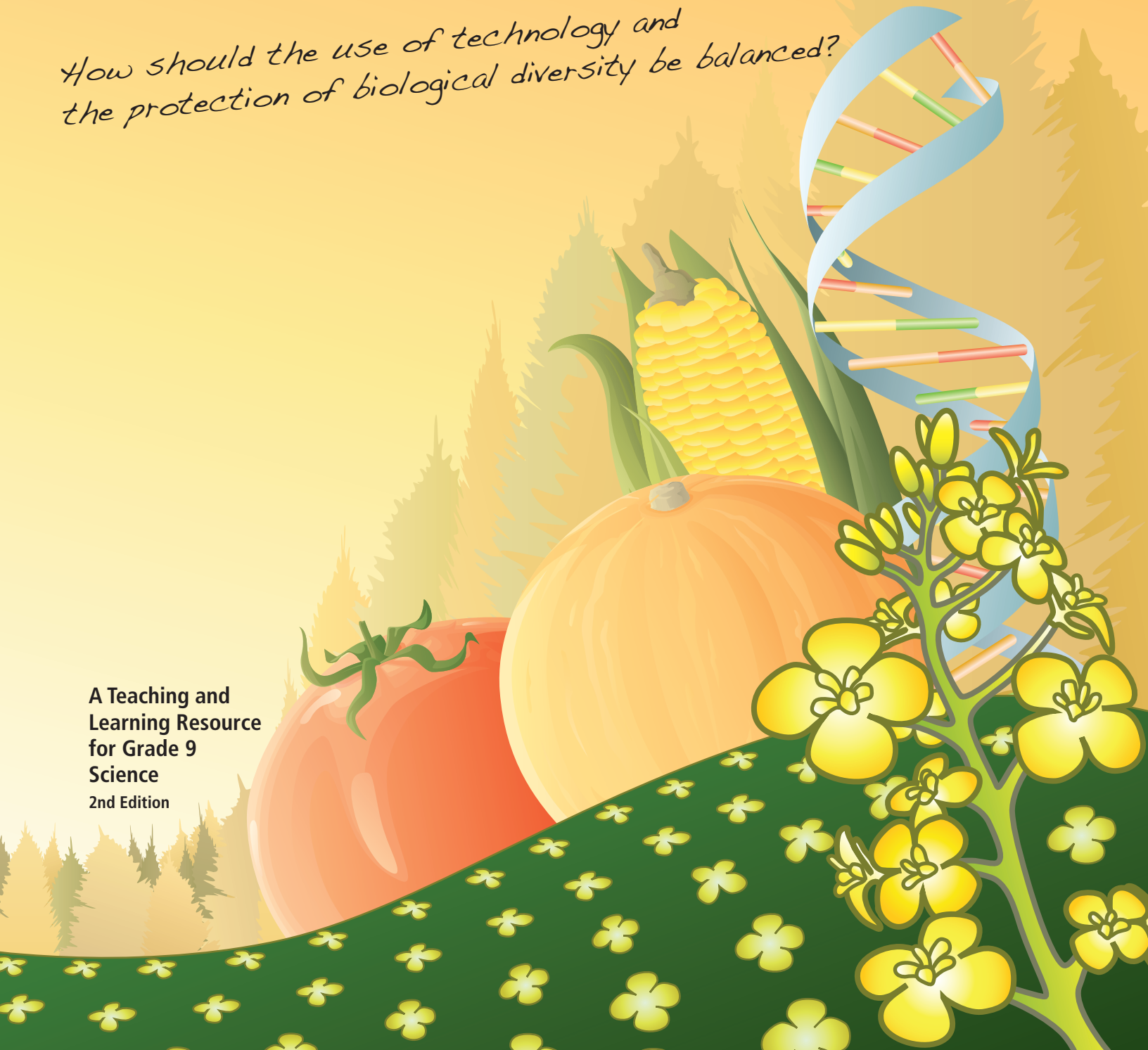
ALBERTA Canola PRODUCERS COMMISSION Critical Issues Guides

Agriculture in Education:
Exploring Critical Issues

Biotechnology & Biological Diversity: A Question of Balance

How should the use of technology and the protection of biological diversity be balanced?



A Teaching and Learning Resource for Grade 9 Science

2nd Edition

Biotechnology & Biological Diversity: A Question of Balance

2nd Edition

Canola producer organizations would like to ensure that teachers and students – today and tomorrow's consumers – have the opportunity to explore scientific, factual information on the effects of genetically modified crops and foods on food safety and the environment. It is essential that, as Canadian citizens, we are aware of both the benefits and the concerns that exist in regard to the production of these crops.

That is why the ***Alberta Canola Producers Commission****, building on curriculum first established in Manitoba and Saskatchewan, is pleased to offer those involved in education in Alberta this resource. We believe that it provides the facts, the options, and some of the opportunities that genetically modified crops offer Canadians. We hope that it is a useful resource in your classroom.*

Simone Demers Collins, BSc, PHEc
Industry Development Officer
Alberta Canola Producers Commission (ACPC)

Alberta Canola Producers Commission gratefully acknowledges the following groups and individuals who have participated in the development of this resource.

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Every effort has been made to acknowledge sources used in this resource. If any have been inadvertently missed, please contact Patricia Shields-Ramsay at InPraxis Group Inc. at 866.925.7163. Corrections will be made in subsequent printings.

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BIOTECHNOLOGY & BIOLOGICAL DIVERSITY: A QUESTION OF BALANCE

How should the use of technology and the protection of biological diversity be balanced?

INTRODUCTION & OVERVIEW

Biological diversity is reflected in the range of species found in local and global environments and by subtle variations in characteristics found within individual species. Diversity is affected by decisions and actions that increasingly rely on complex technologies. This resource explores the impact of biotechnology, focused on agricultural products, on human health and well being as well as on the environment and biodiversity. Students examine biotechnology and explore different perspectives that have created controversy and stimulated much discussion on the issue. The use of canola as an example of a genetically engineered product provides an effective context in which to look at the decisions and options available to society in pursuing biotechnology.

A Critical Issues Approach

Issues that are relevant and meaningful to students support a constructivist, inquiry-based approach to learning. Critical issues frame learning around key questions that pose problems that intrigue and interest students, and set a focus for motivated learning. Posed effectively, critical issues ask students to develop and apply critical thinking skills and look at multiple perspectives, consider alternatives, and recognize that challenges can often involve many different solutions.

This teaching and learning resource is developed around a critical issues approach and promotes inquiry-based learning and critical thinking. The exploration of issues is framed around inquiry questions that are relevant and meaningful to students, engage them in deliberative research and promote social participation skills.

Curriculum Support

This resource supports Alberta's **Grade 9 Science** program of studies. It addresses concepts related to biodiversity and biotechnology and supports the focusing questions of **Topic A: Biological Diversity**. This resource also develops processes and skills, including critical thinking and creative thinking, decision making and problem solving, research and information inquiry, oral, written and visual literacy.

A curriculum correlation chart follows. Specific charts are provided with each of three lesson sequences in this resource, indicating curriculum outcomes for each lesson sequence. These lesson sequences include activities that may take **two to five 50-minute class periods, depending on activities selected.**

Critical Issue & Inquiries

How should the use of technology and the protection of biological diversity be balanced?

Nature or Technology?

How has technology affected species diversity? (Lesson Sequence One)

Vested Interests

How do differing perspectives influence understandings and opinions about biotechnology? (Lesson Sequence Two)

Striking a Balance

How should the needs of humans be balanced with the protection of biological diversity? (Lesson Sequence Three)

Knowledge Outcomes

Focusing Questions
What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts
- biological diversity
- species
- diversity within species
- chromosomes, genes and DNA (introductory treatment)
- natural and artificial selection of genetic characteristics

3. Describe, in general terms, the role of genetic materials in the continuity and variation of species characteristics; and investigate and interpret related technologies

- Describe, in simple terms, some of the newly emerging technologies for recombining genetic material; and identify questions and issues related to their application

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making

- Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity *(e.g., breeding of endangered populations in zoos, development of seed banks, designating protected areas, development of international treaties regulating trade of protected species and animal parts)*

Skill Outcomes

Initiating and Planning
Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*
- State a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict changes to an area of local parkland that is subject to intense use; hypothesize means of impact, such as soil compaction and disturbance of nest sites)*

Performing and Recording
Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting
Analyze qualitative and quantitative data, and develop and assess possible explanations

- Interpret patterns and trends in data, and infer and explain relationships among the variables *(e.g., interpret data on changing animal populations, and infer possible causes)*
- Apply given criteria for evaluating evidence and sources of information *(e.g., evaluate sources based on their currency, credibility and the extent to which claims are supported by data)*
- Identify new questions and problems that arise from what was learned

Knowledge Outcomes

- Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitude Outcomes

- Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., select and explore media on topics related to species diversity; express interest in hobbies and careers that involve the care, culture and study of living things)*
- Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., show awareness that the scientific study of changing animal and plant populations can arise from a variety of global needs, involving many individuals and organizations)*
- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., strive to assess a problem accurately by careful analysis of evidence gathered; critically consider ideas and perceptions, recognizing that the obvious is not always right)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Skill Outcomes

Communication and Teamwork

Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*
- Evaluate individual and group processes used in investigating an issue and evaluating alternative decisions *(e.g., evaluate strategies for locating information, such as the use of particular key words or search tools; evaluate approaches for sharing work on a given research task and for synthesizing the information found)*
- Defend a given position on an issue, based on their findings *(e.g., defend a position on a proposed measure to protect a particular plant or animal population)*

THE CRITICAL ISSUE & INQUIRY PROCESS

How should the use of technology and the protection of biological diversity be balanced?

Related Inquiries

How has technology affected species diversity? (Lesson Sequence One)

In Lesson Sequence One, students focus on the development of biotechnology, using canola as a case study that illustrates the development of genetically altered food, plants, animals and agricultural products. Students investigate the development of agricultural biotechnology over time to develop understandings of the impact of, and issues related to, biotechnology.

How do differing perspectives influence understandings and opinions about biotechnology? (Lesson Sequence Two)

In Lesson Sequence Two, students investigate differing perspectives related to the use of biotechnology and genetically modified food crops. They focus on challenges and benefits for quality of life for farmers, consumers and the environment that result from the use of genetically modified food crops.

How should the needs of humans be balanced with the protection of biological diversity? (Lesson Sequence Three)

In Lesson Sequence Three, students explore discussions and debates around issues surrounding biotechnology, including government regulations, labelling, the potential for loss of biological diversity and benefits that biotechnology can provide.

In their inquiry into this critical issue, students explore the impact of biotechnology on society, the environment and biological diversity. They use canola, a genetically engineered product, as a case study. Students examine the implications of decisions that are made to develop and apply biotechnology and consider how these decisions are interrelated with scientific research, consumer values, environmental movements, economic implications, ethics and social factors. Students reflect on the importance of biological diversity to the maintenance of a balanced environment, and the necessity to explore all perspectives involved in a debate before taking a stance.

This Critical Issues Guide can be integrated with the Critical Issues Guide Consumerism & Quality of Life: Food & Fuel *for Grade 9 Social Studies. It can also be integrated with the Grade 9 lesson sequence in the Critical Issues Guide* Body Image & Food Choices: A Question of Influence *for Grade 9 Health & Life Skills. Discuss the possibility of teaching an integrated lesson with the Social Studies and Health teachers in your school.*

The Process

This resource is structured around inquiry questions that form the basis for exploring the critical issue of the lesson sequence. Each inquiry question provides a focus for the lesson sequence and for deliberative research. Each lesson sequence also contains "I can…" statements that set a context for researching the essential learnings of the lesson sequence, provide criteria for assessment and help students focus their learning. These statements can be shared with students at the beginning of each lesson sequence.

Each of the lesson sequences in this resource is structured around the following features:

- Each lesson sequence provides activities that introduce and explore topics in **two to five 50-minute** class periods. Choices can be made by both the teacher and students about the scope and extent of research and assignments associated with the lesson sequence. Depending on the time available, modify the number of class periods for the lesson sequence.
- Additional activity suggestions provide opportunities to extend the lesson sequence and further develop research and inquiry skills.
- An overview of instructional strategies is provided with each activity.
- Rubrics can be used to assess many of the products that students create in the lesson sequences. Sample rubrics and criteria statements, as well as a template for creating customized rubrics, are provided at the end of this section of the resource.
- Student products may be displayed and shared with other classrooms and students, the school, parents and the community. If appropriate, discuss ways that projects may be completed in cross-curricular contexts with other subject area teachers.

Each lesson sequence is self-contained and provides the instructional process, activity ideas, Briefing Notes and other handouts. **Therefore, teachers should select those activities in the lesson sequences that they are believe will be most effective in supporting their students' learning in the Grade 9 Science program**.

Briefing Notes

Each of the lesson sequences centres on a topic introduced through Briefing Notes. Each Briefing Notes handout opens with *Predict* questions that emphasize critical thinking and connect to students' prior knowledge, understandings, attitudes and assumptions.

The Briefing Notes also provide questions, activities and Internet website links that encourage research and the exploration of multiple viewpoints and opinions on issues relating to agriculture, biodiversity and technology.

The Briefing Notes format provides an opportunity for students to take on a variety of research roles. Each lesson sequence contributes to research that students gather to explore the critical issue. Students should be encouraged revisit, discuss and reflect on the critical issue when the lesson sequences have been completed.

At a Glance

The following chart provides an overview of each lesson sequence, inquiry focus, instructional strategies, curriculum connections and assessment focus in this resource.

Lesson Sequence One

Nature or Technology?

In Lesson Sequence One, students focus on the development of biotechnology, using canola as a case study that illustrates human-caused influences on the development of genetically altered food and agricultural products. Students investigate the development of agricultural biotechnology over time to develop understandings of the impact of, and issues related to, biotechnology.

Inquiry Focus and Key Concepts

How has technology affected species diversity?

- Biodiversity
- Genetic modification
- Genetic engineering
- Transgenic plants
- Genetic variability
- Chromosomes
- Deoxyribonucleic acid (DNA)

Instructional Strategies

- Board Share Brainstorming
- Mind Map and Comparison Chart
- KWHL Chart
- Fiction, Media and Popular Culture

Curriculum Connections

Knowledge

Focusing Questions

What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts

- biological diversity
- species
- diversity within species
- chromosomes, genes and DNA (introductory treatment)
- natural and artificial selection of genetic characteristics

3. Describe, in general terms, the role of genetic materials in the continuity and variation of species characteristics; and investigate and interpret related technologies

- Describe, in simple terms, some of the newly emerging technologies for recombining genetic material; and identify questions and issues related to their application

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making

- Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitudes

- Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., select and explore media on topics related to species diversity; express interest in hobbies and careers that involve the care, culture and study of living things)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Assessment Focus (I Can… Statements)

- **I can** discuss the meaning and implications of biotechnology on agricultural technology and products.
- **I can** identify and describe questions and concerns associated with the use of biotechnology.

Students should understand the impact of biotechnology on society and the environment as well as on diversity of species. They should also start to identify some issues and decisions associated with the use of biotechnology.

Skills

Initiating and Planning

Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*

Performing and Recording

Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting

Analyze qualitative and quantitative data, and develop and assess possible explanations

- Interpret patterns and trends in data, and infer and explain relationships among the variables *(e.g., interpret data on changing animal populations, and infer possible causes)*
- Identify new questions and problems that arise from what was learned

Communication and Teamwork

Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*

Lesson Sequence Two

Vested Interests

In Lesson Sequence Two, students investigate differing perspectives related to the use of biotechnology and genetically modified food crops. They focus on challenges and benefits for quality of life for farmers, consumers and the environment that result from the use of genetically modified food crops.

Inquiry Focus and Key Concepts

How do differing perspectives influence understandings and opinions about biotechnology?

- Biotechnology
- Technology
- Agricultural practices

Instructional Strategies

- Making Predictions with Data
- Research and Inquiry Role Play
- Rotating Interviews
- Futures Wheel

Curriculum Connections

Knowledge

Focusing Questions

What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts

- biological diversity
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- diversity within species

3. Describe, in general terms, the role of genetic materials in the continuity and variation of species characteristics; and investigate and interpret related technologies

- Describe, in simple terms, some of the newly emerging technologies for recombining genetic material; and identify questions and issues related to their application

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making

- Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity *(e.g., breeding of endangered populations in zoos, development of seed banks, designating protected areas, development of international treaties regulating trade of protected species and animal parts)*
- Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitudes

- Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., show awareness that the scientific study of changing animal and plant populations can arise from a variety of global needs, involving many individuals and organizations)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Assessment Focus (I Can… Statements)

- **I can** assess different and conflicting perspectives and opinions on issues involving biotechnology.
- **I can** assess the extent to which biodiversity is affected by human actions.
- **I can** identify and interpret patterns and trends in data relating to biotechnology in order to support my own and others' perspectives.

Students should understand the differing, and sometimes conflicting, perspectives that influence the debate on biotechnology and the effects of human actions on society and the environment.

Skills

Initiating and Planning

Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*
- State a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict changes to an area of local parkland that is subject to intense use; hypothesize means of impact, such as soil compaction and disturbance of nest sites)*

Performing and Recording

Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting

Analyze qualitative and quantitative data, and develop and assess possible explanations

- Interpret patterns and trends in data, and infer and explain relationships among the variables *(e.g., interpret data on changing animal populations, and infer possible causes)*
- Apply given criteria for evaluating evidence and sources of information *(e.g., evaluate sources based on their currency, credibility and the extent to which claims are supported by data)*
- Identify new questions and problems that arise from what was learned

Communication and Teamwork

Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*
- Defend a given position on an issue, based on their findings *(e.g., defend a position on a proposed measure to protect a particular plant or animal population)*

Lesson Sequence Three

Striking a Balance

In Lesson Sequence Three, students explore discussions and debates around issues surrounding biotechnology, including government regulations, labelling, the potential for loss of biological diversity and benefits that biotechnology can provide.

Inquiry Focus and Key Concepts

How should the needs of humans be balanced with the protection of biological diversity?

- Biotechnology
- Producers
- Consumers

Instructional Strategies

- Brainstorming Mind Map
- Policy Statement
- Horseshoe Debate
- Tip Sheet or Top Ten List

Curriculum Connections

Knowledge

Focusing Questions

What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts

- biological diversity
- natural and artificial selection of genetic characteristics

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making

- Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity *(e.g., breeding of endangered populations in zoos, development of seed banks, designating protected areas, development of international treaties regulating trade of protected species and animal parts)*
- Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitudes

- Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., select and explore media on topics related to species diversity; express interest in hobbies and careers that involve the care, culture and study of living things)*
- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., strive to assess a problem accurately by careful analysis of evidence gathered; critically consider ideas and perceptions, recognizing that the obvious is not always right)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Assessment Focus (I Can… Statements)

- **I can** assess conflicting perspectives and consider the balance between the use of biotechnology and the protection of biological diversity.

Students should understand implications and decisions involved in balancing biodiversity with the use and development of biotechnology.

Skills

Initiating and Planning

Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*

Performing and Recording

Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting

Analyze qualitative and quantitative data, and develop and assess possible explanations

- Apply given criteria for evaluating evidence and sources of information (e.g., evaluate sources based on their currency, credibility and the extent to which claims are supported by data)
- Identify new questions and problems that arise from what was learned

Communication and Teamwork

Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*
- Evaluate individual and group processes used in investigating an issue and evaluating alternative decisions *(e.g., evaluate strategies for locating information, such as the use of particular key words or search tools; evaluate approaches for sharing work on a given research task and for synthesizing the information found)*
- Defend a given position on an issue, based on their findings *(e.g., defend a position on a proposed measure to protect a particular plant or animal population)*

ASSESSMENT TOOLS

The assessment criteria statements that follow can be developed into rubrics and applied to many of the products that students develop in the activities in this resource. The criteria statements should be discussed, adapted and developed with students. A template is provided for the creation of customized rubrics.

VISUAL ORGANIZERS

Excellent 4	• Demonstrates a thorough understanding of the topic, its relationships and related concepts and ideas • Provides descriptive labels and organizers; provides information that reflects the topic • Makes appropriate links • Uses the visual organizer to make connections and draw relationships
Proficient 3	• Demonstrates an adequate understanding of the topic and concepts • Provides appropriate labels and organizers • Provides information that relates to the topic • Attempts to make links • Uses the visual organizer appropriately for topic and concepts
Acceptable 2	• Identifies concepts and ideas that relate to the topic • Provides labels and organizers • Includes information that relates to the topic • Uses the format of the visual organizer
Limited 1	• Provides limited information related to the topic • Uses parts of the visual organizer to present information

GROUP ACTIVITIES

Excellent 4	• Demonstrates clear understanding of the group task and their individual contribution to the group • Listens to group members • Expresses original opinions and ideas • Contributes meaningful information and research • Works with the group to fulfill group responsibilities
Proficient 3	• Articulates understanding of the group task and the role they play within the group • Listens to group members • Contributes ideas and information • Fulfills individual responsibilities for the group
Acceptable 2	• Describes the group task • Describes individual role within the group setting • Listens to group members • Contributes information to group task
Limited 1	• Describes individual role within the group setting • Listens to others in the group • Contributes limited ideas

RESEARCH

Excellent 4	• Develops a strategy for conducting research • Develops and identifies research and inquiry questions • Analyzes and assesses sources of information selected for the research task • Records information using an appropriate format • Applies research to inquiry question • Makes effective use of research time
Proficient 3	• Identifies a strategy for conducting research • Identifies research and inquiry questions • Selects and assesses sources of information • Records information using an appropriate format • Identifies links between research collected and inquiry question • Makes effective use of research time
Acceptable 2	• Uses a previously identified strategy for conducting research • Records research and inquiry questions • Selects and reads sources of information • Records information using an appropriate format • Uses information from sources to answer inquiry questions
Limited 1	• Selects and reads sources of information • Records identified research and inquiry questions • Records information using an identified format • Identifies information from sources that relates to inquiry questions

PROJECTS

Excellent 4	• Develops a project planning strategy and process • Identifies goals and purpose of project • Demonstrates understanding of topics and concepts represented in the project • Selects an appropriate method of constructing and creating project • Uses research and information gathered appropriately and effectively in the project • Demonstrates ability to summarize and synthesize infor-mation within the project • Displays learning with pride in final presentation of project
Proficient 3	• Identifies a project planning strategy and process • Identifies purpose of project • Selects information relating to topics and concepts under study for the project • Selects an appropriate method of constructing and creating the project • Uses research and information gathered appropriately and effectively in the project • Demonstrates ability to summarize information within the project • Displays learning appropriately in final presentation of project
Acceptable 2	• Uses a previously identified project planning strategy and process • Selects information relating to topics and concepts under study for the project • Selects a method for constructing and creating the project • Uses research and information gathered throughout the project • Displays learning adequately in final presentation of project
Limited 1	• Selects information relating to topics and concepts under study for the project • Constructs and creates the project using an identified approach • Uses information gathered for the project

RUBRIC

Excellent 4	
Proficient 3	
Acceptable 2	
Limited 1	
No work completed 0	

LESSON SEQUENCE ONE: NATURE OR TECHNOLOGY?

Overview

In Lesson Sequence One, students focus on the development of biotechnology, using canola as a case study that illustrates the development of genetically altered food, plants, animals and agricultural products. Students investigate the development of agricultural biotechnology over time to develop understandings of the impact of, and issues related to, biotechnology.

Rationale

Students should understand the impact of biotechnology on society and the environment as well as on diversity of species. They should also start to identify some issues and decisions associated with the use of biotechnology.

Presenting students with "I can…" statements can help focus their learning and provide a context for assessment with this lesson sequence's activities.

> ***"I CAN"***
>
> *Lesson Sequence One encourages students to demonstrate their learning by developing understandings such as the following:*
>
> - ***I can*** *discuss the meaning and implications of biotechnology on agricultural technology and products.*
> - ***I can*** *identify and describe questions and concerns associated with the use of biotechnology.*

Inquiry

How has technology affected species diversity?

Key Concepts

Biodiversity *Genetic modification* *Genetic engineering*
Transgenic plants *Genetic variability* *Chromosomes*
Deoxyribonucleic acid (DNA)

Preparation

Suggested Time: 2 to 4 50-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
  - o Briefing Notes 1A: Biotechnology & Agriculture
  - o Student Resource 1B: KWHL Chart
- Chart paper
- Optional Extension: Local media sources, including newspapers and magazines (*Ask students to bring copies of current newspapers from home to establish a classroom collection.*)
- Optional Extension: Literature and popular culture sources related to genetic engineering and biotechnologies
- Internet access and interactive whiteboard to display and share website links

Inquiry

Nature or Technology?

How has technology affected species diversity? (Lesson Sequence One)

Knowledge

Focusing Questions
What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts
- biological diversity
- species
- diversity within species
- chromosomes, genes and DNA (introductory treatment)
- natural and artificial selection of genetic characteristics

3. Describe, in general terms, the role of genetic materials in the continuity and variation of species characteristics; and investigate and interpret related technologies

- Describe, in simple terms, some of the newly emerging technologies for recombining genetic material; and identify questions and issues related to their application

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making

- Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitudes

- Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., select and explore media on topics related to species diversity; express interest in hobbies and careers that involve the care, culture and study of living things)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Skills

Initiating and Planning
Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*

Performing and Recording
Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting
Analyze qualitative and quantitative data, and develop and assess possible explanations

- Interpret patterns and trends in data, and infer and explain relationships among the variables *(e.g., interpret data on changing animal populations, and infer possible causes)*
- Identify new questions and problems that arise from what was learned

Communication and Teamwork
Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*

Students should have initially explored the diversity of species and the role of genetic materials in the continuity and variation of species characteristics; and have a general understanding of chromosomes, genes and DNA as repositories of genetic information.

Lesson Sequence One Teaching and Learning Strategies

How has technology affected species diversity?

Introductory Activity

Students begin with a brainstorming activity in which they think about and discuss how human actions affect other species and the environment. Students are encouraged to review and consider what they know about ways technologies have brought about change. Students may be started off with examples such as new or better machines and tools to increase production or the development of chemicals or pesticides.

Instructional Strategy: Board Share Brainstorming

A board share *is a cooperative learning activity that encourages students to work as a whole class group to brainstorm ideas, experiences and insights around a specific topic or question. The board share structure encourages students to generate their own ideas and insights as well as consider, and add to, the ideas of others in the class.*

A board share strategy asks students to work in small groups and brainstorm responses to a question. While the group brainstorms, an appointed recorder records the group's ideas on the board.The recorder is responsible for ensuring that all of the group's ideas are recorded.

PROCESS

1. Place the words "genetics" and "technology" on the board. Ask students to review what they know about each concept.

2. How have genetics and technology resulted in changes to people's ways of life? How have they resulted in changes to the environment? Use a group share strategy such as a board share and record brainstormed ideas in the form of a brainstorming web on the board, an interactive whiteboard or on chart paper.

*Inside the nucleus of a cell are long, thread-like structures called **chromosomes**. Chromosomes are made up of a tightly packed chemical called **deoxyribonucleic acid** (DNA).*

*The structure of DNA is similar to a ladder - each "rung" is made up of two linked molecules called nucleotides. There are only four nucleotides and they are common in all living things - microorganisms, plants, animals and humans. The DNA ladder is organized into sections called **genes**. Each gene contains the instructions for building one specific protein.*

***Genetic engineering** takes advantage of the fact that DNA has the ability to copy itself. First, the DNA splits down the middle, leaving each nucleotide of the pair available to form new rungs with other nucleotides. Since the nucleotides are the same in all living things, scientists can add genes from other species when the DNA is replicating, and the nucleotides will be included in the new DNA molecule.*

*The unique proteins that are produced from the transferred gene can be "fingerprinted" to determine if plant material has been **genetically modified**.*

DIFFERENTIATE

If necessary, use a whole class discussion to review concepts related to genetic information – chromosomes, genes and DNA. Work with the class to record general definitions of each term. Then, ask students to discuss their understandings of technology, listing key terms associated with this concept on the board.

3. **Extend:** Ask students to find evidence of change to society and the environment that has resulted from scientific research and discoveries in the field of genetics from a variety of media sources, such as newspapers, magazines and the internet. Have students work in small groups to create a poster list or collage and display the posters in the classroom.

4. Tell students that a human activity strongly impacted by developments in genetic technology is the field of agriculture. Ask students to think about and share initial ideas about how agricultural practices and products have changed over time. Do they think the use of technology in agriculture has resulted in more and better products? Why or why not?

5. Introduce the critical issue to students by writing it on the board: *How should the use of technology and the protection of biological diversity be balanced?* Tell students that they will be starting to explore this question in the context of agricultural developments and change, biotechnology.

Briefing Notes Activity

Students read and discuss the Briefing Notes with a partner. They review the concept of biodiversity and are introduced to the concept of biotechnology. They then explore the impact of biotechnology on agriculture, focusing on canola as an example of a product that has been affected by genetic engineering.

Instructional Strategy: Mind Map and Comparison Chart

Reading for meaning and summarizing main points by using visual organizers, such as the mind map and comparison chart used in this activity, requires students to synthesize information, critically evaluate relationships and make connections to their prior knowledge and understandings. The visual organizers also ask students to organize information and conclusions in order to start to make comparisons.

PROCESS

1. Provide each student with a copy of **Briefing Notes 1A: Biotechnology & Agriculture**. Work with students to discuss or respond in writing to the *Predict* questions at the beginning of the handout.

2. Have students read the Briefing Notes and respond to the questions at the end of the handout. These questions include:
   - Why do you think species diversity is important to meet people's needs? How do you think it is important for the development of agricultural products?
   - What strategies do you think are most effective in protecting diversity? Why are these strategies effective?
   - How has biotechnology resulted in new food and health-related products over time?
   - What are some of the products that you think are taken for granted today that are produced as a result of biotechnology?
   - What do you think are some possible risks or abuses of biotechnology?
   - What positive and negative effects do you think biotechnology could have on:
     - o Diversity of species
     - o The environment
     - o People's health and well being?

3. Ask students to use the information from the Briefing Notes and their own research to complete the mind map and comparison chart activities.

DIFFERENTIATE

Students can be grouped randomly using a variety of methods:

- *Use playing cards that correspond to the topic numbers and randomly hand them out to assign groups or pairs to a question.*
- *Number each pair randomly to match them to each question.*
- *Use a spinner and numbered wheel to provide each pair or group with the opportunity to select a question on which to focus in the order in which their number is selected.*

A detailed overview of biotechnology in Canada as it relates to agricultural production can be found in Agriculture and Nutrition Biotechnology: The Next Generation of Healthy and Green Living*, accessed at www.biotech.ca/uploads/pdf/agriculture-nutrition-en.pdf.*

The DNA for Dinner *webquest, found at http://dnafordinner.blogspot.ca/, includes a number of links that students may find useful as resources.* ***Remind students that the webquest has been created by individuals and may reflect their perspectives or biases.***

Closing Activity

Students complete a KWHL chart that focuses on the issue of balancing the application of technology with the protection of biological diversity. They apply what they have learned from the Briefing Notes to the development of further research questions.

Instructional Strategy: KWHL Chart

Group discussion, analysis and synthesis of information encourage students to draw conclusions and ask questions that lead to further research. Using a KWHL chart, students link their prior knowledge and understandings to ideas for further research.

PROCESS

1. Present the following questions to students as a class, asking them to share their insights from the Briefing Notes:
   - What are some possible issues and controversies involved in human use of plant and animal species?
   - What future impact might continued use of genetic information have on the ways society uses plant and animal species?
2. Revisit the critical issue question, *How should the use of technology and the protection of biological diversity be balanced?* Have each student complete **Student Resource 1B: KWHL Chart**. Trade the chart with another student and discuss ideas that are similar and different.
3. Ask students to consider how they think scientific research related to genetics and increasing uses of different types of technologies has affected ways of life and the environment. In addition to the questions students have brainstormed in their KWHL charts, work with the class to shape and refine focus questions for further research, such as:
   - To what extent has society's growing knowledge of genetics affected and changed the ways society uses plant and animal species?
   - How do you think the ways we use and depend on plant and animal species has changed because of our use of different types of technology?
   - What impact has scientific research and technology had on the diversity of plant and animal species that society depends upon?

DIFFERENTIATE

Providing the KWHL chart at this point in the lesson provides students with the opportunity to reflect on what they have learned from the Briefing Notes as well as identify questions they have for further research. The KWHL chart can also be used to identify the different interests and learning supports that individual students have. To complete the KWHL chart, provide students with the following choices:

- *Completing the chart on their own*
- *Completing the chart in a small group*
- *Working with you to complete the chart.*

Extension Activity

Students work on their own or with a partner to explore sources of fiction and popular culture that relate to the future impact of technologies, such as genetic engineering. What is based on science and what is not?

Instructional Strategy: Fiction, Media and Popular Culture

Asking students to explore the ways that science is represented in literature and popular culture encourages them to compare and analyze research-based information and concepts with predictive and imaginative conceptions of the present and future. Literature and sources of popular culture bring meaning and personal connections to science concepts. These types of sources can also encourage students to consider the value of imagination in scientific inquiry and the messages that literature and popular culture portray about science and technological advancements.

PROCESS

1. Invite students to share examples of stories, literature, music and media that relate to the applications of existing and possible technologies in agriculture.

2. Ask students to work individually or with a partner to create a poster around one of the examples of literature or popular culture that portrays a message, either positive or negative, about the potential implications of genetic engineering on society, health and well being, or the environment. Alternatively, students can write their own short story or create their own media source around this topic.

3. Ask students to critically analyze the literature or popular culture source they select – how does it reflect "real" or substantiated research and what is unrealistic and fictionalized?

4. Invite students to present and share their projects with others in the class.

DIFFERENTIATE

Students can be provided with the choice of working individually, with a partner or in a small group. Students can also be provided with a number of choices in creating their product – designing a poster, writing a short story or media source, creating a song, script or poem or recording a news broadcast.

Biotechnology & Agriculture

Predict

How would you define the term biotechnology? Think about the items you use on a daily basis. Which items do you think have been affected by biotechnology?

Extend

Do you know anyone who does a lot of gardening? Ask them whether and how they have changed or altered the plants they work with. Keep a record of what you have found out. Share it with your classmates.

***Biotechnology**, as defined in the* Canadian Environmental Protection Act, *is the application of science and engineering in the direct or indirect use of living organisms, or parts or products of living organisms, in their natural or modified forms.*

*Understanding **biotechnology** involves an understanding of the concepts of biology, diversity and technology. Biology is the study of living things and technology refers to the tools and processes used to make products. Together, these concepts mean using biology to make new products, including food products.*

*Biotechnology can involve actions as simple as manipulating an organism for a purpose. Cheese, for example, is a food which is dependent on biotechnology. In the past, **rennet**, an enzyme taken from the stomach of a calf, was needed for the production of cheese. Now the enzyme chymosin is a synthetic replacement for rennet in the manufacturing of cheese. Chymosin is produced through genetic modification. The canola plant is also a genetically modified crop. Crushed seeds from the canola plant are used to produce canola oil. The by-product, canola meal, is used as a livestock feed.*

***Biodiversity** comes from the words biology and diversity. Biodiversity refers to the variety of species found in different environments and the variation in characteristics found within these these species.*

What does biotechnology have to do with agriculture?

Biotechnology is one of the earliest farming practices. The process of clearing an area of land to seed a single plant is biotechnology in its simplest form. However, over a hundred years ago, most farmers only had an instinctive knowledge of the ways that reproduction could be manipulated to produce different plant varieties. As both farmers and scientists learned more about the implications of DNA and the ways plants reproduced, plant breeders started to breed individual varieties with particular traits to emphasize traits in plants that were considered beneficial or desirable. There are examples of biotechnology used for food production as well. Traditional production methods such as grafting plants, breeding animals for desirable traits and using enzymes to make cheese are all examples of biotechnology that we use every day.

Biotechnology is not a new science – it has been used safely in medical and pharmaceutical products for years. One of the best examples is human insulin for the treatment of diabetes. Scientists were able to produce a bacterium that contained the gene for insulin. Before the development of biotechnology, most insulin was taken from the pancreas of animals.

Tools of modern biotechnology also make it possible to move genetic material between species that would otherwise never breed. This has lead to the development of crops that can tolerate herbicides and insects, and to the improvement in the quality of food for processing.

Modern biotechnology also makes changes or modifications to the genetic material of living things. What do we mean by the term **genetic modification** (GM)? In general terms, GM means any change in the heritable traits of an organism. In the past, selective breeding was used to select seeds or animals for reproduction

to influence the traits of the next generation. In today's society, the term is more often used to describe one particular tool called **genetic engineering**, which allows scientists to transfer the **genes**, hereditary units of living things, from one species to another. Genetic engineering is a very precise technology compared with traditional breeding. Genetic engineering of plants results in **transgenic** plants – plants that combine genes from different species. Some genetic engineering practices are widely accepted, while others are controversial.

Source:
Critical Thinking About Biotechnology. Manitoba Canola Growers Association.

EXPLORE

Most techniques for creating new plants can be described by one of these three categories – grafting, hybrids and transgenics. Use a mind map to create a definition for each of these techniques.

- **Put the term "biotechnology" in the centre of your mind map and your definitions for each term in the boxes or circles leading from the map.**
- **Add definitions or examples to each definition by exploring and investigating other sources of information related to biotechnology and these techniques.**

Extend

In a group of three, assign one of these techniques – grafting, hybrids and trangenics – to each group member. Research what is involved in each and share your findings with your group members.

Find Information

Three Ways to Make a New Plant, accessed on the Exploratorium website at www.exploratorium.edu/gardening/control/3ways/index.html, provides information on each of these three categories and discusses examples of ways that reproductive processes are manipulated by people.

Find out more about genes, DNA and heredity on *DNA from the Beginning*, accessed at www.dnaftb.org. You may need to work through the content on this website with a partner.

Explore *Biotech Adventure*, found at http://animalsciences.missouri.edu/biotech/, for animated information and illustrations on topics related to genetics and biotechnology.

Explore a timeline of the development of biotechnologies in the *Biotechnology Learning Center* at www.childrensmuseum.org/biotech. Click on the *Biotech Timeline* link in the left sidebar, or go directly to www.childrensmuseum.org/biotech-timeline.

Source:
This discussion is adapted with permission from *The Value of Biodiversity to Farming on the Prairies* (January 2006) Nature Saskatchewan.

Why be concerned about biodiversity?

Biodiversity is of great importance to farmers. Crops, livestock, insects, water systems, soils and natural landscapes all interact with each other. If the balance of these factors is carefully maintained, they function together to the benefit of agriculture.

The first aspect of biodiversity is **genetic variability** within a species. Genetic variability is vital to the long-term health and economic feasibility of farming, as well as the world's food supply. For example, variability within a crop species is essential for the development of disease resistance, and yield and quality improvement. Genetic variety also allows crops to tolerate a variety of soil or climate conditions.

Encouraging different species is another aspect of biodiversity. Selecting different crop species increases a farmer's ability to respond to events such as pest infestations, climate shifts or consumer demands. It is essential to maintain both types of biodiversity to ensure the sustainability of the world's food supply.

Farmers have long depended on nature and the land for their livelihood and ways of life. Farms also play an important role in the maintenance of biodiversity and healthy ecosystems. Farmers have the opportunity to make great contributions without making major changes to their practices.

Farms act as a buffer between urban or industrial use of the land and nature itself. As human activity increases, the long-term sustainability, production and stability of agriculture and ultimately society may be threatened. Farmers who monitor and encourage biodiversity can help reduce those threats.

Remarkably, as few as 80 plant crops provide approximately 90 percent of the world's food (estimated by the Food and Agriculture Organization). Thousands of other plant species are actively farmed on a small scale, and tens of thousands of plants worldwide are known to have edible parts. Wheat, rice and corn are now the three most abundant plants on earth, providing about 60 percent of human food.

Agriculture and Agri-Food Canada states that the low diversity of our major crops is a serious problem for Canadian agriculture. As the genetic diversity of crops declines, the risk of major failures in the world food supply increases, while the ability to improve food technology decreases.

In cultivated areas, most biodiversity is in the soil. The farm benefits when the soil's natural productivity is managed sustainably. Soil is the most biologically diverse part of the earth. Topsoil has a rich complement of organisms that decompose plant and animal residue, and then release their stored nutrients slowly over time. Living topsoil contains earthworms, fungi, bacteria, protozoa, arthropods, algae and small burrowing mammals, all working to till and fertilize the soil so plants on the surface can thrive.

Natural areas provide buffers to minimize erosion and filter migrating pollutants. These areas are rich in biodiversity and are great sources of beneficial insects such as pollinators, predators and parasites of crop pests. Biodiversity conservation is supported by small natural or semi-natural habitats and by the production of a wide variety of crops and breeds of livestock.

The long-term viability and profitability of agriculture depends on maintaining diversity within crops and their wild relatives, within natural ecosystems and within the agricultural landscape.

EXPLORE

Why do you think species diversity is important to meet people's needs? How do you think it is important for the development of agricultural products?

What strategies do you think are most effective in protecting diversity? Why are these strategies effective?

Find Information

Learn why biodiversity is important on the David Suzuki Foundation website at *www.davidsuzuki.org*. Use the search function on this website and the search term "biodiversity" to find current articles and information.

Explore the *Canadian Biodiversity* website at *http://canadianbiodiversity.mcgill.ca/english/index.htm*.

Find out about agricultural biodiversity from the United Nations Convention on Biological Diversity website at *www.cbd.int/agro/*.

Visit *Why Save Seeds?* on the Science of Gardening website at *www.exploratorium.edu/gardening/control/seeds/two.html*

The case of canola

What is canola?

Canola is the combination of two words – Canadian and oil. Canola oil is produced by crushing seeds from Canada's major oilseed crop – canola. Canadian plant breeders developed canola from rapeseed. This was done using traditional plant breeding methods specifically to enhance nutritional qualities.

Canola is the most commonly grown oilseed crop in Canada. It is grown mostly in western Canada. Canola plants grow up to 2 metres tall and produce groups of yellow, four-petalled flowers. The flowers produce small green pods about 5 cm long. As the plant ripens, the pods turn brown. When harvested, each pod is cracked open to yield about 20 tiny, round, black or brownish-yellow seeds. Each canola seed is approximately 44 percent oil. The seeds are crushed to obtain canola oil for human consumption and the remainder is processed into canola meal that is used as a high protein livestock feed.

Canola oil is used mainly as a cooking or salad oil, or processed into margarine. Canola oil is also used in the manufacture of many other products such as inks and cosmetics. Canola meal is used as feed for livestock, poultry and pets. Scientists are also developing industrial uses for canola oil as possible machinery and biodiesel fuel.

*Traditional plant breeding began many thousands of years ago, when people learned that some crops of the same species grew better or tasted better than others. This was the start of **selective breeding**. As agriculture became an increasingly important part of many societies, farmers experimented more with selection. They looked for plants that adapted better to the environment and produced higher yields. The seeds from these plants were continuously planted and selected to keep improving the crop.*

Find Information

Want to learn more about how canola is grown? Check out the Canola Council of Canada website at *www.canolacouncil.org*. Check out Canola: The Myths Debunked at *www.canolacouncil.org/oil-and-meal/canola-oil/canola-the-myths-debunked*.

Curious about the wide range of products that canola can be used for? Go to the Canola Information Service website at *www.canolainfo.org* and use the links at the top to find information about canola oil, its health benefits and the food industry.

Canola and biotechnology – What's the story?

Producers in Canada can choose to grow a number of different types or varieties of canola. Argentine canola *(Brassica napus)* or long season types are the most commonly grown. Shorter season Polish types *(Brassica rapa)* are grown on about 5 percent of the acreage in western Canada.

Brassica napus types include conventional canola varieties, as well as herbicide-tolerant varieties. Genetically modified (GM) canola types include Roundup Ready, Liberty Link and Bromoxynil-tolerant canola varieties. These varieties are genetically modified because genes that result in tolerance to a specific herbicide were transferred from bacteria into the plant material. The herbicide-tolerant gene was found in bacteria commonly found in the soil.

How are GM crops made?

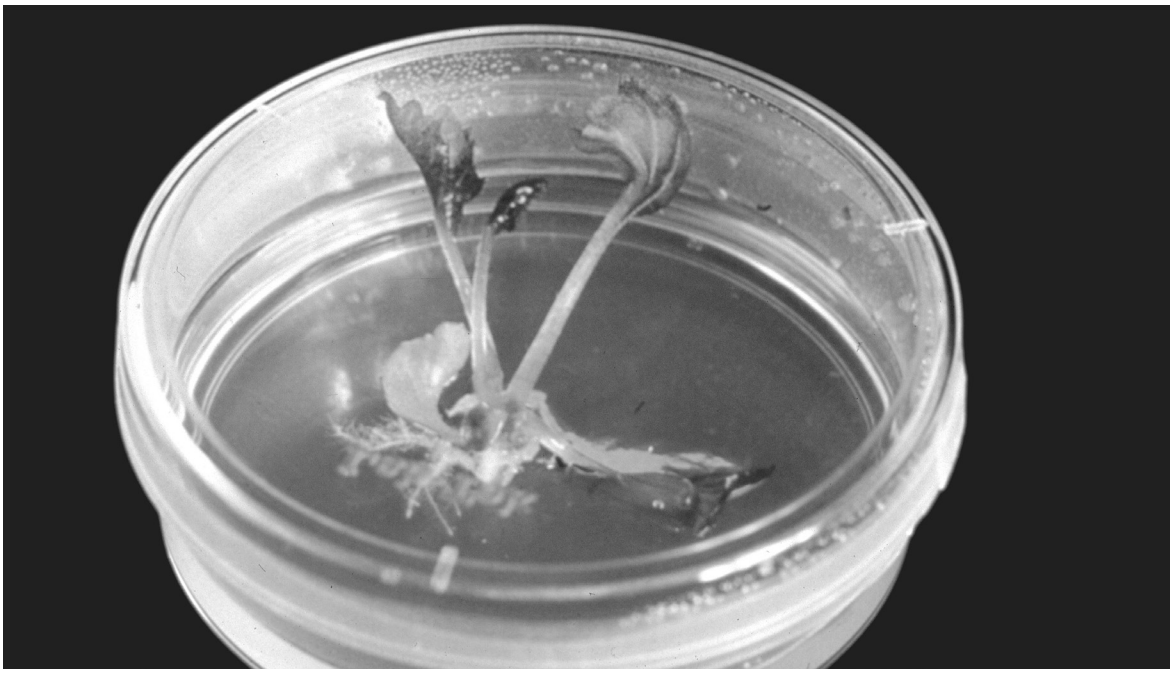
All living things are made up of **cells**, the smallest units of life. At the centre of each cell is the nucleus. Inside the nucleus of a cell are long, thread-like structures called **chromosomes**. Chromosomes are made up of a tightly packed chemical called **deoxyribonucleic acid** (DNA).

The structure of DNA is similar to a ladder – each "rung" is made up of two linked molecules called **nucleotides**. There are only four nucleotides and they are common in all living things – microorganisms, plants, animals and humans. The DNA ladder is organized into sections called **genes**. Each gene contains the instructions for building one specific protein.

Genetic engineering takes advantage of the fact that DNA has the ability to copy itself. First, the DNA splits down the middle, leaving each nucleotide of the pair available to form new rungs with other nucleotides. Since the nucleotides are the same in all living things, scientists can add genes from other species when the DNA is replicating, and the nucleotides will be included in the new DNA molecule.

The unique proteins that are produced from the transferred gene can be "fingerprinted" to determine if plant material has been genetically modified. Canola oil is produced from a GM plant. During heat processing of canola oil, protein is generally removed. Because the genetic modification is attached to the protein, it is accepted that canola oil from a genetically modified seed is the same as the oil extracted from a classic seed.

DNA, or protein, remains in canola meal after the seeds are crushed. By testing the meal, the specific canola can be identified as a genetically modified variety.



Find Information

Want to know more about how scientists are using biotechnology? Check out the *Student Science & Tech* page on the National Research Council Canada website and look for examples of science innovations related to biotechnology. Find out how the National Research Council Canada is involved with canola innovation in *NRC Research Helps Build a Billion-Dollar Canola Business* at *www.nrc-cnrc.gc.ca/eng/education/innovations/discoveries/canola.html*.

EXPLORE

How has biotechnology resulted in new food and health-related products over time?

What are some of the products that you think are taken for granted today that are produced as a result of biotechnology?

What do you think are some possible risks or abuses of biotechnology? Describe at least two examples below.

What positive and negative effects do you think biotechnology could have on:

- **Diversity of species**
- **The environment**
- **People's health and well being?**

	Diversity of species	The environment	People's health and well being
Positive effects			
Negaitive effects			

KWHL Chart

How should the use of technology and the protection of biological diversity be balanced?

Biological diversity is reflected by the range of species found in different environments. This diversity can be influenced by human activity. Biotechnology is an example of a technology used in agricultural production.

What I Know	
What I Want to Know More About	
How I Will Find This Out	
What I Learned	

DEFINING TERMS

Write your definition for each term:

Biodiversity

_____

_____

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Biotechnology

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Genetic engineering

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LESSON SEQUENCE TWO: VESTED INTERESTS

Overview

In Lesson Sequence Two, students investigate differing perspectives related to the use of biotechnology and genetically modified food crops. They focus on challenges and benefits for quality of life for farmers, consumers and the environment that result from the use of genetically modified food crops.

Rationale

Students should understand the differing, and sometimes conflicting, perspectives that influence the debate on biotechnology and the effects of human actions on society and the environment.

Presenting students with "I can…" statements can help focus their learning and provide a context for assessment with this lesson sequence's activities.

Inquiry

How do differing perspectives influence understandings and opinions about biotechnology?

Key Concepts

Biotechnology *Technology* *Agricultural practices*

Preparation

Suggested Time: 3 to 5 50-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
  - Student Resource 2A: What the Data Says
  - Briefing Notes 2B: Vested Interests
  - Student Resource 2C: Explore Perspectives
  - Student Resource 2D: Wheel Chart
- Index cards or file folders
- Variety of research sources related to biotechnology
- Internet access and interactive whiteboard to display and share website links

"I CAN"

Lesson Sequence Two encourages students to demonstrate their learning by developing understandings such as the following:

- ***I can** assess different and conflicting perspectives and opinions on issues involving biotechnology.*
- ***I can** assess the extent to which biodiversity is affected by human actions.*
- ***I can** identify and interpret patterns and trends in data relating to biotechnology in order to support my own and others' perspectives.*

Inquiry

Vested Interests

How do differing perspectives influence understandings and opinions about biotechnology? (Lesson Sequence Two)

Knowledge Outcomes

Focusing Questions
What is biological diversity, and by what processes do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts
- biological diversity
- species
- diversity within species

3. Describe, in general terms, the role of genetic materials in the continuity and variation of species characteristics; and investigate and interpret related technologies
   - Describe, in simple terms, some of the newly emerging technologies for recombining genetic material; and identify questions and issues related to their application
4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making
   - Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity *(e.g., breeding of endangered populations in zoos, development of seed banks, designating protected areas, development of international treaties regulating trade of protected species and animal parts)*
   - Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitude Outcomes

- Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., show awareness that the scientific study of changing animal and plant populations can arise from a variety of global needs, involving many individuals and organizations)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Skill Outcomes

Initiating and Planning
Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*
- State a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict changes to an area of local parkland that is subject to intense use; hypothesize means of impact, such as soil compaction and disturbance of nest sites)*

Performing and Recording
Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting
Analyze qualitative and quantitative data, and develop and assess possible explanations

- Interpret patterns and trends in data, and infer and explain relationships among the variables *(e.g., interpret data on changing animal populations, and infer possible causes)*
- Apply given criteria for evaluating evidence and sources of information *(e.g., evaluate sources based on their currency, credibility and the extent to which claims are supported by data)*
- Identify new questions and problems that arise from what was learned

Communication and Teamwork
Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*
- Defend a given position on an issue, based on their findings *(e.g., defend a position on a proposed measure to protect a particular plant or animal population)*

Lesson Sequence Two Teaching and Learning Strategies

How do differing perspectives influence understandings and opinions about biotechnology??

Introductory Activity

What attitudes towards biotechnology do producers and the public share? In this activity, students examine data related to biotech crop production, population growth and consumer attitudes.

Instructional Strategy: Making Predictions with Data

Asking students to predict and make inferences develops critical thinking skills. The use of visual data encourages students to look for connections and relationships, draw conclusions, and make predictions that can form the basis of research questions.

Asking students to draw conclusions and develop generalizations about patterns and recurring ideas develops critical thinking skills. Activities that ask students to use statistics and data also encourage numerical thinking skills.

PROCESS

1. Ask students to review what they have learned about biotechnology and agriculture from Lesson Sequence One. Introduce the inquiry question to students: *How do differing perspectives influence understandings and opinions about biotechnology?* Have them consider research questions that would help them explore this inquiry question. Students may be encouraged to consider research questions such as:
   - What types of crops are currently modified with biotechnology practices?
   - What attitudes do people have toward products produced as a result of biotechnology?
   - Have attitudes changed over time? How?
2. Have students work with a partner to brainstorm research questions on poster paper, or have the class brainstorm and record their questions on a class list or a smartboard.
3. Provide students with **Student Resource 2A: What the Data Says**. Have students work with a partner to examine the data in the handout and respond to the questions.
4. Invite each pair to make predictions about the range of opinions and perspectives that may influence the use of biotechnology in the future. Record predictions on chart paper and post in the classroom.

Briefing Notes Activity

Students read and discuss the Briefing Notes with a small group. They investigate different perspectives that influence decisions about the use of biotechnology in agriculture.

Instructional Strategy: Research and Inquiry Role Play

Research strategies for an issue should address:

- *The concepts related to the issue: What does this issue mean? How should the terms be defined?*
- *The information connected with the issue: What are the facts? What differing perspectives are represented?*
- *The values and attitudes reflected in positions that people take: What points of view do people have? What facts and/or perspectives are their opinions based on?*

A variety of articles and presentations relating to biotechnology can be found on the CropLife Canada website at www.croplife.ca/plant-biotechnology.

Role play is a strategy that encourages students to develop understandings and appreciation for other perspectives and consider how various factors can influence perspectives, attitudes and opinions. Role play can also encourage students to integrate and compare data and research with values and attitudes.

In a role play, students should be encouraged to research and consider the influences and background of the role they are taking on. They should also investigate the validity and data that supports a point of view or opinion. Therefore, it is important to have students develop a background for the person whose role they are being asked to play. Students can also be asked to develop a role play that represents each attitude or opinion. This helps promote understanding of differences and empathy towards others and solidifies their understanding of the topics at hand.

PROCESS

1. Provide each student with a copy of the **Briefing Note 2B: Vested Interests**. Work with students to discuss or respond in writing to the *Predict* questions at the beginning of the handout.

2. Have students work with a small group to research and investigate the differing perspectives that influence the use and development of biotechnology and the possible impact that biotechnology can have on species diversity, society and the environment.

3. Ask each group to choose a specific role, provided in the Briefing Notes, to investigate further. Have groups use classroom resources, the internet and other research sources to identify perspectives and data that each role would bring to a debate on the extent to which biotechnology should be developed and applied to agricultural products.

4. Provide each group with index cards or a file folder in which to develop their role and record supporting data. Invite groups to present their perspectives, taking on the role that they have researched.

Closing Activity

Students use their research to interview each other and explore different perspective and opinions related to biotechnology. They then prepare an individual position statement.

Instructional Strategy: Rotating Interviews

Interviews provide students with an opportunity to share research and perspectives with others. Rotating interviews are similar to a carousel strategy, in which groups move from one task or learning station to another. In a rotating interview, groups interview each other. Half of the groups stay at their tables or desks, while the other half moves from group to group and conducts the interview. Groups then switch roles.

PROCESS

1. Provide each group with **Student Handout 2C: Explore Perspectives**. Have groups take turns interviewing other groups, using the questions in the handout as an interview guide. Have groups discuss and record their opinions on each topic in the handout.

2. Invite students to individually prepare a position statement with supporting evidence. Encourage students to draw upon their research and learning in the previous lesson sequences.

DIFFERENTIATE

Students can be provided with a number of choices or options as they share their research. Group, rather than individual, interviews can provide a supportive setting for those students who are uncomfortable presenting in front of others.

- *Students can present their information to the whole class and be interviewed by classmates instead of conducting small group interviews.*
- *Students can be regrouped, with a representative for each role in each group. Large groups can then interview each other and individually record what they find out.*
- *Students who need additional support can be paired with another student to conduct and respond to interview questions.*

Extension Activity

Students work individually to create a futures wheel to predict the effects and implications of continued application of biotechnology in agriculture.

Instructional Strategy: Futures Wheel

Visual organizers provide an opportunity for students to synthesize their research and use it to make predictions based on evidence and facts. A futures wheel chart can be used to develop a conclusion and base a prediction on evidence gathered through research. The prediction can be placed in the centre of the wheel, with evidence that supports the viability of the prediction placed in the spokes of the wheel.

PROCESS

1. Invite students to revisit the predictions they made regarding the future of biotechnology in the introductory activity of this lesson sequence. Provide each student with **Student Resource 2D: Wheel Chart**.

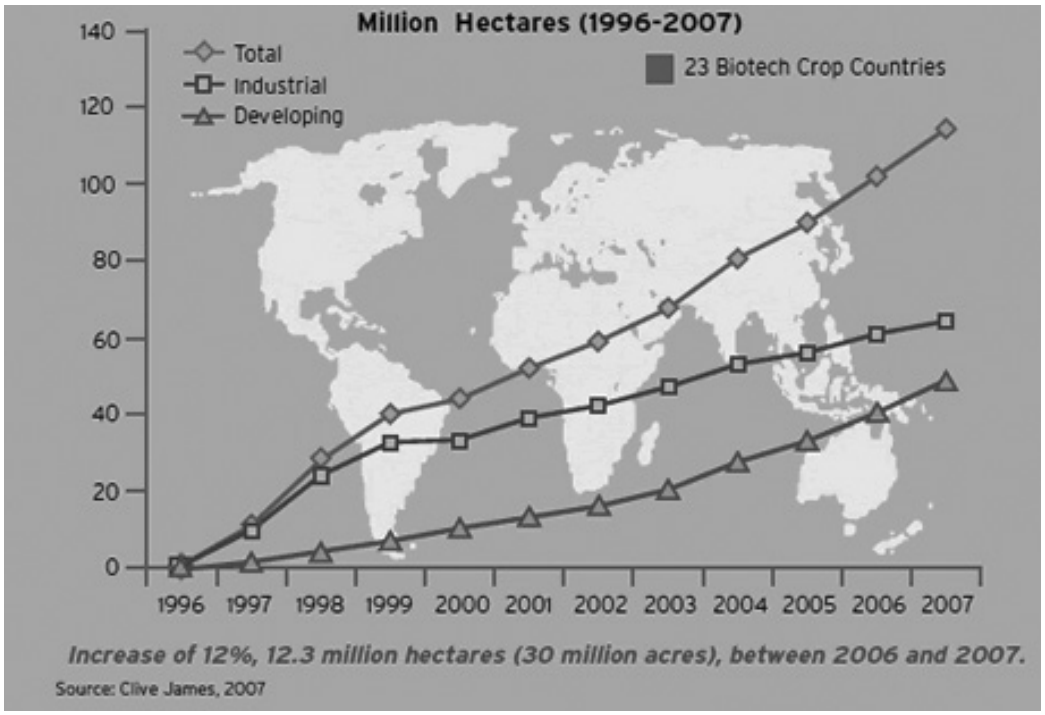
2. Have each student create a futures wheel chart that describes a prediction about the future development and implications of biotechnology in agriculture.

3. Encourage students to use evidence found and shared by classmates to record reasons for their prediction in the spokes of the futures wheel.

What the Data Says

The following data provides some general information about biotechnology. What does this data tell you?

Global Area of Biotech Crops



Views on biotechnology

- 79 percent of Canadians thought biotechnology would bring benefits to agriculture. Eight of every ten Canadians thought the environment would benefit from biotechnology.
- 86 percent of Canadians thought there would be benefits from biotechnology to health sciences.
- Almost nine of every ten Canadians (88 percent) believe biotechnology is important to Canada's future economic prosperity.
- 87 percent of Canadians either strongly or somewhat supported research that involves biotechnology, while only 10 percent of Canadians strongly or somewhat oppose it. Of note, more than nine of every ten Quebecers (92 percent) strongly or somewhat supported biotechnology for research.
- 83 percent of Canadians supported products and processes that involved biotechnology while only 13 percent opposed this activity. Canadians under 30 years of age were comparatively more likely to strongly support the use of biotechnology products and processes.

Source:
Biotech Basics - A Guide to Plant Biotechnology: Council for Biotechnology Information. www.whybiotech.ca/resources/biotech_basics.asp

Canadians Value Biotech: 2008 Annual Opinion Polling Results Overview: BIOTECanada. www.whybiotech.ca/resources/ca_canadians_value_biotech.pdf

Source:
Talking About Agricultural Biotechnology: Council for Biotechnology Information. *www.whybiotech.ca/resources/SpeakUpMessages.pdf*

DID YOU KNOW?

The United Nations predicts there will be 1.7 billion more mouths to feed by 2030.

It is predicted that global demand for food will more than double by 2050.

The World Bank estimates that one hectare of land will need to feed 5 people in 2025, up from just 2 people in 1960.

EXPLORE

What observations can you make from this data?

What questions do you have after reviewing this data?

Vested Interests

Predict

Do you think the use of biotechnology will increase or decrease in the future? Why?

_____

_____

_____

_____

Influences on production choices

"We have recently advanced our knowledge of genetics to a point where we can manipulate life in a way never intended by nature. We must proceed with the utmost caution in the application of this new-found knowledge."

Luther Burbank, 1906

This may sound like a more recent note of caution. Actually, it was made by genetic hybrid researcher Luther Burbank back in 1906, in response to rapid progress in plant breeding. Burbank was a pioneer in the development of several hybrid plants, including plums, prunes, berries and peaches. However, it was his "Russet Burbank Potato," also known as the "Idaho Potato," that he was best known for. Burbank was a contemporary of inventor Thomas Edison. His book, *How Plants Are Treated to Work for Man*, published in 1921, helped inspire passage of the *U.S. Plant Patent Act*, which became law in 1930. Today we take for granted many of the food products Burbank and others developed. We don't think twice about eating them.

Some say that resistance to new foods and changing application of technology is also not new. For example, coffee was outlawed or restricted in Mecca, Cairo, Istanbul, England, Germany and Sweden hundreds of years ago.

"The body becomes a mere shadow of its former self; it goes into a decline and dwindles away. The heart and guts are so weakened that the drinker suffers delusions, and the body receives such a shock that it is though it were bewitched."

French doctors, 1674

Source:
Excerpted from *The Politics of GMO: Sound Science vs. Sound Bites*, a PowerPoint slide presentation given by the Canola Council of Canada, Puerto Vallarta, Mexico, March 23, 2004.

Tomatoes were considered to be poisonous in the United States until 1830. Potatoes were believed to cause a variety of diseases, including leprosy, fever, tuberculosis and rickets. Today, negative stories about biotechnology related to cases such as the effects of genetically modified corn on the monarch butterfly and mad cow disease have continued to raise concerns and questions about food safety and the use of biotechnology.

Some people and organizations raise concerns about the use of biotechnology, and specifically genetic engineering, on the food products they use. There are those who question whether biotechnology provides enough positive benefits. They question food safety, nutritional benefits and raise ethical concerns about the manipulation of genes to produce food and other health-related products. Others are concerned about the effects of genetic engineering on the environment. Some demand that all foods that have been produced with biotechnology should be clearly labelled and that the government should regulate how and when they are produced.

There are many points of view for all sides of the debate on biotechnology. No matter what the opinions are, the debate itself has positive effects. It can help ensure that producers consider people's concerns and promote food safety and adequate knowledge. What other benefits do you think might result from this debate?

Source:
Biotechnology: Agri-science Resources for High School Sciences, Prince Edward Island. www.edu.pe.ca/agriculture/biotech.pdf

> "There are numerous engineered crops being developed and made available for public consumption. Farmers have their choice of several herbicide, insect, and disease resistant hybrids and varieties. Herbicide tolerance and insect resistance are the major genetic constructions in field crops, while delayed ripening and flavour enhancement are the novel properties in vegetables such as tomatoes. Most of this technology began with major field crops such as corn, soybeans, cotton, and potatoes. Now work is being done on specialty crops such as fruits, vegetables, and forages. The amount of acreage occupied by these plants is expected to increase rapidly over the next few years."

What some farmers think about biotechnology

Farmers are in a unique position to talk about biotechnology because they were among the first to use genetically modified (GM) plants. There are over 30 plants with GM traits that have been approved for use by humans in Canada – including corn, canola, potatoes, cottonseed, soybeans, wheat and flax. These traits involve changes to a specific protein that result in the resistance to a **herbicide** – a product applied to the crop to control a particular weed, or insect.

To find out why making a plant resistant to a herbicide or insect is important for food production, you can look at the role herbicides and insects play in modern agriculture.

Managing pests like weeds and insects is a reality of crop production. One tool used by farmers is called **Integrated Pest Management (IPM)**. IPM is a sustainable approach to managing pests that combines biological, genetic, physical and chemical tools in a way that minimizes economic, health and environmental risks. GM crops are a part of IPM programs because they provide another tool that farmers use to grow crops.

Farmers consider the advantages and disadvantages of planting genetically modified crops. Read on to find out about the experiences of some farmers from Manitoba and Saskatchewan.

Ernie Sirski, Dauphin, Manitoba

In 1975, Ernie Sirski took over the family farm in the Dauphin area of Manitoba. Since then there has been no looking back. Ernie's mom and dad first began farming in the Dauphin area in 1948, when his family moved from Swan Plain, Saskatchewan. Ernie helped transform the 40 hectare family farm into a profitable operation with more than 640 hectares in production. This is a lot of land since the average size of a farm in Manitoba is 320 hectares. Some of the crops grown on the farm include winter cereals, canola, oats and barley.

One of the most significant changes on the farm since Ernie took over is the change to seeding his crop without tilling the soil. This practice is called **no-till**, and improves soil structure, decreases fuel costs and requires less time driving the tractor. GM canola helped with the transition to no-till because Ernie does not have to rely on herbicides that are applied directly to crops to control troublesome weeds.

Kelvin Meadows, Moose Jaw, Saskatchewan

Kelvin and Shelley Meadows bought their farm in Moose Jaw, Saskatchewan seven years ago. Kelvin is a select seed grower and therefore has small plot production. They have a seed plant where their seed is processed for export and they clean canola and other crops to be sold locally. Kelvin has also moved into other farm ventures such as vegetable production, bees for crop pollination and agritourism, where he teaches others about food production.

Revisit the implications of genetically modified canola described in Briefing Notes 1A: Biotechnology & Agriculture. *Some varieties of canola are genetically modified, including those that have herbicide-tolerant genes.*

When Kelvin and Shelley bought their farm, one of their first and most significant changes was to phase-out **cultivating**, or turning the soil over to control weeds. They implemented a no-till system in order to reduce fuel costs and the time spent on the tractor, as well as to decrease soil compaction and erosion. They bought an air-drill to direct seed their crops. The use of genetically modified (GM) canola has increased their crop yields and reduced pesticide use.

Marc Loiselle, Vonda, Saskatchewan

"My family and I live on the farm at Vonda in central Saskatchewan. We started farming organically in 1985, and currently manage 530 hectares with cereal, oilseed, pulse (legumes), forage crops and livestock. More specifically, we grow or have grown, Hard Red Spring wheat, malting barley, milling oats, fall rye, canola, yellow mustard, flax, dry peas, alfalfa and clover seeds and hay, and we raise goats, laying hens and roaster chickens.

Our farm motto is 'Holistic Stewardship for Abundant Life' and we strive to uphold these principles and values in our family life as well as the farmland we manage. The attraction to this method of farming came primarily from our desire to be better stewards of the land and resources, without the use of toxic substances and genetic engineering. We believed that is was morally and ethically unacceptable to continue to grow food in such a way that could threaten our health, the health of others, and the environment at large.

Source: *Organic Farming in Saskatchewan.* Organic Agriculture Protection Fund website. *www.saskorganic.com/oapf/farm.html*

Organic farming has provided us with an enriched way of life in many ways, including economic benefit. As part of the growing number of organic farmers, we believe that our agricultural system must be economically viable, environmentally sound, socially just, and meets the needs of today without compromising the needs of future generations. Therefore, as a whole, organic farmers reject the philosophy that we must poison our environment or use radical genetic engineering of plants and animals to produce enough food for us all to eat."

What do other people think about biotechnology?

Many people continue to have questions about the technologies that are used to produce their food, including biotechnology. For some, biotechnology provides the potential of a safe, sustainable and affordable food supply. For others, biotechnology raises more questions than provides answers. What perspectives do you see in the arguments for and against biotechnology that follow? Use the weblinks in each dialogue bubble to find out more about the perspectives of each organization.

Canola Council of Canada

"Consumers can look forward to foods with enhanced nutritional qualities, improved methods of monitoring food safety and extended shelf life. A recent example is high oleic canola oil, which remains stable without hydrogenation, providing new opportunities to reduce trans fat in food....For farmers, innovation means the crop is easier to grow, higher yields, greater hardiness under a wider range of conditions and less pressure to use chemicals. It also means new market opportunities. Within a few years, half of canola acres may be devoted to special kinds of canola developed to meet specific market needs. Biotechnology is greatly accelerating these advances. GM or transgenic canola came on the scene in 1995, and quickly revolutionized the industry. With these new tools and a science-based regulatory regime, Canada is continuing to lead the world in responsible canola innovation." www.canolacouncil.org

Canadian Federation of Agriculture

"The evolution and development of the Canadian agriculture sector has been driven by research, innovation and adoption of new technology. Biotechnology research and development is a new facet of this ongoing process. The nature of agricultural production and possibly the final products will be affected by these development. Our most primary goal is have a government policy and regulatory framework that insures that biotechnology developments are compatible with the needs and expectations of the marketplace and contribute to the success and economic well being of farmers." www.cfa-fca.ca

The Conference Board of Canada

"Countries in search of the next technology platform that will drive innovation are eyeing biotechnology – Canada included. It's time to stop discussing whether or not to embrace biotechnology. Canada should act quickly in order to capitalize on it. Biotechnology is a critical technology platform essential to Canada's ongoing prosperity. Countries like Australia, the United Kingdom, India, the United States and Japan are investing heavily in research and development, aggressively developing and attracting world-class talent, and establishing highly focused strategies to harness the promises of biotechnology." www.conferenceboard.ca

Monsanto – A Company's Perspective

"It's natural to care about where our food comes from. The fact is, biotech crops have been reviewed and tested more than any crop in the history of agriculture and, each time, the result has been the same: they are safe. Biotech crops were first introduced in 1996. Since then, they have become one of the fastest, most widely adopted agricultural innovations in history. In that time, there has not been one documented case of biotech crops being unsafe for humans or the environment." www.monsanto.com/improvingagriculture/Pages/the-importance-of-safety.aspx

Canadian Organic Growers (COG)

"In our view, genetic engineering (GE) runs contrary to the principles of caring for and protecting people and the ecosystems on which they depend. GE is a short-term, ill-conceived and oversimplified approach to agriculture; it does not respect natural systems.

Genetically engineered plants, seeds, pollen, microbes and DNA must not be allowed to compromise the natural complexity on which organic agriculture and the food system itself are based. The biotechnology industry must prove with multi-faceted, long-term research that GE foods are safe to humans and the environment, to avoid potential hazards to the food chain from the following:

- *Pesticide-dependent crops that may reduce native populations of beneficial insects*
- *Cross-pollination of DNA from new 'superspecies' to heritage plants*
- *Modified viruses and bacteria that can cause new diseases foreign to the immune systems of plants, animals and humans.*

COG strongly urges an immediate moratorium on further releases of bioengineered plants, animals and other life forms by developers, producers and patent holders of agricultural biotechnology. Further, we ask scientists to consider carefully the wider implications that their research could have on Canadian and global ecosystems.

COG also calls for an immediate moratorium on the growing of all GE crops. Once these plants are in the field, they cannot be stopped from breeding with adjacent crops and weeds. Some organic growers are losing their livelihood because genetically engineered plants are contaminating their fields. In these cases, the farmers have to begin a three- to five-year process to regain their right to certify their fields as organic.

Until GE crops are eliminated, COG demands mandatory labelling of GE foods in the store and in the field. In the store, this would protect the fundamental rights of Canadian consumers to freely choose their food, based on personal preferences and informed choices." www.cog.ca

EXPLORE

What do you think are the most important agricultural issues of today? Why do you think these issues are so important?

What are two major pros and cons of implementing agricultural biotechnology?

What are two examples of controversial issues related to agricultural biotechnology?

What are the main environmental risks and benefits of implementing agricultural biotechnology?

What are the risks and benefits of biotechnology for species diversity?

Find Information

To find out more about the perspectives of Canadian canola growers, start at *Canola Innovation* on the Canola Council of Canada website at *www.canolacouncil.org/oil-and-meal/canola-innovation/*. Check out *Biotechnology* from the Manitoba Canola Growers at *www.mcgacanola.org/documents/CanolaandBiotechnology-withpictures.pdf*.

Visit *The Buzz About Biotech* at the Children's Museum Indianapolis, at *www.childrensmuseum.org/themuseum/biotech/webquest/resources.htm*, to explore links with different perspectives on biotechnology.

Consider the perspectives presented in *Genetically Modified Seeds, Biodiversity and Food Security* at *www.interpares.ca/en/publications/pdf/biotech_policy_brief_en.pdf*.

The Government of Canada website *BioGateway: A Window to Government*, at *www.biogateway.gc.ca/english/view.asp?x=1*, provides information and links related to biotechnology.

A National Geographic article, *Modified Crops Could Lead to "Superweeds," Study Suggests*, accessed at *http://news.nationalgeographic.com/news/2001/08/0816_geneticplants.html*, addresses the question: "If genetic engineering significantly alters how a plant grows and reproduces, could normal crop plants become more 'weedy' or invasive?"

The Food Safety Network, found at *www.uoguelph.ca/foodsafetynetwork/*, provides links to articles that explore pros and cons of biotechnology. Use the search function on this website with the keywords "Agriculture" and "Biotechnology."

Explore different perspectives on genetically modified foods in *Viewpoints: Is genetically modified food safe to eat?* by listening to the interviews at *www.pbs.org/wgbh/harvest/viewpoints/issafe.html*.

EXPLORE

What are some conflicting points of view regarding the use of biotechnology in food and health-related products? Work with your group to take on one of the following roles.

Roles

- Grain Farmers
- Researchers and Scientists
- Consumers
- Food Safety Organization
- Consumer Protection Organization
- Government Regulators
- Biotechnology Seed Supply Company

- **Research your role carefully. Find out what supporting data could be used by the role you are taking.**
- **Start with the following pros and cons bullets. Select the arguments your role would be most likely to use. Consider the validity of each argument with the supporting data you research.**
- **Develop your role on index cards or in a file folder.**

- ❑ Genetically altering foods could change their nutritional value by lowering vitamin content or other nutrients.
- ❑ The process of inserting genes is not precise. Scientists can not tell exactly where they go or how many reach their target.
- ❑ A foreign gene may not behave in a new crop the way it did in the original species. It may interact with genes around it or with its new environment to produce undesirable traits.
- ❑ Genetically engineered foods may have an effect on special populations, such as infants or people suffering from conditions or diseases. Testing is done on healthy adults, so effects that might emerge in other populations could be missed.
- ❑ A reaction might occur between two food compounds that may be harmless separately, but together could be **toxic**. There are also concerns that harmless plants that have toxic relatives may have the toxic gene turned on in a recombinant plant.
- ❑ The genes for **resistance** which are inserted into plants could be passed to weeds. Insects may build up resistance to the new **pesticide**. A gene that is intended to be toxic only for insects could **mutate** and become toxic to humans as well.

- There is a conflict of interest when a company's own scientific data is used to determine food safety. There should be a great deal more independent testing.
- New plant species may upset the balance of nature, changing the delicate relationships between crop plants, weeds, and the animals that consume them.
- Some genetic engineering projects are designed to increase, not lower, the health attributes of foods.
- Genetic engineering is more precise than traditional **crossbreeding** methods and carries less risk of undesired traits being transferred.
- Traditional plant breeders use well-established practices to eliminate plants with adverse traits prior to commercial use and **transgenic**, or genetically modified, plant breeders can do the same.
- It would be very difficult to test any new product on every specialized population before it is marketed.
- Genetic changes that can lead to unexpected toxins can occur not only in genetically transformed plants, but also in plants developed through traditional breeding practices or as a natural part of growth.
- The potential of pests to develop resistance against defense mechanisms of crops is well-known and is not unique to genetically engineered plants. Insects may develop resistance to a crop defense no matter how it was developed.
- Some companies resent the implication that test results from their own laboratories are false. They argue that it is to their benefit to produce safe, beneficial food products because there is no profit in bad products.
- Supporters of biotechnology foresee a different day when not one, but many improved crop varieties could flourish in areas of the world that currently can not produce enough food crops for the entire population.

Source:
Biotechnology: Agri-science Resources for High School Sciences, Prince Edward Island. www.edu.pe.ca/agriculture/biotech.pdf

Explore Perspectives

Use the following questions to interview your classmates. Summarize what you find out about differing perspectives on the Perspectives on Biotechnology chart. Ensure that you collect at least two different perspectives on each topic.

Ethics

What ethical considerations govern food biotechnology?

Well-defined ethical guidelines governing all aspects of food biotechnology do not really exist. The public, industry and government struggle with various ethical issues that surround this controversial topic.

Suggested questions:

1. Should any type of genetic modification be allowed?

_____

_____

_____

_____

_____

2. Should governments or corporations fund public research on biotechnology?

_____

_____

_____

_____

_____

Other questions?

_____

_____

_____

_____

_____

Public Interaction

The Canadian Biotechnology Strategy states that an emphasis on public participation is a key element of the strategy. What kind of process would ensure that ongoing public participation is a part of policy development and implementation?

Some people feel the public is kept out of the discussion and regulation of food biotechnology. Others feel that any information available to the public is presented in a highly biased manner.

Suggested questions:

1. Should the public have more say in the regulation of biotechnology?

2. How biased is the information on biotechnology that is shared with the public?

3. Do people know enough about the Canadian Food regulation system?

Other questions?

Legislation

Canada has some of the highest industry standards for regulating food biotechnology. The international community looks upon Canada as a role model.

Suggested questions:

1. Should private corporations be allowed to do any type of biotech research? Or should the federal government set tighter rules for what is, or is not, permitted?

   _____

   _____

   _____

   _____

   _____

2. Should the federal government set legislation for mandatory labelling of any genetically modified foods?

   _____

   _____

   _____

   _____

   _____

Other questions?

_____

_____

_____

_____

_____

Environment

What are the environmental impacts of genetically modified organisms (GMOs)? As scientists struggle to design the right variety of plant for this climate, are we losing something in the process? Some people are concerned that biodiversity may be jeopardized. Could we be increasing pesticide resistance? Will environmental problems be created?

Suggested questions:

1. Has the adoption of GM crops reduced pesticide use and soil tillage?

2. **Outcrossing** is the introduction of unrelated genetic material into a breed or species to increase genetic diversity. Could outcrossing of herbicide-tolerant crops create super weeds?

3. Has the increase in GM crops had any impact on non-farmed plants (plants in their natural environments)?

Other questions?

Economic and Social Impact

What are the social and economic impacts of genetically modified food? Consider this topic on a domestic or an international level.

Suggested questions:

1. Who really controls the world's food supply?

2. What could happen to farmers who do not adopt biotechnology?

3. Will undeveloped or developing countries benefit from biotechnology?

Other questions?

Consumer Health and Safety

What are the risks of consuming foods made from genetically modified plants or animals compared to conventional foods? This topic is well debated in newspapers and conferences around the world. Canada is known to have the safest food supply on the planet, yet some people argue that our food safety has been compromised with genetically modified food products. What do you think? What does the research tell you?

Suggested questions:

1. Is Canada's food regulatory system rigorous, or strict, enough?

_____

_____

_____

_____

_____

2. Do we risk our health by eating GM foods or foods made from plants genetically modified for agricultural, not nutritional, reasons?

_____

_____

_____

_____

_____

_____

Other questions?

_____

_____

_____

_____

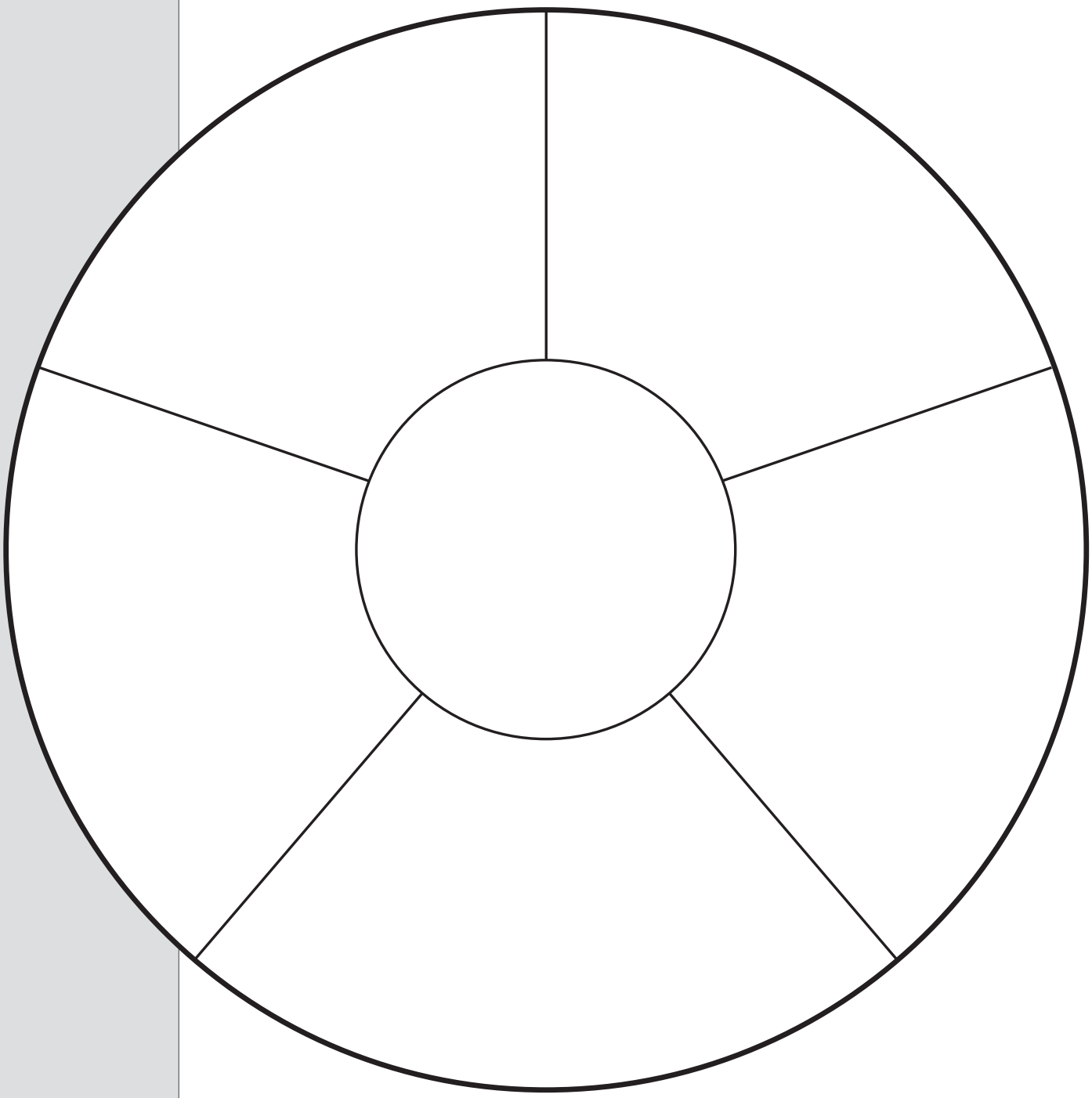
Perspectives on Biotechnology

Topic: _____

Interview 1	Interview 2

Our Opinion and Supporting Evidence

Wheel Chart



LESSON SEQUENCE THREE: STRIKING A BALANCE

Overview

In Lesson Sequence Three, students explore the discussions and debates around issues surrounding biotechnology, including government regulations, labelling, the potential for loss of biological diversity and benefits that biotechnology can provide.

Rationale

Students should understand implications and decisions involved in balancing biodiversity with the use and development of biotechnology.

Presenting students with "I can…" statements can help focus their learning and provide a context for assessment with this lesson sequence's activities.

Inquiry

How should the needs of humans be balanced with the protection of biological diversity?

Key Concepts

Biotechnology *Producers* *Consumers*

Preparation

Suggested Time: 1 to 3 50-minute class periods

The following handouts, materials and resources are used in this lesson sequence:

- Handouts
  - o Briefing Notes 3A: Decisions & Consequences
- Chart paper
- Internet access and interactive whiteboard to display and share website links

"I CAN"

Lesson Sequence Three encourages students to demonstrate their learning by developing understandings such as the following:

- ***I can** assess conflicting perspectives and consider the balance between the use of biotechnology and the protection of biological diversity.*

Inquiry

Striking a Balance

How should the needs of humans be balanced with the protection of biological diversity? (Lesson Sequence Three)

Knowledge

Focusing Questions
What is biological diversity, and by whatprocesses do diverse living things pass on their characteristics to future generations? What impact does human activity have on biological diversity?

Key Concepts
- biological diversity
- natural and artificial selection of genetic characteristics

4. Identify impacts of human action on species survival and variation within species, and analyze related issues for personal and public decision making
   - Evaluate the success and limitations of various local and global strategies for minimizing loss of species diversity *(e.g., breeding of endangered populations in zoos, development of seed banks, designating protected areas, development of international treaties regulating trade of protected species and animal parts)*
   - Investigate and describe the use of biotechnology in environmental, agricultural or forest management; and identify potential impacts and issues *(e.g., investigate issues related to the development of patented crop varieties and varieties that require extensive chemical treatments; identify issues related to selective breeding in game farming and in the rearing of fish stocks)*

Attitudes

- Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., select and explore media on topics related to species diversity; express interest in hobbies and careers that involve the care, culture and study of living things)*
- Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., strive to assess a problem accurately by careful analysis of evidence gathered; critically consider ideas and perceptions, recognizing that the obvious is not always right)*
- Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; accept various roles within a group, including that of leader)*

Skills

Initiating and Planning
Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- Identify science-related issues *(e.g., identify issues related to loss of species diversity)*
- Identify questions to investigate arising from science-related issues *(e.g., "What factors affect the ability of organisms to survive and reproduce in this ecosystem?")*

Performing and Recording
Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- Research information related to a given issue *(e.g., conduct an electronic search for information on factors that affect the reproduction and survival of wood frogs)*

Analyzing and Interpreting
Analyze qualitative and quantitative data, and develop and assess possible explanations

- Apply given criteria for evaluating evidence and sources of information (*e.g., evaluate sources based on their currency, credibility and the extent to which claims are supported by data*)
- Identify new questions and problems that arise from what was learned

Communication and Teamwork
Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- Communicate questions, ideas, intentions, plans and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language and other means *(e.g., illustrate and compare methods of reproduction in sample organisms studied)*
- Evaluate individual and group processes used in investigating an issue and evaluating alternative decisions *(e.g., evaluate strategies for locating information, such as the use of particular key words or search tools; evaluate approaches for sharing work on a given research task and for synthesizing the information found)*
- Defend a given position on an issue, based on their findings *(e.g., defend a position on a proposed measure to protect a particular plant or animal population)*

Lesson Sequence Three Teaching and Learning Strategies

How should the needs of humans be balanced with the protection of biological diversity?

Introductory Activity

Students brainstorm possible decisions about research and applications involving biotechnology while protecting biodiversity, the environment and societal well being, safety and health.

Instructional Strategy: Brainstorming Mind Map

Brainstorming ideas, predicting and summarizing main points by using a visual organizer, such as a mind map, requires students to identify connections, synthesize information, critically evaluate relationships and make connections to their prior knowledge and understandings. Clustering related ideas and concepts encourages students to organize information and inferences.

PROCESS

1. Ask students to consider the impact they think increased use of biotechnology could have on human needs, biodiversity and economic well being. Ask them to brainstorm their initial ideas and responses to the inquiry question, How should the needs of humans be balanced with the protection of biodiversity? Revisit the definition of biodiversity if students need to review this concept.

2. Work together as a class to group and cluster the responses and ideas on a mind map. Create the mind map on the board or using an interactive whiteboard.

Briefing Notes Activity

Students read and discuss the Briefing Notes with a partner. They focus on issues and decisions that arise from the debate on biotechnology and design a proposal for a policy statement on biotechnology.

Instructional Strategy: Policy Statement

The development of a policy statement can provide an authentic context in which students are asked to apply scientific understandings and processes. The format of the policy statement can be collaboratively developed with students, but should contain an introduction, a list of guidelines and recommendations that form the policy and supporting reasons and data. Such a proposal can also ask students to apply research skills in both collecting and organizing research data as well as creative and critical thinking.

PROCESS

1. Provide each student with a copy of **Briefing Notes 3A: Decisions & Consequences**. Work with students to discuss or respond in writing to the *Predict* questions at the beginning of the handout.

2. Invite students to revisit some of the controversial issues involved with biotechnology:
   - Safety – people, crops, other plants, animals and insects
   - Regulation – necessary steps to become approved by the government. (*Ask the students: Why is it important for scientists to keep clear and honest records?*)
   - Environmental benefits and risks
   - Nutritional implications
   - Farming – economic impact, ethical considerations, regulations
   - Consumer choices – ethical choices and benefits, including lowered cost of food and medical supplies

3. Ask students to work with a partner to identify some of the challenges involved in agriculture today. Provide some research time to use the internet or other classroom resources to do this.

4. Challenge students to develop a policy statement that addresses the uses and/or limits of agricultural biotechnology. Their policy statements can be creative and hypothetical as they consider advances in biotechnology in the future.

5. **Extend:** Have students use their policy statements to create recommendations for labelling genetically modified products. Have students include a sample label for a product containing a genetically modified ingredient, such as canola, soybean or corn, that meets the criteria they establish.

Closing Activity

Students identify strategies for change and develop position statements with evidence that they present in a horseshoe debate.

Instructional Strategy: Horseshoe Debate

A horseshoe debate is an informal debating strategy that encourages students to research multiple positions and perspectives, analyze evidence that supports alternatives and present opinions and evidence. In a horseshoe debate, desks are arranged in an open semi-circle, or a horseshoe shape. Students on one half of the semi-circle are assigned the task of presenting a prepared statement and supporting evidence on one side of the issue. Students in the other half take the opposite position. Students can be asked to take turns presenting the position and a brief summary of the evidence they have collected. Once students share their positions and evidence, the floor is opened for questions and challenges. Students can be assessed on both their research and presentation, as well as on their participation in the question and challenge component of the debate.

PROCESS

1. Present the critical issue to students: *How should the use of technology and protection of biological diversity be balanced?*
2. Have students work with a partner and use the Briefing Notes, website links and classroom resources to explore the critical issue. Ask students to collect and organize evidence that supports different positions on the issue.
3. Have each pair prepare a position statement with supporting evidence that responds to two conflicting sides – one that supports the use of biotechnology and the other that is against it. Encourage students to draw upon their research and learning from the previous lesson sequences.
4. Have students use their position statements to participate in a horseshoe debate.

DIFFERENTIATE

There are different options for structuring the debate process. Students can be asked to select the side they will present and defend and sit on that side of the semi-circle. Alternatively, students can be asked to research and support multiple perspectives on an issue, and be assigned one perspective on the day of the debate.

Extension Activity

Students work individually to create a top ten list of the most influential and beneficial biotechnologies for the future.

Instructional Strategy: Tip Sheet or Top Ten List

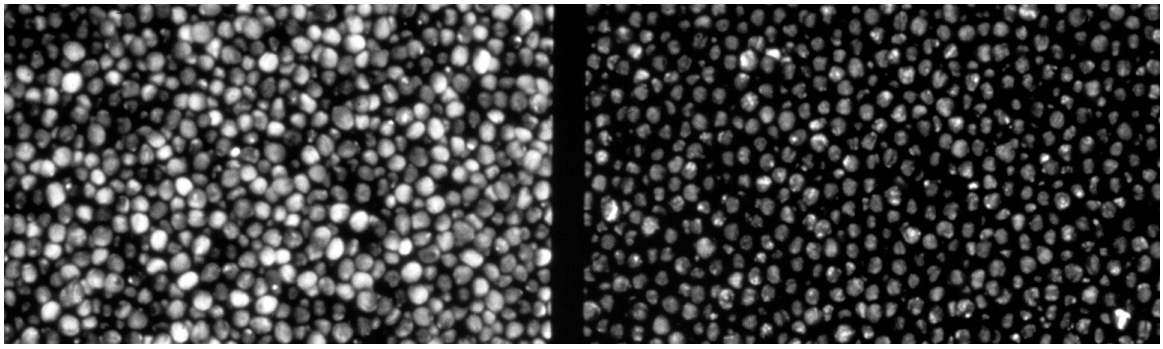
Student products provide an opportunity to summarize, synthesize and communicate learning and display research results. Students can be engaged in creating a "real world" product such as a tip sheet or top ten list.

PROCESS

1. Ask students to work with their partners and use their research to create a tip sheet that outlines the top ten products and potential benefits related to agricultural biotechnology. Encourage each pair to consider biodiversity in creating their lists. Alternatively, students can be asked to develop a list of the top ten controversial issues or practices.

DIFFERENTIATE

Lists can be created and presented as PowerPoint presentations or on an interactive whiteboard.



Decisions & Consequences

Predict

To what extent do you think the benefits of biotechnology are balanced by potential risks? Should all decisions related to biotechnology be regulated by the government? Why or why not?

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There are a number of considerations involved in establishing decisions about how biotechnology should be applied and used to benefit human needs. What decisions guide the development of future products? And what are some of the implications?

Genetically modified crops that have been approved for use in Canada include:

- Corn – herbicide resistant, insect resistant and insect resistant and herbicide tolerant, hybridized corn system
- Canola – herbicide tolerant canola, specialty oil canola, hybridized canola system
- Tomato (approved but not grown in Canada) – delayed ripening tomato, reduced pectin degradation tomato
- Potato – potato beetle resistant potato
- Soybean – herbicide tolerant soybean
- Cotton (approved for import into Canada) – insect resistant cotton, herbicide resistant cotton
- Flax (approved but not grown commercially) – herbicide tolerant flax
- Squash – virus resistant squash.

Source:
Crop Biotechnology: Harvesting the Benefits: Saskatchewan Agricultural Biotechnology Information Centre (SABIC), Ag-West Biotech Inc.

EXPLORE

As you read the discussions about potential decisions, underline the perspectives that support the production of genetically modified canola with one colour highlighter or pen. Circle the arguments against the use of genetically modified canola with a different highlighter or pen.

- **What other arguments for and against the use of genetically modified canola can you find in other sources of information?**
- **What could the effects and consequences of each decision be?**

Decision 1

Farmers should have the option of growing genetically modified canola and consumers should have the option to buy products made from canola oil that has been processed from genetically modified seed.

Canola producers across the prairies and in other parts of Canada already grow canola that has been developed with biotechnology. If producers continue to grow genetically modified canola, food processors will have an affordable supply of canola to use for food products sold in grocery stores and used in restaurants. In turn, consumers will likely continue to have affordable food products.

There are environmental benefits as well as risks with the use of genetically modified canola. Some environmental benefits include better weed control for farmers, better soil conservation and less exposure to herbicides for both the farmer and the environment.

Improved weed control provides an environmental benefit because the herbicides that farmers use with herbicide tolerant canola have low toxicity ratings and are safer for the environment than older herbicides.

Using herbicide tolerant crops also make it easier for farmers to control troublesome weeds that are often associated with no-till. Farmers can control troublesome weeds and do not need to till the soil, so the soil remains intact. **Soil residue**, such as plant material from last year's crop, creates a layer that protects the soil from being washed away by rain and blown away by the wind.

One environmental risk of growing genetically modified canola is the potential for genetically modified canola to **outcross** with wild canola relatives. This means that genetic material from the wild canola relative can be introduced into the genetically modified canola.

Canola was developed using traditional plant breeding techniques, so it was not developed using biotechnology. However, about 80 percent of the canola grown in Canada has now been modified using biotechnology to make it tolerant to some herbicides. Using these specific herbicides has reduced the amount of chemical needed for weed control in the fields. Therefore, Canadian consumers who buy products containing canola oil have a high probability of purchasing canola oil crushed from seed that is harvested from a genetically modified plant.

Decision 2

Producers should have the option to grow genetically modified canola, but consumers should not buy products containing oil made from a genetically modified canola plant.

The outcome of this decision is based on the economic theory of supply and demand. Producers will grow genetically modified canola and canola crushers may even buy the seed for processing into food products. However, when the food product reaches store shelves, consumers will not buy the product.

Farmers watch the market very closely to determine the demand for their crops. Farmers would not grow a crop if they knew in advance that no crushers or processors would buy their crop. If processors decide not to buy the genetically modified canola after spring planting, then canola producers have to explore alternative markets such as selling the canola for fuel, other non-food uses or to feed livestock.

Decision 3

Producers should not grow genetically modified canola and therefore there will not be any genetically modified canola products in the grocery store to buy.

Canola producers in the prairies first grew genetically modified canola in 1997. In 2009, Canada was among the top five countries that produced genetically modified crops. Genetically modified canola made up nearly 90 percent of the canola grown in 2009, mainly because of the easier and improved weed control.

It takes between five and six kilograms of canola to seed one hectare of farmland. This means over 27.5 million kilograms of canola seed would have to be replaced with non-genetically modified types. Because farmers buy canola seed from different companies, the companies must have enough non-genetically modified seed for farmers to grow. The seed has to be grown and bagged before it is sold to farmers.

Canadian food processors need to have a steady supply of canola to make products like salad oil, margarine and other processed products. If they cannot buy adequate supplies from Canada, processors may import seed or oil from other canola-producing countries. Imported seed would be tested to ensure that it was not genetically modified. In the case of canola oil, there would be no need for tests to detect genetically modified material because there is no protein in canola oil. There is no difference in canola oil made from classic or genetically modified canola seed. The farmers and processors would instead use a system called Identity Preservation (IP), in which documentation traces the canola from the initial purchase of seed to the grocery store.

An additional alternative would be for governments to provide incentives for farmers to switch to certified organic canola. There is very little organic canola grown in Canada today. In some places, it can only be grown in isolated areas because of the risk of outcrossing from GM canola crops, since canola is an open-pollinating crop.

How can I be sure genetically engineered products are safe?

Some people raise questions about the safety of genetically engineered food products. These questions have led to differing opinions and perspectives on the ethics and safety of genetically modified foods. Scientists and farmers both continue to deal with issues surrounding the safety of foods.

- The government passes regulations to make sure that the products created by both genetically engineering and traditional growing methods are safe.
- Health Canada is responsible for the regulation of "novel foods." Novel foods include those that have not previously been used as food, food resulting from genetic modification and foods modified from traditional products using new processes or microorganisms. Some novel foods that have been approved include varieties of wheat and rice, enhanced eggs and low linolenic soybean.
- Health Canada and the Canadian Food Inspection Agency share responsibilities for the safety of novel foods developed using agricultural biotechnology.
- The Canadian Food Inspection Agency conducts safety assessments on fertilizers, seeds, plants, animals, animal vaccines or diagnostics and feeds. The Agency also establishes food labelling policies with respect to non-health and safety matters.
- Each biotech product is assessed on a case-by-case basis. Only products that meet standards set by these agencies and that are considered safe for humans, plants, animals and the environment will be approved.

Source:
A Growing Appetite for Information: Consumers Association of Canada.
www.canolainfo.org/news/latest_news.php?detail=31

How do we know if a food has come from a genetically engineered product?

Labelling is voluntary. Since the application of biotechnology is generally regarded as an extension of existing breeding techniques, the rules and laws applied to traditional food products is deemed suitable for biotechnology products.

Whenever the genetic engineering of a product involves a health, safety or nutritional issue, it must be labelled. Issues that must be addressed on product labels include whether or not people with allergies may be at risk, or if there is a change in nutritional value, e.g., a tomato modified to contain higher levels of lycopene. Labelling must be understandable, truthful and not misleading. In principle, food products derived from genetic modification that are demonstrated to be safe and nutritious are labelled in the same way as non-genetically modified foods. In cases where a product has been intentionally modified, special labelling is required to inform consumers of the change to the product. For example, oil derived from high oleic soybean lines must be listed in food ingredient lists by the common name "high oleic soybean oil" to distinguish it from regular soybean oil.

Food manufacturers may choose to use labels promoting the fact that the products have or have not been modified through genetic engineering.

Find Information

Find out more about labelling from *Labelling of Novel Foods Derived Through Genetic Engineering* from Health Canada at *www.hc-sc.gc.ca/fn-an/gmf-agm/fs-if/faq_3-eng.php*.

What is the impact of biotechnology on biodiversity?

People also hold conflicting points of view on the impact that biotechnology actually has on biodiversity. Biodiversity refers to the variety of species – including all plants and animals – in their natural environments. Some believe that biotechnology can have a positive impact on biodiversity. Others argue that biodiversity is threatened by biotechnology.

Research and development in the use of genetically modified foods has allowed increased production of food while not increasing the land that is required to produce it. This protects the natural areas of land that remain and maintains biodiversity.

The use of biotechnology has also meant that crops can be produced in areas that might otherwise be unsuitable, allowing us to make the choice to protect biodiversity.

Introducing new genetic material into existing species may make them more resistant to herbicides. If weeds were inadvertently made herbicide-resistant, for example, they may decrease species diversity.

New diseases that threaten other species may be accidentally developed.

Increased demand for genetically modified seed may result in increased demand for land to be used for genetically modified crop production. This may reduce land that is available for other crops or threaten natural areas.

EXPLORE

Create a policy statement for the use of agricultural biotechnology, using the following questions as a guideline.

1. What guidelines or regulations do you think are needed for the use of biotechnology in agriculture? Brainstorm an initial list of your ideas.
2. What are the main reasons that support the guidelines and regulations you are suggesting? Choose the two guidelines or regulations that have what you think are the strongest reasons and support.
3. How do these two guidelines or regulations address the following?
   - Food safety and nutrition
   - Environmental benefits and risks
   - Farming and farmers – economic benefits and risks
   - Consumers.
4. Evaluate your policy. To what extent does your solution balance human needs with the use of biotechnology? To what extent would your policy affect biological diversity? What risks or cautions might be included with your policy statement?

Find Information

How can each of these sources inform your views on policies and regulations about biotechnology?

Read about *Canada's Biotechnology Strategy* from Health Canada at *www.hc-sc.gc.ca/sr-sr/biotech/role/strateg-eng.php*.

Find out how the Food and Agriculture Organization of the United Nations deals with *Biodiversity and Ecosystem Services* at *www.fao.org/agriculture/crops/core-themes/theme/biodiversity/en/*.

Revisit views on biotechnology in *Talking About Biotechnology* from the Council for Biotechnology Information at *www.whybiotech.ca/resources/SpeakUpMessages.pdf*.

Find out about Crop Life Canada's views on biotechnology in *Cultivating a vibrant Canadian economy* at *www.croplife.ca/wp-content/uploads/2012/02/CropLife-Summary_EN.pdf*.