313-4)

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 a variety of aspects of human reproductive health and sexually transmitted infections - community resources such as physicians or spokespersons from relevant organizations such as sexual health centres.) (213-7, 215-2, 313-3, 313-4)

Resources/Notes

Core Lab # 5
Investigation 15A: "The Menstrual Cycle," MHR *Biology,* pp. 494-495

MHR *Biology,* pp. 496-499

Reproductive Technologies

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• distinguish between scientific questions and technological problems (115-1)	Students should investigate the importance of utilizing fertility techniques for the human population and consider questions such as the following: What are the ethical and practical issues involved when fertility techniques result in multiple births? Is there an argument within society for fetal selection when a multiple birth pregnancy places the fetuses and/or mother at risk?
• evaluate the use of reproductive technologies for humans (313-5, 313-6)	A variety of on-line discussion forum topics could be provided to address various ethical and practical issues related to technological solutions to human infertility and the consequences of their use.
– identify causes of human infertility (i) blocked oviducts (ii) failure to ovulate (iii) endometriosis (iv) damaged egg (v) obstruction in the vas deferens or epididymis (vi) low sperm count (vii) abnormal sperm	Students could be asked to select a fertility technique that would be used in a fertility clinic. They would be required to research the reproductive technique/technology (description, effectiveness, cost) and to create a newspaper advertisement or brochure to advertise the clinics's techniques.
– evaluate technological solutions to human infertility (i) artificial insemination (AI) (ii) in vitro fertilization (IVF) (iii) in vitro maturation (IVM) (iv) surrogate motherhood (v) superovulation using fertility drugs (vi) embryo storage (cryopreservation)	Student are not expected to describe technological solutions in great depth. Essentially, students should understand the intent for which the technological solutions were designed

Reproductive Technologies

Tasks for Instruction and/or Assessment

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 a variety of aspects of reproductive technologies and issues - community resources such as physicians, reproductive technologists, public health workers, or spokespersons from relevant organizations.) (115-1, 118-4, 215-2, 313-5, 313-6)
- Prepare and present a brochure, newspaper advertisement, or another method of advertisement to promote a fertility technique used in a fertility clinic. (115-1, 313-5, 313-6)

Paper and Pencil

- Research and evaluate the use of currently available reproductive technologies. The following are potential options:
  - artificial insemination
  - superovulation using gonadotrophins
  - in vitro fertilization
  - in vitro maturation (IVM)
  - surrogate motherhood
  - hormonal treatment allowing pregnancy after menopause

  Present a brief summary of your topic to the class. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)

Resources/Notes

MHR *Biology,* pp. 500-501

Reproductive Technologies *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to • evaluate the design of birth control technologies/ techniques and the ways they function (118-4)	Students should evaluate the relative effectiveness of various methods of contraception. Teachers may wish to have students organize the information according to the following modes: a) barrier methods (condom, diaphragm, jellies and foams, IUD) b) hormonal methods (birth control pill, Norplant, morning after pill, Depo-Provera) c) surgical methods (tubal ligation, vasectomy) d) other (rhythm method, abstinence)
• construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6) – assess the effects of birth control technology on the population demographics of developed and underdeveloped countries • identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information (214-9) • debate the merits of funding solutions to human fertility problems versus human population control (117-4)	Other STSE topics that students may research include - sperm banks for agriculture - human sperm banks - folklore concerning reproductive success/control - choice of sex of child. Students may debate the merits of funding solutions to human fertility problems versus the funding of human population control. They may investigate methods of population/birth control (e.g., China's one child per family rule; selection of one gender—usually male—and abortion of the other) in various countries around the globe, and assess the effects of these methods on the demographics of these countries.

Reproductive Technologies *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil	MHR *Biology,* pp. 501-503
• Research and evaluate types of contraception that are being promoted for the use of population control in developing countries. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)	
• Use an available case study to analyse moral and ethical implications of new reproductive technologies. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)	
• As a class, create a list of Web-sites useful for information about reproductive technologies. (117-4, 118-6, 213-7, 313-5, 313-6)	
Presentation	
• Investigate a variety of chemical and physical methods of contraception. Explain from a variety of perspectives how these contraceptives work, their effectiveness in prevention of pregnancy and STIs, and societal implications of their use. (118-4, 118-6)	
Journal	
• A couple has discovered that they are unable to conceive due to the male partner's sterility. Donor sperm could be used to artificially inseminate the female partner. What ethical and moral issues could arise? (118-6)	MHR *Biology,* pp. 503-505

Embryonic Differentiation and Development

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain the processes of fertilization and development in human reproduction (313-4)	Students could be provided with available Web-sites that animate the journey of sperm and/or egg from their origin until fertilization and implantation. Similarly, students could be asked to animate this process with available software.
– trace the journey of sperm and egg from their origin until fertilization and implantation	
– explain how fraternal and identical offspring are produced	Students should recognize the distinction between the fertilization and initial embryonic development processes that produce identical and fraternal twins, and discuss the mechanism in which multiple births (triplet, quadruplets) may result naturally. Students could consider the question, Why are fraternal twins no more alike than any set of brothers or sisters?
– describe the following basic stages of embryonic development (i) cleavage (ii) morula (iii) blastocyst (blastula) (iv) gastrula (v) germ layers (vi) neural development	Students should have the opportunity to observe the stages of embryo development - preserved materials, prepared slides (e.g., cleavage of sea stars), audiovisual presentations, or computer simulations - and extrapolate from these events to the development of the human fetus. In addition, there are good Web-sites available on the Internet that illustrate the process of development.
• describe the functions of primary membranes during the embryonic development of animals (313-4) (i) yolk (ii) allantois (iii) amnion (iv) chorion	Students should know the structure that each primary membrane eventually forms, as well as the functions of these structures. Teachers may compare the functions of the membranes in the chick embryo to those in the human embryo, as outlined in fig. 15.15 on page 509 of the textbook.

Embryonic Differentiation and Development

Tasks for Instruction and/or Assessment

Performance

- Perform available laboratory activities on the process of development. These might include microscopic examination of prepared slides of stages of cleavage of sea stars, or sea urchin development; observation of embryo development in the frog (utilizing a culture of frog eggs); or observation of microslides of frog or chick embryo development.

  (Enrichment may be provided by allowing students the opportunity to design their own investigations based on questions that these activities may generate.) (212-3, 313-4)

Resources/Notes

MHR *Biology,* pp. 506-509

NOVA Online: "Life's Greatest Miracle"
http://www.pbs.org/wgbh/nova/miracle/program.html

BLM 15-3: "Identical Twins"

Embryonic Differentiation and Development *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain the processes of development and birth in human reproduction (313-4) – describe the process of childbirth (i) dilation stage (ii) expulsion stage (iii) placental stage	Students should be aware of the physiological events that occur during and after the process of childbirth (cervical dilation, loosening of pelvic ligaments, rupture of the amniotic membrane, uterine contractions, delivery of fetus, and expulsion of the placenta) and the role of hormonal control.
– describe the roles of the placenta and umbilical cord during pregnancy	
– identify chemical control hormones associated with implantation, birth, and lactation (i) progesterone (ii) estrogen (iii) oxytocin (iv) prolactin (v) human chorionic gonadotropin (HCG)	HCG maintains the corpus luteum for the first three months of pregnancy. The functioning corpus luteum continues producing progesterone and estrogen, which maintain the endometrium. Pregnancy tests identify HCG levels in the urine of females. Students should be familiar with the concept of feedback loops during childbirth. The oxytocin feedback from unit I could be reviewed.
– assess the effects of teratogens on the development of the embryo (i) cigarette smoke (ii) alcohol (iii) prescription drugs	The impact of chemical and drug abuse on fetal development (e.g., alcohol, cocaine, cigarettes) may be investigated and discussed. Some prescription drugs have positive effects on adults and children for the treatment of certain medical conditions, but if taken during pregnancy may have serious negative effects on fetal development. Thalidamide, used in the 1950s as a treatment for morning sickness, is one example of this.
• analyse examples where scientific understanding was enhanced or revised as a result of technology (116-2) – describe techniques used to monitor various stages of embryonic or fetal development (i) ultrasound (ii) amniocentesis (iii) fetoscopy (vi) CVS (chorionic villi sampling)	Students may describe how various technologies have improved the success rate of pregnancies and how this fact has led to new technologies. They may investigate the development of fetal surgery techniques to correct biological problems. They may be able to compare the purposes of fetal monitoring techniques to those techniques used for genetic testing. They may also investigate the types of diseases and conditions (e.g., structural abnormalities, spina bifida) that can be identified by various monitoring techniques.

Embryonic Differentiation and Development *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil • Collect information on techniques used for monitoring the health and well-being of a fetus. Techniques to consider may include blood tests, non-stress fetal monitoring, ultrasound, and fetoscopy. (116-2, 313-4)	MHR *Biology,* pp. 510-513 BLM 15-2: "Create a Human Development Game"
Presentation • Research and present the effects of different types of teratogens on development. (116-2, 313-4)	MHR *Biology,* pp. 429-431, 507 MHR *Biology,* pp. 512-514 MHR *Biology,* pp. 607-608

Genetic Continuity *(~31 Classes)*

Introduction

Much of the structure and function of every living organism is determined by deoxyribonucleic acid (DNA). It is important for a scientifically literate person to understand the principles and fundamentals of DNA: what it is, how it works, how and for what purposes humans are manipulating it, and why this major area of scientific and technological endeavour has dramatic implications for humans and planet Earth. This unit will provide the Biology 621A student with the basic information required for the comprehension of genetics.

Focus and Context

In this unit on genetic continuity the primary focus is on problem solving and technology. However, to appreciate the complexity and uniqueness of DNA and how its structure determines protein construction, scientific inquiry and observation are required. With the inclusion of information on biotechnology and associated bioethics, there is also ample opportunity for decision making and STSE components.

Science Curriculum Links

Very early in their study of the life sciences, students begin to consider the individuality of organisms. Students at the elementary level are asked to identify variations that make each person and animal unique from each other and their parents. They also identify traits that remain constant and those that change as organisms grow and develop. The unit on reproduction in grade 9 looks at cell division and develops the idea that the nucleus of a cell contains genetic information and determines cellular processes. Biology 521A continues this theme with its discussion of the nucleus as a critical component of cellular structure.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

114-2 explain the role of evidence, theories, and paradigms in the development of scientific knowledge

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-6 describe and evaluate the design of technological solutions and the way they function, using scientific principles

Social and Environmental Contexts of Science and Technology

117-2 analyse society's influence on scientific and technological endeavours

117-7 identify and describe science- and technology-based careers related to the science they are studying

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives

Skills

Students will be expected to

Initiating and Planning

212-4 state a prediction and a hypothesis based on available evidence and background information

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Analysing and Interpreting

214-5 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables

214-12 explain how data support or refute the hypothesis or prediction

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

215-5 develop, present, and defend a position or course of action, based on findings

Knowledge

Students will be expected to

314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids

315-1 summarize the main scientific discoveries that led to the modern concept of the gene

315-2 describe and illustrate the role of chromosomes in the transmission of hereditary information from one cell to another

315-3 demonstrate an understanding of Mendelian genetics, including the concepts of dominance, co-dominance, recessiveness, and independent assortment, and predict the outcome of various genetic crosses

315-4 compare and contrast the structure of DNA and RNA and explain their role in protein synthesis

315-5 explain the current model of DNA replication

315-6 describe factors that may lead to mutations in a cell's genetic information

315-7 predict the effects of mutations on protein synthesis, phenotypes, and heredity

315-8 explain circumstances that lead to genetic disease

315-9 demonstrate an understanding of genetic engineering, using their knowledge of DNA

315-10 explain the importance of the Human Genome Project and summarize its major findings

317-4 evaluate the impact of viral, bacterial, genetic, and environmental diseases on an organism's homeostasis

Genetics: Mendelian

Outcomes

Students will be expected to

- demonstrate an understanding of Mendelian genetics (315-3)
  - define the terms heredity and genetics
  - explain Mendel's concept of unit characters and describe the unit theory of inheritance
  - explain the meaning of the relevant terms
    (i) trait
    (ii) P generation (parent generation)
    (iii) F_1 and F_2 generation (first and second filial generation)
    (iv) hybrid
    (v) purebred
    (vi) dihybrid
    (vii) monohybrid
    (viii) dominant
    (ix) recessive
    (x) gene
    (xi) allele
    (xii) homozygous
    (xiii) heterozygous
    (xiv) product rule
    (xv) Punnett square
    (xvi) genotype
    (xvii) phenotype
  - explain how Mendel's experiments support
    (i) principle of dominance
    (ii) law of segregation
    (iii) law of independent assortment

Elaborations - Strategies for Learning and Teaching

This unit unit begins with a number of new terms and students should become proficient in their use.

Some possible strategies to address the terminology effectively are the following:

- general brainstorming session to assess prior knowledge (students can discuss the physical traits inherited in their families)
- introduction of terminology through an explanation of Mendel's experiments
- co-operative learning in the introduction of this unit, with small groups asked to define the terms and then come back to the larger group to present and explain their terms and make connections

Teachers should take the opportunity to relate the terms hybrid and heterozygous.

Mendel's detailed experimentation could be emphasized as an example of an exemplary scientific process.

Genetics: Mendelian

Tasks for Instruction and/or Assessment	Resources/Notes
Performance	MHR *Biology,* pp. 526-537
• Perform available activities that deal with the concept of heredity and the inheritance of particular characteristics. Possibilities include examination of ears of genetic corn or study of the performance of crosses of the fruit fly (*Drosophila*). (Assessment would depend on the nature and depth of the activities selected, ranging from the answering of questions to a more detailed discussion of procedures and results.) (315-3)	
• Design an investigation based on questions generated by activities related to the concept of heredity. (212-4, 214-5, 315-2, 315-3)	BLM 16-1: "Applying Mathematical Probability"
Paper and Pencil	
• Develop a glossary of new terms related to, and used during, your discussions in this genetics unit. (315-2, 315-4, 315-3)	MHR *Biology,* pp. 536-539

Genetics: Mendelian *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• interpret patterns and trends in genetic data (214-5)	Students may investigate their own individual dominance/recessiveness as related to visual/sensory traits (e.g., widow's peak, dimples, tongue rolling, attached/free ear lobe, the ability/lack of ability to taste PTC). Data from a class activity of this nature can be collected and the prevalence of dominant and recessive traits within this restricted population can be compared to prevalence in the population in general. Activities can be performed that simulate the chance formation and pairing of gametes (e.g., simulate Mendel's experiments, substituting the tossing of coins and heads/tails for plant characteristics). Students can investigate visually the phenotypic ratios evident during a laboratory activity using artificially pollinated ears of genetic corn. Genotypes of the parent ears can be determined and the expected phenotypic ratios predicted. Students may perform, as an independent study or group project, crosses using fast growing plants or the fruit fly (*Drosophila)* to investigate the inheritance of various characteristics.
• state a prediction and a hypothesis based on available genetic evidence using genetic problems (212-4) – determine the outcome of monohybrid and dihybrid crosses	Students should use Punnett squares and the product rule to determine genotypic and phenotypic ratios in monohybrid crosses, and Punnett squares to determine genotypic and phenotypic ratios in dihybrid crosses. Teachers should use multiple resources to find genetic problems of this type. As an extension, the product rule may be used to determine genotypic and phenotypic ratios in dihybrid crosses.
• demonstrate an understanding of Mendelian genetics (315-3) – explain the meaning of relevant terms (i) incomplete dominance (ii) co-dominance (iii) multiple alleles	Multiple alleles should be explained with reference to blood types. Students could explore other examples of multiple alleles such as eye colour in *Drosophila* and colour patterns in ducks.

Genetics: Mendelian *continued...*

Tasks for Instruction and/or Assessment

Performance

- Collect data on human physical traits and analyse the results for patterns of dominant and recessive inheritance of these traits. (315-3, 214-5, 212-4)
- Human ABO blood type is an example of the expression of multiple alleles. Determine the blood type of the simulated blood sample provided and list the potential genotypes that would correspond to this type. (315-3, 212-4)

Paper and Pencil

- Solve monohybrid and dihybrid genetics questions provided. In each case, analyse the data as requested.

  (Assessment should be based on the accurate solution of the problems using appropriate logic and procedures.) (315-3)

Resources/Notes

Core Lab #6
Appendix B: Human Inheritance Experiment

MHR *Biology,* pp. 529-540

BLM 16-2: "Monohybrid and Dihybrid Crosses"

MHR *Biology,* pp. 541-543

Genetics: Mendelian *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• state a prediction and a hypothesis based on available genetic evidence using genetic problems (212-4) • interpret patterns and trends in genetic data (214-5)	The concepts of incomplete dominance and co-dominance are very similar with respect to phenotypic expression. 1. Co-dominance is the condition in which both alleles of a gene are expressed. Examples include roan horses (red and white hair) and barred-plumage chickens (black and white feathers). 2. Incomplete dominance is inheritance in which an active allele does not entirely compensate for an inactive allele. Examples include snapdragon flowers (heterozygous is pink) and Japanese four-o'clock flowers (heterozygous is pink).
– predict the outcome of monohybrid and dihybrid crosses for incomplete and co-dominance	There are a number of different methods of representing the alleles for incomplete and co-dominance. For example, in incomplete dominance for flower colour in snapdragons the following can be used: (i) R - red R' - white (ii) F^R - red F^w - white (iii) R - red W - white For co-dominance, blood type may be represented as follows: (i) I^A I^B (ii) A B Students should be able to solve dihybrid crosses involving one trait that is completely dominant with one other trait that is not (co-dominance, incomplete dominance, multiple alleles). Teachers should use multiple resources to find genetics problems of this type.
– demonstrate the inheritance of traits governed by multiple alleles by predicting the genotypic and phenotypic ratios in crosses involving human blood types (ABO groups)	
– explain the significance of a test cross – use a test cross to determine the unknown genotype of a dominant organism	It is impossible to determine simply by its appearance the genotype of an organism that is expressing the dominant trait. Teachers should pose the question, How would you determine the unknown genotype? Teachers should note that the absence of the homozygous recessive trait in the offspring does not confirm that the unknown parent is homozygous dominant, especially in small samples of offspring.

Genetics: Mendelian *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil • Solve the monohybrid and dihybrid genetics questions provided. Analyse the data as requested. (Assessment should be based on the accurate solution of the problems using appropriate logic and procedures.) (212-4, 214-5, 315-3) • Analyse the genetic clues presented in a murder mystery to determine the name of the murderer. Write down in point form the logic used to come to conclusions. An example is provided on p. 561 of your text. (212-4, 214-12, 315-3)	MHR *Biology,* pp. 541-543
Presentation • Present data and conclusions of predictions on the outcomes of monohybrid and dihybrid crosses to the class. Compile and organize your data using appropriate formats (e.g., numeric tables, graphs) and be prepared to explain decisions that you have made. (214-12, 215-5)	MHR *Biology,* pp. 533-534

Genetics: Modern Ideas

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• summarize the main scientific discoveries that led to the modern concept of the gene (315-1)	This section could be introduced by re-emphasizing Mendel's conclusions and discussing how the behaviour of Mendel's traits parallels chromosome behaviour.
• describe and illustrate the role of the chromosomes in the transmission of hereditary information from one cell to another (315-2)	
– explain how the work of Gregor Mendel and Walter Sutton led to the chromosome theory of inheritance	Teachers should explain how the behavior of the chromosomes observed by Sutton during meiosis accounts for Mendel's observations and conclusions concerning segregation and independent assortment.
– state and explain the chromosome theory of inheritance	
– describe Morgan's experiments with *Drosophila* and explain how his observations supported the chromosome theory of inheritance	Morgan's experiments restated Mendel's law of independent assortment by including crossing over.
– explain the concepts of gene linkage (linked genes) and crossing-over	Crossing over was introduced in unit 2. The emphasis in this unit is on how crossing over breaks gene linkages and creates variation. Diagrams and simulations may be useful in illustrating these concepts.
– outline, in general terms, the gene-chromosome theory of inheritance	Genes exist on specific sites in chromosomes. When pairs of homologous chromosomes separate during gamete formation, they form two gametes. Each gamete will contain a separate allele for each trait. During fertilization, chromosomes from one gamete will combine with those of another gamete.
– explain how the discovery of gene linkage affected our understanding of Mendel's law of independent assortment	
– state the law of independent assortment in modern terms	The law of independent assortment in modern terms includes gene linkage and crossing over.

Genetics: Modern Ideas

Tasks for Instruction and/or Assessment

Paper and Pencil

- Construct a diagram illustrating the process of crossing over. (315-2)
- Summarize results of scientific discoveries that led to the gene-chromosome theory. (315-1, 315-2)

Journal

- Is there a relationship between the number of chromosomes and the average mass of individuals in a species? Explain. (214-5)
- Is there a relationship between the number of chromosomes and the complexity of the species? Explain. (214-5)

Resources/Notes

MHR *Biology,* pp. 545-548

Genetics: Modern Ideas *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• summarize the main scientific discoveries that led to the modern concept of the gene (315-1) – define sex-linkage – explain why sex-linked defects are more common in males than females – distinguish between genotypes and phenotypes evident in autosomal and sex-linked inheritance – explain the influence of polygenic traits on inheritance patterns	Students should be introduced to the concept of the inheritance of certain characteristics (e.g., red-green colour blindness, hemophilia, muscular dystrophy) through the sex chromosomes. Colour blindness analysis charts are useful to illustrate this sex-linked characteristic. Students should be aware that autosomal inheritance typically involves pairs of genes, with gender being irrelevant to gene expression. Sex-linked inheritance involves pairs of genes on the X chromosome in the female, and a single gene on the X in the male. In this case, gender is important in gene expression and gender must be considered a part of the phenotype. This is also known as multiple gene inheritance. Skin colour and eye colour are examples of polygenic inheritance in which traits are determined by a number of different contributing genes present at different locations, and expression depends on the sum of the influences of all of these. Other examples include animal and plant traits selected by breeders for improving livestock and crops, as well as human characteristics such as susceptibility to cardiovascular disease, or athletic ability.
• interpret patterns and trends in genetic data (214-5) – predict the outcome of monohybrid and dihybrid crosses involving sex-linked traits	Students should solve genetic problems that involve sex-linked traits. In these problems they should predict the genotypes, phenotypes, and ratios among offspring, and compare specific genotypes and phenotypes for males and females. Students should be able to solve dihybrid crosses involving one trait that is completely dominant with one other trait that is sex-linked. Teachers should use multiple resources to find genetic problems of this type.

Genetics: Modern Ideas *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Journal • Reflect and respond to the following statement: True or False: Males are biologically stronger than females. Be prepared to defend your position. (315-1)	MHR *Biology,* pp. 546-548, MHR *Biology,* pp. 555-559
Paper and Pencil • Solve available sex-linked genetics questions. In each case, analyse the pedigree charts provided and determine the mechanism of inheritance. Determine the unknown genotypes and phenotypes for the indicated individuals. (Assessment should be based on the accurate solution of the problems using appropriate logic and procedures.) (212-4, 214-12, 315-3)	MHR *Biology,* p. 549

Genetics: Implications

Outcomes

Students will be expected to

- identify in general terms the impact of genetic diseases on the homeostasis of an organism and explain the circumstances that lead to genetic diseases (317-4, 315-8)
- describe and evaluate the design of technological solutions and the way they function, using genetic principles (116-6)
- construct arguments to support a decision concerning the use of genetic engineering, using evidence and recognizing various perspectives (118-6)
- analyse and describe examples where genetics-based technologies were developed and based on scientific understanding (116-4)
- analyse, from a variety of perspectives, the risks and benefits of applying the scientific knowledge gained through genetic research (118-2)

Elaborations - Strategies for Learning and Teaching

Students should be cognizant of various types of common genetic diseases and their inheritance patterns. Examples could include autosomal recessive inheritance (e.g., Tay-Sachs, PKU); co-dominant inheritance (e.g., sickle cell anemia); autosomal dominant inheritance (e.g., progeria, Huntington's); incomplete dominant inheritance (e.g., FH); and x-linked recessive inheritance (e.g., color blindness, muscular dystrophy, hemophilia). There are many current and relevant issues within the realm of biotechnology. Students can evaluate data on genetic research obtained from Internet Web-sites. They can also evaluate, from a variety of perspectives (e.g., counsellor, prospective parents, potential patient) the role of genetic counselling and gene testing for the identification and treatment of potentially debilitating genetic conditions (e.g., Tay-Sachs, PKU, Huntington's disease, Alzheimer's). They could discuss the personal and ethical considerations increasingly faced by individuals as they consider the identification of genes, the possibility of prenatal diagnoses, and the ability to predict particular disorders. Questions such as the following could be considered:

– Would you, as an individual, want to know if you will suffer from a disabling disease later in life? Do you have a right to know?

– Do insurance companies have a right to accept/reject you for insurance coverage based on the results of voluntary and confidential genetic testing predicting your future health?

– Do employers have a right to know your genetic status as determined by voluntary genetic testing? For example, suppose you are a heterozygous carrier for sickle cell anemia. You know there is a belief within the airline industry that carriers are more sensitive to a decrease in cabin air pressure. Do you inform the airline of your genetic status before accepting a job? As genetic testing becomes more common, and more available, will potential employers have a right to know of your genetic status as a preliminary to hiring?

The STSE component "Genetics Research in Newfoundland and Labrador," found in appendix C, incorporates a broad range of Biology 621A outcomes. More specifically, it targets (in whole or in part) 116-4, 116-6, 117-7, 118-2, 118-6, 315-6, 315-7, 315-8, and 315-9.

Genetics: Implications

Tasks for Instruction and/or Assessment

Paper and Pencil

- Use an available case study to investigate one of the inherited diseases you are studying. (315-8)

Presentation

- Debate the merits of mandatory testing for genetic diseases as a means of reducing health care costs, versus a person's right to privacy.

  (Assessment should be based on the accuracy and relevance of information gathered and completeness of the research shown during class presentation.) (317-4, 315-8, 118-2)

Resources/Notes

MHR *Biology,* pp. 555-559

Appendix C: "Genetics Research in Newfoundland and Labrador"

Genetics: Molecular

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• summarize the main scientific discoveries that led to the modern concept of the gene (315-1)	Students could research and produce a historical time line to illustrate the most significant scientific discoveries leading to the concept of the gene.
• explain the role of evidence, theories, and paradigms in the development of the gene concept (114-2)	
– describe the contributions of scientists to the understanding of the structure and function of DNA (i) Mendel (ii) Sutton and Boveri (iii) Levene (iv) Griffith (v) MacLeod, McCarty, and Avery (vi) Chargaff (vii) Franklin and Wilkins (viii) Beadle and Tatum (ix) Hershey and Chase (x) Watson and Crick (xi) McClintock	The depth of treatment for the work of these scientists should be limited to their contribution to the understanding of the structure and function of DNA. The intent of this outcome is to show how scientific understanding progressed by building on the results of previous research. An approach to making historical time lines more meaningful is to relate the time frame to an event that has some relevance to the student. Example: – 1953 – Watson & Crick discover the structure of DNA – 1953 – the year of the birth of the student's mother/father
• explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3) – describe the Watson and Crick double helix model of DNA	Students can brainstorm ideas about DNA; discuss their preconceptions; organize their ideas; and, based on their current level of understanding, show the interrelationships on a concept web. They should be aware of and be able to explain how knowledge of the structure, function, and replication of DNA revolutionized the understanding of heredity. Students may design and/or construct models of DNA to illustrate the general structure and base arrangement of the molecule.

Genetics: Molecular

Tasks for Instruction and/or Assessment	Resources/Notes
Performance	
• Design and construct a three-dimensional model of a DNA molecule following these structural guidelines: – include a minimum number of six base pairs – show all possible base pair combinations – make the model self-supporting – include a key for part identification (Students will be assessed on accuracy and completeness of their model.) (115-3)	MHR *Biology,* p. 545 MHR *Biology,* pp. 566-574 MHR *Biology,* pp.579-580
Paper and Pencil	
• Given names of scientific investigators and/or achievements that have contributed historically to the concept of the gene, prepare on a large index card a brief summary including the date, names of appropriate individuals, and the contributions made. Present this information to the class. Add your information card to the chronological time line at the front of the classroom. (Assessment can be based on the accuracy and completeness of the information collected.) (115-3, 315-1)	
Journal	
• Provide an example of how the discovery of one technology broadened the circle of knowledge for other areas of science. (115-3, 315-1)	MHR *Biology,* pp. 574-575

Genetics: Molecular *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• identify and describe the structure and function of important biochemical compounds such as nucleic acids (DNA and RNA) (314-3) – compare and contrast the structure of DNA and RNA	Students should describe, in general, how genetic information is contained in a DNA molecule (chromosome); how each DNA molecule replicates itself during cell division; and how information is transcribed into the base sequences of RNA molecules and is finally translated into the sequence of amino acids in cell proteins. They may perform simulations to demonstrate the replication of DNA, and the transcription and translation of its information. They could investigate the rarity of mistakes made during replication of DNA by discussing the role of DNA polymerase and its "proofreading" mechanism, and the influence of DNA repair enzymes.
• explain the semi-conservative model of DNA replication (315-5) – describe the four steps of DNA replication (i) initiation (ii) elongation (iii) termination (iv) proofreading and correction	Students should realize that DNA replication is a process in which a molecule of DNA is made containing one strand of parental DNA and one strand of new DNA. Students should understand that DNA replication is a four-step process. During initiation the DNA molecule unwinds and unzips. Students could better understand this process by identifying the enzymes, their functions, and their order of involvement (i.e., origin enzymes - open origin bubbles (initiation), etc.) Elongation involves the addition of complementary nucleotides to the original DNA strand. Termination is the completion of elongation. During proofreading and correction, DNA polymerase detects and corrects any errors that may have occurred in elongation.
• evaluate and select appropriate models for collecting evidence and appropriate processes for problem solving, inquiring, and decision making (212-8)	The outcomes 212-8, 215-2, and, in part, 315-5 are addressed by completing Investigation 17B: "DNA Structure and Replication."
• select and use appropriate symbolic modes of representation to communicate ideas and results (215-2)	The outcomes 213-7, 215-2, and, in part, 315-4 are addressed by completing Investigation 17C: "Simulating Protein Synthesis."
• explain the role of DNA and RNA (mRNA, tRNA, rRNA) in protein synthesis (315-4) (i) transcription (ii) translation	Analogies may be useful in illustrating how the amino acids in foreign proteins can be reorganized into a variety of human proteins (e.g., the rearrangement of the letters of the alphabet into different words, or Lego blocks into different structures.) Teachers should note the error relating to transcription on page 591 of the text. The anti-sense strand is the strand of the DNA molecule that transcribed the mRNA. The anti-sense strand is also referred to as the DNA template. See Teacher's Resource, p. 209, section 17.4 (numbers 4-5).

Genetics: Molecular *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil • Using the processes of transcription and translation, convert a model DNA strand into its resulting protein. (314-3, 315-4)	MHR *Biology,* pp. 574-576
Performance • Using model kits, construct various organic compounds, including proteins and nucleic acids. (314-3)	
• Perform an experiment to extract DNA from the source provided, following the guidelines given in the laboratory. (Assessment should be based upon observation of the group activity and the answering of appropriate questions.) (315-4)	MHR *Biology,* pp. 582-588 BLM 17-2: "Replication"
Journal • Discuss the role of carbon as a versatile building block for all organic compounds. (314-3)	
	Investigation 17B: "DNA Structure and Replication," MHR *Biology*, pp. 586-587
	Core Lab #7 Investigation 17C: "Simulating Protein Synthesis," MHR *Biology,* pp. 594-595
	MHR *Biology,* pp. 589-594
	BLM 17-3: "Transcription and Translation"

Genetics: Molecular *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• explain the role of DNA and RNA (mRNA, tRNA, rRNA) in protein synthesis (315-4) (**cont'd**)	
– discuss the influence of hormonal and environmental factors on gene expression	Students should be aware that environmental factors might cause a change in the expression of some genetic information of an organism (e.g., the two colour pattern of the Siamese cat involves one hair colour gene producing a temperature sensitive enzyme; the enzyme is active and produces dark pigment only on cooler areas of the body - feet, snout, tip of tail, ears). Sex may also play a role (e.g., baldness gene is only dominant in males). Other examples of the effects of the environment on gene expression include differences in identical twins and the colour of fur in Arctic foxes or hares.
• predict the effects of mutations on protein synthesis, phenotypes, and heredity (315-7)	In particular, students could discuss the dangers of UV radiation as a carcinogenic agent. Students can hypothesize how an alteration may ultimately affect the individual involved. Students may investigate and discuss sources of embryo deforming (teratogenic) chemicals found in the environment (e.g., thalidomide, alcohol) and the responsibility of society, science, and technology to ensure that all children have a good quality of life.
– explain the meaning of mutation and what causes it – explain what is meant by a gene mutation and predict, in general, its effect on protein synthesis	Students should draw the connection between mutations in genetic information and how they may be expressed through human conditions (e.g., cancer, sickle cell anemia, human thallesemia). The critical role of proteins as the link between genes and the human condition should be emphasized.
– distinguish between somatic and germ mutation and compare the inheritability of each	Somatic mutations occur in somatic cells (body cells) and thus cannot be passed on to offspring. Germ mutations occur during meiosis (gamete production) and thus can be passed on to offspring.
– distinguish between the two types of point mutations (gene mutations) (i) substitution -silent -mis-sense -nonsense (ii) frame shift -insertion -deletion	A point mutation is considered a gene mutation because it involves a change in a nucleotide and usually only affects a single gene. Two types of point mutations are substitutions and frame shift mutations.

Genetics: Molecular *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Paper and Pencil	
• Investigate the effects on the developing human embryo of exposure to a specific environmental influence. The following are suggestions:	
– thalidomide	MHR *Biology,* pp. 594-600
– alcohol (fetal alcohol syndrome)	
– tobacco/tobacco smoke	
– DES (diethylstilbesterol)	
– radiation	
– drugs such as cocaine, LSD, marijuana	
– viruses (rubella/German measles, HIV)	BLM 17-4: "Mutations"
– caffeine	
– antibiotics (Streptomycin, acne drugs)	
– streptococcus bacteria	
(Assessment should be based on accuracy and relevance of information gathered and completeness of research shown during class presentation.) (315-6, 315-7)	
• Using the processes of transcription and translation, convert a model DNA strand into its resulting protein. Investigate what effect a change in one base in the DNA sequence might have on the resulting protein. (314-3, 315-4, 315-7)	
Performance	
• Design an experiment to investigate the effect of chemicals or radiation (e.g., microwave, ultraviolet) on the germination of seeds.	
(Once the experiments have been designed and the design approved, there is opportunity for assessing how students actually perform the activities. Do they follow the design, use correct and safe techniques, troubleshoot as required?) (315-7)	
• As an independent project, research, design and perform an experiment to demonstrate the effect of environmental factors on inheritance. Your experiment must be approved before it is attempted. (315-4)	

Genetics: Molecular *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• describe factors that may lead to mutations in a cell's genetic information (315-6) – describe how McClintock's jumping genes contribute to genetic variation – distinguish among the different types of chromosome mutations (i) deletion (ii) duplication (iii) inversion (iv) translocation (v) nondisjunction (monosomy, trisomy)	Students may wish to compare variation in jumping genes to variation in crossing over.
• identify in general terms the impact of genetic diseases on the homeostasis of an organism (317-4)	Students could apply their knowledge of nondisjunction by completing a thinking lab (page 552 of text). This would help reinforce the concepts involved in nondisjunction. Students should describe examples of human genetic diseases caused by chromosomal mutations such as Down syndrome, Turner syndrome, Klinefelter syndrome (XXY syndrome), Jacobs syndrome (XYY syndrome), and Triple X syndrome. Students should explore and compare the severity of chromosomal mutations and gene mutations. Chromosomal mutations are more serious because they involve a larger portion of genetic material. Students may also explore why there are in humans relatively few syndromes involving nondisjunction. Most cases of nondisjunction prove to be fatal.
• interpret patterns and trends in genetic data (215-5) – analyse and interpret models of human karyotypes • state a prediction based on available evidence and background information (212-4) • explain how data support or refute the prediction (214-12)	The laboratory outcomes 212-4, 214-12, and, in part, 214-5 are addressed by completing "Karyotype Lab" (appendix B of guide). Teachers should note that the lab includes three chromosome sets for karyotyping. Students are only required to complete two karyotypes. Teachers can choose any two of these chromosome sets so that the lab can be varied from year to year. Teachers can also create their own abnormal karyotypes if they wish to have further variations.

Genetics: Molecular *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Journal	
• Is it possible for a person born with a chromosomal abnormality (such as Down Syndrome) to have a child without the abnormality? (315-6)	MHR *Biology,* pp. 597-598
Paper and Pencil	
• Using various sources, conduct research on the many hypotheses regarding the role of transposons in the human genome. (315-6, 213-7)	MHR *Biology,* pp. 550-553
Presentation	
• After you have completed your research on transposons, present your findings to the class. This could be done as a multimedia project to incorporate technology and improve computer skills. (315-6, 215-2, 213-7)	
Performance	
• Provided with a selection of human karyotypes, pair and arrange the chromosomes in the manner of a karyotype. Analyse the resulting karyotype for any inherent abnormalities and provide a brief written summary as to causes of the abnormality and what it means to the individual who suffers it. (Assessment should be based on accuracy and completeness of exercise.) (215-5, 215-2)	MHR *Biology,* pp. 553-560 **Core Lab #8** Appendix B: "Karyotype Lab"

Genetics: Implications *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• interpret patterns and trends in genetic data (214-5) – draw and interpret the patterns of inheritance shown on pedigree charts	Students should draw and interpret pedigree charts from data on human single and multiple allele inheritance patterns. They should be able to analyse inheritance data and infer the method of inheritance (e.g., dominant, recessive, sex-linked). They should compare pedigree charts for the inheritance of non sex-linked and sex-linked conditions. (The pedigree of the hemophilia in Queen Victoria's bloodline is readily available and serves to provide a biological/historical cross-curricular link.) Student groups may design procedures, collect data, and prepare family pedigrees to demonstrate the inheritance of autosomal traits determined by single and multiple alleles, and sex-linked traits. Simulations of forensic investigations or murder mysteries involving clues based on genetic traits (e.g., blood type, freckles) and pedigree information that require students to "solve" a crime based on the information provided are an interesting way to enhance student knowledge and interest in genetic analysis.
• describe and evaluate the design of technological solutions and the way they function, using genetic principles (116-6) – describe the importance of genetic counselling – describe various methods of detecting genetic disorders (i) amniocentesis (ii) CVS (chorionic villi sampling) (iii) fetoscopy (iv) genetic markers (linked marker and gene specific marker)	Genetic counsellors study the medical histories of couples and their families and help parents-to-be by advising them of the frequencies of genetic disorders within affected families, and by helping them to determine the probable risk factors associated with their particular cases. It is suggested that Department of Health and Wellness sources be explored and appropriate literature be examined for additional information on this concept. Teachers should make a connection to the "Karyotyping Lab" in appendix B, which discusses methods of detecting genetic disorders. Teachers should note that amniocentesis, CVS, and fetoscopy have already been studied in unit 2.
– describe various methods of treating genetic disorders (i) screening and prevention (ii) surgery (iii) environmental control (iv) gene therapy	Students should research and discuss both the potential and the ethics of biotechnology and somatic cell gene replacement therapy in the treatment of human genetic disorders. What might be the implications of gene therapy on germ or sex cells? Students could discuss the role of gene banks for the preservation of endangered species and genotypes, and debate whether society has the right or responsibility to preserve these species in this way for future generations.

Genetics: Implications *continued...*

Tasks for Instruction and/or Assessment

Journal

- You are a genetics counsellor. What advice would you give a couple who just found out that their unborn child has a 49% chance of having a serious kidney disease? (116-6, 315-8, 215-5)

Paper and Pencil

- Analyse the pedigree charts provided and determine the mechanism of inheritance. Predict the unknown genotypes and phenotypes for the indicated individuals.

  (Assessment should be based on the accurate solution of the problems, using appropriate logic and procedures.) (212-4, 214-12, 315-3)
- Design pedigree charts to show the inheritance of certain characteristics such as freckles, handedness, or other family characteristics.

  (Sample pedigree charts may be found on the Internet and provided to students as examples.) (214-5, 215-2)
- Research the use of gene therapy in the treatment of certain genetic diseases, such as cystic fibrosis. (116-6, 213-7)

Resources/Notes

MHR *Biology,* pp. 544, 558
MHR *Biology,* pp. 560-562

BLM 16-3: "Deciphering Pedigrees"

MHR *Biology,* pp. 606-612

Genetics: Implications *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• demonstrate an understanding of genetic engineering, using knowledge of DNA (315-9)	Genetic engineering can be defined as the manipulation of an organism's genetic material to modify the proteins it produces.
– define genetic engineering – describe the tools and techniques used in genetic engineering (i) restriction enzymes (ii) recombinant DNA (iii) DNA amplification - bacterial vectors - viral vectors - polymerase chain reaction (iv) gel electrophoresis (v) DNA sequencing	The use of restriction enzymes or biological scissors in DNA fingerprinting can be effectively demonstrated by using paper activities. Students could perform simulations to demonstrate the use of restriction enzymes in the creation of new DNA sequences (e.g., recombinant DNA). DNA sequencing can be compared to completing a puzzle, tying together the clues in a murder mystery, reconstructing remains in archaeology.
• explain the importance of the Human Genome Project and why it was initiated (315-10, 117-2)	
– describe the Human Genome Project	Students should know what the Human Genome Project is, how and why it was conducted, and what the implications of decoding the entire human genome are.
– describe the major findings of the project	The two major findings of this project are that 99.9% of all human DNA is identical, and that there are approximately 35,000 different genes in the human population. Individual students or student groups could be assigned an individual human chromosome and asked to investigate its mapping. They could prepare a large cardboard model of this structure, labelled with its identified genes and the characteristics for which they code. They could do a presentation on their chromosome as the class builds a human genome to be displayed in the classroom or school.

Genetics: Implications *continued...*

Tasks for Instruction and/or Assessment

Paper and Pencil

- In assigned groups, research and report to the class on one of the tools or techniques currently available to study genetics. Areas that may be considered include the polymerase chain reaction (PCR) process, DNA "fingerprinting" and gel electrophoresis, gene probes, recombinant DNA, cloning, genetic markers, and gene mapping. (118-2)
- Analyse a simulation of DNA fingerprinting and determine which suspect was in the vicinity of the crime scene. Write down in point form the logic used to come to your conclusion. (212-4, 315-2, 315-10)
- Given one chromosome from the human genome to research and map, prepare a cardboard scale model of this chromosome with its most significant genes clearly labelled. Present to the class information about your chromosome.

  (Student chromosomes could be mounted as part of a common genome, either within the classroom or as a bulletin board display for the school.) (315-2, 315-10)

Journal

- The Human Genome Project raises a number of important issues that might be considered. Reflect on these questions and develop, present, and defend your position based on scientific thinking.
  - Recently a Canadian futurist, Frank Ogden, applied to the U.S. Patent and Trademark office to have his DNA trademarked, in an effort to protect himself and his identity. He feels that his application is important because it paves the way for others to do the same, especially if they have a talent that may interest researchers wishing to study their DNA, the building blocks of life. Do you think Frank Ogden should be successful? Why or why not? (117-2, 315-10)

Resources/Notes

MHR *Biology,* p. 604

MHR *Biology,* pp. 613-620

MHR *Biology,* pp. 614-616, 125

BLM 18-1: "Build a Recombinant Plasmid"

Genetics: Implications *continued...*

Outcomes

Students will be expected to

- analyse, from a variety of perspectives, the risks and benefits to society of applying the scientific knowledge gained through the Human Genome Project (118-2)
  - risks
    - (i) privacy
    - (ii) financial
    - (iii) ethical
  - benefits
    - (i) knowledge of predisposition to disease
    - (ii) analysis, prevention, and treatment of disease
- select and integrate information from various sources on genetically modified organisms and genetically modified foods (213-7)
- analyse from a biological, social, ethical, and environmental perspective the risks and benefits of the development of GMFs and GMOs (118-2)
  - define GMOs and GMFs

Elaborations - Strategies for Learning and Teaching

The completion of the Human Genome Project presents potential risks and benefits to society. Students could brainstorm relevant issues and subsequently research, analyse, and discuss a selection of these.

Students could investigate and perform a risk/benefit analysis and defend their position on situations such as

- the use of genetically modified microorganisms (GMO) for drug production, pollution clean-up, environmental monitoring, and mining;
- the use of genetically modified food (GMF) in the marketplace (the extent to which genetic manipulation currently pervades the food industry, as in processed foods), and how aware or unaware the general public is of this;
- the importance of labelling genetically modified foods, and the practical issues involved.

Students should analyse examples of GMOs or GMFs, and their major significance. GMOs and GMFs to consider may include

- (i) herbicide-resistant plants
- (ii) BST-producing bacteria
- (iii) golden rice
- (iv) transgenic salmon
- (v) insulin-producing bacteria
- (vi) PCB-eating bacteria
- (vii) oil-eating bacteria.

Students could use multiple resources to find other examples of GMOs and GMFs.

Genetics: Implications *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Presentation • Select an area of biotechnology that is of interest and prepare a class presentation and written report which illustrates two differing points of view. Internet Web sources provide an extensive database for this exercise. (Assessment should be based upon quality of both presentation and written report. Teachers could suggest that at least one individual or group choose to deal with the Human Genome Project and its implications for human life and health.) (117-2, 118-2, 118-6, 213-7, 215-5)	MHR *Biology,* pp. 618-620
Paper and Pencil • As a class, create a list of Web-sites useful for information concerning genetics and genetic screening. (213-7) • Create a webquest devoted to moral and ethical concerns associated with genetics. Generate ten questions and list a variety of Web-sites your peers could use to seek answers to the questions. (213-7)	MHR *Biology,* pp. 621, 623-626 MHR *Biology,* p. 630
Journal • Is it ethical for private biotechnology companies to use for profit research information gained with public funding? Should the individuals whose DNA was used for public research in the Human Genome Project be compensated for their contributions? (117-2, 118-2, 315-10)	

Genetics: Implications *continued...*

Outcomes	Elaborations - Strategies for Learning and Teaching
Students will be expected to	
• analyse from a biological, social, ethical, and environmental perspective the risks and benefits of the development of GMFs and GMOs (118-2) **(cont'd)** – identify and explain the major risks associated with GMOs and GMFs (i) environmental threats (ii) health effects (iii) social and economic issues	Students could debate the merits of labelling foods that are genetically modified.
• construct arguments to support or oppose the use of GMOs and GMFs in society (118-6) • present and defend a course of action on the use of GMO and GMF, based on findings (215-5)	Students may examine how our new-found ability to move genes around potentially impacts allergenicity levels. The production of "new" foods or organisms could increase the number of allergens around us.
• analyse from a biological, social, ethical, and environmental perspective the risks and benefits of cloning organisms (118-2) – define cloning – identify and explain the major benefits and risks associated with cloning. • identify and describe science-based careers related to the field of biotechnology (117-7) (i) cytogeneticist (ii) medical geneticist (iii) genetic engineer	This would be an ideal time to do a role-play concerning these arguments. Students could do research on the topic and set up a debate. Cloning was discussed in unit 2, and the concept is expanded in this section. Students could use Dolly the sheep as an illustration of the cloning process. The benefits and risks associated with cloning include (i) speed of reproduction (ii) elimination of disease (iii) manipulation of traits (iv) reduction of genetic variability (v) use and destruction of embryos (vi) loss of individuality.

Genetics: Implications *continued...*

Tasks for Instruction and/or Assessment	Resources/Notes
Presentation • Debate the pros and cons of producing genetically modified foods (or use some other aspect of biotechnology). You will be required to display the results of your research and debate with other stakeholders the merits of using technology for the production of genetically modified foods. You will represent various sectors of society, depending on the issues selected. They may include individuals such as farmers, politicians, Greenpeace activists, consumers, or representatives of development agencies involved in underdeveloped countries. (Teachers could assess the participation of students, preparation of the argument, and thoroughness of the research.) (116-6, 117-2, 118-2, 118-6, 215-5)	BLM 18-3: "Design a Pet"
Paper and Pencil • Research and analyse how the cloning of the sheep Dolly in 1997 influenced our understanding of the potential of biotechnology, and how knowledge of the cloning of mammals continues to evolve. (118-6, 118-2)	
Portfolio • Investigate (through research or interview) a career of your choice related to this unit on genetics and heredity. Examples include biochemist, genetic counsellor, laboratory technologist, geneticist, oncologist, etc. Prepare a small poster on the knowledge and skills required for your chosen career. (Assessment will be based on the quality of the display prepared.) (117-7, 117-2)	MHR *Biology,* pp. 626-631 MHR *Biology,* pp. 608-609 Appendix C: "Genetics Research in Newfoundland and Labrador"

Evolution, Change, and Diversity *(~5 Classes)*

Introduction

Evolution is a concept in biology that links yesterday with today. This unit focusses on the history, importance, and mechanisms of the process of evolution, and how a change in the DNA blueprint creates new traits that propel evolution. It builds upon what the students have learned about mutation and genetic variability and shows how these can lead to changes in species based upon natural selection. This unit also outlines evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth.

Focus and Context

Through the consideration of questions generated by students and teachers, and the discussion of issues raised, various learning and assessment activities will meet specific curriculum outcomes in this section. The main focus of this unit falls within the realm of scientific inquiry and observation as it moves from a historical to a modern perspective on scientific thought and techniques related to evolution, change, and diversity.

Science Curriculum Links

The curricular connections for this unit in Biology 621A exist primarily at the grade 6 level in a unit called “Diversity of Life”. Students at that point in their life science education are asked to compare adaptations of closely related animals that live in different parts of the world, and then discuss possible reasons for any differences noted.
They are then asked to expand their view of this concept by using the fossil record to identify changes that have occurred in animals over time. These considerations provide a framework upon which further discussions can be built.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

114-2 explain the roles of evidence, theories and paradigms in the development of scientific knowledge

114-5 describe the importance of peer review in the development of scientific knowledge

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

Relationships between Science and Technology

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

Social and Environmental Contexts of Science and Technology

118-6 construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives

Skills

Students will be expected to

Initiating and Planning

212-1 identify questions to investigate that arise from practical problems and issues

Performing and Recording

213-6 use library and electronic research tools to collect information on a given topic

Analysing and Interpreting

214-17 identify new questions or problems that arise from what was learned

Communication and Teamwork

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

Knowledge

Students will be expected to

316-1 describe historical and cultural contexts that have changed evolutionary concepts

316-2 evaluate current evidence that supports the theory of evolution and that feeds the debate on gradualism and punctuated equilibrium

316-3 analyse evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction

316-4 outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth

Evolutionary Change: Historical Perspectives

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to • describe historical and cultural contexts that have changed evolutionary concepts (316-1) • describe the importance of peer review in the development of evolutionary knowledge (114-5) – describe key contributions (i) Charles Lyell (ii) Thomas Malthus (iii) Alfred Wallace (iv) Georges Cuvier	Students could begin by discussing some of the cultural aspects that influenced the progression of evolutionary ideas (e.g., the influence of religious beliefs). Students should be aware of the key contributions of Charles Lyell, Thomas Malthus, Alfred Wallace, and Georges Cuvier to the historical development of the theory of evolution. They should recognize that there are many explanations (scientific, religious, philosophical) for changes in life forms over time.
• explain the roles of evidence, theories, and paradigms in the development of evolutionary knowledge (114-2) – describe the theories put forth by Larmarck and Darwin – compare and contrast Lamarckian and Darwinian evolutionary theories	The concept of a paradigm shift was first dealt with in Biology 521A with regard to the development of cell theory. Students should recognize that a paradigm shift occurred when Lamarck's ideas about evolution were generally dropped in favour of the ideas of Darwin. They could examine how a German biologist, August Freidrich Weismann, was able to disprove Lamarck's theory by cutting off the tails of mice and then allowing the mice to reproduce. Weismann showed that after many generations the tails still remained on the offspring and, therefore, disproved the notion that acquired traits could be inherited.

Evolutionary Change: Historical Perspectives

Tasks for Instruction and/or Assessment

Paper and Pencil

- Investigate an occupation that relates to this evolutionary unit and prepare a poster on the knowledge and skills required for each occupation. Posters will be displayed. Examples include anthropologist, palaeontologist, botanist, physiologist, entomologist, etc. (Assessment is to be based on the quality of the display prepared.) (114-5, 213-6, 316-2)
- Develop a time line to illustrate historical progression towards the theory of evolution. (114-2, 114-5, 316-1)

Journal

- Compare the theories of Lamarck and Darwin. (114-2, 114-5)

Resources/Notes

MHR *Biology,* pp. 650-658

Evolutionary Change: Modern Perspectives

Outcomes

Students will be expected to

- evaluate current evidence that supports the theory of evolution and that feeds the debate on gradualism and punctuated equilibrium (316-2)
  - fossil record
  - geographic distribution
  - anatomy
  - embryology
  - heredity
  - molecular biology
  - identify the conditions necessary to maintain a Hardy-Weinberg equilibrium
- explain how knowledge of evolution 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 the result of the invention of a technology (116-2)

Elaborations—Strategies for Learning and Teaching

Students should be familiar with the variety of evidence that supports the modern theory of evolution. Such evidence exists in the areas of fossil record, geographic distribution, anatomy, embryology, heredity, and molecular biology. The depth of treatment of this evidence should be limited.

(Fossil Record) Fossils appear in chronological order (i.e., probable ancestors appear earlier in the fossil record). Organisms do not all appear in fossil records simultaneously, supporting the notion that organisms evolve slowly. (See fig. 19.10, pp. 660-661 of text.)

(Geographical Distribution of Species) Geographically related environments are more likely to be populated by related species. Similarly, geographically isolated environments support many diverse, unrelated species.

(Anatomy) Anatomical signs of evolution include homologous, analogous, and vestigial structures.

(Embryology) Similarities in Embryonic development suggest common ancestral origin.

(Heredity) The present day science of genetics allows for the understanding of variations that lead to natural selection.

(Molecular Biology) The relationship(s) between organisms can now be determined by comparison of DNA structure and subsequent protein composition

Charts can illustrate the differences between gradualism and punctuated equilibrium. Students could investigate and answer the questions, How would a scientist who supports gradualism or punctuated equilibrium explain gaps in the fossil record? and What sort of evidence would you need to be convinced to accept gradualism rather than punctuated equilibrium, or vice versa?

For the purpose of further evaluating how a population evolves, students should understand the conditions necessary to maintain a Hardy-Weinberg equilibrium. A Hardy-Weinberg equilibrium occurs when a population does not change genetically from one generation to the next. Scientists can determine how a real population changes over time by comparing a real population with a hypothetical Hardy-Weinberg population.

Evolutionary Change: Modern Perspectives

Tasks for Instruction and/or Assessment

Paper and Pencil

- Select a modern animal and investigate the evolutionary evidence that exists for its ancestry. Your report on this work may be visual (e.g., videotape, poster, model) or written. (Assessment will be based on accuracy and completeness of research and quality of presentation.) (115-7, 316-2, 316-4)
- Compare the amino acid and protein sequences of different organisms to compare their similarities (e.g., frog, human, chimpanzee, rabbit, cow). (116-2, 316-2)
- Identify the conditions necessary to maintain a Hardy-Weinberg equilibrium and explain how changes in each of these conditions can cause a population to evolve. (316-2)

Performance

- Debate the two opposing viewpoints - gradualism and punctuated equilibrium. Research both points of view to argue points and counterpoints. (316-2)

Resources/Notes

MHR *Biology,* pp. 659-668

MHR *Biology,* pp. 723-725

BLM 19-2: "Design an Organism"

BLM 19-4: "Evolution of the Globin Gene"

MHR *Biology,* pp. 681-683

Evolutionary Change: Modern Perspectives *Continued...*

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• analyse evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction (316-3) (i) mutations (ii) genetic drift (iii) gene flow (iv) non-random mating (v) natural selection (vi) sexual selection	Students should investigate examples of each of the evolutionary mechanisms listed and present their findings to the class (e.g., breeds of dogs are produced by artificial selection, yet all dogs, including the St. Bernard and Chihuahua, remain members of the same species; natural selection, resulting in morphological, behavioural, or reproductive adaptations such as the camouflage of the peppered moth; dwindling of the cheetah population due to inbreeding). Familiarity with the concept of artificial selection can come from studies of pedigrees or student experiments. Artificial selection allows the creation of "breeds" of domestic animals whereas in natural selection, selection is due solely to natural conditions.
• use library and electronic research tools to collect information on the origin, development, and diversity of living organisms on earth (213-6)	Students can use the Internet to access Web-sites and collect relevant information on evolution and biodiversity. Students can brainstorm a list of extinctions that have occurred and research and evaluate the causes of each as naturally occurring or as a result of human activity. This discussion can be expanded into one that examines current and future extinctions and their causes, and hypothesizes the implications of reduced genetic biodiversity.
• identify questions to investigate that arise from practical problems and issues (212-1) – analyse the role of sexually produced genetic variations and mutations on the process of natural selection	The rapid appearance of new antibiotic resistant microbes and the development of pesticide resistant insects can be considered studies in microevolution - rapid evolution due to intense selection. Students could investigate the causes of the appearance of these new strains and the environmental and societal implications they present. Students may investigate questions such as the following: – If mutations play an important role in evolution, why are many scientists concerned about the mutagenic effects of X-rays, radiation from nuclear power plants, chemicals, etc? – What would be the effect on the offspring if DNA polymerase were absolutely infallible in its proofreading capacity? What would be the long-term effect on biological evolution? – What are the implications of the cloning process, if any, for evolution?

Evolutionary Change: Modern Perspectives *Continued...*

Tasks for Instruction and/or Assessment

Journal

- Describe which mechanisms would be at work for a small tribe of humans in a remote part of the world that has not had contact with the outside world. How might these people be different from other humans? At what point might they no longer remain *Homo sapiens*? (316-3)
- Reflect on this statement and develop, present, and defend your position, based on scientific thinking:
  - It has been hypothesized that we are in the midst of a "sixth mass extinction". Fossil records indicate that global mass extinctions have occurred only five times since complex life emerged, and that each time it was due to a single catastrophic event. It has been said that this apparent "sixth mass extinction" is not, however, occurring due to a catastrophic event, but due to the activities of a single species, *Homo sapiens*, called the exterminator species! (118-6, 316-3)

Paper and Pencil

- Explain, using modern evolutionary theory, the recent appearance of antibiotic resistant bacteria populations. (316-3)
- Explain, using modern evolutionary theory, the recent appearance of pesticide resistant insect populations. (316-3)

Presentation

- Conduct research on the nucleic acid sequences of different animal species. Use your findings to describe evolutionary relationships. (316-3)

Resources/Notes

MHR *Biology,* pp. 687-699

BLM 20-2: "Causes of Micro-evolution"

Evolution: Implications

Outcomes

Students will be expected to

- outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth (316-4)
- identify multiple perspectives that influence a science-related decision or issue (215-4)
- construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives (118-6)
- identify new questions or problems that arise from what was learned (214-17)
- use library and electronic research tools to collect information on a given topic (213-6)

Elaborations—Strategies for Learning and Teaching

Students should research, interpret, and evaluate data related to scientific theories on the origin and development of life - e.g., Gaia, symbiosis theory of eukaryotic cell origins, heterotroph hypothesis, mass extinction theories, organic spontaneous origin or chemical evolution (Oparin-Haldane/Miller-Urey) under early conditions. Students could research the conditions on a planet in our solar system and, using the Haldane-Oparine theory, determine whether life may or may not exist (today or in the future).

Evolution: Implications

Tasks for Instruction and/or Assessment

Presentation

- Use library and electronic research to collect information on each theory or a selected theory. Prepare individual written reports and give a class presentation on theory or theories. (213-6, 316-2, 316-4)
- Based on the information found in your research, prepare a chart that outlines the major ideas of each theory of evolution. (316-2, 316-4)

Resources/Notes

MHR *Biology,* pp. 727-730

Appendix A

Modes of Reproduction

Modes of Reproduction

	Types	Description	Representagtive Example
Asexual *One Parent cell divides by mitosis to produce 2 identical cells which are clones of the parent.*	Budding	An outgrowth on the parent organism develops into a new organism that separates from the parent.	Ultimately, yeast, and hydra
	Binary Fission	Through mitotic cell division copies of the parent are made the parent "splits" to create new cells.	Bacteria
	Spore Production	Through mitotic cell division copies of the parent are made the parent "splits" to create offspring.	Fungi eg. Rhizopus
	Fragmentation	Pieces of the parent organism break off and are dipersed. Each section is able to form a new organism.	House Plants grown from cuttings
	Parthenogenesis	Through mitotic cell division offspring are produced from unfertilized eggs.	Some insects eg. Balsam Wolly aphid

Sexual	*New offspring are created as a result of the fusion of egg and sperm nuclei. The offspring resemble but are not identical to the parents.*

Appendix B

Activities / Experiments

Karyotyping

Introduction

You are a genetic counsellor whose job is to discuss with expecting parents any genetic disorder that may affect their child. Currently, you are working with two couples. The two expectant mothers are over thirty-five and are concerned that their unborn children may have chromosomal abnormalities. You have been given a chromosome spread of each of the children. For each couple, you must construct and analyse a karyotype. In addition, you will be expected to give each couple a brief explanation of the test results, including the characteristics of any genetic disorder that may affect their unborn child.

Purpose

To connect and analyse several karyotypes.

Materials

Glue (1)
Ruler (1)
Scissors (1 pair)
Chromosome Spread Sheets (2)
Karyotype Templates #'s 1 and 2

Procedure

1. Obtain two different chromosome spread sheets from your teacher.
2. Cut out the chromosomes of one of the chromosome spread sheets.
3. Arrange the chromosomes into 22 pairs on the karyotype template. The chromosomes of each pair should be the same length (use a ruler!) and have the same centromere position. They should also have similar banding patterns. The two remaining chromosomes are the sex chromosomes. Since the X and Y chromosomes are nonhomologous, they will not have similar lengths, centromere positions, or banding patterns. (Refer to the normal human karyotype.)
4. Now, place the chromosomes in order, with the longest pair at position 1, the shortest at position 22, and the sex chromosomes at position 23.
5. Finally, glue each chromosome into position. Be sure to label your karyotype according to the chromosome spread you were given.
6. Use your constructed karyotype # 1 to answer the analysis question 1.
7. Repeat steps 1 to 5 for your second chromosome spread sheet.
8. Use your constructed karyotype #2 to answer the analysis question 2.

Analysis

1. Analyse karyotype #1 to determine whether a chromosomal abnormality exists.

    a) Will the child have a genetic disorder?
    b) Explain the reason for your answer.
    c) Using the student chart, determine which genetic complication will affect the child.

2. Analyse karyotype #2 to determine whether a chromosomal abnormality exists.

    a) Will the child have a genetic disorder?
    b) Explain the reason for your answer.
    c) Using the student chart, determine which genetic complication will affect the child.

Further Analysis

3. Describe two procedures used by genetic counsellors to obtain a DNA sample for karyotyping.

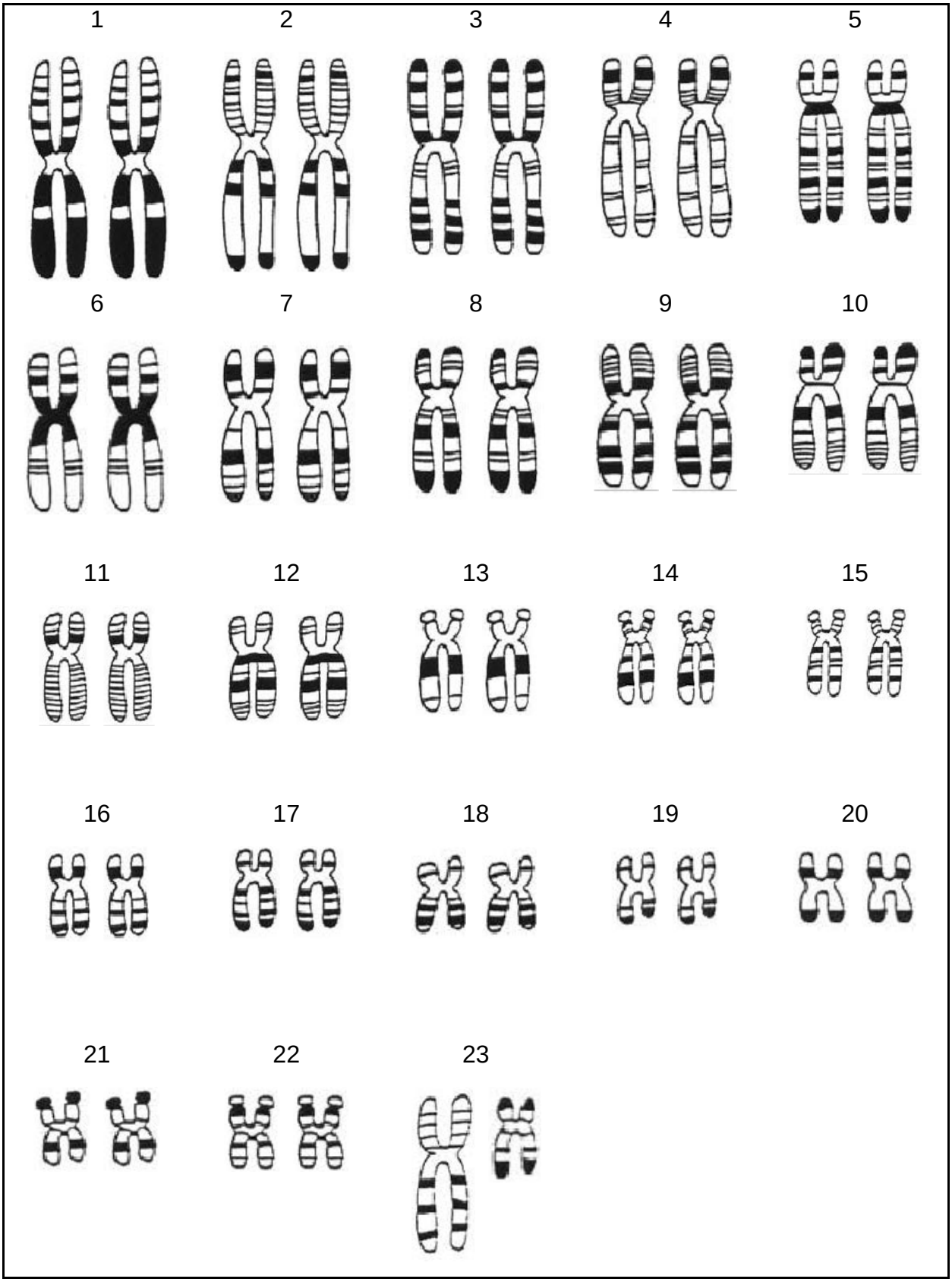
4. Describe two other techniques used to examine the developing fetus for abnormalities.

5. Write a letter to one of the expectant couples informing them of the results of the genetic tests. The letter must include the name of the genetic disorder that affects their child, and the characteristics of the disorder. Since you are a professional, be sure that you use clear language to communicate the test results.

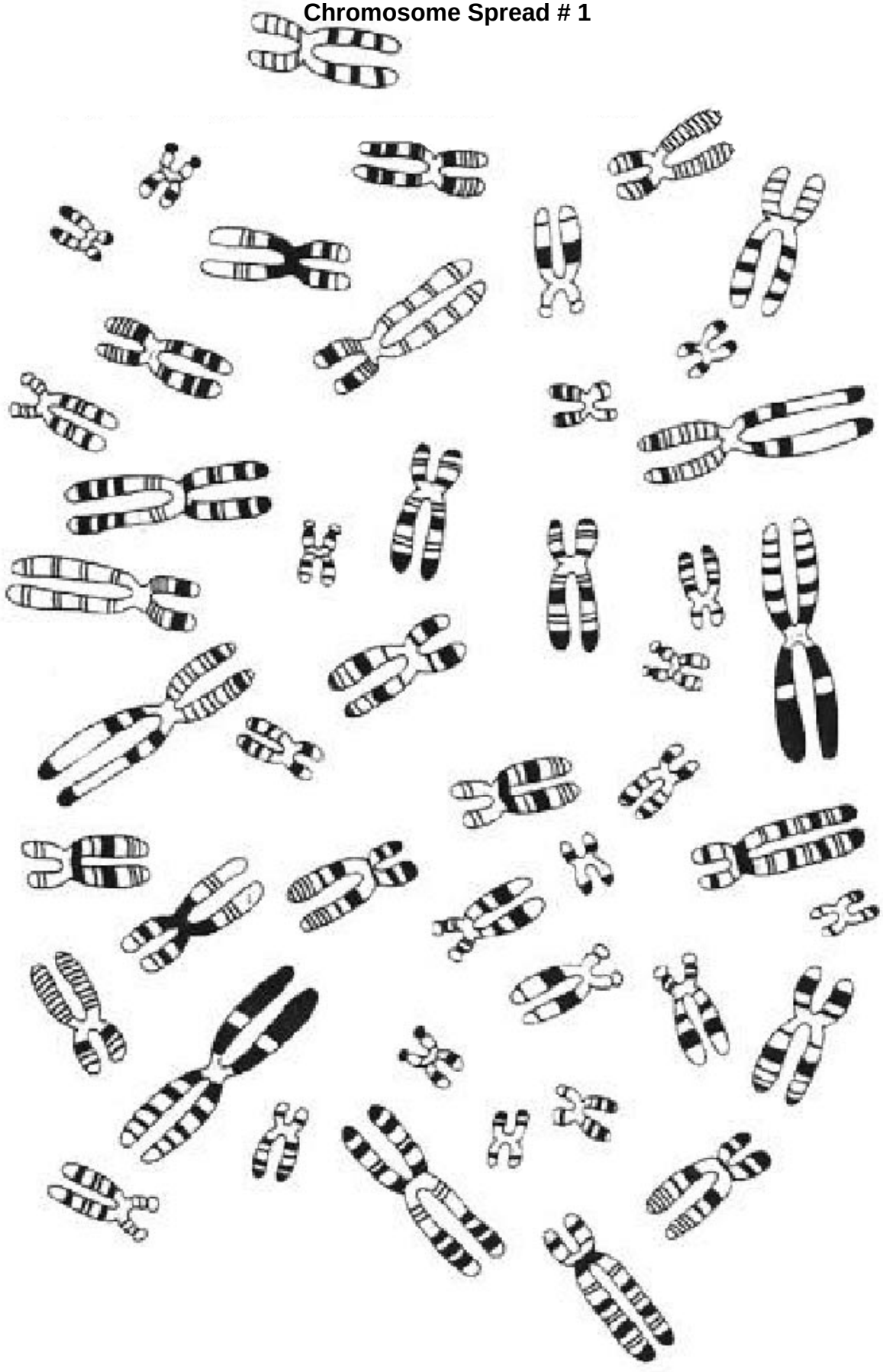
Genetic Disorders

Genetic Disorder	Chromosome Affected	Description of Disorder
Down Syndrome	# 21	47 chromosomes, mild to severe developmental disabilities, almond-shaped eyes, large tongue, prone to heart defects and respiratory problems
Turner Syndrome	Single X in Female (XO)	45 chromosomes, female lacking an X chromosome, normal in childhood, normal intelligence, fails to develop secondary sex characteristics and remains infertile
Klinefelter Syndrome	Extra X in Male (XXY)	47 chromosomes, male with an additional X chromosome, usually normal in appearance, normal intelligence, tall, underdeveloped testes, sterile, possible female characteristics (breast development, feminine body shape)
Jacobs Syndrome	Extra Y in Male (XYY)	47 chromosomes, male with an additional Y chromosome, low mental ability, normal in appearance
Triple X Syndrome	Extra X in Female (XXX)	47 chromosomes, female with an extra X chromosome, normal intelligence, normal in appearance, may be sterile

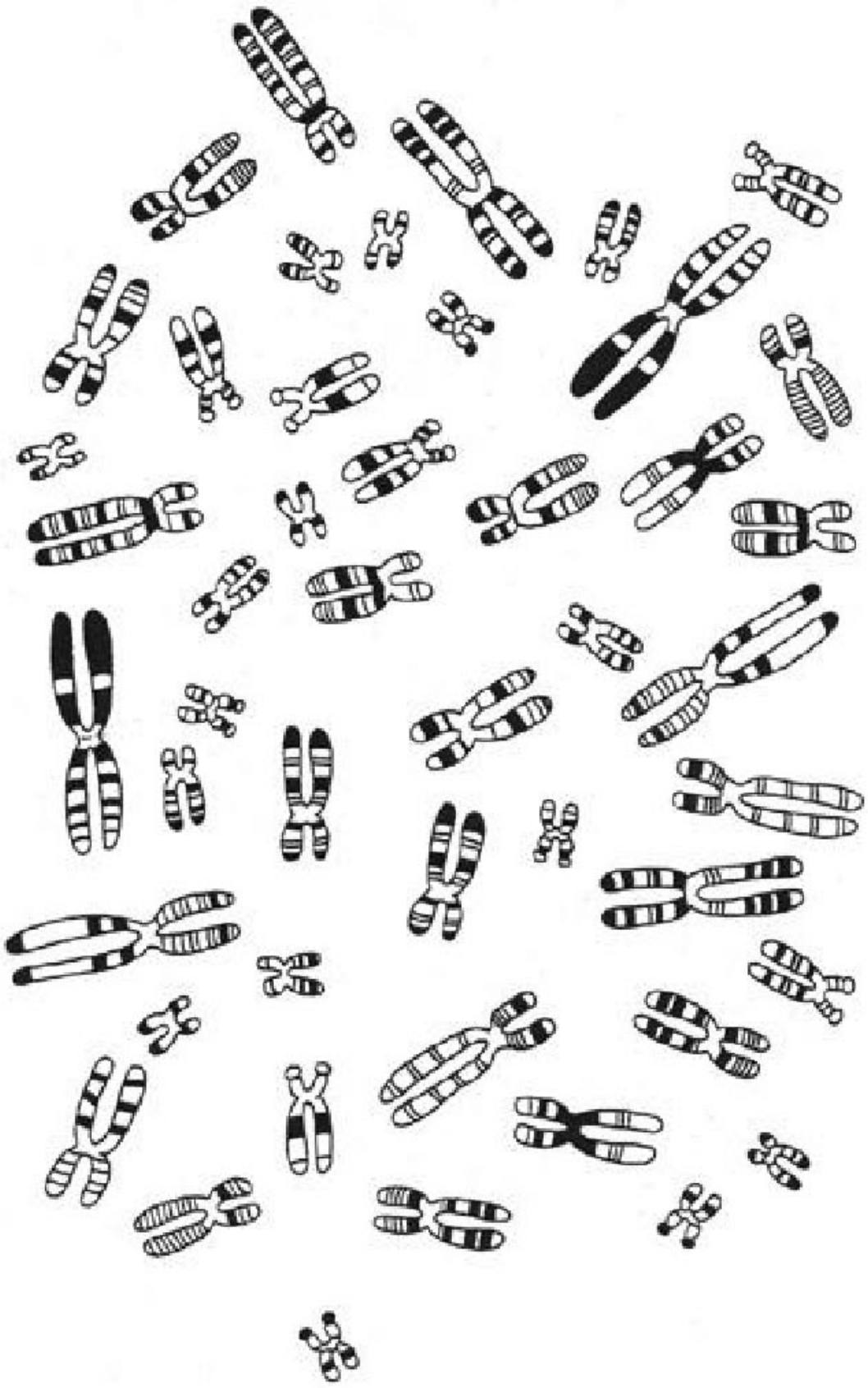
Normal Human Karyotype



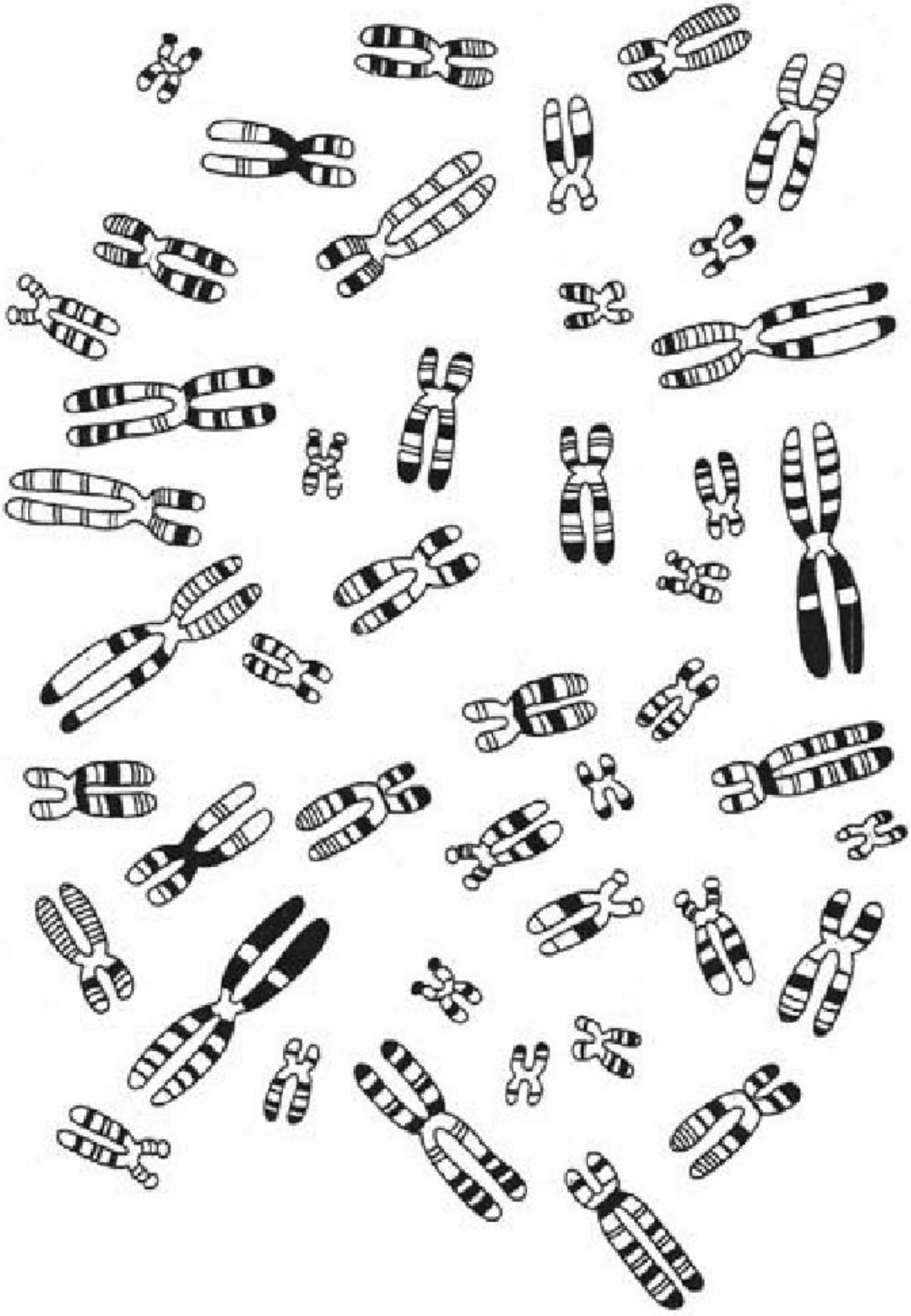
Chromosome Spread # 1



Chromosome Spread # 2



Chromosome Spread # 3



Karyotype # 1

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23		

Karyotype # 2

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23		

Karyotype Lab
(Answers)

1. a) Yes or no, according to whether or not the completed karyotype matches the normal human karyotype.

   b) Answers would probably include that there is an extra chromosome or a missing chromosome.

   c) This will depend on the chromosome spread given to the student.
   Chromosome spread # 1 - Klinefelter syndrome
   Chromosome spread # 2 - Down syndrome
   Chromosome spread # 3 - Turner syndrome

2. Refer to answer in question 1.

3. Two processes: 1. Amniocentesis → use needle to withdraw amniotic fluid

   2. Chorionic villus sampling → remove a small section of chorion (villi)

4. Fetoscopy → fibre optic camera

   Ultrasound → ultrasound imaging

5. Use, for example, trisomy 21 (Down syndrome) which is caused by non-disjunction of the 21st tetrad. The child will have a mild to moderate mental impairment, a large thick tongue causing speech defects, an underdeveloped skeleton, and greater susceptibility to infections. However, the individual will be quite functional in society, generally happy, and outgoing.

Biology 621 - Sense Organs
Vision, Hearing and Equilibrium

Vision Lab

Objective

To investigate aspects of human vision.

Materials

- Snellen eye chart
- paper cup
- ruler
- pencil
- scissors
- paper file card
- coin

Procedure

Part A : Visual Acuity

Have you ever heard someone say that he or she has 20/20 vision? This means that a person is able to read the letters on the "20" line of a Snellen eye chart from a distance of 20 feet. A person with 20/50 vision can only read the letters on the "50" line from 20 feet; this person has poor vision (i.e., reads at 20 feet what the average person can read at 50 feet) and would need corrective lenses to drive a vehicle. A person with 20/15 vision has better vision than a person with 20/20 vision. (20/20 is considered to be normal vision).

1. Stand 20 feet from the eye chart. Cover your right eye and have your partner use a pencil to indicate the letters to be read from each line, starting at the top.
   A) Indicate the visual acuity of your left eye by recording the line at which there was no uncertainty.
2. Repeat the procedure by covering your left eye.
   B) Indicate the visual acuity of your right eye.

Part B: Blind Spot

The blind spot is the place on the retina where the optic nerve enters the eye. There are no rods or cones in this area, so no vision occurs at the blind spot. Both right and left eyes have a blind spot.

3. Cover your left eye. Then hold the following page about 15 cm away and focus on the star in figure 1.

4. Continuing to look at the star, **slowly** move the page away from you. Keep your eye focussed on the star.

Figure 1

C) What happens to the dot to the right of the star as you move the page away?

D) Have your partner measure the distance from your eye to the paper at the point where this happens.

5. Repeat steps 3 and 4, but cover your right eye and stare at the dot with your left.

E) What happened to the star as you moved the page away? At about what distance?

Part C: Eye Dominance
Every person has a dominant eye. The dominant eye takes over when focussing on something. In most people, the right eye is dominant.

6. Make a circle with your right thumb and forefinger. With both eyes open, look at an object across the room through the circle. Have your arm extended fully. First, close your left eye and look at the object.

F) Does the object appear in the centre of the circle?

7. Next, close your right eye and look at the object.

G) Does the object appear in the centre of the circle?

The dominant eye will be the one for which the object remains in the centre of the circle.

H) Which is your dominant eye?

Part D: Field of Vision

Most of what you see with your right eye is also seen with the left eye. Visual fields overlap. Each eye sees the image from a slightly different angle. The image is created in each retina and stored on the opposing cerebral hemispheres. Information is related between the two hemispheres and the two images are superimposed on each other, creating a three-dimensional image. By working together, the eyes provide slightly different angles of view that permit the brain to estimate distance.

8. Place a plastic or paper cup on a table and stand about 3 m away. Cover one eye. Ask your lab partner to hold a coin at arm's length, not quite above the cup.
   I) Describe what you see.

Observing only the cup, direct your lab partner's hand until it is above the cup. Check your accuracy by asking your partner to drop the coin into the cup. Repeat the procedure for five trials. Then, close the opposite eye and record your results for another five separate trials. (✓= coin landed in cup, ✗ = coin did not land in cup)

Trial	Left eye open	Right eye open
1		
2		
3		
4		
5		

9. Hold at arm's length a card with a hole punched in it. In your other hand, hold a pencil at arm's length. Close one of your eyes and attempt to bring the point of the pencil into the hole in the card. Move the pencil and the paper. Repeat the procedure for five trials with each eye. Record your results. (✓= able to put pencil in paper hole, ✗ = not able to put pencil in paper hole)

Trial	Left eye open	Right eye open
1		
2		
3		
4		
5		

Part E: Visual Near Point

The shortest distance from your eye that an object is in sharp focus is called the ***near point***. The shorter the distance the more elastic the lens and the greater the ability of the eye to accommodate changes in distance. Accommodation decreases with age and results in a condition in seniors called presbyopia.

10. Close one eye and hold this page at arm's length. Focus on one word and slowly move the page toward your face until the word becomes blurred. Then move the page away until the image is sharp. At that point, have your partner measure the distance between your eye and the page.

    Repeat, using the other eye.

    J) How does your near point compare to the near point averages in the following table?

Age	10	20	30	40	50	60
Near Point (cm)	7.5	8.8	11.3	17.0	51.8	82.5

Laboratory Application Questions

1. List three occupations for which good visual acuity would be necessary.

2. In question #6 of the lab, you discovered that the object moved when you viewed it with a different eye. Offer an explanation for your observation.

3. Horses and cows have eyes on the sides of their heads; their visual fields overlap very little. What advantage would this kind of vision have over human vision?

4. Based on your data collection and observations from the lab, would it be safe to drive a vehicle with an injured eye? What might happen?

5. How does presbyopia relate to the use of bifocal lenses ?

Hearing & Equilibrium Lab

Objective

To investigate environmental factors that affect both hearing and equilibrium.

Materials

- tuning fork
- rubber hammer
- metre-stick
- swivel chair

Procedure

Part I: Hearing

1. Strike a tuning fork with a rubber hammer and listen to the sound. Place the stem of the tuning fork on your forehead. Place the palm of your free hand over your right ear.

A) From which direction does the sound appear to be coming?

B) Describe any changes in the intensity of the sound.

2. Repeat the procedure, but this time place your free hand over your left ear.

C) From which direction does the sound appear to be coming?

3. Repeat the procedure a third time, but ask your partner to cover both of your ears.

D) Describe any changes in the intensity of the sound.

4. Strike the tuning fork with a rubber hammer and hold the tuning fork approximately 1 m from your ear.

5. Ask your lab partner to place a metre-stick on the bony part immediately behind your ear. Then ask him or her to strike the tuning fork and place the stem of the tuning fork on the metre-stick.

E) Describe any changes in the intensity of the sound compared to that in step 4.

Part II: Equilibrium

6.Ask your lab partner to sit in a swivel chair. Have him or her elevate the legs and begin slowly rotating the chair in a clockwise direction. After 20 rotations, have the subject stand. (Be prepared to support your partner!)

F) In which direction did the subject lean?

7. After a 3-min recovery period, repeat the process, but this time rotate the swivel chair in a counterclockwise direction.

G) In which direction did the subject lean?

8. Ask your lab partner to tilt his or her head to the right, and begin a clockwise rotation of the swivel chair. After 20 rotations, ask the subject to hold his or her head erect and to stand up. (**Be prepared to catch your lab partner** — most people attempt to sit very quickly after they stand.)

H) Ask the subject to describe the sensation

Laboratory Applications Questions

1. Provide explanations for the data collected in response to questions 1 - 3.

2. Using the data collected from the lab, provide evidence to show that sound intensity is greater in fluids than in air.

3. Using the data collected from the lab, provide evidence to support that the fluid in the semicircular canals continues to move even after rotational stimuli have stopped.

4. What causes the falling sensation produced in activity 8?

5. Describe the manner in which the semicircular canals are able to detect changes in motion during a roller-coaster ride.

Human Inheritance

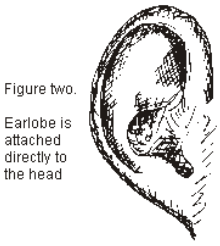
Human Inheritance Lab

Some genetic traits are controlled by only a single pair of genes. If the trait is dominant, it will be expressed when the individual has one or two of the dominant genes. If the trait is recessive, the trait is only expressed when the individual has both of the recessive genes.

Procedure

Survey each member of the class to find out which of the following traits each has. Record data on the chart provided.

Tongue rolling	Dominant - RR or Rr - ability to roll up sides of tongue
	Recessive - rr - not being able to roll up sides of tongue
Teeth position	Dominant - SS or Ss - space between front teeth
	Recessive - ss - no space between front teeth
Hair on fingers	Dominant - MM or Mm - hair on middle section of one or several fingers
	Recessive - mm - no hair on middle part of fingers
Chin shape	Dominant - CC or Cc - cleft in chin
	Recessive - cc - no cleft in chin, smooth chin
Ear lobe shape	Dominant - FF or Ff - having free ear lobes
	Recessive - ff - having attached ear lobes
Handedness	Dominant - HH or Hh - being right-handed
	Recessive - hh - being left-handed
Hair colour	Dominant BB or Bb - having dark hair (brown or black)
	Recessive bb - having light hair (blond or red)
Dimples	Dominant - DD or Dd - having dimples
	Recessive - dd - not having dimples
Straight or curly hair	Dominant - WW or Ww - curly or wavy hair
	Recessive - ww - straight hair
Hairline	Dominant - PP or Pp - having a "widow's peak"
	Recessive - pp - having a straight hairline
Finger length	Dominant - GG or Gg - fourth finger longer than second (count thumb as first finger)
	Recessive - gg - fourth finger shorter than second
'Hitchhiker's thumb"	Dominant - TT or Tt - can bend thumb back extensively
	Recessive - tt - cannot bend thumb back



Questions

1. Find the total number of class members in each category. Totals can be recorded in your data table.
2. The ability to roll the tongue is inherited as a dominant trait. Does your class data support this? Is the ratio of tongue rollers to non-tongue rollers close to 3:1? Why a 3:1 ratio?
3. In the class, how many of the twelve traits are more often dominant than recessive? Can you think of a reason or reasons for this?
4. One half of the genes for a trait come from your mother and the other half from your father. Supposing you have dark-haired parents, but you have light hair. What would this tell you about their genotype for hair colour? What type of gene for hair colour will you pass on to any children you may eventually have?

Data Table

Trait	Your Phenotype	# of Each Phenotype in Class		Ratio of Dominant to Recessive
		Dominant	Recessive	
Tongue rolling				
Teeth position				
Hair on fingers				
Chin shape				
Ear lobe shape				
Handedness				
Hair colour				
Dimples				
Straight or curly hair				
Hairline				
Finger length				
“Hitchhiker's thumb"				

Appendix C

STSE

Science-Technology-Society and the Environment

Drugs and Homeostasis

Outcomes

1. Explain how the nervous system helps maintain homeostasis. (317-1)
2. Describe disorders linked to the nervous system and their effects on the homeostasis of the system and the organism as a whole. (317-4)
3. Analyse how and why technologies related to the treatment of nervous system disorders were developed and improved over time. (115-5)
4. Describe how the use of prescription and nonprescription drugs can have a role in maintaining or disrupting homeostasis. (317-7)
5. Distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot. (118-8)
   - Debate the merits of using drugs for treatment of nervous disorders vs. the long-term side effects.
6. Propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability. (118-10)
   - Debate the legalization of certain drugs, such as marijuana for medicinal purposes.

Introduction

Drugs have been considered invaluable to society as instruments in the treatment of disease. Insulin is a hormone used to control diabetes. Chemotherapy uses drugs to destroy cancer cells. The use of painkillers, such as Tylenol, and antibiotics is prevalent in society. Prozac is a well-known drug used in the treatment of depression. But drugs have also been considered a danger in society because of their potential for inappropriate use and their addictive nature. Many high profile actors have admitted to drug and alcohol abuse (e.g., Ben Affleck, Winona Rider, Robert Downey Jr.) and have sought rehabilitation for their addictions. This module will examine the medical use of drugs in the treatment of disease, as well as their abuse in society. It will also examine the long-term affects of drugs on the health of the human body.

Neurotransmitters and the Nervous Response

Many drugs affect neurotransmitters. Neurotransmitters are chemicals secreted by neurons which stimulate motor neurons or neurons of the central nervous system. If you recall, a wave of depolarization is carried across a presynaptic neuron until it reaches the bulblike end of the axon. The end of the axon contains the neurotransmitter in its vesicles. Depolarization causes the calcium gates to open and trigger the release of the neurotransmitter through exocytosis. The neurotransmitter diffuses between the synapse of the terminal end of the axon of the presynaptic neuron and the dendrites of the postsynaptic neuron. The dendrites of the postsynaptic neuron have specialized receptor sites to which the neurotransmitter will attach. The neurotransmitter will then either excite or inhibit the neuron. Once a neurotransmitter has attached to the receptor site of the postsynaptic neuron, an enzyme is released from the presynaptic neuron to break down the neurotransmitter.

Some neurotransmitters are excitory, including acetylcholine, norepinephrine (noradrenaline), serotonin, and dopamine. Other neurotransmitters are associated with relaxation, including dopamine and serotonin. Many neurotransmitters can have multiple functions.

The drugs abused in society are typically stimulants or depressants thought to block or enhance certain neurotransmitters. Diseases of the nervous system are often associated with either the improper functioning of a neurotransmitter or with improper functioning of the enzyme used to break them down once they have been released and attached to the receptor site of the postsynaptic neuron. Drugs can be developed to treat these disorders by mimicing the effects on the neurotransmitter or enzyme.

Drugs in the Treatment of Disease

As just outlined, imbalances in neurotransmitters can contribute to certain diseases. Several well known examples are Parkinson's disease and Huntington's disease. Parkinson's disease is believed to be caused by a dopamine deficiency due to the gradual death of the neurons that produce dopamine. A dopamine deficiency can result in tremors and rigidity in the limbs because messages cannot be sent between the areas of the brain controlling body movement.

Huntington's disease is believed to be caused by a malfunctioning of an inhibitory neurotransmitter. Huntington's is a genetic disorder characterized by jerky movements and loss of mental and emotional abilities due to the destruction of neurons in certain areas of the brain.

Potential treatment in both of these cases is aimed at replacing the damaged neurons through the experimental use of stem cell transplants. At present, other treatments involve targeting the defective neurotransmitters (e.g., increasing dopamine levels in Parkinson's patients).

More and more research has shown that mental illness is also a result of imbalances of neurotransmitters. Mental illnesses were once considered to have no biological basis but rather to be due to factors in an individual's environment, such as stress or mental and/or physical abuse. At one time, sufferers of mental illness were deemed to be "weak-minded" and lacking the skills to cope with life.

As science has progressed, genetic connections have been made with individuals in the same family suffering from mental illness. This led to the exploration of a biological basis for mental disorders and resulted in a greater understanding by society regarding the causes of mental illness. Mental illness is now discussed more openly in society and is appreciated as a medical condition.

Debate still continues regarding the issue of nature versus nurture in the onset of mental illness, but all must agree that the biological basis of mental disorders exists. The effective treatment of mental disorders with drugs also adds support to the argument that there is a biological basis for these disorders. This next section will explore the biological basis of certain mental illnesses and the use of drugs in their treatment.

Clinical Depression

Clinical depression is the most frequently encountered mental illness. Clinical depression is now considered a physical condition in which there is a fault in the brain chemistry, and it may afflict up to 5% of the population. Symptoms of depression include a distinct change in mood accompanied by an extreme feeling of hopelessness. Other symptoms include loss of appetite, weight loss, headaches, sleeplessness, loss of energy, tiredness, and anxiety. Suicide is common in about 15% of depressed patients.

Serotonin, dopamine, and noradrenaline are neurotransmitters linked to clinical depression. Those suffering from depression either secrete too little of a particular neurotransmitter or too much of the neurotransmitter which is broken down by enzymes (monoamine oxidases) when it is reabsorbed into nerve endings.

Three major classes of drugs are used in the treatment of depression. They are monoamine oxidase inhibitors (MAOIs) , selective serotonin re-uptake inhibitors (SSRIs), and tricyclic compounds. Drug treatment is difficult because some drugs may have no effect and the patient may spend a period of time searching for the proper drug and dosage to help alleviate the depression. It also takes several weeks for the drugs to take effect. In this time

period, the patient could go into remission or the condition may worsen. The result can be unrelated to the drug. These factors may make the treatment with drugs difficult and the process of finding a successful drug very lengthy. It is unknown why drugs take such a long time to have an effect, or why some drug treatments are successful and others are not. More research into the causes of depression is needed in order to develop more successful treatments.

Tricyclic inhibitors appear to slow the re-uptake of serotonin and noradrenaline.

MAOIs are believed to inhibit monoamine oxidase (MAO). MAO is an enzyme that is believed to break down serotonin and noradrenaline. It has been shown that enhancement of these neurotransmitter systems leads to the elevation of mood. A danger of MAOIs and tricyclic compounds is the increased risk of heart failure. MAO inhibitors can not be taken with certain foods, such as cheese, avocado, and wine, because this interaction will raise blood pressure and can cause heart failure and death. For these reasons, doctors will often avoid prescribing MAOIs. These drugs can also be lethal at relatively low dosages, which is a concern in the case of suicidal patients.

Serotonin re-uptake inhibitors are the most widely prescribed antidepressants. They appear to have fewer dangerous side effects. A well known example is Prozac. It functions by blocking serotonin uptake and therefore increases the levels of serotonin at the synapse. Side effects may include nausea, headache, insomnia, and anxiety.

Bipolar Disorder

Bipolar disorder is also known as manic depression. It affects about 5 in 1000 people. It is characterized by severe mood swings ranging from mania to depression, with normal periods in between. During a manic phase, individuals may think that they are invincible, behave recklessly, or believe in delusions (e.g., fame). During the depressive phase, the individual loses interest in his/her usual activities, may sleep excessively, or may suffer from insomnia. They may also be at risk of suicide during the depressive stage.

At one time, sufferers from manic depression were unable to function normally. Fortunately, manic depression can now be treated with both medication and psychotherapy. The most common medication is lithium carbonate. It functions by maintaining the chemical balances in the brain to prevent mood swings. Lithium appears to work in the treatment of both mania and depression. This is believed to be because the depressive phase is a result of the preceding manic phase. If the manic phase can be controlled, then the depressive phase can be controlled indirectly. Other drugs may also be used to treat the symptoms of depression.

Unfortunately, the long term use of lithium can affect the kidneys and thyroid gland since lithium interferes with water and salt balance. There must be regular checkups to ensure that the lithium levels do not rise to a toxic level. Other side effects of lithium treatment may include diarrhea, nausea, hand tremor, blurred vision, confusion, and swelling in the legs and feet. The side effects of lithium make some manic depressives reluctant to continue use of this drug. Researchers and drug companies are working to find better medications with fewer side effects. In the meantime, patients are left with the dilemma of taking a medication that provides the benefit of treating their mental disorder while having grave concerns about some of its very serious side effects.

The causes of manic depression are still unclear. There appears to be a genetic link, and episodes can also be triggered by stress. Chemical changes are also being studied. Manic behaviour is believed to be due to a high level of noradrenergic activity. This activity continues until the neurotransmitter systems are depleted. It is believed that lithium may prevent mania by preventing noradrenaline depletion.

Schizophrenia

A greater understanding in society of schizophrenia as a mental illness was created by the award winning movie *A Beautiful Mind*. The movie focusses on the life of John Forbes Nash Jr. and his struggle to cope with his mental illness. Nash was a mathematical

genius who later received a Nobel Prize in Economics. Actor Russell Crowe plays Nash and portrays the symptoms of the disorder, as well as Nash's struggle. The primary symptoms of schizophrenia include disturbance of thought patterns, disturbance of affective reactions, and autism or withdrawal. Secondary symptoms include hallucinations, delusions, and paranoia. These symptoms all represent a loss of contact with reality. This disorder appears at a rate of 1% to 2% of the population.

There is a biological predisposition to the development of schizophrenia. A form of dopamine dysfunction (e.g., excessive dopamine activity) is believed to cause the disease. Schizophrenic patients seem to have an excess number of dopamine receptors.

Chlorpromazine and related drugs have been used in the treatment of schizophrenia and function by blocking the dopamine receptors. Unfortunately, there are side effects similar to Parkinson's disease, and others that include abnormal body and facial movements and extreme pacing. If these occur, either the dosage is adjusted or a new medication is prescribed. Other side effects may include dry mouth, constipation, blurred vision, and/or low blood pressure. Unfortunately, patients with schizophrenia are faced with a similar dilemma as those with bipolar disorder. They must rely on a drug to treat their disorder and enable normal functioning, but many of these drugs have unpleasant side effects.

Commonly Abused Drugs

Alcohol

Alcohol is probably the most commonly abused drug in society, and of all abused drugs, is presently the only one that is legal for those who are of age. It has been a feature of our culture for many years, and is often associated with social functions and celebrations. However, alcohol use definitely has its dark side. It is known to alter personalities and cause people to behave in a manner contrary to their normal personalities. A night of abusing alcohol can lead to embarrassment and regret once the effects have worn off. Poor judgment while drinking alcohol can lead to deadly decisions, such as drunk driving. Also, people have abused alcohol, vomit in their sleep, and choked to death. Groups such as MADD (Mothers Against Drunk Driving) are advocating for the responsible use of alcohol.

Alcohol is usually considered to be a depressant, but can act as a stimulant in small doses. Alcohol affects the nervous system by increasing the inhibitory neurotransmitter GABA (gamma-aminobutryic acid). It also modifies the effects of another excitory neurotransmitter called glutamate. A blood alcohol content of 0.10 can induce blurred vision, slurred speech, poor muscle co-ordination, and impaired judgment. A blood alcohol content of 0.40 to 0.50 g/100 ml will induce coma, and a level of 0.60 will result in death. If a Newfoundland and Labrador driver is found to have a blood alcohol concentrate (BAC) of 0.05 g/100 ml, he/she receives a fine and a 24-hour suspension of driver's licence. If the driver is found to have a BAC of 0.08 g/100 ml or greater, criminal charges will be laid. Alcohol abuse can lead to short-term memory loss and blackouts. It can irritate the gastrointestinal tract and increase hydrochloric acid production. Its long-term use can also cause disorders such as cirrhosis of the liver and heart disease.

Alcoholism is considered to be a genetic and environmental disease that can lead to death. It is associated with addictive personalities and may be a secondary result of depression. Severe alcoholics often appear jaundiced due to cirrhosis of the liver. Their immune systems are impaired and they are more prone to disease. There are organizations such as Alcoholics Anonymous that enable sufferers of alcoholism and their families to cope with this disease.

Marijuana

A Canadian Senate committee has proposal the legalization of marijuana for non-medical use, arguing that it is less harmful than alcohol. They believe

that marijuana should be governed by the same laws as alcohol, and that legalization would allow for regulation and taxation of the drug. Many argue that prohibition of drugs such as marijuana supports organized crime, and that legalization would save money in law enforcement. Legalized, it could potentially be sold in corner stores. Opponents of legalization raise concerns about addiction, health, and the fear that marijuana may be the "gateway" to abuse of more dangerous drugs. It is believed that if marijuana is legalized, more teens will abuse the drug because access would be easier. To date, the Supreme Court of Canada has drafted legislation that would decriminalize marijuana usage. Individuals possessing a small amount of the drug would be fined, much as they mightreceive a speeding ticket. It is quite possible that within the lifetime of this module marijuana will be decriminalized.

Marijuana is derived from the Indian hemp plant *Cannabis sativa.* The active compound in marijuana, tetrahydrocannabinol (THC), works by binding to CB1 receptors found on presynaptic membranes in the brain. These receptors function by blunting pain. THC also causes the release of the neurotransmitter dopamine which elevates mood and controls muscle movements. These biochemical pathways can explain how the drug affects its users and how it may also be used for medicinal purposes.

In low concentrations, THC causes euphoria, can enable the user to block out pain, frustration, or confusion. But, there are also some serious health concerns related to the use of marijuana. In high concentrations it can cause hallucinations, anxiety, depression, and psychotic symptoms. Smoking marijuana can cause lung cancer, sinusitis, and bronchitis. It increases the level of carbon monoxide in the blood which, in turn, reduces the amount of oxygen reaching the heart. Repeated use tends to lead to the inability to deal with everyday challenges. Long-term use can result in impaired speech, memory loss, difficulty in understanding complex ideas, insomnia, impaired visual perception, and infertility. Marijuana use has also been linked to reduction of immunity to disease.

Marijuana has been demonstrated to have some positive effects in the treatment of disease. It has been used to treat nausea in chemotherapy patients and to stimulate appetite in AIDS patients. It may also offer relief from pain and reduce spasticity due to multiple sclerosis. It has been shown to help sufferers of severe arthritis. It can be used as an anti-epileptic and anti-depressant. It is believed to be far less addictive than many prescribed painkillers. Furthermore, it is believed that marijuana could be manufactured in various forms so that it does not have to be smoked and harm the lungs.

Regulations are now in place that permit sufferers from terminal illnesses and chronic conditions to grow and smoke their own marijuana. They may also designate someone to grow it for them. At present, the Canadian Medical Society opposes marijuana use for medicinal purposes because of the lack of clinical research. Debate continues within the medical community about prescribing the use of marijuana. The legal system, however, supports the use of marijuana for medicinal purposes since denying an individual treatment that may alleviate a medical problem would be infringing on his/her human rights.

Cocaine

Cocaine is derived from the plant *Erthoxylon coca* and can be inhaled, smoked, or injected. It results in a feeling of euphoria followed by depression. Cocaine acts by first stimulating the release of norepinephrine and dopamine and, in higher doses, the release of serotonin. Cocaine then interferes with the re-uptake of these neurotransmitters and these neurotransmitters build up in the synapse. Prolonged use will cause the body to produce less

dopamine and the user will need more cocaine. Side effects include mental impairment, convulsions, hallucinations, stroke, heart attack, and death.

Heroin

Heroin is a highly addictive derivative of morphine and comes from the opium poppy, *Papaver somniferum*. Heroin is normally injected but can also be snorted or smoked. It operates by binding to opioid receptors in the brain where natural chemical endorphins are involved in the relief of pain. Heroin mimics the action of endorphins. After initial exposure, users experience a surge of euphoria (rush) followed by a drowsy, trance-like slate. Prolonged use can cause less endorphin production. Side effects include depressed respiration, impaired co-ordination, and decreased tolerance to pain. Long-term effects can include collapsed veins, infection of heart valves, and liver disease. Death can result from overdose.

Rohypnol

Rohypnol, from the benzodiazepine family, is a drug associated with underground college and high school parties called raves. It is considered to be a "date rape" drug and has become infamous for its use in sexual assault. It is often dissolved in a beverage given to unsuspecting victims. It is similar to Valium but has ten times its strength. In combination with alcohol, it can be deadly. Rohypnol is highly addictive and induces severe withdrawal symptoms. Its use can cause deep sedation, respiratory distress, blackouts for up 24 hours, and amnesia.

Ecstasy

Ecstasy, or methylenedioxymethamphetamine (MDMA), has street names such as X, Rolls, E, Adam, beans and buddies. It is one of the designer drugs associated with rave parties. When ecstasy first became popular, it was believed to be a "safe" drug with no side effects. It was soon discovered, like many drugs, to have deadly consequences if abused.

The initial use of ecstasy results in increased heart rate, increased blood pressure, dilation of pupils and bronchi, brain stimulation, increased motor activity, tightening of jaw muscles, grinding of jaws, overheating, sweating, heat stroke, and dehydration. Complications can result in renal failure, depression, liver failure, cardiovascular collapse, and respiratory failure, to name a few. The long-term use of ecstasy can result in irreparable brain damage. Its use is known to damage the brain cells that produce serotonin. In fact, nerve fibres in the brain that were destroyed by long-term use of ecstasy have grown back abnormally or not at all.

OxyContin

OxyContin is a trade name for the drug oxycodone hydrochloride. It was developed in 1996 as a slow release pain reliever for people who suffer from severe or chronic pain. Chemically similar to codeine, methadone, and morphine, this semisynthetic opiate works by acting as a central nervous system depressant, causing a range of effects from analgesia to respiratory depression.

At the street level, OxyContin is often referred to as Oxy's, OCs or hillbilly heroin. Most abusers of this drug avoid the slow release properties by chewing, snorting, or injecting the medication to get an instant and intense "high." Since its introduction, OxyContin abuse has caused a dramatic rise in the incidence of overdose, emergency room treatment, and death.

The short term effects of this drug are constipation, nausea, vomiting, lack of interest, dizziness, sweating and weakness. The long-term effect is primarily addiction. OxyContin abuse is no different from heroin, cocaine, or alcohol abuse. Addicts change their lifestyles to allow more and more drug use.

Designer Drugs

Designer drugs are often associated with raves. They are called designer drugs because they are created by altering the molecular structure of existing drugs to enhance their effects. They are prepared by underground chemists known as "cookers." Cookers are untrained and unlicensed chemists that work in poorly constructed laboratories. Of course, these conditions offer little quality control and makes abuse of these drugs even more dangerous.

Designer drugs are derived from three different types of drugs - PCP, fentanyl, and amphetamine/methamphetamine. The street drugs created from these drugs are known as XTC, ecstasy, Adam, Eve, lover's speed, GHB, Special K, fantasy and nature's quaalude. Fentanyl derivatives are known to be up to 1000 times more potent than heroin. In general, designer drugs can create a wide range of physical problems such as hypertension, uncontrolled tremors, total paralysis, seizures, permanent brain damage, and death.

Prescription Drugs

In recent years, concern has arisen over the abuse of prescription drugs. Some prescription drugs are easily addictive and patients can experience difficulty with withdrawal, along with dangerous side effects. Some adolescents are becoming abusers of prescription drugs because of the euphoria that can be produced. Related crimes (e.g., breaking and entering pharmacies for the purpose of stealing prescription drugs) are on the rise. The three prescription drugs that are most commonly abused are Opioids, CNS depressants, and stimulants.

Opioids

Opioids are typically used to treat pain. These medications fall into a class of narcotics and include Oxycontin, morphine, codeine and Demerol. Opioids function by attaching to specific proteins called opioid receptors. These receptors are found in the brain, spinal cord, and gastrointestinal tract. When opioids attach to the opioid receptors they are able to block the transmission of pain messages to the brain. Opioids can produce a feeling of euphoria by affecting regions of the brain that enable us to perceive pleasure. However, they can also result in physical dependence and addiction. Tolerance of opioids can result in the need to take higher doses to achieve the same effect. Withdrawal will cause restlessness, muscle and bone pain, insomnia, diarrhea, vomiting, cold flashes, goose bumps, and involuntary leg movements. A large dose can lead to respiratory depression resulting in death.

CNS Depressants

CNS depressants are often used to treat anxiety and sleep disorders by slowing normal brain function. Common CNS depressants include barbiturates and Valium. Most CNS depressants act on the brain by affecting the neurotransmitter gamma-aminobutryic acid (GABA). The function of GABA in the human body is to decrease brain activity. Therefore, increased doses will create the drowsy effect required to treat anxiety and sleep disorders. Individuals can build a tolerance to CNS depressants over time and require larger doses. Withdrawal effects can be opposite to those of the drug. The mind can race out of control, possibly resulting in seizures and other problems.

Stimulants

Stimulants are used to treat narcolepsy, obesity, depression, and attention-deficit hyperactivity disorder (ADHD). These drugs enhance brain activity and result in increased alertness, energy, elevated blood pressure, increased heart rate and respiration. Examples of stimulants include Ritalin and Dexandrine. The chemical structure of stimulants is similar to the chemical structure of the neurotransmitters norepinephrine and dopamine. Stimulants work by increasing the amount of these neurotransmitters to the brain. An increase in dopamine results in an increase in blood pressure, heart rate and blood glucose; constriction of blood vessels; and opening of the pathways of the respiratory system. Stimulants do not result in physical dependence or withdrawal. However, they can be used compulsively, and repeated high doses can lead to feelings of hostility and paranoia. High doses can cause body

temperatures to rise to a dangerously high level, or they can create an irregular heartbeat, leading to the risk of cardiovascular failure. There is also the potential of lethal seizures.

Conclusion

Drugs can play a role in both maintaining and disrupting homeostasis. When problems in the neurotransmitter balance occur, such as in the case of mental illness, drugs can play a role in restoring the balance. However, further study into the effects of different neurotransmitters is essential to achieving a better understanding of diseases caused by neurotransmitter imbalance. This can lead to better drug treatments that have less-serious side effects. Drug abuse can also disrupt homeostasis. Understanding the effects of drug abuse on neural pathways and overall health can aid individuals considering drug abuse. It can also aid in the treatment of those suffering from addiction. Understanding the effects of drug abuse on long-term health may make one think twice about engaging in the legal and illegal use of drugs.

Questions

Understanding Concepts

1. For each mental illness discussed (clinical depression, bipolar disorder, and schizophrenia), list the neurotransmitters involved, the nature of the imbalance of the neurotransmitters, the drugs used in their treatment, and side effects of each of these drugs. This may be done in the form of a chart.

2. For each of alcohol, marijuana, cocaine, heroin, Rohypnol, ecstasy and OxyContin list the effects on neural pathways, the short-term effects of the drug, and the long-term effects of the drug.

3. What are the dangers of using designer drugs?

4. For each of opioids, CNS depressants, and stimulants list the effects on neural pathways, the short-term effects of the drug, and the long-term effects of the drug.

Extensions

1. Debate the pros and cons of the use of marijuana in the treatment of chronic pain.

2. Debate the merits of using drugs for treatment of nervous diseases (e.g., mental illness) despite the side effects of these drugs.

3. Debate the merits of legalizing marijuana. Research the present legislation regarding the use of marijuana.

4. Using the knowledge that you have gained about the causes of mental illness, respond to the following statement: Mental illness is a figment of one's imagination and one can choose whether or not to control one's thoughts.

5. Choose a drug of interest to research. Report your findings in the form of a magazine article.

6. Write a letter to an imaginary friend who you know is abusing drugs. In this letter, use what you know about the dangers of drug use to persuade him/her to quit and seek help.

References

Bullard, Chetty et al. (2003). *Biology*. McGraw-Hill Ryerson. Toronto

Brown, DeNeen L. (2002). Canadian Panel Back Legalizing Marijuana. WP Foreign Press. Available at: http://www.cannibisnews.com/news/thread14010.shtml

Common Drugs and Their Symptoms. Available at: www.cornerdrugstore.org/CommonDrugsPage.htm

Drug Abuse: Chemical Changes in the Brain. Available at: www.epub.org.br/cm/n08/doencas/drugs/abuse06_i.htm

Drugs and the Nervous System. Available at: http://learn.dccc.edu/~saquilan/ppt/nervous/sld056.html

Drugs and the Nervous System. Available at: http://users,rcn.com/jkimball.ma.ultranet/BiologyPages/D/Drugs.html

Facts about Manic Depression. Missouri Council for Comprehensive Psychiatric Services. Available at: www.parquad.org/mdfacts.htm

NIDA- Research Report Series – Marijuana Abuse. Available at: wysiwyg://86http://www.nida.nih.gov/ResearchReports/Marijuana/Marijuana3.html

OxyContin Diversion and Abuse. National Drug Intelligence Center. January 2002.

OxyContin: Pharmaceutical Diversion. DEA Drug Intelligence Brief. March 2002.

Research Report Series – Prescription Drugs: Abuse and Addiction. Available at: wysiwyg://143/http://www.nida.nih.gov/Re...hReports/Prescription/prescription2.html

Substance Abuse and Mental Health Services Administration's (SAMHSA), Drug Abuse Warming Network (DAWN).

SANE. Available at: www.sane.org.uk/About_Mental_Illness/

The Nervous System. Available at: www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBoookNERV.html

Timmons and Hamilton. Drugs,Brain and Behavior – Ch. 6. Available at: www.rci.rutgers.edu/~lwh/drugs/chap06.htm

Timmons and Hamilton. Drugs,Brain and Behavior – Ch. 7. Available at: www.rci.rutgers.edu/~lwh/drugs/chap07.htm.

Wadler,Gary. Designer drugs. Available at: http://espn.go.com/special/s/drugsandsports/

Stem Cell Research

Outcomes

1. Identify examples of technologies that were developed based on understanding of cell division. (116-3)
2. Describe disorders linked to the nervous system and their effects on the homeostasis of the system and the organisms as a whole. (317-4)
3. Analyse why and how technologies related to the treatment of nervous system disorders were developed and improved over time. (115-5)
4. Select and integrate information on the application of technologies based on cell division. (213-7)
5. Construct arguments to support a decision, using examples and evidence and recognizing various perspectives. (118-6)
6. Debate the merits of funding specific scientific or technological endeavours and not others. (117-4)

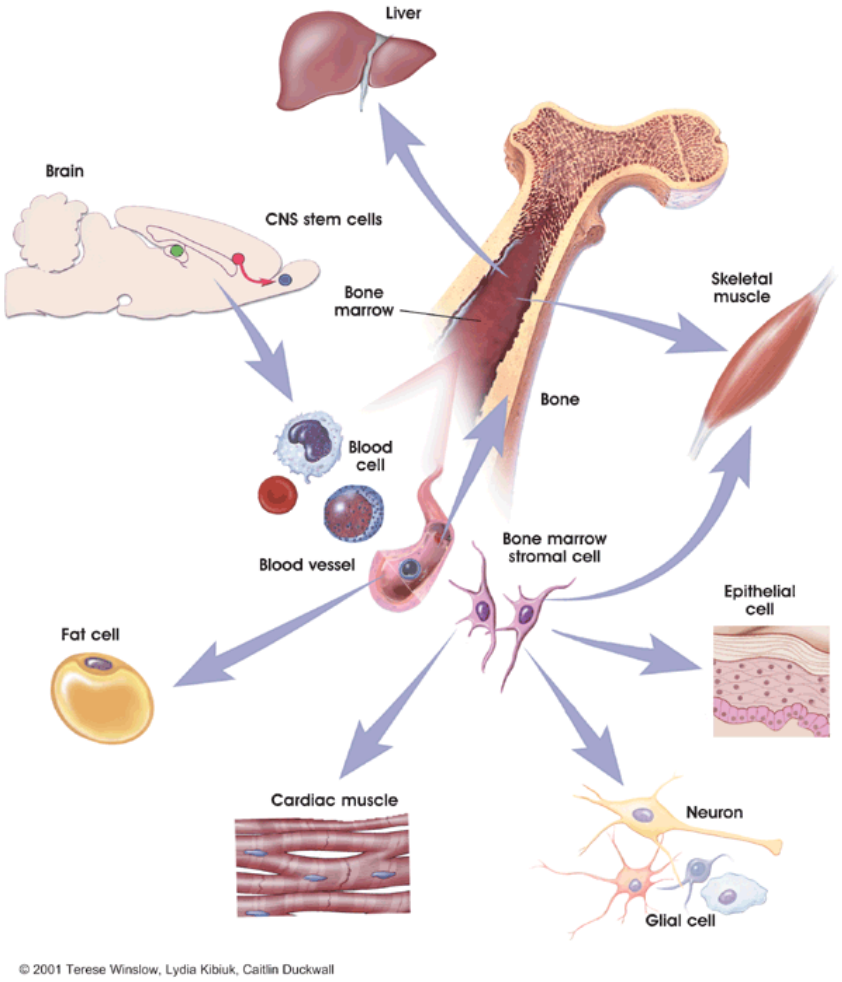
Introduction

Imagine that your father has been diagnosed with Parkinson's disease and you begin to watch his condition deteriorate. Tremors become more evident and his movements more rigid. He is unable to enjoy his normal day-to-day activities. You fear how the debilitation of this disease will affect his human spirit and you know the condition can only get worse. You hear of countries in Europe who are transplanting embryonic stem cells in the brains of Parkinson's patients. It is a relatively new treatment that is considered unethical in North America due to the lack of research and the use of embryonic stem cells. You begin to ask yourself questions about the ethical use of an embryo's stem cells to treat your father. If you pursue this treatment, will you be sacrificing the life of an unborn child for your father's quality of life?

When does human life begin? The scientific community, the pro-life movement, and the pro-choice movement have debated this question for a number of years. The onset of stem cell research has added another dimension to this debate. Is it morally acceptable to cultivate cells from a human embryo to cure a terminal disease? Where do scientists obtain these embryos? Should the therapeutic cloning of an individual be permitted in order to cure a disease of this individual? What happens to the embryo from which the stem cells were retrieved? As these questions are being debated, scientists are researching the use of stem cells to understand and treat cancer, spinal cord injuries, and Parkinson's disease.

What are Stem Cells?

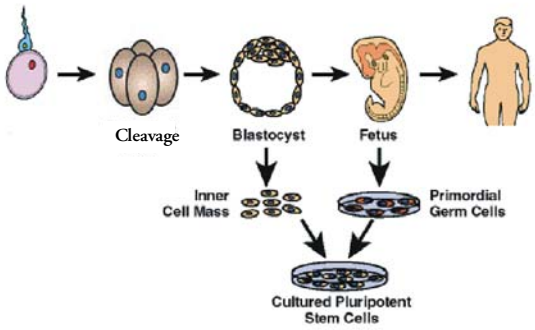
When the human egg is fertilized with sperm, all the genetic information is in place to begin development. Scientists are beginning to understand how a single fertilized egg cell can divide into a multicellular organism with cells that have differentiated to perform a variety of purposes. Each of these differentiated cells has been derived from a single cell and, despite performing different functions, contains identical genetic information. Prior to differentiation, embryonic cells are known as stem cells and have the ability to form any type of cell in our bodies. The inner cell mass of the blastocyst contains stem cells that later differentiate into the hundreds of specialized cells that make up the human organism. In adults, stem cells can be found in tissue such as bone marrow, skin, liver, peripheral blood, blood vessels, muscle, and brain. The stem cells in adults are used to replace cells that need to be replaced through normal wear and tear, cells that have been damaged through injury, and cells that have been damaged through disease.



Stem cells have three unique properties. First, they have the ability to divide and renew themselves for a long period of time. Secondly, they are unspecialized. Thirdly, they have the ability to differentiate into specialized cells.

Types of Stem Cells

There are two main types of stem cells that scientists are interested in studying: embryonic stem cells and adult stem cells. Embryonic stem cells can be obtained from the inner cell mass of the blastocyst four or five days after fertilization. Embryonic stem cells can be also derived from a five to ten week old fetus. It is more common to use stem cells from the blastocyst rather than the fetus. Embryonic stem cells are considered to be pluripotent, which means they may eventually give rise to any type of cell in the human body. Ethical issues arise from the use of embryonic stem cells since the embryos are destroyed and the debate continues to rage about when life begins.



Initially, adult stem cells were believed to mainly give rise to the types of cells found in the tissue from which they were taken. However, recent research has been exploring the possibility that adult stem cells from one tissue may be able to differentiate into cells of another tissue type. This is known as

transdifferentiation or plasticity. This is an area of research that is rapidly advancing, especially since it avoids the ethical issue of using stem cells from embryos. For example, hematopoietic stem cells normally give rise to all the types of blood cells. Recently, they have also shown the ability to differentiate into brain cells, skeletal muscle cells, cardiac muscle cells, and liver cells. Bone marrow stromal cells normally give rise to bone cells, cartilage cells, fat cells, and other types of connective tissue cells. However, recent research is showing that they may also differentiate into cardiac muscle cells and skeletal muscle cells. Brain stem cells can be shown to differentiate into blood cells and skeletal muscle cells.

If adult stem cells are able to demonstrate plasticity, then it is believed that liposuction could potentially provide a source of stem cells, which have been known to reside in fat tissues. Discarded human umbilical cords and human placentas could also provide valuable sources of stem cells. In the future, a person could also be asked to donate his/her stem cells to be used later in life, if the need arises.

Present Research

Stem cell research began over 20 years ago when scientists isolated stem cells from mouse embryos. Human stem cells were first isolated from human embryos in 1998. These human embryos were obtained from embryos that were produced for the purpose of in vitro fertilization and were no longer required by the donor for fertility purposes. In this case, the donor was required to provide informed consent for their embryos to be used in stem cell research.

Scientists are presently trying to understand two main properties of stem cells. First, they would like to understand how stem cells can remain unspecialized for a period of time and renew themselves for a period of years. Secondly, scientists would like to understand the signals that eventually cause cells to differentiate into specialized cells. Scientists believe that certain genes within a cell must be "turned on" and other genes must be "turned off" to become these specialized cells. This fundamental knowledge would enable scientists to develop treatment for diseases in which cells have been damaged beyond the means of the body to normally repair them.

Scientists have found that embryonic stem cells that divide within the laboratory renew themselves without differentiating for a year or more. The same can not yet be said for adult stem cells. Scientists are hoping to understand the processes that regulate stem cell division to remain unspecialized and proliferate as opposed to the processes that lead to the differentiation of cells. This knowledge can enable scientists to more effectively grow embryonic and adult stem cells in the laboratory. It has actually taken twenty years for scientists to learn how to grow embryonic stem cells without having them spontaneously differentiate into specialized cells. The ability to grow large numbers of unspecialized cells in the laboratory is critical to continued research.

Scientists believe that certain genes found within stem cells produce internal signals that guide cell differentiation. They also believe that there are external signals that guide cell differentiation. These signals include chemicals secreted by other cells, physical contact with neighbouring cells, and the presence of certain molecules. Understanding these signals can better enable scientists to learn how to control differentiation into the desired cell type.

Scientists are also learning to direct the differentiation of stem cells through a variety of techniques. Such techniques include changing the chemical composition of the medium, altering the surface of the culture dish, or modifying the cells by inserting specific genes. The development and refinement of techniques that control differentiation will eventually lead to cells that can be transplanted to cure diseases such as heart disease, muscular dystrophy, and diabetes.

Finally, scientists are developing methods of therapeutic cloning (also known as somatic cell transfer). Stem cells are created by transferring genetic material from a transplant recipient into an egg cell. This egg cell is stimulated to divide and produce stem cells that contain genetic information identical to that of the patient. However, this process has resulted in several ethical debates. Does the production of these stem cells result in the production of an embryo that is later destroyed? Is this process essentially the cloning of an individual?

The Technique of Culturing Embryonic Stem Cells

Millions of stem cells can be cultured in about six months from approximately 30 cells taken from the inner cell mass of the blastocyst.

When the cells from the inner cell mass are removed, they are transferred to a plastic laboratory culture dish. This culture dish contains a nutrient broth. The inner surface of the culture dish is coated with a feeder layer. This layer contains mouse embryonic skin cells that are treated so that they will not divide. The feeder layer is important because it provides the inner cells a mass with a sticky layer to which they may adhere. It also releases nutrients into the culture medium. The feeder layer of mouse embryonic stem cells does pose some problems in that viruses and other macromolecules could be transmitted to human cells. Scientists are presently developing methods of culturing human stem cells that do not require the mouse feeder cells.

The stem cells will divide very quickly and overcrowd the culture dish. They will then be plated to other culture dishes. This process of replating will continue for about six months. Stem cells can be frozen and used later for experimentation.

The Potential use of Stem Cells in the Treatment of Disease

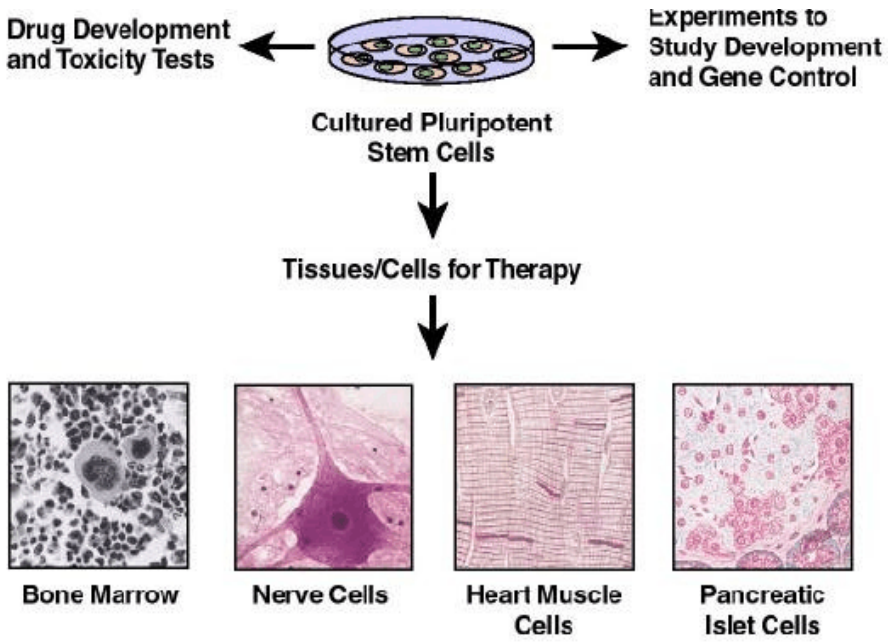
As described earlier, stem cells are useful in research because they are unspecialized cells that have the potential to differentiate into specialized cells.

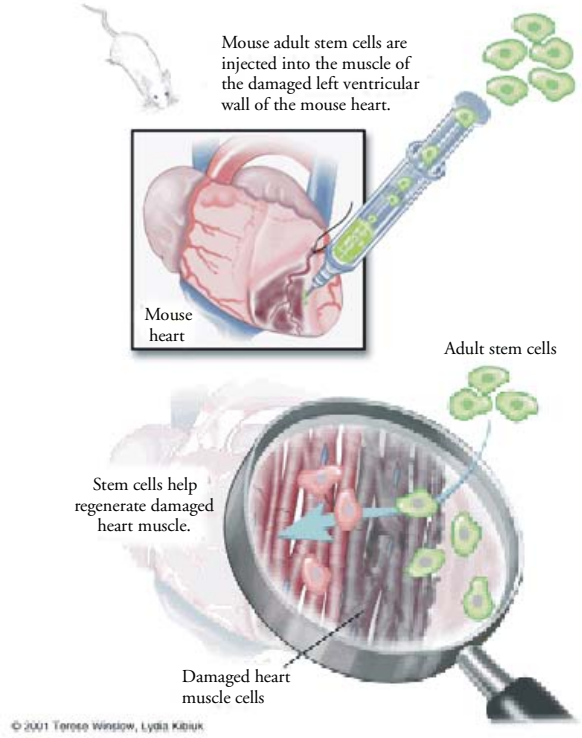
Specialized cells in the human body that have been damaged through injury or disease could be replaced by stem cells if these stem cells can be induced to differentiate into the cell type that has been damaged. This process is known as cell-based therapy.

For example, stem cells can potentially be used to replace damaged cells of a pancreas that no longer produces insulin. Stem cells could replace the nervous cells that have deteriorated in an individual with Parkinson's disease. There are a great many other diseases and conditions that may ultimately be treated through the success of stem cell research. They include spinal cord injury, stroke, Alzheimer's disease, burns, osteoarthritis, rheumatoid arthritis, cancer, Purkinje cell degeneration, Duchenne muscular dystrophy, heart disease, vision loss, and hearing loss. Scientists are specifically working on the directed differentiation of adult stem cells in the treatment of Parkinson's disease, diabetes, and heart disease. These specific cell types include dopamine-producing neurons, insulin-producing cells, and cardiac muscle cells.

In Parkinson's disease, a particular nerve cell or neuron called the dopamine-producing (DA) neuron has been degenerated or destroyed. Loss of the DA neuron leads to the tremor, rigidity, and loss of mobility observed in Parkinson's patients. Studies on mice with Parkinson's disease indicate that when dopamine-producing neurons were transplanted into the brains of mice, symptoms of Parkinson's were alleviated. Scientists are now trying to produce dopamine-producing neurons from human stem cells for neurotransplantation of Parkinson's patients. It is quite possible that within the lifetime of this module, a cure for Parkinson's disease could be found.

As our knowledge of stem cell differentiation unfolds, a better understanding of diseases caused by abnormal cell division and differentiation (e.g., cancer) can be gained and may ultimately lead to a cure. Understanding these processes can also lead to the prevention of birth defects.


Drug Development and Toxicity Tests
Experiments to Study Development and Gene Control
Cultured Pluripotent Stem Cells
Tissues/Cells for Therapy
Bone Marrow
Nerve Cells
Heart Muscle Cells
Pancreatic Islet Cells


Mouse adult stem cells are injected into the muscle of the damaged left ventricular wall of the mouse heart.
Mouse heart
Adult stem cells
Stem cells help regenerate damaged heart muscle.
Damaged heart muscle cells
© 2001 Terese Winslow, Lydia Kibiuk

The use of stem cells in cancer treatment can have a wide range of applications. Cancer cells and stem cells both have the ability to renew themselves. Understanding these processes can help scientists understand why cancer cells resist aggressive treatments and continue to proliferate. As well, cancer treatments such as chemotherapy can cause a high degree of damage to healthy cells and tissues in the body. Stem cells can be used to restore the immune system for aggressive cancer treatments. Embryonic stem cells could also be used to restore the immune system of patients undergoing bone marrow transplants.

Stem cells that are resistant to chemotherapy may eventually be produced and will better enable patients to deal with the effects of chemotherapy. In addition, stem cells could be used to create cancer vaccines by providing antibodies against cancer cells.

The Benefits and Risks of Using Embryological Stem Cells and Adult Stem Cells

Most of the debate around stem cell research centers around the use of embryological stem cells as opposed to adult stem cells. Embryonic stem cells can differentiate into any type of specialized cell. The plasticity of adult stem cells is only now being investigated and more research is needed to determine how adult stem cells can differentiate into other types of cells. Researchers have known how to culture embryonic stem cells in large numbers for the past twenty years, but adult stem cells are difficult to find in mature tissues and researchers have not developed techniques to culture them in large numbers.

The use of adult stem cells from a patient offers a distinct advantage in that a patient will not reject his/her own stem cells after transplantation. Not only is the risk of rejection eliminated, but also immunosuppressant drugs will not be necessary. It has not been determined whether a patient might reject stem cells from a donor, as is the case with embryonic stem cells.

There is the potential that stem cells derived from an embryo could contain viruses or diseases that could be transmitted to a patient. There is also a concern that these stem cells lead to the development of tumors after transplantation.

Conclusion

Research on the use of stem cells is advancing quickly. Stem cell research has also gained momentum through the involvement of such celebrities as Michael J. Fox and Christopher Reeves. Stem cells could be used to replace the damaged neurons in the brain of Parkinson's patients such as Michael J. Fox. They could also be used to repair damaged spinal cord tissue, such as in the case of Christopher Reeves. Some, however, will argue that one should not devalue human life from the moment of conception until death and that it would be immoral to use embryonic stem cells in the treatment of disease. As of 2004, the Canadian Institute of Health Research has developed guidelines that prohibit cloning and the production of embryos strictly for research purposes. Research on embryos is only permitted if those embryos were developed for reproductive purposes and they are obtained with full informed consent of the donors.

The debate about the ethical use of stem cells rages on. In the meantime, researchers continue their work with stem cells from the existing embryos produced through in vitro fertilization, and are developing possibilities from adult stem cells. They must do this in the hope of finding successful treatments for disease and damaged tissue while respecting the ethical issues surrounding stem cell research.

References

Cohen, Elizabeth. Actor Christopher Reeve believes that embryonic stem cell research will allow him to walk again one day. CNN Medical Correspondent

Hedrick, Marc (2001). Life Must Take Priority over Research. Available at: http://www.prolifeinfo.org/stemcell038.html

NCIC Media Release. Human Embryonic Stem Cell Research Guidelines Announced Today Supported by the Canadian Cancer Society and the National Institute of Canada. Available at:

http://www.neic.cancer.ca/pubs/media/02/mar4_e.htm

Text of Bush Speech on Embryonic Stem Cell Research. Available at: http://www.prolifeinfo.org/stemcell033.html

Public Funding of Stem Cell Research Enhances Likelihood of Attaining Medical Breakthroughs. Stem Cells and the Future of Regenerative Medicine. The National Academies. Available at: http://www4.nationalacademies.org.news.nsf/ibsn0309076307?OpenDocument

Stem Cells and Regenerative Medicine. The National Academies. Available: http://www4.nas.edu/onpi/webextra.nsf/44

Stem Cells: A Primer. Available: http://www.nih.gov/news/stemcell/primer.htm

The Center for Bioethics and Human Dignity. Available: http://cbhd.org/resources/overview/stemcell.html

Questions

Understanding Concepts

1. Construct a table that compares the benefits and risks of using embryological stem cells as opposed to adult stem cells.

2. What are the potential sources of embryological stem cells? What are the potential sources of adult stem cells?

3. What are three properties possessed by embryonic stem cells that scientists find valuable in their effort to use stem cells to treat disease?

4. Describe what scientists know about the factors that cause the differentiation of cells.

5. What techniques have scientists begun to develop that direct the differentiation of stem cells?

6. What is meant by cell-based therapies?

7. Describe the process of therapeutic cloning.

8. Briefly outline the steps used to culture large numbers of embryonic stem cells.

Extensions

1. Scientific research in the use of stem cells is quickly advancing. This is an opportunity for students to update this module in keeping with the latest research. Research the most current findings in any of the following areas:

   - **The use of embryological stem cells**. Are scientists still using embryological stem cells? From where are these stem cells obtained? What are the present advantages offered by the use of these stem cells? What are the present disadvantages offered by the use of these stem cells? If these types of stem cells are not being used, why not?

   - **The use of adult stem cells.** Are scientists still using adult stem cells? From where are these stem cells obtained? What are the present advantages offered by the use of these stem cells? What are the present disadvantages offered by the use of these stem cells? If these types of stem are not being used, why not?

   - **The use of stem cells in cell-based therapies.** What therapies are presently being explored that may benefit from stem cell research? Are there any disorders that are being successfully treated through the use of stem cells? Are these therapies using embryological or adult stem cells? What are some potential problems with these treatments?

   - **The use of stem cells in developing drugs.** What type of research is taking place on the development of drugs to treat disease? Are stem cells being used successfully in the development of drugs to treat disease? If so, what types of diseases are being treated?

   This research may be done individually or by student groups. Presentations may be a valuable way for students to share what they have learned.

2. Explore the latest stem cell research directed toward the treatment of a particular disease or disorder (e.g., Parkinson's disease, diabetes, spinal cord injury, stroke, Alzheimer's disease,

burns, osteoarthritis, rheumatoid arthritis, cancer, Purkinje cell degeneration, Duchenne muscular dystrophy, heart disease, vision loss, hearing loss). Findings may be presented in the form of a paper or class presentation.

Genetics Research in Newfoundland and Labrador

Outcomes:

1. Predict the effects of mutations on protein synthesis, phenotypes, and heredity. (315-7)
2. Describe factors that may lead to mutations in a cell's genetic information. (315-6)
3. Explain the circumstances that lead to genetic disease. (315-8)
4. Demonstrate an understanding of genetic engineering, using knowledge of DNA. (315-9)
5. Describe and evaluate the design of technological solutions and the way they function, using genetic principles. (116-6)
6. Construct arguments to support a decision or judgment concerning the use of genetic engineering, using examples and evidence and recognizing various perspectives. (118-6)
7. Analyse and describe examples where genetics-based technologies were developed based on scientific understanding. (116-4)
8. Analyse from a variety of perspectives the risks and benefits to society and the environment of applying the scientific knowledge gained through genetic research. (118-2)
9. Identify and describe science- and technology-based careers in the field of biotechnology. (117-7)

Introduction

If you had the opportunity to help scientists cure a particular disease, would you do so? Most people would likely say yes. There are many people across Newfoundland and Labrador who are doing exactly that. They are giving consent to a local company called Newfound Genomics to use their DNA in genetic research.

Newfoundland and Labrador has recently become the focus of some exciting research in the field of genetics. Newfound Genomics Incorporated is a biotechnology company that was established in Newfoundland and Labrador in June 2000 to study how genes affect human health and disease. Genomics is the study of how genes apply to health and disease.

Founder Populations

Newfoundland's population rose from about 20,000 to 30,000 immigrants from Ireland, Scotland, and Southwest England between the late 1600's and the 1840's, making those early immigrants Newfoundland's founding population. The allele frequencies changed because this population was smaller than the original and did not contain all genes of the parent population. This is known as the founder effect. The population also grew largely from expansion rather than through immigration, which limited genetic diversity. Such a population is known as a founder population. Certain genetic traits became more prevalent in the new population while other traits were eradicated. This explains why, compared to other populations, there is a higher incidence of some diseases in Newfoundland and Labrador while some other diseases are rare or non-existent.

Newfound Genomics and their Research

Scientists at Newfound Genomics are presently studying some common diseases in Newfoundland and Labrador. These diseases include obesity, type 2 diabetes, inflammatory bowel disease, and osteoarthritis. Their research includes clinical, environmental and genetic factors of these diseases. Future studies may include inflammatory arthritis and respiratory, infectious, and dermatological diseases. They will also examine genetic relationships between different diseases.

Genes and Disease

DNA in our cells is used to make proteins. When genes in our DNA are altered, the proteins produced by them are altered as well, and we become more susceptible to disease. Some of these variations in the genetic code are referred to as Single Nucleotide Polymorphisms (SNPs). In the case of SNPs, a nucleotide *substitution* has taken place in the genome. Other variants in the genome include *insertions* and *deletions* in the nucleotide sequence. These are considered to be point mutations.

Some SNPs have already been identified as being associated with some diseases. The Affymetrix and MassARRAY genotyping systems are two types of technology discussed later that scientists are using to determine if an individual possesses the genetic make-up (SNP) that contributes to a particular disease. Imagine that you can now provide a genetics company with a swab of your cheek cells and they can use this technology to determine the presence of variations in your genome that can either diagnose a particular disease or predict the onset of a disease.

Other SNPs have not been identified with any disease. These SNPs may have no effect on the health of the individual, or the SNP may have yet to be connected to a particular disease. This is largely the work that researchers at Newfound Genomics are performing. They can examine the genome for SNPs and are hoping to make connections between individuals with a particular SNP and a disease. Researchers can then examine in more detail the sequences of nucleotides in these SNPs in order to understand their effect on disease.

A better understanding of the sequences of these genes can lead to a better understanding of the physiological effects of their variations. This may, in turn, lead to the development of drugs that may restore the normal functioning of the affected protein. This is a revolutionary way of treating disease. Instead of treating the symptoms of a disease, scientists are discovering the exact cause of a disease on the basis of genetic variation. Determining the precise genetic cause and the affected protein will likely greater enable scientists to treat the cause of a disease as opposed to the symptoms.

Laboratory Technology

Scientists at Newfound Genomics obtain DNA samples and supporting medical information from patient donors. The DNA samples taken from patient volunteers are either in the form of blood samples or buccal cells. Buccal cells are epithelial cells taken from the inside of the cheek. DNA is then extracted from either the blood samples or the buccal cells.

DNA Extraction

Laboratory technologists extract DNA using blood cells or buccal cells. The DNA is extracted using a kit from a scientific supply company.

In the case of blood samples, DNA extraction begins with lysing the red blood cells and collecting the white blood cells. A solution (enzyme) is then used to break down the lipid membranes of the cells and the nuclei of the cells to release DNA. Another solution is used to remove protein from the DNA sample. The DNA is precipitated in alcohol. After drying, the DNA is dissolved in a solution used to protect the DNA from enzymes that cause shearing. In the case of buccal cells, the same procedure is used but does not include the red cell lysis.

After DNA extraction has taken place, freezers are used to store DNA at -86° C for an indefinite period of time for analysis and further study.

DNA Genotyping

Scientists will use the DNA samples to carry out a process called genotyping, analysis using genetic markers. Researchers at Newfound Genomics are presently looking at gene markers that could indicate the presence of a gene sequence contributing to a particular disease. A gene marker is a specific portion of a chromosome that lies near a particular gene, or is part of a particular gene that is being studied. Once the gene marker is identified, a probe can be developed to search for the gene marker in other DNA samples. This probe consists of a DNA sequence that is complementary to the sequence of the gene marker. Sometimes this probe also contains a radioactive or fluorescent chemical tag so it can easily be determined whether it bonds to the gene marker.

Newfound Genomics uses three methods of genotyping.

Basic Molecular Genotyping

This involves a PCR reaction to amplify DNA. Specific primers have been developed for the variant to be examined in the genome.

Gel electrophoresis is then used to determine if the variant is present. In gel electrophoresis, a 2% agarose gel is used with ethidium bromide (EtBr) stain to adhere to the DNA. The EtBr will illuminate with UV light. If the variant is present in the DNA sample, then the primer would have enabled the DNA to amplify and the EtBr would bind to the DNA and would be evident in UV light.

This is a more time-consuming method of genotyping and tends to be used with small projects. With the new MassARRAY technology recently implemented at Newfound Genomics, it will likely be used less often.

Affymetrix Genotyping

The Affymetrix technology will perform a general scan of the genome. The system has a gene chip that can search for 1500 SNPs, and a chip is presently being developed that can scan for 10,000 SNPs. As discussed earlier, the technology can be used to determine whether a SNP known to contribute to disease is present or to make connections between the presence of SNPs and the appearance of a disease.

The Affymetrix technology can also be used in gene expression studies. In gene expression studies, scientists are examining particular genes that may be "turned on" or "turned off" during the different stages of a disease.

The Affymetrix technology incorporates PCR into its technology. It will use both probes and fluorescent chemical tags to detect the presence of genetic markers.

MassARRAY Genotyping

MassARRAY technology is more specific than the Affymetrix technology and can compare a greater number of parameters for experimental work. MassARRAY will analyse genetic samples for a particular SNP or a number of SNPs. It is capable of examining the entire genome, several areas of the genome, or one specific area of the genome for an SNP. It can examine the genetic information for one individual or many individuals, for one or many SNPs. In addition, it can examine and compare a large number of individuals for SNPs. Like the Affymetrix technology, it is useful is making the connection between the presence of an SNP and a disease. It can also examine the genome for the presence of SNPs that are known to be related to disease.

MassARRAY also incorporates PCR into its technology, in addition to the use of primers. Sequenom Inc, a partner of Newfound Genomics, developed this technology.

Ethics

All studies at Newfound Genomics are approved by the HIC (Human Investigations Committee) at the Faculty of Medicine, Memorial University. Donor volunteers are required to give their full informed consent. This consent allows researchers to use the donor volunteers' DNA for one particular study, or for other similar studies. All participants must be volunteers because in Canada it is considered unethical to purchase body fluids. Newfound Genomics does not provide individual feedback to participating volunteers regarding their specific genetic makeup. The genetic information obtained is pooled with information from all participating

volunteers with a similar medical condition.

The main ethical issue concerning the use of donor volunteers' DNA relates to privacy. To protect the privacy of volunteers, Newfound Genomics does not provide insurance companies or employers access to DNA information. Since it is expected that the type of research done by Newfound Genomics can determine the presence of genes that may contribute to certain diseases, one may ask, If insurance companies were able to access this kind of information, would it likely influence their decisions regarding the issue of life insurance policies? If employers were aware that an employee or a potential employee had a genetic make-up that would likely lead to the development of a debilitating disease, would they use this information to make decisions regarding future or continued employment? As scientists continue to uncover the connection between genes and disease, in the hope of better medical treatment, it is conceivable that there are other agencies (e.g., businesses) that might use this knowledge to further their own interests. This is why genomics companies are careful to ensure the confidentiality of those who volunteer the use of their DNA to further the interests of science, and will develop their own codes of ethical conduct to reassure volunteers and the public about the nature of their research.

The Business Community

Newfound Genomics must act as an instrument of science but also must operate in the business world. It is important that their research be properly financed. The company is focussing on three lines of business: novel gene discovery, validation studies, and laboratory services. It is also important that Newfound Genomics not work in isolation from other genetic research companies and academic institutions. For example, Newfound Genomics has developed a partnership with Memorial University, working to build research capacity and joint research initiatives.

Once Newfound Genomics discovers genes that are responsible for the development of certain diseases, they will patent the use of this information for the development of drugs and diagnostic applications. It is predicted that drugs developed from genomics research will represent 30%-50% of global drug revenues by the year 2020.

Genetic companies are cautious regarding the ownership of genetic information. For example, if you are patenting DNA, is it the property of the individual who volunteered the use of his/her DNA that is being patented? Do genetic companies have the right to patent DNA if it can be argued that it is the property of the donor? If DNA is patented, then do those who volunteered their DNA have a right to reap the economic benefits of the research? Imagine how difficult it could be for genetic companies to exist as business institutions if all those who donated their DNA were provided royalties based on the success of the research. Furthermore, is it ethical for one to sell one's DNA for research or for companies to buy it?

Careers in Biotechnology

At present, Newfound Genomics, located in St. John's on the west coast of the province, employs about 10 people. Newfound Genomics collaborates with Memorial University in the training of scientists, students, and health care professionals for research. Their intention is to advance the academic, intellectual, social and economic benefits for this province. It is expected that genetics research will be a fast growing industry, due to the unique genetic make-up of this province, and will offer employment opportunities to a number of people.

Conclusion

Newfound Genomics is an established and well-recognized biotechnology research company with a number of research projects underway. Although it is too early for major results, any findings at present are kept within the domain of the company. In fact, the company will not release any findings until they

are published and have undergone a peer review. This is because the information is considered "intellectual property" and it must remain private so that Newfound Genomics can reap the academic and financial benefits of their work. It will be interesting to see the extent of the development of biotechnology and genetics research in our province and to anticipate the benefits for Newfoundland and Labrador both economically and medically.

References

Lana Hays. Introduction to DNA Extractions. Available at: http://www.accessexcellence.org/AE/AEC/CC/DNA_extractions.html

Bullard, Chetty et al. (2003). *Biology*. McGraw-Hill Ryerson. Toronto

Newfound Genomics. Website available at: www.newfound-genomics.com

Government of Canada. Family Genes hold the Key to Understanding Disease. Follow the Leader.

Sequenom SNP Genotyping Technology. Available at: www.sequenom.com

To Know Ourselves. US Department of Energy, Office of Health and Environmental Research. Available at: www.ornl.gov/hgmis/publicat/tko/index.htm

Special thanks to Hilary Vavasour, RN, RSCN, SCM who provided a tour of the facilities at Newfound Genomics and answered many questions regarding their work.

Special thanks to Lynette Peddle, BSc who took the time to explain the technological aspects of Newfound Genomics.

Questions

Understanding Concepts

1. Outline the benefits, both medical and economic, of genetics research in NL.

2. What is a founder population? How does it lend itself to genetics research?

3. Why are researchers looking for genetic markers?

4. What are some of the long term goals of Newfound Genomics?

5. Why is it important to study genes in relation to disease?

6. What are some of the benefits offered to Newfound Genomics by their partnership with other biotechnology companies?

7. What is the benefit of using Affymetrix and MassARRAY technology ?

8. Give two reasons why Newfound Genomics does not release the results of their research until they are published.

Extensions

1. Go to the Web-site for Newfound Genomics (www.newfound-genomics.com) and follow the links to "**About Us**" and "**Our Team**". Examine the educational background and work experience of the Newfound Genomics team members. Make a list of 15 items that describe the qualifications and work experience required to work in the field of biotechnology. What conclusions can you make about this list?

2. Why is it important that Newfound Genomics assure their patient volunteers that access to their DNA by outside groups will be prohibited?

3. Consider the following issues:

    a. Do you want to know if you will suffer from a genetic condition later in life?
    b. Do employers have the right to know your genetic status? Insurance companies?
    c. Who should have ownership of genetic information?

4. Research how you can carry out a DNA extraction using a DNA source (e.g., onion cells), a blender, salt, detergent, meat tenderizer, and ethanol. What is the reasoning behind the use of each of the materials used in this type of DNA extraction?

Appendix D

Instructional Planning
Transparency Correlations

INSTRUCTIONAL PLAN

Biology 621A

Term 1 (~36 Classes)

Maintaining Dynamic Equilibrium II (~20 Classes)

Curriculum Guide Section	Suggested Time	Text Sections	Text Pages	Suggested Core Investigations
Nervous System	~14 Classes	12.1, 12.2, 12.3	392 - 416 (60- 61)	1 Inv. 12A: "The Nervous System and Reflex Response" 2. Inv. 12B: "The Effect of Light on Pupil Size" 3. "Sense Organs" (Appendix B, document)
Endocrine System	~6 Classes	13.1, 13.2, 13.3	420 - 446 (302-303) (486-487) (490-493)	

Reproduction and Development (~16 Classes)

Curriculum Guide Section	Suggested Time	Text Sections	Text Pages	Suggested Core Investigations
Cell Division	~8 Classes	14.1, 14.2	460-479 (628-630)	4. Inv. 14A: "Observing the Cell Cycle in Plant and Animal Cells"
Reproductive Systems and Technologies	~5 Classes	Chapters 5 & 6 (various pages) 15.1, 15.2	134, 154-155, 157, 165, 175-181, 186 486 - 505	5. Inv. 5A: "The Menstrual Cycle"
Embryonic Differentiation and Development	~3 Classes	15.3	506-514 (429-431) (607-608)	

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 621A

Term 2 (~36 Classes)

Genetic Continuity (~31 Classes)

Curriculum Guide Section	Suggested Time	Text Sections	Text Pages	Suggested Core Investigations
Genetics: Mendelian	~9 Classes	16.1, 16.2	526-543	6. "Human Inheritance" (Appendix B, document)
Genetics: Modern and Molecular	~15 Classes	16.3, 16.4, 17.1, 17.2, 17.3, 17.4	545-600	7. Inv. 17C: "Simulating Protein Synthesis"
Genetics: Implications	~7 Classes	18.1, 18.2, 18-3	(125, 554, 558, 560-562) 604-621, 623-631	8. "Karyotyping" (Appendix B, document)

Evolution (~5 Classes)

Curriculum Guide Section	Suggested Time	Text Sections	Text Pages	Suggested Core Investigations
Evolutionary Change: Historical Perspectives		19.2	650-658	---------
Evolutionary Change: Modern Perspectives		19.3, 20.2, 20.3	659-668, 681-683, 687-699, (723-725)	---------
Evolution: Implications		21.4	727-730	---------

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 ***Biology*** text - Transparencies Set ***Biology 7th Ed.***

McGraw-Hill Biology Text (Biology 521A)	Overhead Transparencies Chapters
Chapter 1	Chapters 4, 5, 6, 26, 27
Chapter 2	Chapter 3
Chapter 3	Chapters 8, 9, 55
Chapter 4	Chapter 25
Chapter 5	Chapters 4, 26, 27, 28, 30
Chapter 6	Chapters 29, 31, 32, 33, 34, 35, 36, 37
Chapter 7	Chapters 53, 55, 56, 57
Chapter 8	Chapter 53, 55, 56, 57
Chapter 9	Chapters 42, 44, 48
Chapter 10	Chapters 20, 42
Chapter 11	Chapters 42, 43, 48, 49

McGraw-Hill Biology Text (Biology 621A)	Overhead Transparencies Chapters
Chapter 12	Chapters 14, 15
Chapter 13	Chapters 47, 49
Chapter 14	Chapters 11, 12
Chapter 15	Chapters 50, 51
Chapter 16	Chapter 13
Chapter 17	Chapters 14,15
Chapter 18	Chapters 16,17
Chapter 19	Chapters 21, 22

Appendix E

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:

National Science Teachers Association, (2008, March). NSTA position statement: Responsible use of live animals and dissection in the science classroom. Retrieved May 20, 2008, from www.nsta.org Web site: http://www.nsta.org/about/positions/animals.aspx

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.

Student Name: _____

Course: _____

Teacher: _____

Date: _____

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)

Date: _____

_____ (Teacher Signature)

Date: _____

_____ (Parent/Guardian Signature)

Date: _____