SECTION 2: IMPLEMENTATION OF SENIOR 3 CURRENT TOPICS IN THE SCIENCES

IMPLEMENTATION OF SENIOR 3 CURRENT TOPICS IN THE SCIENCES

The Senior 3 Student and the Science Learning Environment

An understanding of the unique qualities of each student and how each one learns will aid in making decisions regarding curricular content, learning materials and resources, and instructional and assessment strategies.

In recent decades, cognitive psychology, brain-imaging technology, and multiple intelligences theory have transformed our understanding of learning. Ongoing professional development is important to teachers as they seek to update their knowledge of the processes of learning.

The students that teachers encounter today are different in many respects from students a generation ago. Students are more likely to be living with a single parent or stepfamily. More have part-time jobs. Students are more sophisticated in their knowledge and use of information technology, and much of their understanding of the world comes from television. Classrooms are more likely to be ethnically diverse.

Family relationships, academic and life experiences, personality, interests, learning approaches, socioeconomic status, and rate of development all influence a student's ability to learn.

Characteristics of Senior 3 Learners

For many students, Senior 3 is a stable and productive year. Many Senior 3 students have developed a degree of security within their peer group and a sense of belonging in school. They show increasing maturity in dealing with the freedoms and responsibilities of late adolescence: romantic relationships, part-time jobs, and driver's licences. In Senior 3, most students have a great deal of energy and a growing capacity for abstract and critical thinking. Many are prepared to express themselves with confidence and to take creative and intellectual risks. The stresses and preoccupations of preparing for graduation, post-secondary education, or full-time jobs are still a year away. For many students, Senior 3 may be their most profitable academic year of the Senior Years.

Although many Senior 3 students handle their new responsibilities and the demands on their time with ease, others experience difficulty. External interests may seem more important than school. Because of their increased autonomy, students who previously had problems managing their behaviour at school may now express their difficulties through poor attendance, alcohol and drug use, or other behaviours that place them at risk.

Students struggling to control their lives and circumstances may make choices that seem contrary to their best interests. Communication with the home and awareness of what students are experiencing outside school continue to be important for Senior 3 teachers. Although the developmental variance evident in previous years has narrowed, students in Senior 3 can still change a great deal in the course of one year or even one semester.

Characteristics of Senior 3 Learners: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 1-4 to 1-5.

Sensitivity to the dynamic classroom atmosphere and recognition when shifts in interests, capabilities, and needs are occurring allows teachers to adjust learning experiences for their students.

The following chart identifies some common characteristics of late adolescence observed in educational studies (Glatthorn; Maxwell and Meiser; Probst) and by Manitoba teachers, and discusses the implications of these characteristics for teachers.

Senior 3 Learners: Implications for Teachers

Characteristics of Senior 3 Learners	Significance for Senior 3 Teachers
Cognitive Characteristics	
• Most Senior 3 learners are capable of abstract thought and are in the process of revising their former concrete thinking into fuller understanding of principles.	• Teach to the big picture. Help students forge links between what they already know and what they are learning. Be cognizant of individual differences and build bridges for students who think concretely.
• Students are less absolute in their reasoning, more able to consider diverse points of view. They recognize that knowledge may be relative to context.	• Focus on developing problem-solving and critical-thinking skills, particularly those related to STSE and decision making.
• Many basic learning processes have become automatic by Senior 3, freeing students to concentrate on complex learning.	• Identify the knowledge, skills, and strategies that students already possess, and build the course around new challenges. Through assessment, identify students who have not mastered learning processes at Senior 3 levels and provide additional assistance and support.
• Students have a clearer self-understanding and have developed specialized interests and expertise. They need to connect what they are learning to the world outside the school.	• Use strategies that enhance students' metacognition. Encourage students to develop scientific skills through exploring areas of interest. Cultivate classroom experts and invite students with individual interests to enrich the learning experience of the class.
Psychological and Emotional Characteristics	
• It is important for Senior 3 students to see that their autonomy and emerging independence are respected. They need a measure of control over what happens to them in school.	• Provide choice. Allow students to select many of the resources they will explore and the forms they will use to demonstrate their learning. Collaborate with students in assessment. Teach students to be independent learners. Gradually release responsibility to students.
• Students are preparing for senior leadership roles within the school and may be more involved with leadership in their communities.	• Provide students with leadership opportunities within the classroom and with a forum to practise skills in public speaking and group facilitation.
• Students need to understand the purpose and relevance of practices, policies, and processes. They may express their growing independence through a general cynicism about authority and institutions.	• Use students' tendency to question social mores to help them develop critical thinking. Negotiate policies and demonstrate a willingness to make compromises. Use students' questions to fuel classroom inquiry.
• Senior 3 students have a clearer sense of identity than they had previously and are capable of being more reflective and self-aware. Some students are more willing to express themselves and disclose their thoughts and ideas.	• Provide optional and gradual opportunities for self-disclosure. Invite students to explore and express themselves through their work. Celebrate student differences.

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Senior 3 Learners: Implications for Teachers: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 1-5 to 1-7.

Senior 3 Learners: Implications for Teachers *(continued)*

Characteristics of Senior 3 Learners	Significance for Senior 3 Teachers
Physical Characteristics	
• Many Senior 3 students have reached adult physical stature. Others, particularly males, are still in a stage of extremely rapid growth and experience a changing body image and self-consciousness.	• Be sensitive to the risk students may feel in public performances and increase expectations gradually. Provide students with positive information about themselves.
• By Senior 3, students are able to sit still and concentrate on one learning task for longer periods than previously, but they still need interaction and variety. They have a great deal of energy.	• Put physical energy to the service of active learning instead of trying to contain it. Provide variety; change the pace frequently; use kinesthetic learning experiences.
• Senior 3 students still need more sleep than adults do, and may come to school tired as a result of part-time jobs or activity overload.	• Be aware that inertia or indifference may be the result of fatigue. Work with students and families to set goals and plan activities realistically so that school work assumes a higher priority.
Moral and Ethical Characteristics	
• Senior 3 students are working at developing a personal ethic, rather than following an ascribed set of values and code of behaviour.	• Explore the ethical meaning of situations in life and in scientific contexts. Provide opportunities for students to reflect on their thoughts in discussion, writing, or representation.
• Students are sensitive to personal or systemic injustice but are increasingly realistic about the factors affecting social change.	• Explore ways decision-making activities can effect social change and link to the continuum of science, technology, society, and the environment.
• Students are shifting from an egocentric view of the world to one centred in relationships and community. They are able to recognize different points of view and adapt to difficult situations.	• Provide opportunities for students to make and follow through on commitments and to refine their interactive skills.
• Students are becoming realistic about the complexities of adult responsibilities but resist arbitrary authority.	• Explain the purpose of every learning experience. Enlist student collaboration in developing classroom policies. Strive to be consistent.
Social Characteristics	
• By Senior 3, certain individuals will take risks in individual identity. Many students, however, continue to be intensely concerned with how peers view their appearance and behaviour. Much of their sense of self is drawn from peers, with whom they may adopt a "group consciousness," rather than from making autonomous decisions.	• Ensure that the classroom has an accepting climate. Model respect for each student. Use learning experiences that foster student self-understanding and self-reflection. Challenge students to make personal judgements about situations in life and in their natural environment.
• Adolescents frequently express identification with peer groups through slang, musical choices, clothing, body decoration, and behaviour.	• Foster a classroom identity and culture. Ensure that every student is included and valued. Structure learning so that students can interact with peers, and teach strategies for effective interaction.
• Crises of friendship and romance and a preoccupation with relationships can distract students from academics.	• Open doors for students to study relationships in science (for example, through biographies of scientists). Respect confidentiality, except where a student's safety is at risk.
• Students begin to recognize teachers as individuals and welcome a personal connection.	• Nurture and enjoy a relationship with each student. Try to find areas of common interest with each one. Respond with openness, empathy, and warmth.

Fostering a Will to Learn

Experiences of intense involvement are optimal opportunities for teaching engagement in learning, and teachers should endeavour to ensure they happen frequently in the classroom. Not every necessary learning task, however, can be intrinsically rewarding to every learner. Being a successful learner also requires a high degree of what Corno and Randi call "sustained voluntary effort"—an attitude that is expressed in committing oneself to less interesting tasks, persisting in solving problems, paying conscientious attention to detail, managing time, self-monitoring, and making choices between competing values, such as the desire to do well on a homework assignment and the desire to spend the evening with friends. The willingness to make this sustained effort constitutes motivation.

Motivation is a concern of teachers, not only because it is essential to classroom learning, but also because volition and self-direction are central to lifelong learning. Science courses seek to teach students how to interpret and analyze science concepts, and to foster the desire to do so. Motivation is not a single factor that students either bring or do not bring to the classroom. It is multi-dimensional, individual, and often comprises both intrinsic and extrinsic elements. Students hold certain presuppositions about science learning that affect the way they learn. There are certain attitudes and skills that teachers can promote to facilitate students' engagement in each learning task, while recognizing and affirming entry-level abilities.

In considering how they can foster motivation, teachers may explore students' appreciation of the value (intrinsic and extrinsic) of learning experiences and their belief about their likelihood of success. Good and Brophy suggest that these two elements can be expressed as an equation: the effort students are willing to expend on a task is a product of their expectation of success and of the value they ascribe to success.

Expectancy	**x**	**Value**	**=**	**Motivation**
(the degree to which students expect to be able to perform the task successfully if they apply themselves)		(the degree to which students value the rewards of performing the task successfully)		

Teachers may, therefore, want to focus on ensuring students can succeed if they apply reasonable effort, and on helping students recognize the value of classroom learning experiences. The following chart provides teachers with suggestions for fostering motivation.

Fostering a Will to Learn: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 1-8.

Fostering Motivation

Ways to Foster Expectations of Success	Best Practice and Research
• Help students to develop a sense of self-efficacy, a confidence in their leaning capabilities.	• Schunk and Zimmerman found that students who have a sense of self-efficacy are more willing to participate, work harder, persist longer when they encounter difficulties, and achieve at a higher level than students who doubt their learning capabilities. • Teachers foster student self-efficacy by recognizing that each student can succeed and by communicating that belief to the student. Silver and Marshall found that a student's perception that he or she is a poor learner is a strong predictor of poor performance, overriding natural ability and previous learning. All students benefit from knowing that the teacher believes they can succeed and will provide the necessary supports to ensure that learning takes place. • Teachers also foster a sense of self-efficacy by teaching students that they can learn how to learn. Students who experience difficulty often view the learning process as mysterious and outside their control. They believe that others who succeed in school do so entirely because of natural, superior abilities. It is highly motivating for these students to discover that they, too, can learn and apply the strategies that successful students use when learning.
• Help students to learn about and monitor their own learning processes.	• Research shows that students with high metacognition (students who understand how they learn) learn more efficiently, are more adept at transferring what they know to other situations, and are more autonomous than students who have little awareness of how they learn. Teachers enhance metacognition by embedding, into all aspects of the curriculum, instruction in the importance of planning, monitoring, and self-assessing. Turner found that teachers foster a will to learn when they support "the cognitive curriculum with a metacognitive and motivational one" (199).
• Assign tasks of appropriate difficulty, communicating assessment criteria clearly, and ensuring that students have clear instruction, modelling, and practice so they can complete the tasks successfully.	• Ellis et al found that systematic instruction helps students learn strategies they can apply independently.
• Help students to set specific and realistic personal goals and to learn from situations where they do not attain their goals. Celebrate student achievements.	• Research shows that learning is enhanced when students set goals that incorporate specific criteria and performance standards (Foster; Locke and Latham). • Teachers promote goal-setting skills by working in collaboration with students in developing assessment strategies and rubrics (see Section 3 and Appendix 8).

(continued)

Fostering Motivation: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 1-9 to 1-10.

Fostering Motivation *(continued)*	
Ways to Foster Expectations of Success	**Best Practice and Research**
• Offer choices.	• Intrinsic motivation is closely tied to students' self-selection of topics, texts, learning activities, and creative forms. Teachers may involve students in the choice of a topic for thematic development. Teachers need to support students in the search for learning resources that are developmentally appropriate and of high interest, and encourage students to bring the world views they value into the classroom. Self-selection allows students to build their learning on the foundation of their personal interests and enthusiasm.
• Set worthwhile academic objectives.	• Rather than asking students to execute isolated skills or perform exercises that are without context, teachers need to embed instruction in meaningful events and activities that simulate real-world settings, and ensure that students share performances and products with a peer audience.
• Help students to learn about and monitor their own learning processes.	• In teaching specific learning strategies, teachers need to focus on the usefulness of each strategy for making meaning of information or for expressing ideas of importance to students. Teachers need to emphasize the importance of science to the richness and effectiveness of students' lives, and de-emphasize external rewards and consequences such as marks.
• Ensure that scientific experiences are interactive.	• A community that encourages students to share their learning with each other values science. Teachers who model curiosity, enthusiasm, and pleasure in learning science-related concepts and who share their experiences foster motivation for scientific literacy.

Creating a Stimulating Learning Environment

A vital science class grows out of, and is reflected in, a stimulating and inviting physical environment. While the resources and physical realities of classrooms vary, a well-equipped science classroom offers or contains a variety of resources that help stimulate learning. It is helpful to involve students in the classroom design.

Ways to create a stimulating learning environment include the following:

- **Flexible seating arrangements:** Use movable desks or tables to design seating arrangements that reflect a student-centred philosophy and that allow students to interact in various configurations.
- **A media-rich environment:** Have a classroom library of books for self-selected reading. The classroom library may include science periodicals, newspaper articles, newsletters, Internet articles, science-fiction literature, and students' published work. It may also include a binder of student reviews and recommendations, and may be decorated by student-designed posters or book jackets. Classroom reference materials could include dictionaries/encyclopedias of science, books of facts, software and CD-ROM titles, past examinations collated into binders, and manuals.
- **Access to electronic equipment:** Provide access to a computer, television, video cassette recorder, and videorecorder, if possible.
- **Wall displays:** Exhibit posters, Hall of Fame displays, murals, banners, and collages that celebrate student accomplishments. Change these frequently to reflect student interests and active involvement in the science classroom.
- **Display items and artifacts:** Have models, plants, photographs, art reproductions, newspaper and magazine clippings, fossils, musical instruments, and so on, in your classroom to stimulate inquiry and to express the link between the science classroom and the larger world.
- **Animals:** Provide interaction with an assortment of classroom animals.
- **Communication:** Post checklists, processes, and strategies to facilitate and encourage students' independent learning. Provide a bulletin board for administrative announcements and schedules.
- **Well-equipped and safe laboratory:** Provide regular access to a well-equipped and safe science lab to foster the development of critical lab skills.

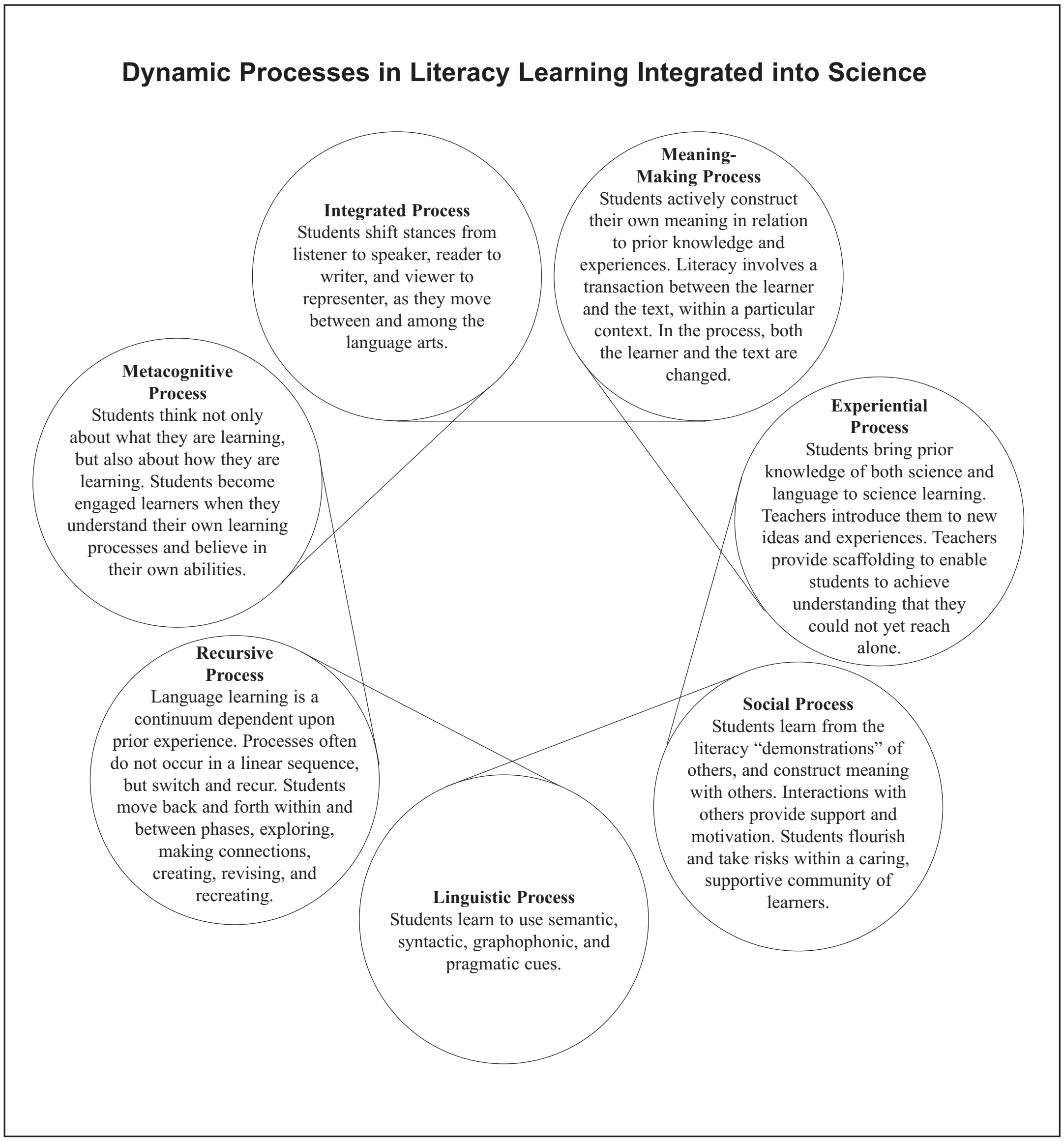
Language Learning Connected to Science

Science curricula involve all aspects of language and literacy development. Halliday (cited in Strickland and Strickland 203) suggests that as students actively use the language arts, they engage in three kinds of language learning, which can be linked to broader scientific literacy:

- **Students learn language:** Language learning is a social process that begins at infancy and continues throughout life. Language-rich environments enhance and accelerate the process. Terminology-rich science has a role in new language development.
- **Students learn through language:** As students listen, read, or view, they focus primarily on making meaning from the text at hand. Students use language to increase their knowledge of the world.

- **Students learn about language:** Knowledge of language and how it works is a subject in and of itself; nevertheless, science as a discipline of inquiry relies on a particular use of language for effective communication. Consequently, students also focus on the language arts and their role when applied to science.

Scientific literacy learning is dynamic and involves many processes. The following graphic identifies some of the dynamic processes that form the foundation for effective literacy learning in science classrooms.



Dynamic Processes in Literacy Learning Integrated into Science: Adapted from Manitoba Education and Training, *Senior 2 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1998) Overview–11.

The Nature of Science, Scientific Theories, and Science Education Today

Science is a method of explaining the natural world. It assumes that anything that can be observed or measured is amenable to scientific investigation. Science also assumes that the universe operates according to regularities that can be discovered and understood through scientific investigations. The testing of various explanations of natural phenomena for their consistency with empirical data is an essential part of the methodology of science. Explanations that are not consistent with empirical evidence or cannot be tested empirically are not a part of science. As a result, explanations of natural phenomena that are not based on evidence but on myths, personal beliefs, religious values, and superstitions are not scientific. Furthermore, because science is limited to explaining natural phenomena through the use of empirical evidence, it cannot provide religious or ultimate explanations.

The most important scientific explanations are usually termed “theories.” In ordinary speech, “theory” is often used to mean “guess” or “hunch,” whereas in scientific terminology, a theory is a set of universal statements that explain some aspect of the natural world. Theories are powerful tools. Scientists seek to develop theories that

- are firmly based upon evidence
- are logically consistent with other well-established principles
- explain more than rival theories
- have the potential to lead to new knowledge

The body of scientific knowledge changes as new observations and discoveries are made. Theories and other explanations change. New theories emerge, and other theories are modified or discarded. Throughout this process, theories are formulated and tested on the basis of evidence, internal consistency, and their explanatory power.

Ethical Issues and the Nature of Scientific Theories

The development of thematic units in Senior 3 Current Topics in the Sciences should lead to issues and questions that go beyond a traditional acquisition of scientific knowledge. For example, the application of population biology research to the reintroduction of species into former habitats, or the implementation of international protocols related to global climate change, raises questions of ethics, values, and responsible use of scientific information. The environmental consequences of the industrial applications of chemistry, or climate change science, raise issues of considerable merit, as do the topics of cloning and genetically modified foods. These are among the important issues that science is often called upon for advice. As students and teachers address these issues, they will naturally be drawn to the study of the underlying scientific concepts. Students should realize that science provides the background for informed personal and social decisions and that, as informed decision-makers, they may have an impact on society and the world.

Although the specific learning outcomes of Senior 3 Current Topics in the Sciences do not specifically ask students to engage in ethical considerations (to be emphasized in Senior 4), teachers are encouraged to give ethics and values appropriate treatment, particularily if a unit has an emphasis on the Nature of Science and Technology (GLO A) or on Science, Technology, Society, and the Environment (GLO B).

Instructional Philosophy in Science

Teaching Senior 3 Current Topics in the Sciences through a focus on current issues naturally allows for the use of a variety of instructional strategies that include the collection and analysis of data from both laboratory and field work; group and individual instruction; a diversity of questioning techniques; decision-making, problem-solving, and design-process activities; and a resource-based approach to learning. Senior Years science programming fosters critical thinking skills and promotes the integration of knowledge and application of facts to real-life situations. Scientific concepts from other Senior Years science courses may become part of the subject matter as units develop in Senior 3 Current Topics in the Sciences. This approach is a valuable and useful means of reinforcing and validating interdisciplinary concepts as having relevant and contextual applications.

In general, science is a way of thinking that has rules for judging the validity of answers applicable to everyday life. Science is an intense human activity, full of trial and error, that is influenced by cultural priorities and perspectives. The myth of total objectivity that often permeates scientific dialogue also needs to be exposed. Among the natural sciences, truth is no longer viewed as an objective reality awaiting discovery; rather, it is placed in the context of something always to be sought. In recognition of the tentative nature of current knowledge claims, "scientific truth" is not a goal that can be reached in absolute terms.

Students should be encouraged to make distinctions between what is observable and testable, as well as develop the ability to consider the abstract deductions, models, and themes that flow from evolving scientific research and thinking.

Conceptual knowledge in science must also be integrated with principles from other disciplines. The inclusion of social, historical, and political implications in the study of science provides students with opportunities to develop a facility to communicate ideas effectively through verbal and written expression. Finally, students will benefit from opportunities to develop an awareness of the options available to them for careers and vocations in the wide diversity of sciences.

Senior 3 Current Topics in the Sciences, as a component of young people's whole educational experience, will help prepare them for a full and satisfying life in the world of the 21st century. This curriculum will sustain and develop the curiosity of young people about the natural world around them, and build their confidence in their ability to inquire into its behaviour, now and in the future. It seeks to foster a sense of wonder, enthusiasm, and interest in science so that young people feel confident and competent to engage with everyday scientific and technological applications and solutions. As students study a range of topics through various themes, they will acquire a broad, general understanding of the important ideas and explanatory frameworks of science, and of the procedures of scientific inquiry, which have had a major impact on our material environment and on our culture. They will develop an appreciation for why these ideas are valued and the underlying rationale for decisions that they may wish, or be advised, to take in everyday contexts, both now and in later life. They will be able to understand, and respond critically to, media reports of issues with a science component. They will feel empowered to hold and express a personal point of view on issues with a science component that enter the arena of public debate, and perhaps to become actively involved in some of these issues (Alsop and Benoze; Millar and Osborne 12).

Results-Based Learning

In results-based learning, the programming focus is on what students know and can do, rather than on what material is "covered." The learning outcomes are an elaboration of the knowledge, skills and strategies, and attitudes expected of each Senior 3 Current Topics in the Sciences student. All programming decisions are directed toward addressing the gap between students' present level of performance and the performance specified in the learning outcomes.

Bridging the Gap Between
Student Performance and the Identified Learning Outcomes

Present Level of Student Performance → Programming Decisions → Senior 3 Student Learning Outcomes

- Instructional Strategies
- Materials and Resources
- Assessment Tools and Strategies

The student learning outcomes are not taught separately or in isolation. Nor are they taught consecutively in the order in which they appear in the curriculum documents. Most lessons or units draw on knowledge, skills and strategies, and attitudes addressed in several or all general learning outcomes. In the process of planning, teachers are encouraged to identify the learning outcomes they intend to assess.

In implementing results-based curricula, teachers may find that they use many of the instructional strategies and resources they have used previously. However, the nature of results-based learning will reshape their programming in several ways:

- Planning is ongoing throughout the semester or year because instruction is informed by learning requirements that become evident through continuous assessment.
- Many learning outcomes are addressed repeatedly in different ways throughout the school semester or year. The learning outcomes should be mastered by the end of the semester/year. As well as developing new scientific knowledge, skills and strategies, and attitudes, students need to practise and refine those learned previously.

Varied Instructional Approaches

Teachers wear a number of different "pedagogical hats," and change their teaching styles in relation to the cognitive gains, attitudes, and skills demanded of the task at hand (Hodson). In planning instruction for Senior 3 Current Topics in the Sciences, teachers may draw upon a repertoire of instructional approaches and methods and use combinations of these in each unit and lesson.

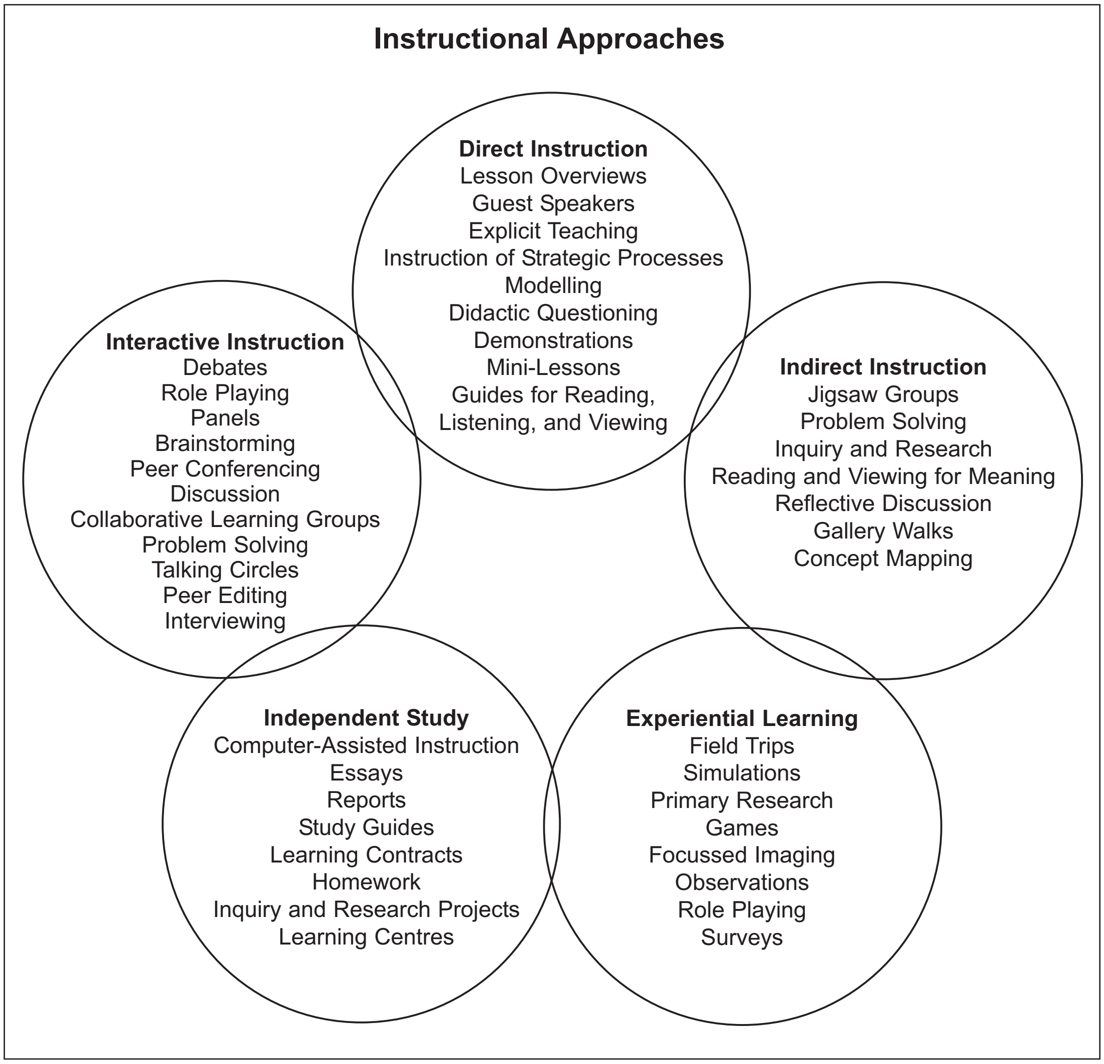
Instructional approaches may be categorized as

- direct instruction
- indirect instruction
- experiential learning
- independent study
- interactive instruction

Results-Based Learning and Varied Instructional Approaches: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 2-3.

Most teachers draw from all these categories to ensure variety in their classroom learning experiences, to engage students with various intelligences and a range of learning approaches, and to achieve instructional goals.

The following diagram displays instructional approaches and suggests some examples of methods within each approach. Note that the approaches overlap.



In selecting instructional approaches and methods, teachers consider which combination will assist students in achieving the learning outcomes targeted for a particular lesson or unit. Teachers consider the advantages and limitations of the approaches and methods, as well as the interests, knowledge, skills, and attitudes of their students. Some of these elements are represented in the following chart.

Instructional Approaches: Adapted from Saskatchewan Education, *Instructional Approaches: A Framework for Professional Practice* (Regina, SK: Saskatchewan Education, 1991) 20. Adapted by permission of Saskatchewan Learning.

Instructional Approaches: Roles, Purposes, and Methods				
Instructional Approaches	**Roles**	**Purposes/Uses**	**Methods**	**Advantages/ Limitations**
Direct Instruction	• Highly teacher-directed • Teacher uses didactic questioning to elicit student involvement	• Providing information • Developing step-by-step skills and strategies • Introducing other approaches and methods • Teaching active listening and note making	Teachers: • Explicit teaching • Lesson overviews • Guest speakers • Instruction of strategic processes • Lecturing • Didactic questioning • Demonstrating and modelling prior to guided practice • Mini-lessons • Guides for reading, listening, and viewing	• Effective in providing students with knowledge of steps of highly sequenced skills and strategies • Limited use in developing abilities, processes, and attitudes for critical thinking and interpersonal learning • May encourage passive not active learning
Indirect Instruction	• Mainly student-centred • Teacher's role shifts to facilitator, supporter, resource person • Teacher monitors progress to determine when intervention or another approach is required	• Activating student interest and curiosity • Developing creativity and interpersonal skills and strategies • Exploring diverse possibilities • Forming hypotheses and developing concepts • Solving problems • Drawing inferences	Students: • Observing • Investigating • Inquiring and researching • Jigsaw groups • Problem solving • Reading and viewing for meaning • Reflective discussion • Concept mapping	• Active involvement an effective way for students to learn • High degree of differentiation and pursuit of individual interests possible • Excellent facilitation and organizational skills required of teachers • Some difficulty integrating focused instruction and concepts of content
Interactive Instruction	• Student-centred • Teacher forms groups, teaches and guides small-group skills and strategies	• Activating student interest and curiosity • Developing creativity and interpersonal skills and strategies • Exploring diverse possibilities • Forming hypotheses and developing concepts • Solving problems • Drawing inferences	Students: • Discussing • Sharing • Generating alternative ways of thinking and feeling • Decision making • Debates • Role-playing • Panels • Brainstorming • Peer conferencing • Collaborative learning groups • Problem solving • Talking circles • Interviewing • Peer editing	• Increase of student motivation and learning through active involvement in groups • Key to success is teacher's knowledge and skill in forming groups, instructing, and guiding group dynamics • Effective in assisting students' development of life skills in cooperation and collaboration

(continued)

Instructional Approaches: Roles, Purposes and Methods: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 2-5 to 2-6.

Instructional Approaches: Roles, Purposes, and Methods *(continued)*				
Instructional Approaches	**Roles**	**Purposes/Uses**	**Methods**	**Advantages/ Limitations**
Experiential Learning	• Student-centred • Teacher's role may be to design the order and steps of the process	• Focusing on processes of learning rather than products • Developing students' knowledge and experience • Preparing students for direct instruction	Students: • Participating in learning activities • Field trips • Simulations • Primary research • Games • Focused imaging • Role-playing • Surveys • Sharing observations and reflections • Reflecting critically on experiences • Developing hypotheses and generalizations in new situations	• Increase in student understanding and retention • Additional resources and time required for hands-on learning
Independent Study	• Student-centred • Teacher's role to guide or supervise students' independent study, teach knowledge, skills, and strategies that students require for independent learning, and provide adequate practice	• Accessing and developing student initiative • Developing student responsibility • Developing self-reliance and independence	Students: • Inquiry and research projects using a variety of approaches and methods • Computer-assisted instruction • Essays and reports • Study guides • Learning contracts • Homework • Learning centres	• Students grow as independent, lifelong learners • Student maturity, knowledge, skills, and strategies important to success • Student access to resources essential • Approach flexible (may be used with individual students while other students use other approaches)

Linking Instructional Approaches with Specific Instructional Strategies

The interactions of the five instructional approaches just discussed can be linked to more specific strategies commonly found within this curriculum document. Although not exhaustive, the instructional strategies that follow may be used with Senior 3 Current Topics in the Sciences as starting points toward a broader array of strategically used classroom learning experiences with students.

Direct Instruction

- **Teacher demonstrations:** Demonstrations, such as discrepant events, may be used to arouse student interest and allow for visualization of phenomena. Demonstrations can activate prior knowledge and generate discussion around learning outcomes.
- **Community connections:** Field trips and guest speakers may provide students with opportunities to see science applied in their community and in local natural environments.
- **Prior knowledge activities:** Students learn best when they are able to relate new knowledge to what they already know. Brainstorming, KWL (Know, Want to know, Learned) charts, and Listen-Think-Pair-Share (see *SYSTH*) are just a few of the strategies that may be used to activate and assess students' prior knowledge.

Indirect Instruction

- **Class discussion (teacher facilitated):** Discussions may be used in a variety of ways. They may spark interest in a topic or learning outcome, activate prior knowledge by inviting speculation on why certain events occur, or generate ideas for solutions to problems.
- **Collaborative teamwork:** Instructional strategies, such as the Jigsaw or Roundtable (see *SYSTH*), encourage students to learn from one another and to develop teamwork skills. The use of cooperative learning activities may lead to increased understanding of content and improved thinking skills.

Interactive Instruction

- **Class discussion (student facilitated):** Student-led discussions may be used with groups of students who are amenable to this form of interaction once procedures have been well developed in advance. They may spark interest in a topic or learning outcome, activate prior knowledge by inviting speculation on why certain events occur, or generate ideas for solutions to problems.
- **Debates:** Debates draw upon students' own positions on STSE issues. When carefully structured, debates may be used to encourage students' consideration of societal concerns and the opinions of others, and improve their communication and research skills.

Experiential Learning

- **Student research/reports:** Learning projects that involve student research are among the most effective ways to individualize instruction in a diverse classroom. These learning activities provide students with opportunities to develop their research skills as they gather, process, and evaluate information.
- **Problem-based learning (PBL):** PBL is a curricular design that centres on an authentic problem. Students are assigned roles and presented with a problem that has no single, clear-cut solution. Students acquire content knowledge as they work toward solving the problem.
- **Journal writing:** Science journal writing allows students to explore and record various aspects of their experiences in science class. By sorting out their thoughts on paper or thinking about their learning (metacognition), students are better able to process what they are learning.
- **Laboratory activities:** Laboratory activities, whether student- or teacher-designed, provide students with opportunities to apply their scientific knowledge and skills related to a group of learning outcomes. Students will appreciate the hands-on experience of *doing* science as opposed to a sense of just learning about science.

Independent Study

- **WebQuests:** A WebQuest is an inquiry-oriented activity in which most or all of the information used by learners comes from resources on the Internet. WebQuests are designed to use learners' time well, to focus on using information rather than looking for it, and to support learners' thinking at the levels of analysis, synthesis, and evaluation.
- **Visual displays:** When students create visual displays, they make their thinking visible. Generating diagrams, concept maps, posters, and models provides students with opportunities to represent abstract information in a more concrete form.

Phases of Learning

When preparing instructional plans and goals, many teachers find it helpful to consider three learning phases:

- **activating** (preparing for learning)
- **acquiring** (integrating and processing learning)
- **applying** (consolidating learning)

These phases are not entirely linear but are a useful way of thinking and planning. A variety of activating, acquiring, and applying strategies are discussed in the *Senior Years Science Teachers' Handbook* (Manitoba Education and Training).

Activating (Preparing for Learning)

One of the strongest indications of how well students comprehend new information is their prior knowledge of the subject. Some educators observe that more student learning occurs during this activating phase than at any other time. In planning instruction and assessment, teachers develop student learning experiences and select strategies for activating their students' prior knowledge. These learning experiences provide information about the extent of students' prior knowledge of the topic to be studied, their knowledge of and familiarity with the forms of media to be used, and their knowledge of and proficiency in applying skills for learning and using these forms.

Learning experiences that draw on students' prior knowledge

- help students relate new information, skills, and strategies to what they already know and can do (for example, if a text includes unfamiliar vocabulary, students may not recognize the connection between what they know and the new material being presented)
- allow teachers to recognize misconceptions that might make learning difficult for students
- allow teachers to augment and strengthen students' knowledge base when students do not possess adequate prior knowledge and experience to engage with new information and ideas
- help students recognize gaps in their knowledge
- stimulate curiosity and initiate the inquiry process that will direct learning

Acquiring (Integrating and Processing Learning)

In the second phase of learning, students engage with new information and integrate it with what they already know, adding to and revising their previous knowledge. Part of the teacher's role in this phase is to present this new information or to help students access it from various resources.

Since learning is an internal process, however, facilitating learning requires more of teachers than simply presenting information. In the acquiring phase, teachers instruct students in strategies that help them make meaning of information, integrate it with what they already know, and express their new understanding. In addition, teachers monitor these processes to ensure that learning is taking place, using a variety of instruments, tools, and strategies such as observations, conferences, and examination of student work.

Phases of Learning: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 2-6 to 2-8.

In practice, within an actual lesson or unit, the acquiring phase of learning may include a series of steps and strategies, such as

- setting the purpose (for example, discrepant events, lesson overviews)
- presenting information (for example, lab demonstrations, guest speakers, mini-lessons, active reading)
- processing information (for example, note making, group discussions, logs, visual representations)
- modelling (for example, role-playing, demonstrations)
- checking for understanding (for example, quizzes, informal conferences)

Applying (Consolidating Learning)

New learning that is not reinforced is soon forgotten. The products and performances by which students demonstrate new learning are not simply required for assessment; they have an essential instructional purpose in providing students with opportunities to demonstrate and consolidate their new knowledge, skills and strategies, and attitudes. Students also need opportunities to reflect on what they have learned and to consider how new learning applies to new situations. By restructuring information, expressing new ideas in another form, or integrating what they have learned in science with concepts from other subject areas, students strengthen and extend learning.

To ensure that students consolidate new learning, teachers plan various learning experiences involving

- reflection (for example, journals, Exit Slips)
- closure (for example, sharing of products, debriefing on processes)
- application (for example, inquiry, design process)

Differentiating Instruction

How can Senior Years science teachers meet each student's learning requirements and still make learning experiences challenging and meaningful for all? One way to help all students achieve the identified student learning outcomes is to differentiate the instructional strategies.

Through differentiating instruction, teachers can

- activate students' prior knowledge
- accommodate multiple intelligences and the variety of learning and thinking approaches
- help students interpret, apply, and integrate information
- facilitate the transfer of knowledge, skills and strategies, and attitudes to students' daily lives
- challenge students to realize academic and personal progress and achievement

Differentiating instruction does not mean offering different programming to each student. Classroom experiences can be differentiated by offering students choices and by varying instructional and assessment strategies to provide challenging and effective learning experiences for all. Ideas and strategies for differentiating instruction are provided in *Senior Years Science Teachers' Handbook* (Manitoba Education and Training) and in *Success for All Learners* (Manitoba Education and Training).

Promoting Strategic Learning

Many of the tasks science students perform are problem-solving tasks, such as finding sources of information for a decision-making activity or developing a method for an inquiry task. To solve problems, students require a strategic mindset. When confronted with a problem, students survey a number of possible strategies, select the one that seems likely to work best for the situation, and try an alternative method if the first one does not produce results.

Strategic learners in the sciences need to have not only a strategic mindset, but also a repertoire of strategies for making meaning, for processing information, and for expressing ideas and information effectively. Whereas skills are largely unconscious mental processes that learners use in accomplishing learning tasks, strategies are systematic and conscious plans, actions, and thoughts that learners select or invent and adapt to each task. Strategies are often described as "knowing what to do, how to do it, when to do it, and why it is useful."

Scaffolding: Supporting Students in Strategic Learning

Many scientific tasks involve a complex interaction of skills. The most effective way to learn, however, is not by breaking down the tasks into manageable parts and teaching the skills separately and in isolation. In fact, this approach may be counter-productive. Purcell-Gates uses the analogy of learning to ride a bicycle, a skill that requires children to develop an intuitive sense of balance while also learning to pedal and steer. Children do not learn to ride a bicycle by focusing on only one of these skills at a time. Instead, they observe others who can ride a bicycle successfully, and then make an attempt themselves. In the early stages of learning to ride, a child counts on someone to provide support—to hold the bicycle upright while the child mounts, to keep a hand on the seat to stabilize the bicycle for the first few metres, and to coach and encourage. Gradually, these supports are withdrawn as the rider becomes more competent. Eventually, the process becomes automatic, and the rider is no longer aware of the skills being performed.

Providing this sort of support in teaching is called "scaffolding" and is based on the work of Wood, Bruner, and Ross. Teachers scaffold by

- structuring tasks so that learners begin with something they can do
- reducing the complexity of tasks
- calling students' attention to critical features of the tasks
- modelling steps
- providing sufficient guided and independent practice

Promoting Strategic Learning: Adapted from Manitoba Education and Training, *Senior 3 English Language Arts: A Foundation for Implementation* (Winnipeg, MB: Manitoba Education and Training, 1999) Section 2-8 to 2-10.

In a sense, each learning strategy is an external support or scaffold. At first, working with a new strategy may be challenging and the main focus of students' attention. Eventually, students use the strategy automatically and rely on it as a learning tool. Students gradually internalize the process of the strategy. They begin to adjust and personalize the process and to apply the thinking behind the strategy automatically.

In strategic instruction, teachers observe and monitor students' use of a strategy for a time, intervening where necessary. Students vary in the length of time they require scaffolding. In this respect, strategic instruction is also a useful tool for differentiation. Struggling learners may work with simplified versions of a strategy, and they may continue to use the supports of a strategy (for example, a graphic organizer for laboratory reports) after other students have internalized the process.

Strategic instruction works best when teachers pace the instruction of new strategies carefully (so that students have time to practise each one), and when they teach a strategy in the context of a specific task of relevant scientific experience.

Learning Resources

Traditionally, the teaching of science in Senior Years has largely been a textbook-centred exercise. The use of a single textbook as the sole resource for the teaching and learning of science severely restricts the development of knowledge, skills and strategies, and attitudes that are critical for today's students. Furthermore, it promotes the idea that all answers are enshrined in a textbook. The successful implementation of Senior 3 Current Topics in the Sciences depends on a resource-based learning approach in which textbooks are used only as one of many reference sources. Research suggests that we should provide a wide range of learning resources for structuring teaching and learning experiences. These include human resources, textbooks, magazines/journals, films, audio and video recordings, computer-based multimedia resources, the Internet, and other materials.

Resources referenced in this curriculum include print reference materials such as *Senior Years Science Teachers' Handbook: A Teaching Resource (SYSTH)* (Manitoba Education and Training) and *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions* (Manitoba Education and Training).

The choice of learning resources, such as textbook(s), multimedia learning resources, including video, software, CD-ROMs, microcomputer-based laboratory (MBL) probeware, calculator-based laboratory (CBL) probeware, and the websites on the Internet, will depend on the unit of study, the local situation, the reading level of students, background of the teacher, community resources, and availability of other materials. A concerted effort should be made to use appropriate learning resources from a wide variety of sources, as not all curricular outcomes can be achieved by using any one resource in the study of a particular theme.

Implementing the Curriculum

Science curricula in the past have focused primarily on presenting a breadth of knowledge (that is, a large amount of content) deemed essential. While the Senior 3 Current Topics in the Sciences curriculum continues to be concerned with students acquiring relevant knowledge, it is equally concerned both with fostering the development of various skills (context-based process skills, as well as skills in decision making, problem solving, laboratory experimentation, critical thinking, and independent learning), and with effecting a change of attitude. A strong focus of this curriculum is to link science to the experiential life of the student.

By offering a multidisciplinary focus, Senior 3 Current Topics in the Sciences provides a solid foundation for scientific literacy. The curriculum, consisting of four general learning outcomes (GLOs), each with a number of specific learning outcomes (SLOs), will build upon what students know and are able to do as a result of their studies in Kindergarten to Senior 2 science. (Refer to Topic Chart for Kindergarten to Senior 2 Science at the end of Section 1.)

Senior 3 Current Topics in the Sciences assumes 110 hours of instructional time.

Unit Development

Senior 3 Current Topics in the Sciences is driven by learning outcomes and process. This design empowers teachers to plan appropriate learning experiences based on the nature of their students, school, and community. Teachers are encouraged to seek their own comfort level with the new curriculum, to share approaches and experiences with colleagues, and to use an integrated interdisciplinary focus to develop and extend student experiences and understandings in new ways. The thematic approach to integrated instruction will allow teachers to work closely together as they develop units that extend across disciplines (Willis).

Working with bigger ideas will allow a more in-depth inquiry. Organizing units around a problem or theme will generally present information in the context of real-world applications (Willis). Students will be presented with opportunities to uncover concepts from each of the sciences during the year in a substantial way and to make coherent connections between them.

> Science deals with major themes in which people are already interested or can readily be interested: life and living things, matter, the Universe, information, the "made-world." A primary reason, therefore, for teaching science to young people is to pass on to them some of this knowledge about the material world, simply because it is both interesting and important—and to convey the sense of excitement that scientific knowledge brings (Millar and Osborne 7).

Choosing a Current Topic

The flexibility of Senior 3 Current Topics in the Sciences allows teachers to design meaningful and engaging interdisciplinary units based on current scientific issues and developments. It is suggested that teachers develop three or four units for this course. The first step in the development of a unit is choosing a topic.

Choosing an effective topic is critical to the success of Senior 3 Current Topics in the Sciences. An engaging topic should have one or more of the following characteristics:

- is age appropriate and accessible to a diversity of learning styles, interests, and abilities
- is meaningful and engaging to students
- is of current societal and scientific significance
- incorporates a significant number of the student learning outcomes identified for this course
- connects a range of science disciplines
- is framed within the context of a question or problem
- provides opportunities for in-depth student-driven inquiry
- provides opportunities for both knowledge acquisition and skill development to arise naturally in context
- will result in a performance-based activity as a culminating experience

Teachers may decide to choose a topic from the suggestions listed below, develop a topic based on one of their own strengths or interests, or involve students in brainstorming a current scientific topic of interest that includes a significant treatment of scientific ideas, perspectives, content, and processes.

Possible Current Themes or Topics

- Are We Alone in the Universe?
- Biotechnology: The Good, the Bad, and the Unknown
- What in the World Is Climate Change?
- Cloning: What Can We Do and What Should We Do?
- Forensic Sciences: Crime Scene Investigation
- Where Will the Next Earthquake Occur?
- Energy Today and Tomorrow: Can We Avoid Large-Scale Blackouts?
- Environmental Interactions
- The Evolution of the Human Species: Where Did We Come From? Where Are We Going?
- Global Warming: Fact or Fiction?
- The Human Endeavour in Space
- Medical Technologies: What’s New?
- Great Geological Controversies: Expanded Earth or Plate Tectonics?
- The “Snowball Earth”: Has the Entire Planet Frozen over in the Past?
- Is the World Doing Enough to Reduce Pollution?
- Recycling: Is It Working?
- Science of Music: Why Do We Like It So Much?
- Sports Science: How Do Science and Technology Aid the Athlete?
- Stem-Cell Research: Ideas and Issues
- Technologies of the Future: What Was Predicted in 1950 and Where Are We Now?
- Transportation in the Future: Getting From A to B
- Water: Will We Ever Run Out?
- Causes and Consequences of Wildfires
- Human Population Cycles: Is There Room for Us All?

Senior 3 Current Topics in the Sciences welcomes and encourages the input of students in the choice of topics and in topic development. Teachers may choose to involve students in the development of a thematic unit. A brainstorming session with the class could allow students to generate topics of interest, from which a unit may be planned, or develop the essential understandings within the chosen unit.

The Forensic Sciences topic has been developed as a sample unit for teachers to consider for use in implementing this curriculum. For a detailed discussion of suggested elements for effective unit design, see Appendix 1. Teachers are encouraged to consult this section of the document before engaging in unit design.