CANADA
4-H Ontario

www.4-hontario.ca

4-H ONTARIO PROJECT

Introduction to Agricultural Biotechnology

REFERENCE MANUAL

The 4-H Pledge
I pledge my Head to clearer thinking,
my Heart to greater loyalty,
my Hands to larger service,
my Health to better living,
for my club, my community and my country.

The 4-H Motto
Learn To Do By Doing

CANADA
4-H Ontario

4-H Ontario Provincial Office
111 Main Street, Box 212
Rockwood, ON N0B 2K0
TF: 1.877.410.6748
TEL: 519.856.0992
FAX: 519.856.0515
EMAIL: inquiries@4-hontario.ca
WEB: www.4-HOntario.ca

Project Resource Information:
Written by: Robert Matson
Layout by: Holly McFarlane
Date: March, 2019

Thank you to the 4-H Introduction to Agricultural Biotechnology Advisory Committee members who assisted with the creation of this resource:

Rajib Hazarika, Research and Innovation Branch, OMAFRA
Jack Kyle, retired OMAFRA Crop Specialist and Pasture Specialist
Dr. Gord Surgeoner, retired Professor, University of Guelph, Past President OAFT
Valerie Stone, 4-H Volunteer, Brant 4-H Association
Maria Trainer, Croplife, Managing Director, Science and Regulatory Affairs, Chemistry

Thank you to Mercedes Unwin and Cassi Brunsveld from AgScape who reviewed this project.

Thank you to the 4-H Club that piloted this project.

Club Leaders – Brittany Barkley & Kimberly Barkley; Club Members – Faythe Barkley, Brandon Doucet, Hayden Doucet, Terry Ennis, Hannah MacIntyre, Nathan Stewart, Bobby Robinson, Claire Stewart; Stormont 4-H Association

The development of this project resource was made possible through the support of the Grand River Agricultural Society.

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4-H Inclusion Statement

4-H in Canada is open to all* without discrimination based on race, national or ethnic origin, colour, religion, sex, age or, mental or physical disability.**

4-H is dedicated to providing a safe and inclusive environment that allows for universal access and participation. Where barriers to participation are identified, 4-H will, with reasonable accommodation, adapt programs, rules, policies, or expectations to reduce or remove the barriers.

Any accommodations, changes or exceptions will be assessed on an individual basis, taking into account the individual experience of the member and their family. The physical safety and emotional well-being of members, leaders, staff and volunteers is 4-H's highest priority, and is the ultimate consideration in final decisions.

4-H Canada and local 4-H organizations consider inclusion a priority. Leaders are encouraged to work with individuals and their families to identify and discuss accommodations as required, and to reach out to provincial or national office staff for help with unresolved concerns.

**This applies to youth members (ages 6 to 21), volunteers, leaders, staff and professionals.*
***Definition of discrimination as per Canadian Charter of Rights and Freedoms.*

Déclaration sur l'inclusion des 4-H

L'adhésion aux 4-H au Canada est ouverte à tous les jeunes* sans discrimination fondée sur la race, l'origine nationale ou ethnique, la couleur de la peau, la religion, le sexe, l'âge ou le handicap mental ou physique. **

Les 4-H ont pour mission d'offrir un environnement sécuritaire et inclusif qui permet l'accès et la participation de tous. Lorsque des obstacles à la participation sont décelés, les 4-H adapteront, à l'aide de mesures d'adaptation raisonnables, les programmes, les règles, les politiques ou les attentes afin de réduire ou d'éliminer ces obstacles.

Toute mesure d'adaptation, modification ou exception sera évaluée au cas par cas, en tenant compte de l'expérience personnelle du membre et de sa famille. La sécurité physique et le bien-être émotionnel des membres, des animateurs et des animatrices, des membres du personnel et des bénévoles sont la priorité absolue des 4-H et constituent le facteur ultime à considérer lors de la prise des décisions définitives.

Les 4-H du Canada et les organisations locales des 4-H considèrent l'inclusion comme étant une priorité. Les animateurs et les animatrices sont encouragés à collaborer avec les personnes et leurs familles afin de définir et d'examiner les mesures d'adaptation, selon les besoins, et de communiquer avec le personnel du bureau provincial ou national pour obtenir de l'aide en cas de préoccupations non résolues.

**Ceci s'applique aux jeunes membres (âgés de 6 à 21 ans), aux bénévoles, aux animateurs, aux membres du personnel et aux professionnels.*
***Selon la définition de discrimination en vertu de la Charte canadienne des droits et libertés*

Welcome to 4-H Ontario's Agricultural Biotechnology Project!

Welcome to 4-H Ontario's Introduction to Agricultural Biotechnology project! This resource was developed to introduce members to the fundamental principles of biotechnology covering topics from plants and animals to future directions of biotechnology. The project focuses on agriculture to explain the basics of biotechnology while also exploring the social and scientific challenges of biotechnology.

How to Use This Manual

4-H Ontario's Agricultural Biotechnology project is made up of 2 parts:

1. <u>The Reference Book:</u>

The reference book is laid out into 6 meetings.

Meeting 1 – Breaking Down Agricultural Biotechnology
Meeting 2 – Traits, Resistance and Genetically Modified Organisms
Meeting 3 – Regulations, Animals and Welfare
Meeting 4 – Precision, Food and Partnerships!
Meeting 5 – Bioproducts and Biotech in Developing Countries
Meeting 6 – The Future of Agricultural Biotechnology

Each meeting has been broken down into an Introduction with Sample Meeting agendas, References and Resources, Topic Information and Activities.

<u>Sample Meeting Agendas:</u> are at the beginning of each meeting. The agendas give suggestions for topic information, activities and judging and/or communications activities along with suggested times for each section. These are only suggestions – you will know your group best and will know the skill and attention level of your members. There is more topic information and activities than what can be completed in a two hour meeting. Be creative!

Activities: should be used in combination with the discussion of topic information to teach members in a hands-on, interactive learning environment.

2. **<u>The Record Book:</u>**
This booklet is designed to make it easier for members to record information throughout the club. Members are to record their expectations and goals for the project in addition to contact information, meeting dates and roll calls. Print or photocopy pages from the Reference Book that you think will benefit the members either as a resource or an activity.

The Record Book should be given to each member at the beginning of the first meeting. Ask members to keep it in a binder or duotang so they can add to it easily.

Go through the Record Book with the members and explain the charts and forms. Encourage them to use their Record Books at every meeting and record as much information as possible. As an added incentive, a prize could be given at the end of the project for the best Record Book.

INCLUDING STEM IN THE 4-H INTRODUCTION TO AGRICULTURAL BIOTECHNOLOGY PROJECT

WHAT IS STEM AND WHY IS IT IMPORTANT?

Since 1915, 4-H in Ontario has engaged youth in science, technology, engineering, and math (STEM). This has traditionally meant a solid focus on agricultural science, mechanics, entrepreneurship, natural sciences and household science. Today, 4-H has grown to include rocketry, robotics, computer science, environmental sciences, and more. 4-H provides hands-on learning experiences to encourage learning about the world around us. Our lives are completely immersed in science and technology.
Understanding how science, engineering, and technology impact our lives, solve problems and create new ones makes it easier to navigate our modern world.

In school, science classes need to cover a broad range of topics in a limited amount of time while STEM in 4-H allows members and leaders time to dig deeper into ideas and concepts and to spend as much time as desired to work on projects based on personal interests, questions, and skills.

STEM in 4-H allows a person to work on their own questions, design their own tests, create their own models, build their understanding, and share their work with others – learn to do by doing. That's what science and engineering are, trying to understand the natural universe and develop solutions to the problems faced in our world today. Science is inquiry that uses a specific approaches and skills. But all learning is an inquiry process so working with science helps develop your learning muscles.

Within 4-H, the STEM process can go even further to include the Arts, thus changing the acronym to STEAM – Science, Technology, Engineering, Art & Math.

STEAM IN 4-H ONTARIO PROJECTS

As you work through the Introduction to Agricultural Biotechnology Project, you will see STEAM integrated throughout the project within almost all of the activities that members will be completing.

STEAM can be challenging but it can also be fun! Be sure to try out the activities. Observe what works and what doesn't and how activities can be changed slightly to get different results. It's all a part of the STEAM learning process!

Planning a Meeting

Plan your meetings well. Review all the information well in advance so you are prepared and ready!

Before Each Meeting:

- Read the topic information and activities and photocopy any relevant resources for the members' Record Books.
- Be familiar with the topic information for each meeting. Think of imaginative ways to present the information to the members. Do not rely on just reading the information out loud. Review available resources, plan the meetings and choose activities and themes that complement the ages and interests of your members.
- Gather any equipment and/or resources that will be needed to complete the meeting.
- At least 12 hours of club meeting time is required for every project; including club business, specific project information and social recreation. The delivery format for that material is left to the discretion of the leaders. Before each meeting, create a timeline to ensure that you are providing an adequate amount of instructional time for club completion. Note: the best practice recommendation is that a club have multiple meeting times for each project.

Included on the following page is a Leader's Planning Chart to help with the planning of meetings. In addition to the chart, keep track of what went well and what should be changed next time. That way, each time this project is run, the content of the meetings can be different!

When planning each meeting, a typical 4-H meeting agenda should include the following:

- Welcome & Call to Order
    - 4-H Pledge
    - Roll Call
    - Parliamentary Procedure:
        - Secretary's Report
        - Treasurer's Report (if any)
        - Press Report
        - New Business: local and provincial 4-H activities/opportunities, upcoming club activities
    - Meeting content and activities
    - Clean-up
    - Social Recreation and/or refreshments

Judging and Communications:

Each meeting must include either a judging or public speaking activity.

- Judging gives the members an opportunity to use judging techniques as part of the learning process. Through judging, members learn to evaluate, make decisions and communicate with others. They also develop critical thinking skills, confidence and self-esteem. Many examples are used in this reference book but use your imagination! As long as members are setting criteria and critically thinking about where items fit within that set of criteria, they are learning the basic skills of judging!

- A communications activity has been provided for each meeting but can be included in the Roll Call or social recreation time. These activities do not need to involve the topic of agricultural biotechnology as the outcome is more about understanding the concepts of effective communication.

LEADER'S PLANNING CHART

Meeting #	Date/Place/ Time	Topics Covered	Activities	Materials Needed

As a club volunteer your responsibilities are to:

- Complete the volunteer screening process and attend a volunteer training session.
- Notify the local association of the club, arrange a meeting schedule and participate in club meetings, activities and the Achievement program.
- Review the project material in the Reference and Record books to familiarize yourself with the information and adapt it to fit your group. Be well organized and teach the material based on your group's age, interest and experience level.
- Organize the club so members gain parliamentary procedure, judging and communication skills.
- Have membership lists completed and submitted along with fee collected (if applicable) by the end of the second meeting.
- Have members fill out a Participant Agreement Form and identify any health concerns. Ensure that all members, leaders and parent helpers know the appropriate actions during any emergency. Check with members for any food allergies or dietary restrictions and plan snacks accordingly.

As a club member your responsibilities are to:

- Participate in at least 2/3 of his/her own club meeting time. Clubs must have a minimum of 12 hours of meeting time.
- Complete the project requirement to the satisfaction of the club leaders.
- Take part in the project Achievement Program.
- Fill in and complete the Record Book.
- Complete any other project as required by the club leaders.

Achievement Program Ideas/Suggestions

- Make a display about agricultural biotechnology and display it at a local fair, in the mall, in a store front, etc.
- Have members make a presentation at school about agricultural biotechnology and how it can have an effect on their lives.
- Create a skit about agricultural biotechnology and perform it at school, at a senior's home, at another organization's meeting, etc.
- Use your imagination! Discuss as a group what ideas members might have for an Achievement Program for the Agricultural Biotechnology project.

Special Projects

These projects are done outside of meeting time and are for members interested in doing more – often senior members. It's up to you as the leader to decide if you will require members to complete a Special Project for club completion. Some ideas include:

- Write a press release about agricultural biotechnology and submit it to your local newspaper.
- Interview someone who works in the agricultural biotechnology industry and write a press release for the newspaper or a blog post about them and what they do within the industry.
- Create a display showcasing a product created as a result of biotechnology. Include information such as effect on the environment, why the product is needed and the economics of producing the product.
- Create a video about any aspect of agricultural biotechnology found in the project. Post on YouTube.

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MEETING 1: BREAKING DOWN AGRICULTURAL BIOTECHNOLOGY

Setting Objectives:

When discussing biotechnology, it is essential to understand the principles while also examining the value that biotechnology can bring and the controversies that it creates. This meeting should introduce members to the topic of agri-food biotechnology, the reasons for its adoption, and why the technology is controversial. Members should also be able to identify good sources of scientific information to help inform debates.

Suggested Lesson Outcomes

- ☐ For members to explain what biotechnology is and the role it has in the agri-food industry
- ☐ For members to recognize the development of plant, animal and microbial breeding over the years
- ☐ Members should have a good understanding of why biotechnology is used and what controversies surround it.
- ☐ Members can recognize factually accurate sources of information and can make fact-based arguments.

Roll Call:

Introduce yourself and something that you already know about agricultural biotechnology.

Sample Meeting Agenda Time: 2 hours 15 minutes

Note: Agendas are provided as a suggestion. There is more meeting content than what can be completed in 2 hours. Please choose activities according to skill and attention level of your members. Be creative!

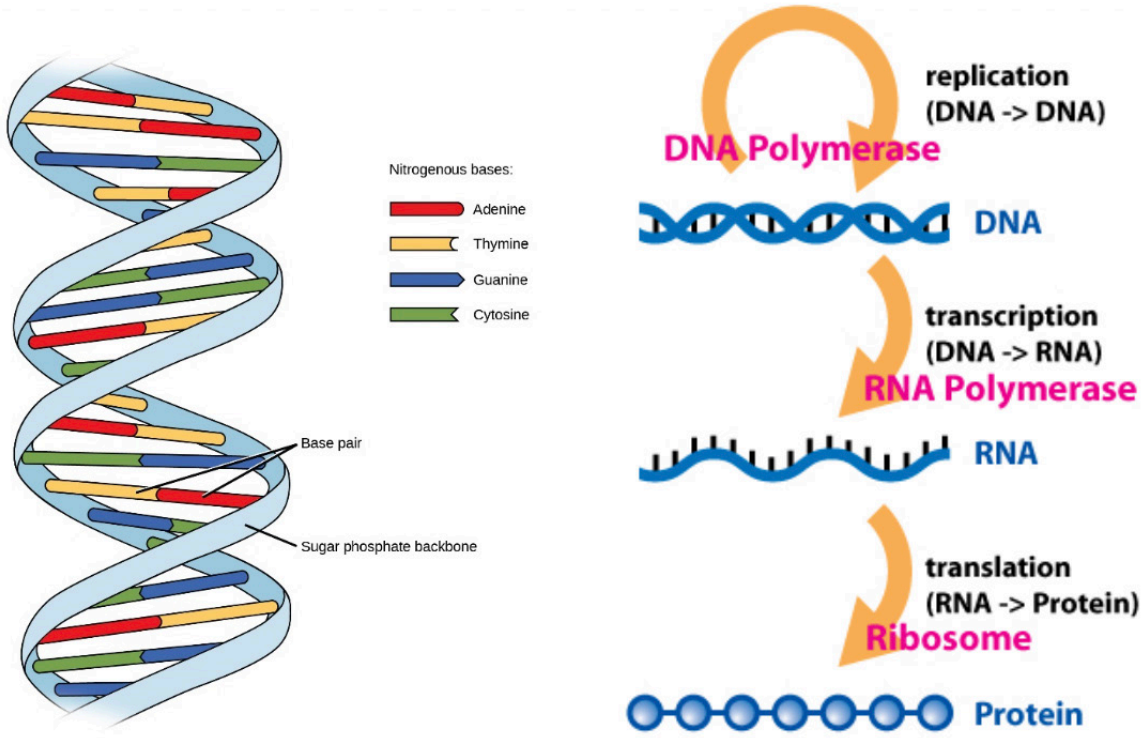
Welcome, Call to Order and Pledge		20 min
Parliamentary Procedure	Election of Officers, Roll Call, Introduction & Business	25 min
Activities Related to Topic	Activity # 1 – What does Biotechnology mean to you? (worksheet)	10 min
Topic Information Discussion	Topic Discussion- Importance of Biotechnology	15 min
Activities Related to Topic	Activity # 2 – Soylutions: Creating Plastic out of Everyday Items	20 min
Topic Information Discussion	Topic Discussion- Accessing Information	10 min
Activities Related to Topic	Activity #3—Who do you believe?	15 min
At Home Activity	Biotechnology Article	
At Home Activity	Choose one of the activities	5 min
Wrap up, Adjournment & Social Time		15 min

Topic Information: What is Biotechnology?

Biotechnology = Biology + Technology.
Biotechnology is the use of living organism, especially microbes, to produce beneficial products. It is also the use of recombinant DNA techniques to harness the power of organisms to make useful products. It is the use of biological processes for industrial and other purposes. Harnessing these biotechnological processes enable scientists to produce antibiotics, hormones, crops etc.
For thousands of years, we have used biological processes of microorganisms to make products such as bread, cheese and to preserve certain dairy products. Other microorganisms (yeast) have been used for their fermentation processes to make alcohol. The World Health Organization (WHO) defines biotechnology as "biological processes that have been engineered." The Canadian Food Inspection Agency (CFIA) is more specific and defines Biotechnology as, "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. This term is very broad and includes the use of traditional or conventional breeding, as well as more modern techniques such as genetic engineering.

What are Genes?

Genes are the genetic material of an organism. Together they form the genome of an organism. The genome is like the blueprint of the organism that tells the organism what to do. The genes of an organism are made up of molecules called nucleic acids that form the DNA (Deoxyribonucleic Acid). Four nucleic acids make up DNA, and these are cytosine, guanine, adenine and thymine. DNA is a double helix bond with a phosphate backbone. The combination of these four nucleic acids are what determine the way that an organism functions. The DNA is transcribed to RNA (ribonucleic acid), then the RNA is translated to protein. The protein is what mainly dictates the way that an organism interacts with its environment. By changing the DNA, you can influence many different aspects of an organism. There are two main ways to accomplish this which include conventional breeding and genetic engineering. Both are forms of genetic modification that we will go into further.



Source: Wikimedia

What is Conventional Breeding?

Conventional breeding (also called selective breeding) is used to produce plants and animals that have improved characteristics. The method works by crossing together plants or animals with desired characteristics and selecting only the offspring with the desired combination of characteristics. As a result of this selection, the characteristics that you want are passed on in the form of genes.
This process of conventional breeding is best explained through the work of Gregor Mendel. This famous scientist worked with pea plants to establish many of the laws that we know today. This topic is covered further in the 4-H Ontario manual- Veterinary- Genetics.

Genetically Modified vs. Genetically Engineered?

The term genetically modified (GM) can refer to a plant, animal or microorganism. These organisms can be genetically modified if its genetic material has been altered through any method including conventional breeding. A GMO simply refers to a genetically modified organism.
In comparison, genetic engineering is when an organism is genetically modified using techniques that permit the direct transfer or removal of genes in that organism. When the gene comes from an organism that is unrelated to the original organism this is referred to as transgenic. A good example of this is, Bt. corn (named after Baciullus thuringiensis) which has a gene from a

bacterium that protects the corn from a pest that once devastated corn crops. Innovations like these can be found in many crops.
Gene-editing, the process of inserting or removing genes, can involve changes within the gene structure of the plant, or it can be transgenic, introducing genes from another organism.

The Importance of Biotechnology

Did You Know?

Herbicide resistance and Insect Resistance in plants are the two most common genetic engineered traits.

The first genetically engineered crop was approved for use in Canada in 1994. In 2017 13.8 million hectares (equivalent to around 34.1 million acres) of biotech crops were grown in Canada (source: AgScape). Worldwide 189.9 million hectares (equivalent to around 469 million acres) of genetically engineered crops were grown (Source: ISAAA).The topic of biotechnology is too big to ignore and it has an impact on agriculture today, and will have more in the future! There are genetically modified plants which include corn, soybeans, sugarbeets, canola, Innate® potato, Artic® apples and many others. There are also genetically modified animals which include AquAdvantage Salmon® and Enviropigs™.

Not all genetically modified organisms are used in the food industry. For example, genetically modified yeasts are used in the production of ethanol. Ethanol is a fuel source that is made by fermenting sugar. This sugar can come from corn and other crop sources but in the end becomes a fuel source or other alcohol product (i.e. hand sanitizers). The field of biotechnology is massive and includes everything from GMOs to cheese and dairy products.

Conversion of corn into ethanol through sugar

Over the next six meetings, we will introduce members to some of the intricacies of modern agricultural biotechnology while also discussing the social factors affecting their acceptance. It is important to remember that not all biotechnology is GMOs. Certain bioproducts are made using organisms that are not genetically modified. Bioplastics and fermented products are two of these examples. In the next activity, you will learn about soy plastics to introduce yourself to the different sides of biotechnology.

Accessing Information

Did You Know?

Insulin was the first genetically engineered product produced in Canada in the year 1978.

There are many different types of sources in today's increasingly digital world. Blog posts, social media and journal articles are just some of the ways that authors can send information that really matters out to the world.

Is It Scientific Research?

This is always the first question that you should ask when examining any science-based article. In this manual, we look at a fact-based approach to make arguments. Some online and print sources may not always follow this. The key here is if there has been no experiments, collected results or conclusions from those results you are likely not looking at high-quality scientific research. If the publication is a scientific paper, it will have a title and list the authors and steps that the authors took to reach their conclusions. Scientific journal articles are some of the best sources for information and are peer reviewed. What does that mean?

Peer review means that experts in the field have reviewed the article and have agreed with the findings based on the results. There are usually three reviewers for every article that is published who are all experts in that field of study. That is what makes journals so reliable. However, the publishing time can often take a very long time which can slow the flow of information or products to the consumer.

A review or literature review is often done by either scientific publishing companies or the scientific journals themselves. The process looks at taking primary literature (journal research papers) and citing them to summarize all the work for that field. Reviews can act as an excellent source for people who are first researching a topic.

Newspaper articles, television and radio adverts are also commonly used to provide information to the public. This information is often based on one set of research or a survey, however. Also, little context is often given so take this information with a grain of salt. It is important when looking at these types of results to consider the way the information was collected. Essentially if the information does not tell you where the information for their headline or claim was obtained, the quality of the information may not be good.

Sales brochure or ads can be very important for members of the industry. They often involve the brand making a claim about how their product or service is better than their competition. In agricultural biotechnology, this is often about the yield rates, the effectiveness of a new pesticide or something that the company has rigorously tested. These companies have to vigorously defend these claims by doing field trials or other similar examples. These results may

come from within the company or may come from a public institution. We will talk about the importance of public/private partnerships later in this manual, but they are often great sources of innovation and communication with the public.

A tweet, blog posts or social media posts is the last one that we will talk about. These should all be deeply considered for scientific meaning. We should not blindly trust any of these without knowing the facts, but these will often have some sort of lean or bias associated with them. These online methods are the ones that many anti-GMO advocates use. They link to other blog posts and use their "findings" like results. They are a problem as they can look official and yet have misleading information. The next activity will get you to look at headlines and sources and see if you can make decisions on what headline you would trust based on the source. The activity is meant to test your intuition but understand that not all of the options may be trustworthy. You really have to find out where the results are coming from and read the conclusions to know for sure.

Scientific writers and imposters alike can publish in most of these, so it is essential to understand how they all work.

ACTIVITY #1: WHAT DOES BIOTECHNOLOGY MEAN TO YOU?

DO	**Time:** 10 minutes **Materials Needed:** • Biotechnology worksheet • Writing utensil **Instructions:** • Give each member a Biotechnology worksheet. This worksheet is not meant to be a test. It is meant to assess what each member knows already and to introduce some new ideas. Some younger members may find this activity difficult so have members work in groups or as a team to complete this sheet. If members look like they are frustrated take up the answers and move on to the games to bring the members back in. • Explain the worksheet and have members fill in the blanks (get members to work collaboratively) • Review the worksheet to ensure that all members have the blanks filled in correctly
REFLECT	**Learning Outcomes:** To allow members to identify and understand the various aspects and topics related to biotechnology as they progress in their knowledge, so members are better equipped to learn about examples of technology and controversies surrounding these topics.

APPLY	**Processing Prompts:** • Why is it important to understand the basics of biotechnology? • Was it easy or hard to fill out the worksheet? • Are you more familiar with biotechnology now that you have completed the activity? • Are there topics of biotechnology that you did not find on the worksheet?

ACTIVITY #1: WHAT DOES BIOTECHNOLOGY MEAN TO YOU?

Highlighted answers are the correct answers. Worksheet for members found in the Record Book.

1. What does biotechnology mean?
    a. The use of human ingenuity and robotics to make physical products
    b. The use of biological processes in plants, animals and microorganisms for practical or industrial purposes.
    c. The use of software and other technological components to complete biological analysis
    d. None of the above.

2. Genes are the _____ material and _____ of an organism (Genetic, Blueprint)

3. The genome of higher organisms is made up of _____?
    a. Neurons
    b. RNA
    c. Protein
    d. DNA

4. The genome of an organism is found in _____ of cells that have a nucleus?
    a. 100 %
    b. 50 %
    c. 30 %
    d. 80 %

5. When was the first genetically engineered crop approved in Canada?
    a. 1994
    b. 1969
    c. 2001
    d. 2018

6. What was the first genetically engineered product produced in Canada (1978)?
    a. Bt Soy
    b. Human Insulin
    c. GE Sheep
    d. Kosher Salt

7. How many hectares of biotech crops were grown in Canada in 2017?

a. 3 million Hectares
b. 1.5 million Hectares
c. 13.8 million Hectares
d. 10.2 million Hectares

8. The term GMO stands for: Genetically Modified Organism

9. There are several genetically engineered crops that are grown in Canada. Can you name 3?
Corn, Soybeans, SugarBeets, Canola, Innate® Potatoes, Artic® Apple

10. True or False: Herbicide and Insect Resistance are the 2 most common Genetic Engineering Traits?

11. There are a few types of genetically engineered animals? Can you name one of these?
Enviro Pig, AquAdvantage Salmon

12. Biotechnology often is associated with GMO. What are some other products that involve biotechnology? Bioplastics, cheese, yogurt, modern drugs etc.

13. True or False: The purpose of biotechnology is to increase the amount of pesticide and that farmers will have to use?

14. A Transgenic organism has a gene from another organism that is foreign to the original organism

15. Are GMOs currently sold on the market safe based on all of our scientific knowledge? Yes

16. The population is expected to grow to ____ billion by 2050. This will require farms to produce ___ % more food. (9 Billion, 70%)

17. What is the largest consumer of GMO products? Animals

18. Will herbicide-tolerant and pesticidal genetically engineered crops lead to intensified use of pesticides or herbicides? _____
_____
_____

No, the tolerance allows for the use of less herbicide and some traits are designed to work towards the reduced need for them (i.e.: Bt. corn)

19. In Canada, it costs _____ million and can take ___ + years for a plant biotech product to get to market?
    a. 150 million, 10 years
    b. 1 million, 10 years
    c. 50 million, 1 year
    d. 100 million, 5 years

20. Health Canada and the Canadian Food Inspection Agency evaluate all biotechnology products for:
    a. Only the effects on human and livestock animal health
    b. Potential effect on human, livestock animal and environmental health
    c. Only the environmental impacts
    d. Only the effect on humans

21. Once a new product makes it to market does it still undergo re-evaluation by regulatory bodies?
    a. Yes
    b. No

ACTIVITY #2 - SOYLUTION: CREATING PLASTIC OUT OF EVERYDAY ITEMS

DO	**Soylution: Creating Plastic Out of Everyday Items** **Time:** 20 minutes **Materials Needed:** • 1 Tbsp of corn starch • 2 drops of soybean oil • 1 Tbsp of Water • Food Colouring **Instructions:** 1. Place 1 tbsp of cornstarch into the plastic bag 2. Add 2 drops of soybean oil 3. Add 1 Tbsp of water 4. Close bag and knead it, mixing the contents 5. Add two drops of food colouring 6. Seal bag leaving a corner of the bag open to vent the contents 7. Heat bag in the microwave for 20-25 seconds on high (Caution: Bag will be hot!) 8. Remove the cornstarch and oil mixture and see what shapes you can form
REFLECT	**Learning Outcomes:** The purpose of this meeting is to show a real-life application of biotechnology. By the end of the meeting, members should have a deeper understanding of the diversity of the field of biotechnology.

APPLY	**Processing Prompts:** • Why is this plastic unique? Do you think the biodegradability of soy plastic is important in today's world? • How do you think the plastic was formed? • The cornstarch binds to the oil when the cornstarch and oil mixture is heated • Do you think this could be done with other types of oil or techniques? • There are many ways to make bioplastics with different strengths and properties. Think about the plastic you use every day. There are harder containers, and then there is very thin plastic for covering dishes.. • Did you like this activity? • If so we will talk more about bioproducts in meeting 5!

Source: National 4-H Council (USA) Agbiotech Facilitator's Guide

ACTIVITY #3 - HEADLINES - WHO DO YOU BELIEVE?

DO

Headlines- Who do you Believe?

Time: 15 minutes

Required Information:

- Headlines - A catchy phrase that gives the reader an idea of what will be in the article, post or paper.
- Source - The company or institution that publishes the claim and evidence.

Materials Needed:

- The five headlines printed and stuck to the wall in the meeting area
- 8 "Tokens" for each member – these can be small post-it notes or square pieces of paper
- Optional: Sealed Boxes

Instructions:

1. Place the printed claims around the room and place ballot boxes around the room to collect the tokens for each headline.
2. Tell members to read each headline and the source (8 minutes).
3. Once you have read all the headlines and sources use your trust token to show your trust in both that headline and the source. (1 minute)
4. The president should count the number of tokens under each option and show the results. (2 minutes)
5. Discuss with members about the need to use judgement in reviewing headlines and sources, the importance of scientific research and reading the article to get all the facts. (4 minutes)

REFLECT	**Learning Outcomes:** For members to understand the importance of sourcing information within the scientific field while examining apparent scientific claims. This should show members that not all sources are reliable.
APPLY	**Processing Prompts:** • Why did you choose the source that you did? • Did you think any of the claims were so outrageous that they could not be right? • How do you feel about traditional sources (scientific paper, science review article) vs social media posts? • Do you think that all scientific peer reviewed articles should be trusted blindly?

Adapted from Sense About Science

#1

The CLAIM

“Rice plants engineered to be better at photosynthesis make more rice”

The SOURCE: ScienceDaily, a science news site (summary of a single piece of research)

ScienceDaily®

https://www.sciencedaily.com/releases/2019/01/190110141814.htm

#2

The CLAIM

“Recent advances in rice biotechnology—towards genetically superior transgenic rice”

The SOURCE: Plant Biotechnology Journal, a scientific open assess journal

https://onlinelibrary.wiley.com/doi/full/10.1111/j.1467-7652.2005.00130.x

#3

The CLAIM

“Poor could benefit from biotechnology: UN food agency”

The SOURCE: CBC News (Newspaper that aggregates sources)

https://www.cbc.ca/news/technology/poor-could-benefit-from-biotechnology-un-food-agency-1.474081

#4

The CLAIM

“Light-weight plastic cylinders are easier to manage than glass alternatives”

The SOURCE: Twitter- Thermofisher (Biotech Sales Company)

https://twitter.com/thermofisher

#5

The CLAIM

“Hollywood and the Anti-Biotechnology Food Movement”

The SOURCE: Biotech Now- Biotechnology (Science Blog)

BIOtechNOW

http://www.biotech-now.org/food-and-agriculture/2017/03/hollywood-and-the-anti-biotechnology-food-movement

MEETING 2: TRAITS, RESISTANCE AND GENETICALLY MODIFIED ORGANISMS

Setting Objectives:

When discussing plant biotechnology, it is important to understand the development of traits that give plants resistance to herbicide, pests and even weather conditions. Through this meeting members will learn about traits in a group brainstorm session and will learn about the science of resistance. Members will also use knowledge from the last meeting to focus on the topic of genetically modified organisms (GMO). Members will discuss the portrayal of GMOs in the media and overall safety in the marketplace using the most recent scientific information.

Suggested Lesson Outcomes

- ☐ For members to explain the meaning of the word trait and to understand different examples.
- ☐ Members should have a good understanding of why we use resistances and the impact of these resistances.
- ☐ Members will be able to make fact-based arguments and discuss the importance of GMOs in our everyday lives.
- ☐ Members should be able to conduct research and find emerging frontiers in trait and chemical biotechnology.

Roll Call:

Bring a reputable piece of scientific literature about agricultural biotechnology (newspaper, research article, etc.) and talk about why it is a good source of information

Sample Meeting Agenda Time: 2 hours 30 minutes

Welcome, Call to Order & Pledge		10 min
Roll Call		5 min
Parliamentary Procedure	Minutes & Business	10 min
Activities Related to Topic	Activity # 1 – Resistance Biology.	30 min
Topic Information Discussion	Topic Discussion- History of Animal and Plant Breeding	10 min 10 min
Activities Related to Topic	Activity # 2 – What is a trait?	15 min
Topic Information Discussion	Activity #3- Controlling Resistance.	20 min
Activities Related to Topic	Activity #4—The Real Deal on GMO	20 min
Wrap up, Adjournment &	Choose one of the activities	5 min
Social Time		15 min

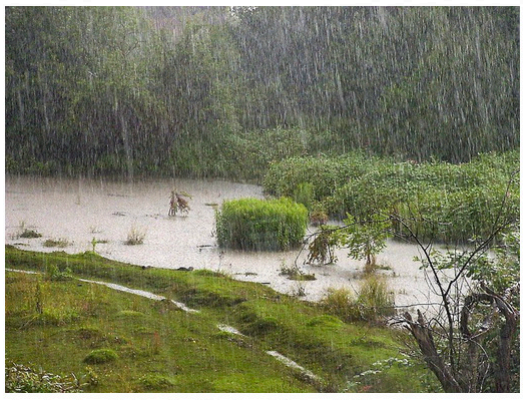
Topic Information: Resistance Biology

Biological resistance is defined by the USDA to involve the natural or genetic ability of an organism to avoid or repel attacks by biotic or abiotic agents

- Biotic refer to anything that is living. Examples include pathogens, pests and parasites. When an organism is given traits that make it more resilient to a certain type of pest (such as Bt. corn) we claim that this resistance is to a biotic agent. In the case of Bt. corn the biotic agent is an insect.

Corn Borer

- Abiotic agents include chemicals, pesticide, salt, wind, heavy metals. These are those aspects that impact an organism that are not living. A good way of thinking about this is through the most famous example of Roundup Ready gene technology.



Rainy Conditions

In 1970, a young chemist by the name of John Franz and his supervisor Dr. Phil Hamm discovered a molecule called glyphosate after receiving information on potential herbicides. Both individuals worked for Monsanto and the product was revolutionary. In the past herbicides

were designed to kill only one plant or certain groups of plants. In these early herbicide types the crops were left mainly unharmed, but some weeds still managed to survive if the herbicides were not selected properly. Glyphosate is a non-selective herbicide, meaning it will kill most plants. It prevents the plants from making certain proteins that are needed for plant growth by inhibiting a specific enzyme pathway, that plant or animals do not have. When used at the right rate it was more environmentally friendly than other alternatives at the time. What came next?

In 1976 Roundup® was approved for agricultural use in Canada. Following this, biotechnology became a big part of Monsanto's vision in order to get a gene into valuable crops that would be resistant to the glyphosate. In a special strain of bacteria (Agrobacteria) the enzyme that would normally be affected by glyphosate has a slightly different shape. The enzyme in question is EPSPS or 5-enolpyruvyl-shikimate synthase. This enzyme is important for plants as it is the necessary enzyme to produce amino acids. When the enzyme is bound by glyphosate the enzyme is inactive and the plant dies as it cannot produce the building blocks for protein. In the case of the Roundup ready plants the original EPSPS is supplemented with another enzyme by using a process called transformation. This will be discussed in a later meeting but essentially this is the process that was used to introduce external DNA (from Agrobacterium strain CP4) into the host plant.

Bacteria and plants can also acquire resistances that we do not give them through the process of evolution. To imply resistance means one of three things:

1. Enzymatic Degradation- Some enzymes can be used to degrade chemicals or antibiotics. By converting these chemicals into inert (non-reactive) molecules the organism can survive the effects.
2. Mutational Resistance- In all organisms a process called replication is always ongoing. Replication is how the genetic material is copied and how new cells are made. Organisms are not static and must constantly undergo replication to reproduce and maintain themselves. This process of replication of their DNA sometimes malfunctions and produces mutations in the genetic code. In some cases, these changes produce such an effect that the original function no longer exists. Some chemicals and antibiotics also bind to specific proteins. Proteins are coded by specific DNA sequences so changing these can change the binding ability.
3. Changes in physical aspects to membranes- An organism can change their membrane features so that the chemical or antibiotic no longer works.

Organisms are constantly undergoing replication and as a result they are constantly gaining differences in their genetic material over time. When a selective pressure is brought in, those who are fittest will survive to pass on their genes to the next generation. When we misuse

antibiotics or other industrial chemicals, we allow selective pressure to be exerted on those plants. All those organisms that have partial resistance can now survive and as the generations go on the chemical or antibiotic no longer works.

This leads into the serious problem with resistance that we have today. In plants farmers and researchers often find the hardest problem with resistance in weeds. Worldwide there are more than 249 herbicide resistant weedy biotypes in 47 countries (OMAFRA).

Canada Fleabane surviving herbicide (source: Washington University in St. Louis)

In general, these resistances have developed based on management practices. The same trend is also seen in antibiotic use. Antibiotics are medicines used to prevent and treat bacterial infections. Antibiotic resistance (or Antimicrobial resistance) occurs when bacteria change in response to the use of these medicines (WHO). It is estimated that 2 million people become infected with bacteria that are resistant to antibiotics in the US each year. This causes serious strains on the medical system and the remaining antibiotics that must now be used to treat these infections.

So, what can we do to prevent resistance? The following is a list of suggestions that applies to all chemicals and antibiotics for all organisms:

- Use pesticides, chemicals or antibiotics only when necessary
- Use the recommended rate, dose or prescribed amount.
- For herbicides, use mixtures that include 2 or more herbicide groups

- Rotate herbicides between herbicide groups
- Do not use chemicals that are not labelled for use on that plant

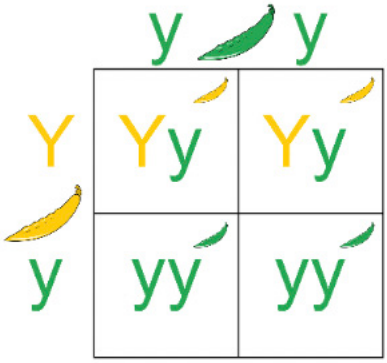
History of Animal and Plant Breeding: Impact on Biotechnology

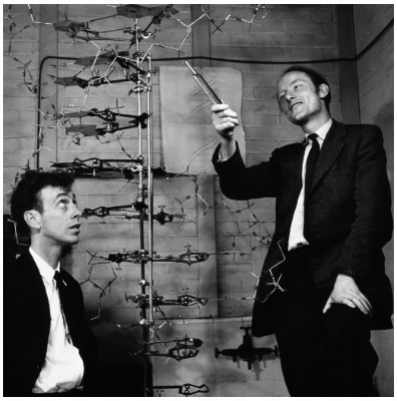
The history of both plant and animal breeding has been an ongoing process since the dawn of agriculture. Early farmers recognized a few crops and animals that if domesticated and crossed could make valuable hybrids. The term cross refers to taking two distinct lines of an organism and breeding them together. This is what forms a hybrid. These early farmers increased their yields slightly, but improvements were very slow. Still, agriculture allowed nations and civilizations to form and supported more and more people in one geographical location.

The lack of yield improvements changed in the 17th and 18th centuries when Europe was in the age of enlightenment. Humans now understood that they could improve their yields by experimenting with different crops and varieties. One of the ways that crop improvements were undertaken was by crossing two breeds from the same, or closely related species (transgenic). This produced an effect called hybrid vigour where the crop or animal outperformed their parental lines. Through these experimental approaches, early farmers and scientists quickly gained an appreciation for pollination and breeding.

The work of two Scientists really led the way for genetics. These two Scientists were Mendel and Darwin. Both scientists set out many of the rules that we build off today and were the fathers of genetics and evolution. Specifically, Mendel provided predictability for breeding using ratios. He noticed that some traits were dominantly observed upon crossing two lines of peas. He classified these as dominant and those that were overshadowed as recessive. Mendel worked a lot with statistics and used these to both evaluate and design breeding experiments. Mendel worked with only one type of plant (the pea) and only a handful of traits. Darwin is the father of evolution and talked a lot about how certain species survive through a term he coined as fitness. This means that only the strongest plants and animals would survive and pass on their genes to another generation. He also hypothesized that selective pressure could drive a species to adapt or die. It was thought that nature was constantly undergoing mutations (changes in the genome of the organism) and these changes were evaluated by their overall fitness. This is how diversity has really shaped this world.

These scientists were followed by others who worked and improved on their work. If this manual discussed all of them it could be its own topic all together but use the timeline below to look at important events throughout the years in the field of biotechnology. Remember that a lot of the innovation has come within the last 100 to 200 years.

Year	Discovery or Invention
1866	Gregor Mendel demonstrates the role of invisible factors which would be later called genes.
1870	First experimental corn hybrid produced in the laboratory **Punnet Square:** A chart that helps predict all the possible gene combinations in a cross between parental lines. 
1903	Wilhelm Johannsen developed the Pure-line theory. This theory states that selection techniques could produce uniform cultivars or true breeding. He also coined the terms: **Genotype:** A plant's genetic makeup (its genes or DNA) **Phenotype:** A plants observable or seen characteristic
1909	Nils Heribert-Nilsson publishes a paper demonstrating how the results between crosses, or hybrids produced plants that outperformed their parental lines. (This is where the term **Hybrid Vigor** was coined)
1925	The first hybrid corn breeding plot is established using the double-cross method developed by Donald Forsha Jones
1928	Alexander Fleming discovers penicillin
1933	Hybrid corn is first commercialized that had a 35% yield boost.
1942	Penicillin becomes mass produced in microbes for the first time
1951	The first artificial insemination of livestock is accomplished using semen that was frozen by liquid nitrogen.

1953	James D. Watson and Francis Crick determine the structure of DNA. The structure of DNA is found to be a double helix which would stand as one of the most important discoveries of the 20th century.  Source: Science History Institute
1955	The first polio vaccine is founded by Dr. Jonas Salk
1978	Recombinant human insulin is produced for the first time. This is one of the major events in biotechnology and led to the fast growth of the industry
1988	The first pest-resistant crop, Bt corn is produced. Bt or Bacillus thuringiensis is a bacterium found in soils throughout the world and produces Cry proteins that selectively kill a particular insect species. The species in question is the European corn borer, the corn rootworm or both depending on the genes added to the corn. These insects once were a major problem for corn but have since become a distant memory. This was big news for the biotechnology industry.
1988	The enzyme chymosin is the first enzyme to be produced from a genetically modified yeast source and to be approved. Chymosin is another name for Rennin and plays an integral part in the creation of cheese cultures.
1993	The Food and Drug Administration of America declared that GM food is not inherently dangerous and do not require special regulations. FDA
1995	Genetically modified potatoes that reduce the need for pesticides are sold in both the United States and Canada. These potatoes branded as NewLeaf™ potatoes control the Colorado potato beetle similarly to Bt. corn. However, these potatoes were taken off the market in 2001 as they were not overly well taken up by industry.
1996	Monsanto receives approval and markets their first Roundup (Glyphosate) ready product

2004	The UN Food and Agriculture Organization endorses biotech crops and claims that they are a complementary tool to traditional farming methods.
2006	The first plant-made vaccine receives approval
2013	CRISPR is founded from a defence mechanism used in bacteria and was suggested to be used for gene editing
2016	AquAdvantage Salmon® is approved for sale in Canada. By 2017 the parent company said that they had sold 4.5 tons of salmon fillets to customers in Canada

What is the difference between the government regulating a product vs a process?

What is a product? In general terms a product is anything that consumers use. You are a consumer and everything in your room and fridge are products. Governments can place regulations or control on products to ensure that they conform to all standards, rules, guidelines and laws.

Alternatively, the government can regulate a process. A process is the way that a product is made but can also include the government channels that a product must flow through to get to market.

Think about the two like so. Everyday meat is inspected by the Canadian Food Inspection Agency in different parts of the country. When the meat is inspected prior to being sold it is a regulated product and is graded for quality. To produce the product this involves other players in the industry. Farmers and transporters are also regulated by various government agencies. Farmers have rules about antibiotic use and animal welfare. Transporters must abide by laws under the Highway Traffic Act. Through these regulations a process becomes regulated. Biotechnology products face very stringent regulation and are often regulated by more than just one agency and more than just one regulatory process.

The Real Deal on GMO

You may have heard of these already but what are they? GMOs or genetically modified organisms and face an uphill battle in public debate. The problem is that although these GMOs have been approved for human consumption there is a cloud of misinformation over genetically modified organisms.

So what fuels that debate? Well the fact is that it is human nature to resist change and fear the unknown. In addition, there has also been a lot of words thrown around to describe genetically modified organisms such as Frankenfood. So what evidence is there that genetically modified foods are harmful?

The answer is none. There has been no scientific study that has linked GMOs to any sort of health-related problems. Think about a roast beef dinner. The beef was likely raised with the help of corn, hay, soybean meal, etc. All of those were almost entirely genetically modified sources. Nothing is wrong with this. On the topic of genetically engineered organisms they have faced one of the hardest uphill battles in recent times. Genetically engineered crops are a subsection of GMOs which involve those organisms that have been modified using gene editing technology. These organisms can have genes added, removed or modified. This allows scientists to give resistances to plants for pesticide resistance, specialized traits to animals for growth and production ability to bacteria to produce many of our vital human drugs. So why are there so much negative stigma around genetically modified and engineered organisms and what are their benefits?

Myth Vs. Fact

Myth: Changes in Nutritional Content

To dispel this myth. In Canada, to be labelled as the food product that the product claims, the nutritional information must be the same. There is also a belief that the new product may somehow create allergens or provide toxic effects to bodily organs. The fact is that a lot of the genes that are genetically engineered into plants have very little to do with the products that we consume. In fact, thousands of studies have looked into whether these effects exist, and the results have all came out with an unequivocal no.

Myth: The GMO industry has made it, so farmers have no choice

There is a lot of misinformation that farmers are somehow forced into growing genetically modified organisms. The fact is that farmers make choices about what they wish to grow every year. Farmers can choose from multiple seeds/products developed by different companies. And they do! Diverse options on the market helps farmers to better manage their operations through crop rotation and integrated pest management approaches.

Myth: GMOs Increase the Price of Food

The opposite is true. GMOs reduce the price of food. GMOs have allowed farmers to adopt new lower cost farming practices and increase yields. These savings are passed along to the

consumer through lower food prices.

Myth: Genetically Modified Foods are Intensified in the Food Chain

GMOs have never been detected in milk, meat or eggs. GMOs simply make it safer, cheaper and more efficient than previous alternatives. Additionally, all the food we eat is broken down the same way. Food is made up of fats, protein, carbohydrates and nucleic acids. All of these are broken into their building blocks and then put back together to make up the building blocks of your body. It is for this reason that animals often do not have the Genetically modified traces that some people expect them to have. These animals consume the feed and then break it down and use it to grow.

Myth: No Long-Term Studies Exist

This is plainly false. Both the FDA (Food and Drug Administration of the United States) and Health Canada are consistently undergoing testing and review. In addition, private and public research is always ongoing in the field to ensure that products are in fact safe and to safeguard the public.

Myth: GMOs have a negative environmental impact

Once again this is false. GMOs help with reducing insecticide use, herbicide use and increase yields. GMO crops also allow for important practices like conservation tillage. The result of this is that these GMOs contribute to reducing soil erosion and conservation of water. The fact is that we are getting more out of the crop land today than we ever have in the past.

What can we do?

Simply promote the proper information. The main reason that this problem exists is that there is not enough promotion of the importance of GMOs. In addition, we are not open about the benefits that GMOs have given to farmers. Look at the list below and think about how important these products are. Some plants like seedless watermelon, grape tomatoes, baby carrots are all examples of traditional plant breeding and are not classified as GMOs. Regardless through these examples of both GMO and non-GMO foods it can be seen that humans have always tried to produce products that improve taste, quality and utility.

Which Crops can be GMOs (and what they are engineered for)?

Crop	Insect Resistant	Herbicide Resistant	Disease Resistant	Other
Corn	X	X		
Soybeans	x	X		
Cotton	x	X		
Alfalfa		X		
Sugar Beets		X		
Canola		X		
Squash/Zucchini			X	
Papaya			X	
Potato				Reduced Bruising, Black Spot, Non-Browning, Low Acrylamide and Blight resistant
Apple				Non-Browning

ACTIVITY #1 - RESISTANCE BIOLOGY

DO

Time: 30 minutes

Materials Needed:

- Print out and cut out the sheets into squares.
- Open area for running or walking around

Instructions:

To understand the role of traits it is important to start with the role of selection and environmental pressures on crop systems. The activity involves a game which will start with around 5/6 of the group divided into crops and 1/6 of the group in the pest's group. If a member of the crops group is tagged by a member of the pest's group, this means that the person must stop and freeze in place. If another member of the crops group tags a frozen crop member, then the frozen crop member is unfrozen and considered to be free. In the second and third game, the task is kept the same, but the number of pests will be steadily increased. In the next game a natural disaster will be added by converting one of the members into this natural disaster part way through the game. The natural disaster can tag any member pest or crop, and that member must stop in their place, and they cannot be revived by another member. This should cut down on the number of people. Over time the boundaries will also be decreased meaning that there is nowhere for the crops and pest to go. Next 2/6 of the members will be assigned a resistant crop tag. Another 3/6 will be allocated a regular crop square. The final 1/6 will be pests. Pests cannot tag resistant crops, but resistant crops can unfreeze the tagged non-resistant crops. In the final game, one of the regular crops again becomes the natural disaster and repeat the game one last time. You can also increase and decrease the area and show that it gets easier and harder.

REFLECT	**Learning Outcomes:** The purpose of this activity is to show the power of resistant crops. The activity also serves to introduce the idea of traits to members.
APPLY	**Processing Prompts:** • Did the first and second round of the game seem like they were fair? • When there were three pests how hard was it to avoid getting tagged? • The natural disaster could tag all the members but did so indiscriminately. If the pest were to tag you and you were frozen how easy do you think a natural disaster could impact you? • Do you think pest pressure made it easier or harder to escape the natural disaster? • Did the introduction of the resistant crop make it easier to avoid the pests? • When you repeated the natural disaster with the resistant crops did the pests play as large of a role? Did the pests do their job and target the non-resistant crop?

Crop	Crop	Crop	Crop
Crop	Crop	Crop	Crop
Crop	Crop	Crop	Crop
Crop	Crop	Pest	Pest
Natural Disaster	Natural Disaster	Natural Disaster	Pest
Pest	Pest	Pest	Pest
Resistant Crop	Resistant Crop	Resistant Crop	Resistant Crop
Resistant Crop	Resistant Crop	Resistant Crop	Resistant Crop

Resistant Crop	Resistant Crop	Resistant Crop	Pest
Crop	Crop	Crop	Crop
Crop	Crop	Crop	Crop
Crop	Crop	Crop	Crop

ACTIVITY #2 - WHAT IS A TRAIT?

DO	**Time:** 20 minutes **Materials Needed:** • Paper/Bristol Board/White Board and appropriate marker **Instructions:** • Ask the questions in the "Apply" section and lead the discussion towards a more clear understanding
REFLECT	**Learning Outcomes:** The activity serves to bring in the idea of traits and resistance. This will act as the beginning before a subsequent discussion on different examples of traits can be made.
APPLY	**Processing Prompts:** Ask the following questions and write the responses. What is a trait? (A genetically determined characteristic) From the first meeting we talked about traits. Can you think of any traits that you have heard of? (Herbicide resistance, drought resistance, pest resistant, etc.) Can you think of a reason why we would incorporate these traits into our crop genomes? Based on the first activity do you think traits are beneficial? Why or why not?

ACTIVITY #3 - CONTROLLING RESISTANCE?

DO

Time: 20 minutes

Materials Needed:

- Numbers from 1 to 10 in a hat.

Instructions:

Round 1

1. You are all plants in a patch. Get members to draw a number.
2. If one member draws a 1 then all members are out and the game is over regardless of the other numbers drawn.
3. If the member draws a 2-4 they will be out at the end of the round
4. If the member draws an 5-8 they are safe
5. If the member draws a 9 they are safe for the rest of the game and can choose one other non-safe person to also be safe for that round
6. If the member draws a 10 then all members are safe for that round and that game is over.
7. You can repeat this game over and over again and then ask the processing prompts

Round 2

8. Play the game again. If you draw a 1-4 all are out
9. If you draw a 5-9 then you are safe
10. If you draw a 10 then you can choose one non-safe member to save

REFLECT	**Learning Outcomes:** The spread of resistance to other microorganisms has become a problem in many different biological species. We see this mainly in bacteria, for example with antibiotic resistance in medicine, but the trend is coming to plants. This game allows members to explore the area of resistance in weeds which can be applied to other examples.
APPLY	**Processing Prompts:** <u>Round 1- Not Enough Pesticide</u> ● If you drew a 1 then you got extremely unlucky. Improper use of pesticide is a serious problem and can lead to resistant weed development. That is why it is always important to read the label. The pesticide needs to be used as instructed. ● If you drew a 2-4 you were personally not saved and the pesticide made sure you did not make it. That being said the rest of the population would carry on and cause yield and resistance problems. ● If you drew a 5-8 congratulations unless a 1 was drawn you were safe this round. What do you think the problem with even 1 surviving weed is? ● If you drew a 9 you pass on your resistance to another plant that may not have survived. This is a very simplified explanation to how this happens as this usually happens over generations. ● If you drew a 10 the whole team was resistant as long as no 1 was drawn. This is an example of a resistant weed variety. There are currently 21 pesticide resistant weeds that are in or will be in Ontario shortly. Most of these weeds came from South of the border where crop rotation is not always followed. What do you think is the effect on yield and economic impact of these weeds? ● (Attach a picture of Canada Fleabane destroying field)- Hold up the photo and ask members how they feel about this weed?

APPLY	Round 2- Properly Applied Pesticide ● If one member drew a 1-4. What happened? Was this game a lot harder? ● Do you think that it is easier to apply the label the right way? ● If anyone survived how lucky do you think you were? Do you think there is any chance that this could happen in the real world? What do you think the impact is if this were to happen? ● It takes years and a lot of money to get pesticides approved, and roundup is a once in one-hundred-year discovery. Therefore how important is it to look after this technology? Why? Consideration – Antibiotic Resistance Prevention • If you were a malignant bacterium rather than a pest, and we applied antibiotics rather than pesticide – what happens to that bacteria? How does it affect the future bacteria generations if you take your prescribed antibiotics right to the end, rather than stopping when you feel better? How does it affect the people who become infected after you if the bacteria has become resistant?

ACTIVITY #4 - THE REAL DEAL ON GMO- SPLIT THE ROOM

DO

Time: 20 minutes

Materials Needed:

- The statements below
- A room where members can be split into two different groups (Yes- Right, No-Left)

Instructions:

Split the room is a great activity to make members think about what exactly they believe in for each question and to commit to something. Members start in the middle of the room and are asked a question. If they agree with the question, they go on one side of the room. If they disagree, they go to the other. You can then ask questions to individual members. The purpose of this activity is not to challenge their opinions but to understand why they believe what they believe in.

Instruction Questions:

- Start the session off by asking if members know what GMOs are?
  - o Members will split into Yes and No. Those in the Yes ask them if they know what it means? Then ask the no group if they have heard of them now.
- I have heard a lot of negatives about GMOs?
  - o For the members who answered yes ask them where they have heard this?
- I have a positive outlook on GMOs?
  - o Ask the no group why they may not have a positive image.
- Genetically Modified foods contain the same nutritional attributes as like foods produced with non-genetically modified foods?
  - o For those who answered no, ask them why they think

DO	that? What makes the genetically modified organisms different? If they cannot think of an answer ask another person what a resistance gene has to do with nutritional components in corn or soybeans. ● I believe that organic farming is better for the environment and more sustainable? o For those who answered no. Why? Ask them if they know what the yield is like for organic products? If yield was 15-50% lower in non-GMO crops does that change your opinion? For those who answered yes, why? ● I think that the advent in GMOs has caused new ecologically protective practices. o For those who answered no, why? Have you heard of the process of no-till which allows for crops to be planted into fields with very minimal displacement of sod? ● I think Genetically modified organisms are beneficial? o The answers should be mainly yes now. No follow up questions this time. ● I think the government does enough to monitor GMOs? o This is a question to introduce the topic. For those who answered yes ask who regulates GMOs in Canada? (Health Canada and Canadian Food Inspection Agency)
REFLECT	**Learning Outcomes:** The activity serves to allow members to think about Genetically Modified Organisms and to clear up misconceptions that may exist. The purpose of this is also to check what members may already know about GMOs.

APPLY	**Processing Prompts:** When we asked you if you knew about GMOs, we were trying to get an idea of how many ideas members already have. The second question is meant to allow members to discuss what they already know about GMOs. The third question is meant to determine the opinion of each member. We are going to expand on this. The fourth question is about the nutritional attributes of these GMOs. For those on the No side let them know that the GM and non-GM foods are the same. There are no differences between the two but start by asking them why they are on that side. The fifth question addresses the organic farming vs non-organic. Did you know that organically grown food is 15-50% less efficient than non-organic farming? This leads into the next question where you can discuss the environmental impact of using no-till farming in GMOs and the need for less land to produce the same amount of produce. The last few questions are to get members thinking about future meeting topics as a way to link the ideas together.

MEETING 3: REGULATIONS, ANIMALS AND WELFARE

Setting Objectives:

When discussing animal biotechnology, it is important to understand the regulations about GMOs and preventing genes from passing into the natural population. Through this meeting members will learn the importance of animal biotechnology and present several examples of different types of animal biotechnology. The meeting will also discuss ethical issues and animal welfare with an example of the use of production systems involving engineered salmon.

Suggested Lesson Outcomes

- ☐ For members to explain the regulatory bodies that control agricultural biotechnology and their importance in protecting Canadians
- ☐ Members should have a good understanding of different types of animal agricultural biotechnology and understand their potential benefits
- ☐ Members will be able to look at animal welfare and gene control and make decisions based on their knowledge

Roll call:

Think of something that an animal has that could be improved? How would you improve it? Do you think that would be the right thing to do?

Sample Meeting Agenda Time: 2 hours 5 minutes

Welcome, Call to Order & Pledge		10 min
Roll Call		5 min
Parliamentary Procedure	Minutes & Business	10 min
Activities Related to Topic	Activity # 1 – Controlling Biotechnology- Regulatory Bodies and their roles.	15 min
Topic Information Discussion	Topic Discussion- Regulatory Bodies and Need.	5 min
Activities Related to Topic	Activity # 2 – What's that Animal?	15 min
Topic Information Discussion	Topic Discussion- Importance of Animal Biotechnology	20 min
Activities Related to Topic	Activity #3— Housing and Containment Control- Judging	25 min
Wrap up, Adjournment &	Choose one of the activities	5 min
Social Time		15 min

Roll call - Think of something that an animal has that could be improved? How would you improve it? Do you think that would be the right thing to do?

Topic Information: Regulatory Bodies

The role of the Canadian government in the biotechnology industry is to minimize risk, maximize health and safety, and ensure potential benefit. The agencies that control biotechnology include Health Canada, the Canadian Food Inspection Agency (CFIA), Fisheries and Oceans Canada and Environment Canada. All these government agencies work together to determine if the products derived from biotechnology are safe for both Canadians and the environment.

Health Canada

This government agency is responsible for helping the people of Canada in maintaining and improving their health. Health Canada regulates health, food, environmental and industrial products. It takes years of development and testing to bring a new biotechnology product to the Canadian market. In fact, the following table shows the amount of time that it takes for a crop to get to market.

Area of Regulation	Number of Years
Research	5-7
Field Trials	2-3
Evaluation	1-3
Re-evaluation	Ongoing

Health Canada will only authorize a product for sale in Canada when there is enough evidence supporting the safe and effective use of the product. Health Canada separates biotechnology products into three groups. These include health products, food and environmental or industrial products. Each of these sections has different regulatory processes.

Health Products

Health products make up a broad group of regulated products that Health Canada monitors. These products include vaccines, products made from animal and human fluids, tissues and organs, recombinant proteins, hormones, growth factors, and many others. The regulatory procedures for these products are set out as review and evaluation; compliance and enforcement activities; and monitoring and tracking. The Food and Drugs Act, Food and Drug Regulations and the Medical Devices Regulations are the documents that support the regulation of health products in Canada.

Food Products

The regulatory bodies refer to new food products developed, whether or not development is through biotechnology, as "novel foods." At the time of writing this manual 100 novel foods are approved for sale by Health Canada. If there are questions about the safety of a product, it will not be approved. The CFIA's role in this is to carry out safety assessments for the release of plants with novel traits into the environment. Also, the CFIA also looks at livestock feed, seeds, plants and soil supplements.

If a biotech product passes the assessment process and the other regulatory approvals a "letter of no objection" is given. This outlines any restriction or requirements relevant to the Health Canada decision but also allows the product to be sold in Canada. One aspect of this is that the labelling of these products must follow the Food and Drugs Act.

Labelling of Foods from Biotechnology

This is an important issue. We have outlined previously that there is no proven risk of genetically modified organisms that have been approved, but some members of the general public still wish for GM food to be marked. The only time that labelling is required is if the nutrient content is different for the GM food however this is rarely the case. Otherwise, the process of labelling GE foods is voluntary under the Canadian General Standards Board.

Environmental/Industrial Products

The last of the three groups. This group includes biological pesticides, biofuels, biomining, tree biotechnology, and many others. Both Health Canada and Environment Canada have joint responsibility for this category under the Canadian Environmental Protections Act, 1999. Both agencies manage substances that pose a risk to human health and the environment regardless of whether they occur naturally or are genetically modified. Another important regulatory law is the Pest Control Products Act which imposes rules for pesticides that include herbicides, insecticides and fungicides. It is critical that human health, animal and environmental health are always considered.

Examples of Animal Biotechnology

Example	Problem it Solves/ How it Works
Aquadvantage Salmon	- Salmon is a valuable food source full of many good fats and oils as well as an excellent source of protein. - Salmon is hard to farm and there is a need to produce fish faster for the growing population. - The fish is an Atlantic Salmon with one Chinook salmon gene inserted into the genome. With this additional gene the fish can produce growth hormones all year round. - The fish also has a promoter from another breed of fish that allows the fish to grow at much lower temperatures which allows for promotion of growth. - While the non-GMO salmon takes 24-30 months to reach market size, the GM salmon only takes 18 months.
BioSteel/ Silk From Goats Milk	-Spider silk is seen as one of the strongest and most tensile fibers in the world. Yet it is not economically feasible to produce this in large quantities. -One company, Nexia Biotechnologies used transgenic goats' milk to produce these fibers that were 7-10 X stronger than steel. There is a potential that these fibers may make bulletproof material more resilient.
Enviropig	- Livestock produce phosphorus in their waste. This manure is spread onto the fields, causing phosphorus to leak into the Great Lakes, resulting in algal blooms

Enviropig	- The Enviropig is genetic engineered to produce the enzyme phytase in its salivary gland. This allows the pig to digest phytate, which is the form of phosphorus found in both corn and soybeans (both large parts of pig feed). - Enviropig manure has phosphorus levels that are 30-65% lower than those in regular pig manure.
Polled Dairy Cattle	- Dairy cattle are often born with horns. These cattle use these horns to establish territory, harming members of the herd, but these horns can also really harm farmers who look after these cattle. - There is an alternative and that is “polled” cattle. When a cow is polled it means that they do not have horns. - Biotechnology has aided this problem by taking DNA from the genome of Red Angus cattle. This gene is known to suppress horn growth. - These genes were inserted into cells taken from an elite bull called Randy. These cells were then cloned and as a result these cows should be the non-horned version of Randy.
Silkworm	- Silkworms are an important part of sericulture (the production of silk) but may also be useful in drug development - Silk worms are easy to raise and as a result by getting these silkworms to produce proteins that might be economically costly otherwise. - Scientists insert these genes into the worms which allows them to use the machinery of the host organism to harvest the final product

Importance of Animal Biotechnology

As you can see from the previous activity, biotechnology has a great potential to help the world through solving many environmental and health-related problems. There has been a concern however over the transfer of biological material to native populations. To discuss this, we will look at the example of the AquAdvantage® Salmon.

As discussed previously the AquAdvantage® Salmon is a transgenic breed of Atlantic Salmon. The salmon has a gene that increases the growth rate of these salmon. When AquAdvantage® salmon was first approved through the FDA (Food and Drug Administration- USA) there was approval for one egg production facility in Canada and one specific fish production facility in Panama.

The reason for the limits on where the fish were produced was to prevent the release of the GMO salmon into the environment. Since AquAdvantage® Salmon have really been the first native species that have been used for biotechnology, there has been increased regulations on containment. These include biological, physical and environmental control.

Biological Containment Controls

To prevent transgenic fish from mating with native or wild salmon the best type of control is to use only fish that cannot breed. How does this work? The simple answer is that these fish have one more set of sex chromosomes (gene-containing molecules). Normal cells have two sets of chromosomes, but by adding a third, we can prevent female fish from producing eggs. This works through the use of pressure, temperature or other chemicals. The problem is that the pressure treatment that is often used is only 98% effective. That is still 2% of fish, and if you have 100 fish, 2 will be non-sterile. This creates the need for other techniques.

Physical Containment Controls

Controlling biotechnology is a big deal! Fences, security and several walls between tanks are normal to see. Even the water outflow is controlled through filters, nets and screens. In addition, water is chlorinated to kill any eggs that may escape the filters.

Environment Containment Controls

The physical location of the egg production facility is away from where Atlantic Salmon would normally spawn. Since Atlantic Salmon spawn in the same spot as they were born this is very important. In the highly unlikely case where a female (only gender that is spawned) escapes it

would not find a male to mate.

Why Does this All Matter?

Overall if the salmon were to get into the natural population, it would be larger than the native population. This would give an unfair advantage and would likely cause a shift to the transgenic species. A female can lay 1000 to 17000 eggs. In normal conditions, very few of these will hatch, but that is still a situation that you do not want to get into. Therefore, the controls need to be in place

ACTIVITY #1 - CONTROLLING BIOTECHNOLOGY-REGULATORY BODIES AND THEIR ROLES

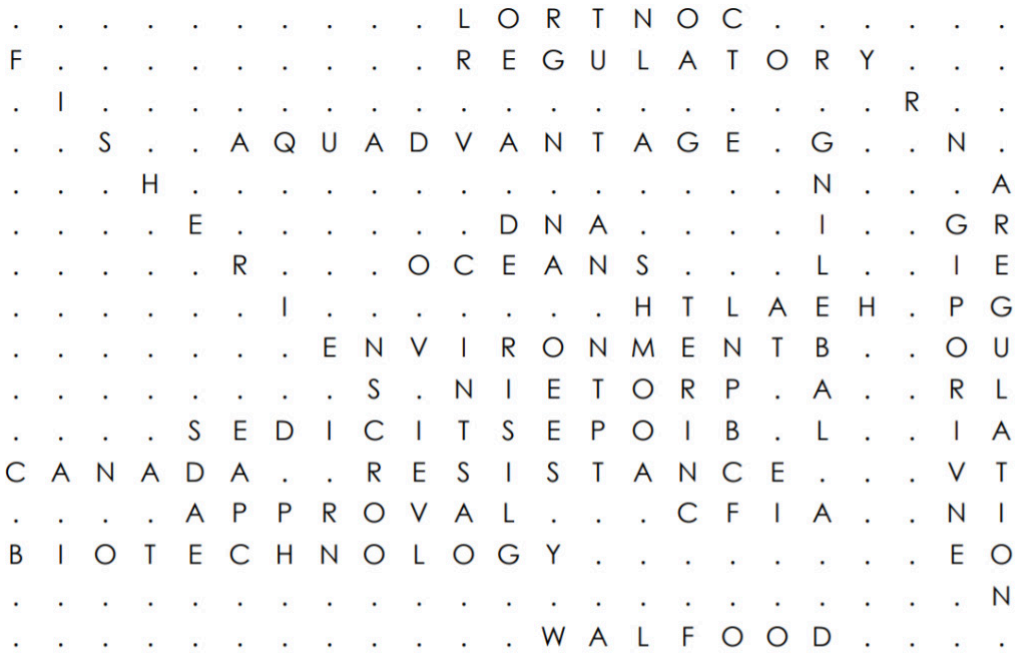
DO	**Time:** 15 minutes **Materials Needed:** • Members manual - contains crossword • Writing Utensil **Instructions:** 1. Introduce the crossword and get members to complete it 2. In the last five minutes get members to work together pairing older members with younger members.
REFLECT	**Learning Outcomes:** To introduce terms that will be used in this meeting.
APPLY	**Processing Prompts:** • Are there any words that you do not understand or not know the meaning?

Controlling Biotechnology

X S J K P V A V N N L O R T N O C N G D I W Z
F C R X J V A P J C R E G U L A T O R Y W F Z
E I P M C I V M Y R N T E B H K E P H D R S Y
B C S U C A Q U A D V A N T A G E R G E F N N
J E S H Z Q V H M I F D W Z I X H T N C W A A
G P Z I E R T K J X P D N A W H U P I H K G R
L O X T U R A P T O C E A N S J N B L C Q I E
X C X N B F I F V Q O T G L H T L A E H B P G
A B I K M X I E N V I R O N M E N T B F R O U
I V L R J M U Z S K N I E T O R P W A X Y R L
Y C D U S E D I C I T S E P O I B T L R N I A
C A N A D A Z D R E S I S T A N C E P Z E V T
X K Q U A P P R O V A L S W M C F I A B S N I
B I O T E C H N O L O G Y Y S B K M B V J E O
Y T I B X C U P Q T S F T X D D N Y V K L W N
C J P E U C F P M E J U W A L F O O D F G X A

APPROVAL
AQUADVANTAGE
BIOPESTICIDES
BIOTECHNOLOGY
CANADA
CFIA
CONTROL
DNA
ENVIRONMENT
ENVIROPIG
FISHERIES
FOOD
HEALTH
LABELING
LAW
OCEANS
PROTEIN
REGULATION
REGULATORY
RESISTANCE
RNA

Controlling Biotechnology - Solutions



ACTIVITY #2 - What's that Animal?

DO	**Time:** 15 minutes **Materials Needed:** • Fact Sheets- 3 (1 for each group) • Chart Paper or Writing Surface • Marker or Writing Instrument **Instructions:** **Activity:** 1. Split the club into three separate and equal groups 2. Give each group a fact sheet 3. Make a visual aid (mind map, picture, thought process) discussing the problem the biotech animal deals with and the potential impacts for animals, humans and the environment 4. Come back together and teach the other groups using your mind map 5. At the end talk about how the discussed biotech can be seen as being useful and humane.
REFLECT	**Learning Outcomes:** The purpose of this activity is for each member to learn about the animals that are approved by Health Canada. Also, members will learn about the advantages that these animals provide to both the human population and the environment.
APPLY	**Processing Prompts:** • Why do you think biotech animals are some of the most controversial GMOs?

The Enviropig™

Background

The Enviropig™ is the name given to a pig that has been genetically engineered to excrete less phosphorus in its feces. It was the first transgenic animal created to solve an environmental problem. The name is trademarked and was developed by researchers from the University of Guelph.

The problem with phosphorus is that in large quantities it acts as a pollutant. Plants need phosphorus, but if there is too much of it, then the excess runs off into streams and lakes. This runoff, along with other sources (eg sewage) has resulted in serious problems especially in the Great Lakes Basin in the form of algal blooms.

Algal Bloom (Source: NASA)

Science of the Animal

The Enviropig™ has genetic engineering that causes it to produce the enzyme phytase in its salivary gland. This allows the pig to digest phytate, which is the form of phosphorus found in both corn and soybeans (both large parts of pig feed). To create this enzyme scientists took the enzyme from an E. coli bacterium that naturally produces the phytase gene. Overall, published scientific studies have confirmed that Enviropig™ manure has phosphorus levels that are 30-65% lower than those in regular pig manure. What do you think the effect of this animal could be on controlling algal blooms in the Great Lakes basin?

Problems

It seems that the Enviropig came into the biotechnology world at the wrong time. The University of Guelph euthanized their animals. China has seen the advantage of these animals however and has moved towards reopening this research source. What do you think was the reason that the Enviropig™ project was terminated in Canada?

AquAdvantage® Salmon

Background

The AquAdvantage Salmon® is a transgenic species of Atlantic Salmon that is produced by AquaBounty. If you look at AquaBounty's vision, you will find that they want "to raise the world's finest, most sustainable Atlantic salmon. A fish that is nutritious, delicious, fresh and affordable".
Salmon is low in calories, low in saturated and trans fats but is an excellent source of protein, essential vitamins, minerals and omega-3 polyunsaturated fatty acids. The problem arises when we consider feeding 9-billion people by the year 2050. We simply must be getting more out of what we are feeding to our animals. In addition, most of the available land for raising animals is currently in use. The solution is aquaculture. In this realm Aquadvantage® Salmon requires 20-25% less feed than other farmed Atlantic salmon on the market today. How?

An example of non- GMO Salmon

(Source: Wikimedia)

Scientific Background

AquAdvantage® salmon contains a recombinant DNA construct that is comprised of the growth hormone from Chinook Salmon under the control of a promoter. Recombinant DNA is a copy of the original host's DNA while the term promoter refers to a gene sequence that promotes expression of another characteristic when it is turned on. In this case the promoter comes from another type of fish called an ocean pout. In the most straightforward terms the reason that the fish can use 20-25% less feed is that it grows so fast and has good feed efficiency. Why do you think there has been so much backlash over the aquadvantage salmon in the industry? Do you think labelling laws need to be strict in order to deal with these problems? Brainstorm.

Polled Cattle

Background

It is estimated that 80% of dairy cows have their horns removed each year. This is not done maliciously but rather to protect both their handlers and other cattle. Cattle are herd species that fight for dominance. However, the process of "disbudding" or removing the horns is both potentially painful for the animal while also being a costly expense for the farmer. Within the realm of dairy cattle when an animal is born without horns it is naturally polled. The polled trait has been on the radar of farmers for a long time and selective breeding has reduced the need to disbud animals.

Polled Cattle (Source: USDA.gov)

Scientific Background

In 2016 it was pointed out that 80% of dairy cows needed to be disbudded while only 25% of beef cows had to go through this procedure. The reason is the small number of sires within the dairy industry producing polled offspring (6%). The result of this was the use of a biotechnology technique called TALENs (transcription activator-liked effector nucleases). Think of this as a fancy way of cutting DNA at a very specific site and having the opportunity of putting in your gene of interest. In this case the gene of interest was one from polled animals. Scientists used this gene and were able to create a polled animal in the next generation. Overall the technology could be used to decrease the need for disbudding in dairy cows. Do you think this technology should be used to improve the safety of farmers and cows?

ACTIVITY #3 - HOUSING AND CONTAINMENT CONTROL-JUDGING

DO	**Time:** 25 minutes **Materials Needed:** • The 4 Case Scenarios (Following Page) • Judging Sheets (Optional) • Pen + Paper **Instructions:** 1. Read the following: You are tasked with assigning a contract for a AquAdvantage® and have been given 4 locations to choose from. You must first weigh the gene control procedures using the biological, physical and environmental factors. You will then need to look at the habitat of the salmon and rank your facilities. 2. Read the descriptions of each of the scenarios 3. Make notes and determine what is best for the animal welfare and containment based on the first statement.
REFLECT	**Learning Outcomes:** Members will be able to determine best practices for control of transgenic animal species and to make decisions. Members will also work on their judging skills through this task.
APPLY	**Processing Prompts:** • What was the giveaway that you had a problem with two of these locations? • How did you determine the difference between the two? • The official placing should be 1, 2, 4, 3 (placed from highest to lowest) but members may have reasons why they placed others higher or lower.

Facilities- Judging

Facility #1

- In a Panama river basin away from the natural spawning location for Atlantic Salmon
- Water is filtered and chlorinated on the way out of the facility
- Sexing is done on the fish to ensure that only females are in the population
- Proper controls are in place for sterilization.

River Basin

Facility #2

- In a town outside of Vancouver where Pacific Salmon spawn but not Atlantic
- Water is not filtered but is chlorinated before being dumped into the surrounding rivers
- Sexing and sterilization is done by a certified company that is not affiliated with the company.

Pond Outside of Vancouver

Facility #3

- A previous facility in Quebec used for raising trout has expanded their tank to include a surrounding ocean bay
- Fish are not sterilized to cut cost
- Fish are housed in a continuous fashion

Open Ocean

Facility #4

- Open sea pond in the Atlantic Ocean (Potential to cross)
- Cheapest alternative but high chance that there might be escape or predation
- Only separation from rest of ocean is two nets that are anchored to the bottom of the ocean.
- Sterilization is done on all fish prior to being put in the pond

Ocean Fish Farm

MEETING 4: PRECISION, FOOD AND PARTNERSHIPS!

Setting Objectives:

Food Biotechnology is an important aspect of Agricultural Biotechnology. In this meeting, we will discuss Arctic® apples, golden rice, Innate® potatoes and packaging that detects food spoilage. We will also explore the role of precision agriculture in food production and the role of public/private partnerships to boost innovation.

Suggested Lesson Outcomes

- □ For members to explore different types of Agricultural Food Biotechnology
- □ Members should be able to explain the purpose of precision agriculture in aiding agricultural biotechnology for food production
- □ Members will be able to explain the importance of public/private partnership for innovation and the role of intellectual property protection.

Roll Call:

Pick one of the types of intellectual property (patents, trademarks, copyrights, trade secrets). Look into the definition of the class and an example of something protected in this way.

Sample Meeting Agenda Time: 2 hours 35 minutes

Welcome, Call to Order & Pledge		10 min
Roll Call		5 min
Parliamentary Procedure	Minutes & Business	10 min
Activities Related to Topic	Activity # 1 – The Role of Precision Agriculture in Biotechnology- Judging	20 min
Activities Related to Topic	Activity # 2 – Innovations in Food Biotechnology!	25 min
Activities Related to Topic	Activity # 3- Public/Private Partnership	15 min
Topic Information Discussion	Activity #4- Patents and Intellectual Property	20 min
Wrap up, Adjournment &	Discussions: 1-7	25 min
Social Time		15 min
Wrap up, Adjournment & Social Time		10 min

Topic Information - Precision Agriculture

Precision agriculture is farm management that involves observing, measuring and responding to the variability in crops. The technique would not have been possible if it weren't for the advent of global positioning system (GPS) data. GPS involves triangulation using satellites that gives farmers the ability to determine their precise location in a field. In addition, maps can also be used along with soil test data to make precise adjustments of inputs to the crop. From the soil test in the field we can find the organic matter content, moisture levels, nitrogen levels, pH, among others). This is valuable information if you can use it and that is where the software comes in.

Software and technology have become a big part of many modern-day agricultural operations. At the time of writing this manual GPS in planters has become more and more popular. Farmers simply line up their rows and plant straight. This really takes the non-uniformity out of planting and ensures consistent row spacing and uniformity. Further technology is available for planters that detect pressure and depth of seed, but this is still in the product development phase.

Drone and camera technology have really advanced over last 10 years. They are costly investments ranging from $2,500 all the way up to approximately $20,000. At the higher price they can take very precise and detailed images from up to 120 meters in the air. However, not every farmer can afford their own drone. This is where companies come into the picture. Agricultural consulting companies often hire out drone services to farmers. This becomes advantageous when the acreage of the farm increases. It is almost impossible to watch over all of your crops today and the drone technology along with other technology above makes it much more manageable.

Finally, at the end of the season, combines and harvesting equipment complete the precision agriculture picture. They can capture yield level data and moisture throughout the fields. This data can then be collected and compared back to the other data the farmer has for the field. Why is this important to agricultural biotechnology? Precision agriculture plays a powerful role along with our biotechnology and crop related advancements. When used together these technologies work to make life better for farmers. The farmer can make decisions on variety or adjust their crop rotation, fertilizer rates or seed population rate per acre to better the agricultural operation as a whole.

https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag1950
https://www.cbc.ca/news/canada/calgary/drone-technology-on-the-rise-1.4633625

Innovation in Food Biotechnology

The role of biotechnology in the food industry has grown within recent years. In the next pages we will talk more about recent developments to introduce them:

Innate® Potatoes

The Innate potato was approved by the US Food and Drug Administration in 2015. The same product received approval from the Canadian Food Inspection Agency (CFIA) and Health Canada in 2017. With this approval these Innate® potatoes could be sold in Canada and could also be imported or planted. The potatoes come from a company called J.R. Simplot Co. The first generation of the Innate Potato covered protection from browning, bruising these potatoes and having much less peel. This make these potatoes more desirable to the consumer.

These first-generation potatoes are less prone to bruising and black spots due to genetic engineering. The result of this is that the consumer wastes less and fewer potatoes end up in the landfill or compost pile. In addition, these potatoes contain less asparagine which means that they provide the chance of 58-72% less acrylamide produced by these potatoes. The FDA has identified acrylamide as a possible carcinogen (cancer causing agent) and reducing acrylamide may mitigate potential human health risks.

The second generation of these potatoes is meant to do all the aspects mentioned previously but also deals with the problems to do with blight. Best practices for blight on other potato varieties is to use fungicide to prevent this disease. Blight is not a new issue and has always plagued the potato crops around the world. In fact, blight was the reason for the Irish potato famine that caused millions to die between 1844 and 1851.

Arctic® Apples

Have you ever cut an apple only to return when the apple had turned brown? Arctic apples look to address this problem. These apples are anti-browning which means that they can be readily cut and be taken to school or work without a problem. In addition, the company claims that since the apples do not change colour, they also do not burn up their antioxidants.

Source: Okanagan Specialty Fruits Inc

Golden Rice

A rice that could save millions of children per year sounds like something that the world could get behind. That is what Golden Rice provides to the world. Vitamin A deficiency (VAD) is prevalent among the poor and the reason for this is that the diets of these poor individuals is often high in carbohydrates while being micronutrient poor. In many of these low-income diets rice is a huge part of the diet. Rice is not a very micronutrient rich food and as a result this is a serious problem. Golden rice contains β-carotene which is a precursor to vitamin A. How did this get in the golden rice?

Well the answer is complicated but essentially the gene for β-carotene already exists in the other machinery of the plant. In fact, it is fully active in leaves but is turned off in the grain. The scientists who created the rice created this transgenic rice by adding two genes – one from daffodils and one from a soil bacterium - to the rice. When a series of enzymes (proteins) work together to create a compound it is called a pathway. By including a plant phytoene synthase (psy) and a phytoene desaturase (crt I) gene we complete the pathway.

The result is a change in the colour of the rice which causes the rice to now be yellow or golden depending on how you look at it.

Source: Wikimedia

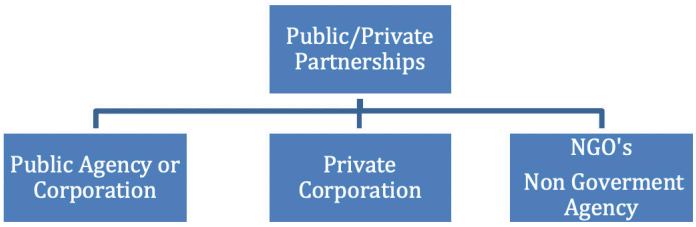
Food Packaging

Briefly we will cover food packaging to complete the food biotechnology discussion. Food packaging has stayed rather static but that may be changing. Recent technology could use

biotechnology to know when food has spoiled. When food spoils it releases compounds that show the food may not be edible. By using these compound along with packaging you can prevent food born illness from further happening.

Public/Private Partnerships

What is a public private partnership? In an essence public private partnerships (PPPs) are cooperative ventures between a government agency and the private sector for the development or delivery of goods or services. PPPs can be commonly seen in infrastructure projects such as roads or public buildings. What groups are normally involved in public private partnerships?



Public Agency or Crown Corporation

These are the government agencies or corporations. Examples of these public agencies and crown corporations include AgriFood Canada, Agriculture Canada and the public universities across Canada. Through the electoral process all Canadians get to decide on what these agencies or corporations do. Every political party has a platform that they pitch to the public in the election. The public then gets a vote by voting for their MPs and MPPs. The party with the most representatives becomes the party in power and is responsible for appointing Ministers from their elected representatives to oversee the various agencies and crown corporations under the government. An example of an important minister to the Canadian Agricultural industry is the Minister of Agriculture. The Ministers are responsible for the actions of their agencies and can promote various policy changes through the form of bills (laws) or policy.

Private Corporation

These companies are owned by a single person, small number of people or large group of people. Examples of private corporations include Bayer, BASF and Corteva. The responsibility of these companies is back to their investors and owners by making returns in the form of assets or profits. The need for returns on investment is best seen in the publicly traded companies which

must publish their revenue and current state in the interest so the public can see. The reason for this is that members of the public can buy shares of these publicly traded companies and become shareholders. The activity of the shareholders and the company determine the price of the company.

Non-Government Organizations (NGOs)

This is the last group that contribute to public private partnerships. These are organizations or charities which work to address a problem that impacts a group, people or country. Examples of these include the Gates Foundation or CIMMYT. These organizations get the money they require to operate from donations from outside sources (private companies, individuals, government groups) and this makes them accountable to those groups.

Why Do These Organizations Work Together?

Private corporations are looking for solutions and help to make the world a better place. At the same time these private corporations can maintain intellectual property rights for their inventions. The public corporations or agencies represent the people who have a very diverse view on what needs to be researched or funded. Often there is policy and solutions that need to be made and this can often be done well with the help of the private corporations. These agencies can maintain intellectual property rights as well in some cases. Non-Government Organizations wish to work with these previous two groups to promote the work that their organization addresses. By working together these organizations can spread both their risks and their costs across multiple entities. They also allow for the free flow of expertise to work on problems that may have been more challenging for one of these groups to do alone.

Overall this provides a method for innovation when there are less scientific resources and skilled personal. In addition, it allows scientists to do research on problems that may be of importance to smaller groups that may not have the means to do the research on their own.

How do these groups work through this process?

It depends on the project. Sometimes the project is funded directly by a funding agency and the private company works to oversee the process, as we often see in the case of building infrastructure or paving highways. Other times a public institution is supported by a private corporation (through unrestricted grants, gifts, or other funding mechanisms). A new trend in the University community is the need for public private partnerships to get research funding. The national funding agencies (NSERC, SSHRC, CIHR) now often require a private company to support the work that the University researcher is working on in order to complete the funding

for the project.

What are examples of public/private partnerships?

- Infrastructure projects (Highways or constructions of schools)
- Private Companies collaborating with public research institution Projects (eg- Genome Canada)
- The development of Golden Rice
- Improvement in seed distribution services

Patents and Intellectual Property

Intellectual Property is known as an intangible asset as it is often based off an idea or process (cannot be held in your hand). These assets include inventions, new technologies, new brands, original software, novel designs, unique processes among others. All these assets have value within the marketplace, and it is very important to protect them. So how do you protect your intellectual property rights?

In general, there are five ways that you can protect your innovation in Canada but there is also a sixth if you include the rights that are given to plant breeders. We will discuss each of them in depth in the following topic discussion section.

Patents

Patents confer exclusive rights to the inventor for their innovation or invention. Exclusive rights mean that you as the inventor can decide what you would like to do with your invention. A patent is granted to the inventor by the government and gives the inventor the right to exclude others from making, using or selling your invention for a period of 20 years. It is important to remember that a patent is granted by a government and only applies in the country where it was granted. In addition, the 20 years of protection starts from the date that the application is filed with the government in the first country that it was filed.

Patents must cover an invention (process, machine, product, composition of matter) or any new and useful improvements to an existing invention. In addition, a patent must meet the following three criteria; it must be useful, novel (new), and non-obvious to one skilled in the art. A patent cannot be renewed, and the application becomes public after 18 months to promote the spread of knowledge to all inventors in the field.

To give an example of a patent, think of your phone. Many of the technical components will have an individual patent. The camera, battery, processing chip, screen, etc. These come together to give you the phone.

Plant Breeders Rights

They are administered by the Canadian Food Inspection Agency and provide legal protection to plant breeders for new plant varieties for up to 25 years for a tree and vine and 20 years for all other varieties of plants. These rights allow those who are involved in plant breeding to collect royalties each time the propagating material of their protected plant is sold (think of this as collecting royalties off of a copyrighted book). An example of these include many of the items that might be on your weekly shopping list from the super market.

Industrial Designs

These are not commonly looked at in intellectual property but make up a large portion of applications to the Canadian Intellectual Property Office (CIPO) every year. These are the visual features of shape, configuration, pattern or ornament applied to a finished article. In addition, any of these visual features can also be combined. An industrial design must have features that appeal to the eye and must be original. The term of protection for industrial designs in Canada is up to 10 years from the date of filing.

To give an example of an industrial design, think of a ketch up bottle. If a company came up with a new design, they could protect this with an industrial design.

Trademarks

A trademark can be a combination of words, sounds or designs used to distinguish the goods or services of one person or organization from those of others in the marketplace (CIPO). When you are granted a patent, you are granted exclusive rights to the item or process for the first 20 years following your application date. Following this, a trademark act as a way for consumers to know the brand that they are buying and to support the original creator. Trademarks are identifiers and a way to differentiate products in the market which help those companies to establish market space after their first 20 years is complete. The term for trademarks is for 15 years but can also be renewed.

To give an example of a trademark think of those items in your life that have either a ™ or a ® after brand name this is what you are looking at. The Aquadvantage and Arctic apple brand names are two very good examples for this type of protection. By registering your trademark,

you protect it from misuse by others.

Copyright

The sole right to produce or reproduce a work or a substantial part of it, in any form. Copyrights are for manuscripts, books and other artistic works of art. In addition, copyrights can protect certain computer and technological software that is not protected by patents. Copyrights are not like patents as copyrights are automatically protected. You do not need to register before you can publish. Your copyright exists during your lifetime and for 50 years after your death. In addition, copyrights protect unpublished works as well. This is what makes this class of intellectual property so broad and overreaching. However, unlike a patent the protection is for that specific work and does not apply to alterations.

To give an example of a copyright think of your favourite book. The publisher and author own the copyright for this book.

Trade Secrets

Trade secrets include any valuable business information that derives its value from the secrecy. While a patent is protected for 20-years, the information of the patent is published for the public after 18 years. For a company like Coke or Pepsi this would be a problem as their recipe could be used freely after the 20-year period under a different name. Trade Secrets exist to protect the intellectual property in these cases. Trade secrets include various assets such as sales methods, distribution methods, customer profiles, client lists, supplier lists, product ingredients and formulas, etc. (CIPO).

One important aspect to note about trade secrets is that the protection could potentially last forever provided the information remains a secret. If the secret gets out, the value of the invention is lost. The Canadian government also takes no responsibility for these types of intellectual property and you as the owner are responsible for the protection and legal costs to protect it.

Protection Type	Years of Protection (Canada)	Renewable?	Advantages	Products Examples
Patent	20 Years	No	Protects inventions and grants exclusive rights	-Cell Phone -Precision Planter
Plant Breeders Rights	25 Years (Trees and Vines) 20 Years- All other plants	No	Gives further rights and protections to plant breeders	-Corn Variety -New Apple Breed
Industrial Designs	10 Years	No	Protects designs that otherwise would not have been protected	-Ketchup Bottle Design -Seed Bag Design
Trademarks	15 Years	Yes	Gives companies the ability to protect their identity	-Aquadvantage® -Arctic® Apple
Copyright	Lifetime + 50 Years	No	Protects works of art and others for the life of the original creator with the protection for after the passing (this varies a lot by country)	-Book -Play -Speech -Cartoon
Trade Secrets	Potentially Forever	No	Allows the secret to be kept away from the public	-Recipe -Secret Process

https://www.britannica.com/event/Great-Famine-Irish-history
http://www.innatepotatoes.com/gen-one
http://www.innatepotatoes.com/gen-two
http://www.goldenrice.org/Content2-How/how1_sci.php

ACTIVITY #1 - THE ROLE OF SCIENCE AND PRECISION AGRICULTURE IN BIOTECHNOLOGY- JUDGING

DO	**Time:** 20 minutes **Materials Needed:** • The cases (found on the pages following these activity instruction • Judging Sheets (optional) • Paper and Pencil for notes **Instructions:** • The following case should be read: As you have read, there has been a very large investment in the genetic improvement of crops and animals that we grow for food. Traits for pesticide resistance and functional transgenic mutations (Artic® Apple brown resistance) have added value to the agri-food industry. However, we have other technological improvements in our computing capabilities. The following judging activity will introduce you to the idea of a concept called precision agriculture along with other technological advances. Precision agriculture is farm management that involves observing, measuring and responding to the variability in crops.
REFLECT	**Learning Outcomes:** Members will learn more about precision agriculture and other technological management options in cropping systems. By the end of this meeting members will understand the basics of crop rotations, the use of technology and the overall ability of farmers to use that data with genetic solutions to come up with the right method for their farm.

APPLY

Processing Prompts:

1. Do you know what no-till is or why people use it? What are the advantages and disadvantages?
   - Process by which no tillage (plowing or cultivating) is used and seeds are planted directly into the soil.
   - Advantages- Less Soil Erosion (soil flowing away), Soil Compaction (soil being pressed down making it harder for plants to grow), lower fuel cost, saves time, healthier soil (not turning over the microbe population) and less soil moisture loss.
   - Disadvantages- Specialized equipment must be acquired often at a higher cost, more chemical use
2. One of the farmers uses soil tests. What are they looking for?
   - This farmer is likely looking at nutrient deficiencies (nitrogen, phosphorus, potassium, and other smaller micronutrients). If the farmer sees a deficiency they address it.
3. Overall what is the best management method for the farmers?
   - To use both a management and technological approach to reach the highest yields.
4. Get a few members to give reasons. Did the members place number four at the bottom and three at the top?
5. Would you agree with an official placing of 3, 1, 2, 4?
   a. Why or why not?
6. What other questions would you ask
   a. Which farm netted the most profit per acre of land grown?
   b. Did the farmer have crop insurance?
   c. Which farmer had the best returns over 6 years i.e 2 cycles?

Farm #1

This farm uses a three-crop rotation to introduce diversity in their crop cycle (Corn, soybeans, wheat). Every year the fields are plowed in the fall and cultivated in the spring. The farmer actively tracks all his field weather data which allows him to make more informed decisions about his crops with the help of his crop advisor. Every year the farm grows four different genetic hybrids. This farmer does not use technology to plant, spray or harvest. His operational costs are moderate, but his financial returns are moderate.

Farm #2

This farm uses a two-crop rotation (corn and soybeans). The farmer uses a system called no-till (does not plow or cultivate) and plants directly into the ground from the crop before. The farmer does not track any field level data for his crops and plants only one hybrid to get discount on seed rates. The farmer plants, sprays and harvests with GPS. His operation has moderate operational costs, but his financial returns are moderate.

Farm #3

This farm uses a three-crop rotation to introduce diversity in the crop cycle. The farmer also plants cover crops following the growing season and utilizes the no till system. He does soil samples for analysis in different parts of his field each year and flies a drone to find disease and pest hotspots. He also has a planter that detects seed and plant depth using specialized sensors. The farmer plants three different hybrids every year to examine each for effectiveness. The farmer plants, sprays and harvests with GPS. His operation has high operational costs, but financial returns are high.

Farm #4

This farm plants corn year after year in a single field. He uses conservative tillage when the ground has significant moisture still in it. He doesn't do any field level data and has planted the same variety of corn with his old open cab tractor. He does not use GPS and has no specific technology. His operation has low operational costs, but financial returns are very low.

ACTIVITY #2 - INNOVATIONS IN FOOD BIOTECHNOLOGY!

DO

Time: 25 minutes

Materials Needed:

- 3 x Potato (Cut one potato 3 hours before)
- 2 x Apple (Cut an Apple 3 hours before)- Neither of these apples need to be an arctic apple
- 1 Cup of Rice and Various Vegetables
- Polystyrene Tray (foam tray) washed and cleaned
- Peeler

Instructions:

Potato

1. First, hand the members the cut potato. What do they notice? Do they notice the browning on the flesh? What do they think the reason for this is? Potatoes are made up of cells that have enzymes. There are enzymes in every cell! In this case the enzyme is breaking down compounds in the flesh and produces this brown colour. Fun Fact: The enzyme that converts these compounds is called polyphenol oxidase or tyrosinase.
2. Peel the second potato. Do you notice the presence of black coloured “eyes”? How much peel did you waste?
3. Drop the third potato on the ground or table from 90 cm. Get each member to drop it. We are trying to bruise it but not break it open. Be careful with the height and force. When you cut the potato open what is happening? The potato has been bruised. Any drops from 6 inches or above will cause this bruise type.
4. What if I told you that this bruising can all be solved through food biotechnology? The Innate® Potato is less prone to bruising and is also less prone to disease. In addition, the potato has less eyes which means that you waste less of the potato that you must transport. The result is increased efficiency. Do you think this is an important

DO

innovation in biotechnology? Who benefits from this innovation and how?

Apple

1. First, hand the members the cut apple. What do they notice? Do they notice the browning on the flesh? What do they think the reason for this is? Apples are also made up of cells that have enzymes. There are many enzymes in every cell! In this case the enzyme is breaking down compounds in the flesh and produces this brown colour. Fun Fact: The enzyme that converts these compounds is also called polyphenol oxidase or tyrosinase. This is the same enzyme as what the potato uses.
2. Introduce the Arctic® Apple. This apple does not require the anti-browning treatments of normal cut apples. If you were to cut these apples and bring them to school or work do you think they would still be the same colour as before? Probably not. In addition, in the process of browning antioxidants are lost in the process. Do you think that this is a problem? This makes these apples easier to package. Do you think there is a need to ensure there is access to these products? Who and how do they benefit from this innovation? (consumers, growers, developers)
3. Look back at the apples. This process does not happen in Arctic® Apples but still does happen in Innate® potatoes. What do you think the difference is?

Rice

1. Hold up a cup of white rice and the vegetables. Get members to brainstorm nutrients in each. Now what if you could incorporate some of these benefits of the vegetables into rice? Would that be useful? In some countries they cannot grow or afford some of the vegetables that we take advantage of in Canada. Vitamin A deficiency is something that a GMO crop known as Golden Rice addresses. This is very important for developing countries. We will discuss this

DO	later but remember that there is a controversy around the acceptance of this product. Food Packaging 1. Hold up a Styrofoam tray. Ask members if they think this tray is recyclable. For those who say yes tell them that the tray is hardly ever recyclable. Now introduce the idea that this may not be the smartest way of packaging our food. What if we could use biotechnology to know when food has spoiled? That is something that scientists are working on. When food spoils it releases compounds that show the food may not be edible. Do you think this is a good solution? Do you agree that this is a good use of biotechnology? How is this different from other products?
REFLECT	**Learning Outcomes:** Members will gain an appreciation of the different kinds of biotechnology and the reason for their use.
APPLY	**Processing Prompts:** 1. Do you think any of these products should not be on the market? Do you remember the approval process? Does that change your opinion?

ACTIVITY #3 - PUBLIC/PRIVATE PARTNERSHIP (PPPS)

DO

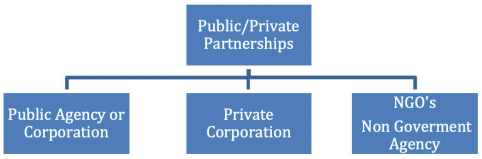
Time: 15 minutes

Materials Needed:

- Chart Paper
- Marker

Instructions:

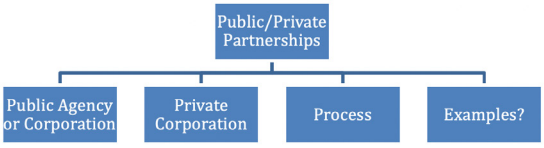
- Write the following responses on the chart paper using the following thought tree.



- Do you know what a public/private partnership is?
  o A cooperative venture between a government agency and the private sector for the development or delivery of goods or services.
  • What is considered a private corporation?
  o These are corporations owned by a single person, small number of people, large group of people or publicly traded on the stock exchange (Examples: Bayer, BASF, Corteva, etc.)
- What is a public or Crown Corporation?
  o These are the government agencies and/or corporations. All Canadians have a vote on what these corporations do by participating in the democratic voting process of MPs and MPPs (Examples: AgriFood Canada, Agriculture Canada, University of Guelph, etc.)
- What is a Non-Government Organization (NGO)?
  o An organization or charity which works to address a problem that impacts a group, people or country (Examples: Gates Foundation or CIMMYT)
- What is the purpose of these two working together?

DO

- What are their motivations?
  - o Private corporations- look for solutions and help to make the world a better place. At the same time these private corporations can maintain intellectual property rights for their inventions.
  - o Public corporations or Agencies- these entities represent the people. Different groups of people often look for solutions and by contributing to this public corporations or agencies can get this done. Often there is policy and solutions that need to be made and this can often be done well through private corporations. These agencies can maintain intellectual property rights as well.
  - o NGOs- Wish to work with these groups to promote the work that their organization addresses.
  - o Spreading Risks and Costs- across multiple entities and access to expertise.
- Overall what do public/private partnerships provide for the public in the field of biotechnology? Where would farm cooperatives fit into this framework?
  - o Provides a method for innovation when there are less scientific resources and skilled personal. In addition, it allows scientists to do research on problems that may be of importance to smaller groups that may not have the means to do the research on their own.
- How do these two groups work through this process?
  - o It depends on the project. Sometimes the project is funded directly by a funding agency and the private company works to oversee the process. Other times a public institution is supported by a private corporation (University funding).



DO	• Do you know any examples of public/private partnerships? o Infrastructure projects (Highways or constructions of schools) o Private Companies Funding Public Institutions Projects (University Research) o The Invention of Golden Rice o Improvement in seed distribution services • As you can see from the list it is not just a scientific issue but also a policy issue. How can Public Private Partnerships be used in other ways to help subsistent farmers and consumers in developing countries? Can you think of examples?
REFLECT	**Learning Outcomes:** For members to discover more about public/private partnerships and to understand their importance.
APPLY	**Processing Prompts:** 1. Do you think these partnerships have been overly successful in developing countries? • There has been a lot of pushback from developing countries and certain non-government agencies who have prevented them from functioning. In addition, developing countries may not have the capital to support these projects on their own. We will talk more about this in meeting 5.

ACTIVITY #4 - A BRIEF INTRODUCTION ON INTELLECTUAL PROPERTY

DO	**Time:** 20 minutes **Materials Needed:** • Photos following this page (one for start and one for end) • Piece of paper and pen to write thoughts **Instructions:** 1. Divide the members into groups of four or less 2. Ask members to think about the two photos in their members manual and to draw lines to all the inventions on the photo and label them. Give them 5-7 minutes for this depending on the age of the youth and interest level. 3. Ask members to share their responses and why they thought those inventions were important in the photo. 4. Talk about the two photos and show the technology indicated. Did members find all the labelled inventions? Were there others that members found that were not listed. The combine has many moving parts so there are many different technologies listed. What did they notice about the kitchen? How many types of intellectual property are shown on the picture? Did you just look at technology? 5. Do you know what intellectual property is? An invention or work that is the result of creativity (manuscript, design, process, etc.) that the inventor has rights which can be protected by various means. These protections can include trade secrets, patents, copyrights or trademarks. 6. From what you now know about intellectual property do you agree with the practice? Many of these technologies takes years to perfect, and millions of dollars to gain government approval. Does that change your opinion? 7. Can you think of something like a tractor and something like your loved ones secret muffin recipe. One is tangible while the other is intangible. Do you know what tangible

DO	means? (can touch the object). Do you think both of these should be treated equally by intellectual property rights? **Activity:** **All ages:** Tell members that they will now do a group activity to apply their entrepreneurial talents. Divide the groups into groups of two or three, and distribute Handout 2 to each group member. Tell them to imagine that they are partners in a new business, and ask them to decide and write their business name and the products or services they provide on the handout. Share business names and products briefly with the group.
REFLECT	**Learning Outcomes:** For members to get a background into the field of intellectual property. Members should become more comfortable with patents, trademarks and the reason for their use.
APPLY	**Processing Prompts:** 1. A patent gives a company exclusive rights to a product or process for a period of 20 years. Why is it important that companies have the exclusive rights for a product after its development? • A lot of money goes into the development of new products. A patent gives these companies a way to recoup the cost. Patents also encourage the disclosure of information to the public so that they can be used to invent even better technology.

APPLY

Processing Prompts:

2. Companies often use trademarks at the beginning of their product development phase. Why do companies use trademarks?

- When you are granted a patent, you are granted exclusive rights to the item or process for the first 20 years following your application date. Following this, a trademark act as a way for consumers to know the brand that they are buying and to support the original creator. Trademarks are identifiers and a way to differentiate products in the market which help those companies to establish market space after their first 20 years is complete.

3. Plants products are protected differently than other forms of intellectual property. There are two other forms of protection for these products. These are plant variety protection and plant breeders' rights. Who are these rules administered by? How many years of protection do they provide? Why are these rules different?

- They are administered by the Canadian Food Inspection Agency and provide legal protection to plant breeders for new plant varieties for up to 25 years for a tree and vine and 20 years for all other varieties of plants.
- This allows those who are involved in plant breeding can collect royalties each time the propagating material of their protected plant is sold (think of this as collecting royalties off of a copyrighted book)

4. Who do you think would use these forms of intellectual property protection?

- Private Corporations but also universities, public research institutes and even individuals can all use IP to protect their inventions.

5. Trade secrets and copyrights are the final two ways that companies can protect an idea or manuscript. Do you know

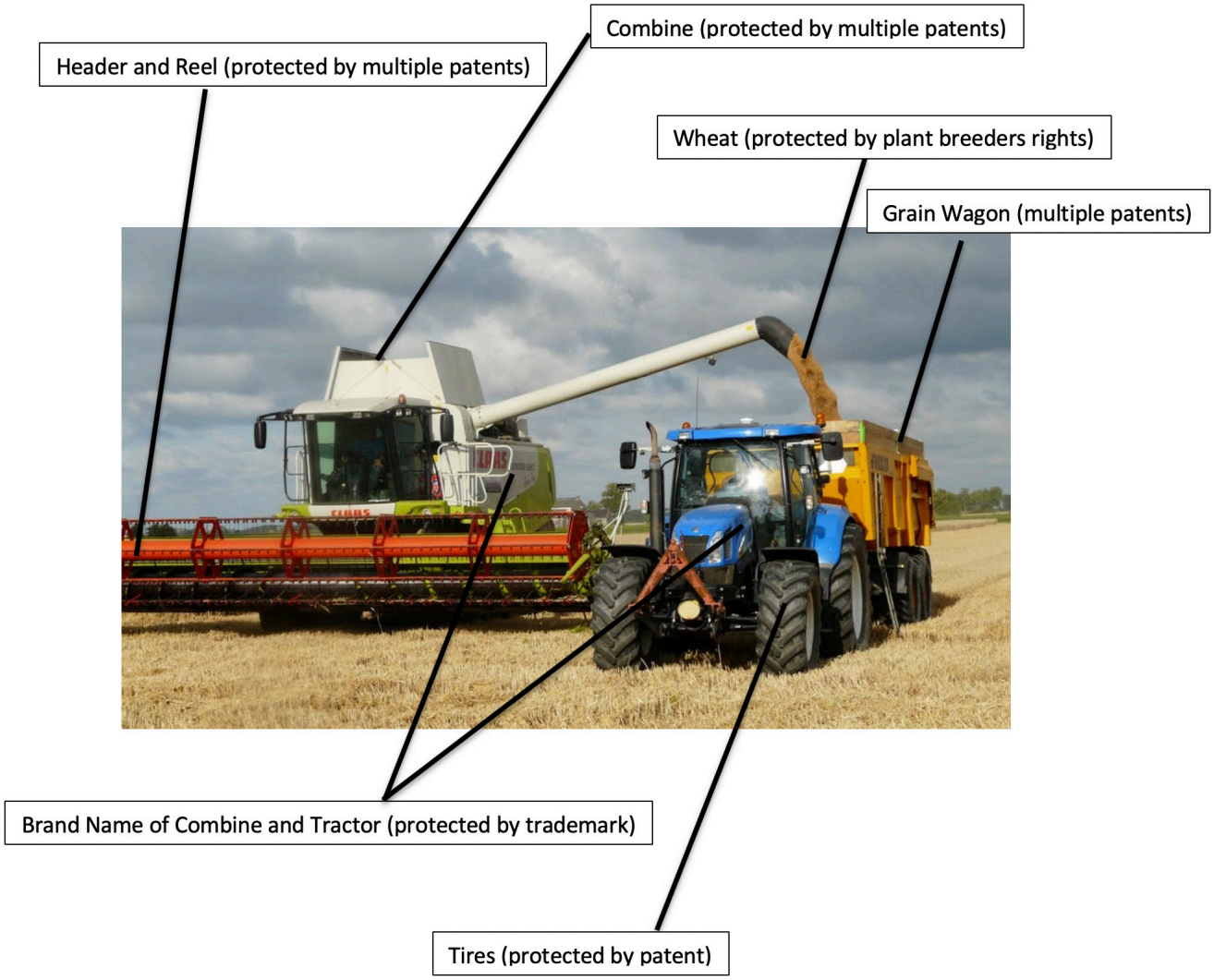
APPLY

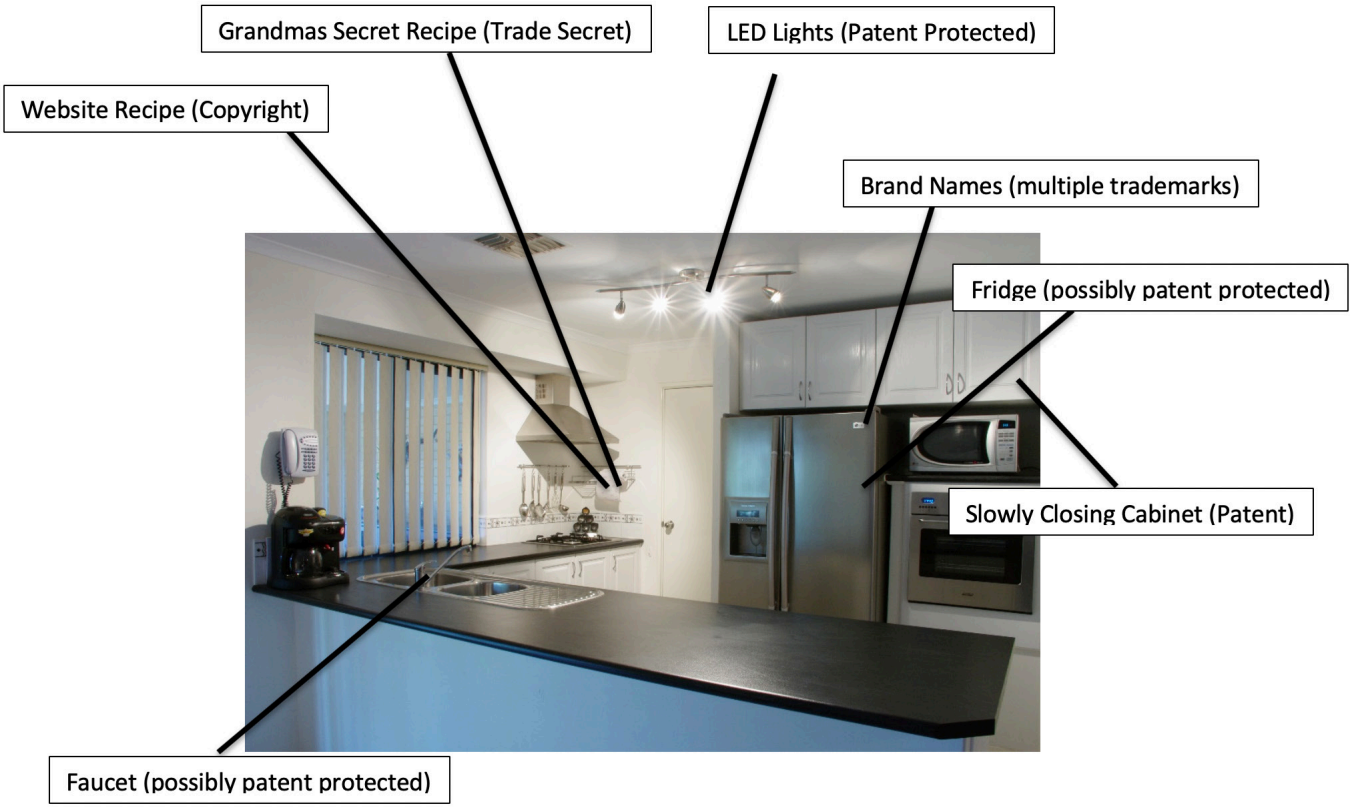
what a trade secret is? Do you know what a copyright is?

- Trade secrets are used by companies to not disclose their invention or process to the general public. To think about this, I like to picture Charlie and the Chocolate Factory. Willy Wonka owns the chocolate factory and no one on the outside knows about how his factory works. In addition, his everlasting gobstopper is another good example. Overall that movie is great for an intro to protecting your intellectual property.
- Copyrights are for manuscripts, books and other artistic works of art. In addition, copyrights can protect certain computer and technological software that is not protected by patents. Copyrights are not like patents as copyrights are always protected and do not need to registered before you can publish. You may apply to the Canadian Intellectual Property Office (CIPO) for even further evidence that you own a copyright.

Photos - Unlabelled

Photos - Labelled




Grandmas Secret Recipe (Trade Secret)
LED Lights (Patent Protected)
Website Recipe (Copyright)
Brand Names (multiple trademarks)
Fridge (possibly patent protected)
Slowly Closing Cabinet (Patent)
Faucet (possibly patent protected)

MEETING 5: BIOPRODUCTS AND BIOTECH IN DEVELOPING COUNTRIES

Setting Learning Objectives:

Bioproducts are the last topic that will be discussed in this resource. In this meeting, we will discuss the purpose and development of bioproducts. We will also explore the golden rice dilemma relating to the politics, ethics and culture of the countries in which Western values are often dictated. Finally, we will look at DNA in terms of sequencing and how that applies to the world of biotechnology.

Suggested Lesson Outcomes

- □ For members to explore bioproducts and their current implementation
- □ Members should be able to discuss politics, ethics and the implementation problems of different types of biotechnology
- □ Members will be able to brainstorm an idea to discuss problem solving for biotechnology problems by examining a current research project

Roll Call:

Find a product that is made using bacteria? Is the product made using transgenic means (drug, vitamin, molecule) or is it made by a natural bacteria (fermented product).

Sample Meeting Agenda Time: 3 hours 5 minutes

Welcome, Call to Order & Pledge		10 min
Roll Call		5 min
Parliamentary Procedure	Minutes & Business	10 min
Activities Related to Topic	Activity # 1 – Discussion on Bioproducts	20 min
Activities Related to Topic	Activity # 2 – The Golden Rice Dilemma- Case Study	30 min
Activities Related to Topic	Activity #3— Translation and Sequencing	30 min
Wrap up, Adjournment &	Activity # 4: Credit Card IQ	20 min 30 min
Social Time		15 min
At Home Activities/ Digging Deeper (for Senior Members)	Choose one of the activities	5 min
Wrap up, Adjournment &		10 min

Topic Information: Bioproducts

In meeting one members used the power of bioproducts to create a soy based plastic. What is a bioproduct? Agriculture and Agrifood Canada defines a bioproduct as any renewable product other than food and feed that are derived from agriculture, aquatic or forestry resource, or municipal wastes. So why are these so important in the field of biotechnology?
One of the major benefits of bioproducts is the additional market for commodities and even waste products. So what are some of the ways that the agricultural industry has been changed by the advent of bioproducts? (Source: Agriculture and Agri-Food Canada)

- Transforming hemp and flax into biomaterials for automotive and construction industry
- Using crop residues to create bio-based chemicals for household cleaning products
- Creating power through agricultural waste
- Converting crop sugars to biofuels (ethanol) or crop oils to useful compounds

Source: Earth Sweet Home

History of Bioproducts

While bioproducts are thought to be a relatively new thing there are many cases where biomaterials have been used even thousands of years ago. For example, Linen, derived from flax, was widely traded as early as 2 000 BCE. Straw has also been used as a building material (thatched roofs). They are not new but the advent of various enzymes and technology has made them more widely used. In activity 1, members will have the chance to discuss the world of bioproducts briefly.

Background Information: Genetics and DNA

Why do parents usually resemble their kids? Why does my dog look more like my its father? The answer is in genetics. Genetics is about storing and passing on information. The messages of genetics are stored as DNA, which can be found in almost every cell of a living things body. Living things are made up of cells. A cell is made up of organelles, a cell membrane and DNA. There are two types of cells; Eukaryotes and Prokaryotes. Eukaryotes (Greek for true kernel or nut) have a nucleus that is surrounded by a membrane that keeps all the DNA in one area. The are where the DNA resides is known as the nucleus. Prokaryotes lack a nucleus and generally have a region where their genetic material accumulates. Prokaryotes are almost always single celled while more "advanced" organisms are usually eukaryotes. Each living thing has a unique genetic code made up of DNA.

DNA is also known as deoxyribonucleic acid (de-oxy-ribo-nuclayic)

Within DNA is repeating A, T, G and C molecules. Each of these molecules have three parts:

- Five Carbon Sugar (Deoxyribose)
- Phosphate Group
- Nucleic Base

It is the nucleic bases that cause the DNA to have its variability. DNA is composed of four different nucleic bases. These are adenine, thymine, guanine, cytosine. These are often shortened to AT and GC. In DNA you will always see AT and GC together. This is because these two molecules pair together (through something called a hydrogen bond). A to T has two hydrogen bonds while G to C has three. This is what makes the structure of DNA double stranded. There is very small chance that a molecule called DNA polymerase can get this wrong. DNA polymerase is an enzyme. Enzymes produce reactions that are important for our everyday life. These enzymes are proteins that have a function or role to catalyze (initiate) a specific reaction. DNA polymerase catalyzes the replication of DNA and is responsible for copying all the genetic material of a cell. This event is so important because DNA must be fully copied before a cell can divide.

How do four bases produce so much variability in the genetic makeup of an offspring? What tells the cells to make hair red or black? Curly or straight?

DNA stores the instructions for making specific proteins but before it can be "read", it must be transcribed. To explain this think of a archeologist who transcribes ancient writings into a manuscript. In the process of transcription, the two strands of DNA separate and a complimentary strand of RNA is formed.

RNA is also known as ribonucleic acid (ribo-nuclayic)
Within RNA are repeating A, U, G and C molecules. In RNA the thymine of DNA is replaced with Uracil. In addition, RNA is single stranded. Each of these molecules have three parts:

- Five Carbon Sugar (ribose)
- Phosphate Group
- Nucleic Base

It is these specific and numerous possible combinations of adenine, cytosine, guanine and uracil that allow the transcribed RNA to be translated into protein. Think of translation as someone taking the transcribed transcript and translating it into something that we can read. When three base pairs are strung together, they form a codon. As the name suggests each codon codes for a specific amino acid. Amino acids are the building blocks and stringing different combinations of amino acids together produces different proteins. In addition, three codons code for stop sequences which end the growing chain of amino acids.

Why not make DNA directly into protein? Why do we go through an RNA intermediate? The process just seems redundant but is for two very good reasons.

- A gene on DNA (a site of interest) can be replicated into RNA multiple times and this can then be translated many more times than the DNA alone. The DNA often only has one copy for a specific gene but hundreds of RNA molecules can be made.
- This keeps the DNA safe from any degrading factors.

How does Biotechnology use this Process to Make Useful Products?

Modern biotechnology has used the flow from DNA to protein to their advantage to make transgenic organisms. When genome sequencing became more prominent this really led to a boom in our understanding of organisms. Pair this with a process known as PCR. PCR or Polymerase Chain Reaction is how scientists make copies of DNA to transfer into other organisms. The process involves designing a primer (exact complimentary copy to the template DNA for the specific site of interest). Something that will anneal to the single stranded DNA. The PCR primer is paired with a machine called a thermocycler. A thermocycler has three phases which mimic the process used in DNA replication:

- Denaturation- When the double stranded “template” DNA is heated and separated
- Annealing- When the temperature is lowered to allow this primer to stick to the DNA (form the hydrogen bonds again
- Elongation- When DNTPs (deoxyribonucleotides phosphatases) are added to the primer by DNA polymerase

Now why do we need to use a primer? The answer is that DNA Polymerase needs something to bind onto to go to work. By using this primer and the natural machinery of biology scientists can read DNA and make transgenic organisms.

Some say the invention of PCR changed modern science but there have also been many other innovations that have allowed us to use PCR to our fullest capacity. We will talk about one of these in meeting 6 when we discuss CRISPR cas9 and other ways of incorporating DNA into cells.

ACTIVITY #1 - DISCUSSION ON BIOPRODUCTS

DO	
	Time: 20 minutes **Materials Needed:** • Flax Seeds in a small jar • Straw • An oil (Soybean, Corn or Canola Oil) in a small glass jar (will be used for display purposes) • Plastic Keurig Coffee pod or picture • Biodegradable Coffee pod or picture **Instructions:** 1. Hand around the flax seeds in the jar. Get members to describe the properties of the flax. What do they notice? Get members to remove one seed from the jar. What do you think this seed looks like when it is grown? 2. Linen has been made from a part of the flax plant since 2000 BCE. How do you think they did this? They made the flax linen out of the stalks of the flax plant. Flax is one of the oldest cultivated plants in human history and has cellulose fibers that make up the inside of the stalks. Why do you think flax is so popular today? The seeds have become very popular as a source of dietary fiber and omega-3 fatty acids. The textiles have been lost but the theory has not. 3. Next show members the picture of straw (if you have straw bring it in). Ask members where they think this comes from? Most likely the answer will be wheat or barley, but this straw can come from any cereal crop. Where is straw used today? It is often used in bedding packs as a moisture absorber and an insulator for livestock. Do you know how this could be used in construction? 4. Straw has been used as a natural insulator for a very long time and is still used today in some home designs. What do you think an advantage of this insulation might be? 5. Show the members the oil of choice. Get members to

DO	move it around notice how it clings to the side of the jar. What is the purpose of this oil? (cooking) How is it made? (pressing the seed of the plant). Have you heard about ethanol? (yes or no) In this case instead of creating oil out of the seed the sugar is extracted and turned into ethanol with the use of yeast. This process happens through the work of yeast that perform fermentation. Fermentation is a process by which an organism uses sugar for energy and produces alcohol as a by-product. What do we use ethanol for? Is this resource a good alternative to what we already use? Ethanol is a temporary solution to a problem. It should be used now to supplement crude oil products but cannot stand entirely on its own. Industrial use of ethanol-hand sanitizers, alcoholic beverages, hospital equipment sterilization and other alcohol-based products. 6. Next show the members the plastic Keurig pod. What is a major problem with this product? It is not recyclable or compostable. That plastic goes directly into the landfill. Can you think of any better alternatives? The University of Guelph has developed a degradable alternative. Do you know how these are made? (answer is bioplastics which are made using materials that do not require petroleum products and breakdown in compost environment). What do you think the next steps in biomaterials are? These pods came to the market in 2016. What do you think their reception was? (overall very positive). http://www.competitivegreentechnologies.com/
REFLECT	**Learning Outcomes:** For members to explore the wide world of biomaterials. Members will also gain an appreciation for the developments that are recent in discovery.

APPLY	**Processing Prompts:** 1. What did you learn? 2. Do you think there is a bigger market for bioproducts? Do you think this will drive innovation?

ACTIVITY #2 - THE GOLDEN RICE DILEMMA: THINK, PAIR AND SHARE

DO

Time: 30 minutes

Materials Needed:

- Pen and paper

Instructions:

1. Read the Following Case (members will have this in their record books): An invention has just been made in the field of agricultural biotechnology. A plant that has been a staple of many cultures in the past has just been bioengineered. The plant is rice and the invention is being called Golden Rice. The reason for this is due to the colour of the grains of rice. The reason for the colour of the rice is due to the addition of genes into rice that add vitamin A content. While rice produces the vitamin A gene in its leaves it lacks it in the grain. In this case since the genome is found in all cells this means the gene is turned off. This can be fixed by adding two genes from bacteria and from daffodils that will produce the beta-carotene (vitamin A) which is what produces the brilliant yellow colour.

   This private partnership was between universities and companies allowed the use of intellectual property for this humanitarian purpose. The reason for this development and public/private partnership was to fix an ongoing problem in the developing world. So much of the micronutrient deficiencies in the world come from low dietary intakes of iron, vitamin A, iodine and zinc. Specifically, vitamin A is a severely deficient micronutrient due to the intake of mainly rice and other high carbohydrate sources. Golden Rice addresses this by containing the vitamin A that these people need. There is one problem and that has been the acceptance of this product.

DO

The overall goal is to have farmers in developing countries grow this rice as a replacement for their traditional rice. This would help the estimated 250 million pre-school children that have vitamin A deficiency (VAD) in the developing countries. It is also estimated that 2.7 million children a year die because of that deficiency or from complications of the condition.

When the GMO was announced it quickly gained opposition. Many different people and organizations made arguments to halt the Golden Rice Project. This debate became less about Golden Rice and more about GMOs in general. Those who oppose it claim that the partnership that was promoting the GMO rice was only doing so to enhance public support of GMOs. In addition, some of these organizations raised issues that GMOs are not safe (despite well published research as mentioned earlier). In addition, it was suggested that people would not consume the rice due to the colour which was seen as being wrong.

The supporters of Golden Rice stated its health benefits. They also stated that there was freedom for the rice to be used free of charge. That eroded the argument by the other side that the biotechnology for-profit companies somehow had a hidden agenda here.

The technology has been around for 24 years with billions of dollars invested. The project has not been widely implemented mainly due to opposition. However that seems to be changing. Why?

- In June 2016 a letter was signed by 110 Nobel Laureates and 5591 scientists against opposition to genetically modified organisms (GMOs) and in support of GMOs
- Research in 16 national sites is still underway to get the rice approved and to answer final research questions,

DO	2. After reading the case think about the following questions and write your responses in your manual personally. a. What is Golden Rice? b. What issue is Golden Rice trying to address c. Are you for or against the use of golden rice? d. Do you think the opposition is simply opposing Golden Rice to send a political message about GMOs? e. Are there any risks to GMOs? f. How do you think the developing countries feel? g. Do you think we should continue our investment in this type of research? h. What is another example of a genetically modified organism debate? i. Do you think we should argue about the process to make Golden Rice or the product use itself (the product)? 3. Get together with a partner and discuss your answers. What did you learn? Did you have different answers than your partner? If so, why do you think you differed?
REFLECT	**Learning Outcomes:** For members to explore the politics and ethics of biotechnology adoption in the world today by using Golden Rice as a guide.
APPLY	**Processing Prompts:** • What did you learn?

ACTIVITY #3 - TRANSLATION AND SEQUENCING

DO

Time: 30 minutes

Materials/Resources:

- Manual and pen/pencil

DNA	RNA
A←→T	A→U
G←→C	T→A
	G←→C

Instructions:

1. Take your original sequence of ATCG and replicate this. Explain that all organisms use DNA to code for their genetic make up. adenine (A) pairs with thymine (T) while guanine (G) pairs with cytosine (C). Whenever you see a T replace it for an A. When you see a G replace it for a C. If you do this you will get a replicated piece of the original DNA. (Allow members to do this).
   ATG ACG GGG CCC GAT CAT GCA ACG TTT GTG GGG TAA
   TAC TGC CCC GGG CTA GTA CGT TGC AAA CAC CCC ATT
2. Following replication let us reflect on the process. Sequencing uses this process through one of several methods. (1) Sequencing by synthesis: This method does what you did essentially. You use a primer strand that base pairs as shown above. Following this an enzyme called DNA polymerase copies the strand the same way you did. (2) Sequencing by ligation: A much more complicated method that produces light or energy based on the pair that is shown on the original repair. You repeat these numerous times and you get your sequence. There are other methods involving everything from light to measuring electrical conductivity, but this is the basics.
3. Now that you have a replicated strand of the original DNA you can convert the replicated strand that you just

DO

made into Ribonucleic Acid (RNA). This process is called transcription. RNA is the copy of the original DNA and allows for protein to be made quicker and for DNA to be protected. In this case the old rules apply but Thymine (T) is replaced with another nucleotide, Uracil (U). In this case adenine (A) becomes uracil (U) while guanine (G) still pairs with cytosine (C). (Hint you can use the original sequence in this case and replace the Thymine's with Uracil's)

TAC TGC CCC GGG CTA GTA CGT TGC AAA CAC CCC ATT

AUG ACG GGG CCC GAU CAU GCA ACG UUU GUG GGG UAA

4. Now you are ready to translate your RNA into protein. Normally you would look for the start sequence which is made up of the three letters ATG which would tell the translation into protein to start. We group nucleotides into codons (sets of three) in order to perform translation. The reason is that is the way that nature dictates it. There are 20 amino acids, but we will avoid that here and use words instead. We will also avoid the discussion about reading frame as you start with AUG and end with one of three codons. You can use the table below to translate your codon code into a message. Say you had CCC as your codon from the previous question. Go down the codon table to CCC and across to the word under the translation heading. This will be your word. In this case Process.

Codon	**Translation**	**Codon**	**Translation**
GUG	TO	GGG	THE
ACG	IS	GAU	BY
AUG	TRANSLATION	GGG	PROTEIN
CCC	PROCESS	CAU	WHICH
AAA	TERMINATE	AAG	REALLY
UUU	CONVERTED	GCA	RNA
UAG	Question Mark (?)	UAA	Exclamation Mark (!)

DO	AUG ACG GGG CCC GAU CAU GCA ACG UUU GUG GGG UAA TRANSLATION IS THE PROCESS BY WHICH RNA IS CONVERTED TO PROTEIN!
REFLECT	**Learning Outcomes:** For members to explore the topic of replication, transcription and translation. Members will use basic methods to translate a sequence in a similar method that a cell would.
APPLY	**Prompts:** 1. What did you learn? 2. Have you heard about the central dogma of cell biology? This is what you did in this activity. You took DNA and formed it into RNA which then turned into protein. This is considered to be the way that a lot of cell biology operates. 3. When A, U, G, and C are put in groups of 3 there are 64 possible codons. Yet there are 20 amino acids. Why? (the table is redundant, so certain amino acids are represented by multiple codons) 4. What happens if one of your letters were to change. Would you still be able to properly translate it? This is called a mutation. Some mutations in nature produce no change in amino acid. What do you think these are called? (**Hint they are very quiet- Silent). There are other types as well that you can talk about.

MEETING 6: THE FUTURE OF AGRICULTURAL BIOTECHNOLOGY

Setting Objectives:

Biotechnology is an evolving industry with a lot of innovation happening at the time of writing. In this meeting members will first explore older methods of genetic engineering. Members will then explore emerging biotechnology including CRISPR and farmaceuticals. Members will also discuss advocacy and activism. Following these members will have the opportunity of designing an achievement program to demonstrate what they have learned.

Suggested Lesson Outcomes

- □ For members to explore the basics of PCR, ligation and subcloning through the completion of a fun restriction enzyme activity.
- □ Members should be able to understand the basics of CRISPR and other emerging technologies in the field of biotechnology.
- □ Members will be able to understand the difference between advocacy and activism

Roll Call:

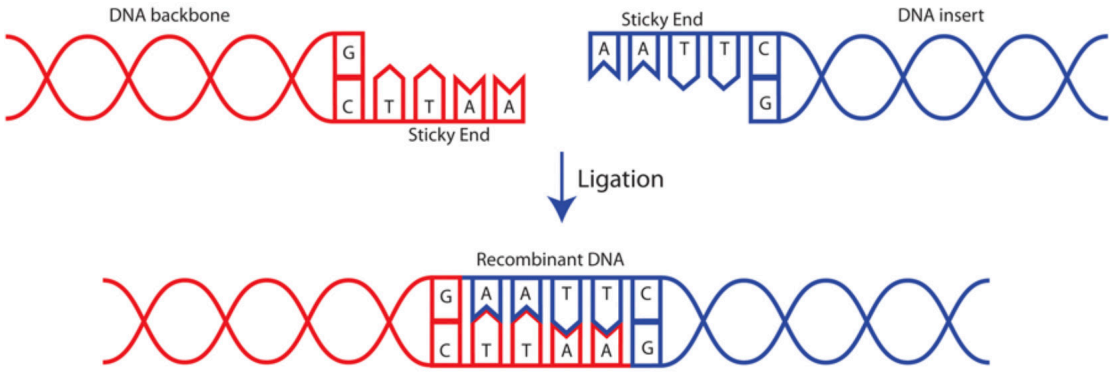
Name a crop or animal you have learned about that has been genetically modified (is a GMO product).

Sample Meeting Agenda Time: 2 hours 10 minutes

Welcome, Call to Order & Pledge		10 min
Roll Call		5 min
Parliamentary Procedure	Minutes & Business	10 min
Activities Related to Topic	Activity # 1 – Digestion and Ligation	25 min
Topic Information Discussion	Activity #2 - CRISPR Cas 9	20 min
Activities Related to Topic	Activity # 3 – Senior Member Project-farmaceutical and biopharming	20 min
Activities Related to Topic	Activity #4— Advocacy vs Activism	10 min
	Evaluations/Achievement Program Design	10 min
Wrap up, Adjournment &	Choose one of the activities	5 min
Social Time		15 min

Digestion and Ligation

Following the work of PCR, we can use another process called digestion to input our specific gene into another organism or vector. Digestive enzymes or Restriction enzymes work by finding very specific sites in a sequence of DNA. When a restriction enzyme finds this site they cut it and leave an overhang. Since DNA is double stranded this overhang can be complimentary to another cut made in another organism. To make things simple another enzyme called DNA ligase can then put the DNA back together but this time with your gene of interest in the host DNA. This was the method by which Insulin was first produced in bacteria and is still the way that we make a lot of our biological products, but we have some new technology on the horizon which you will also see this meeting.



Source: Addgene

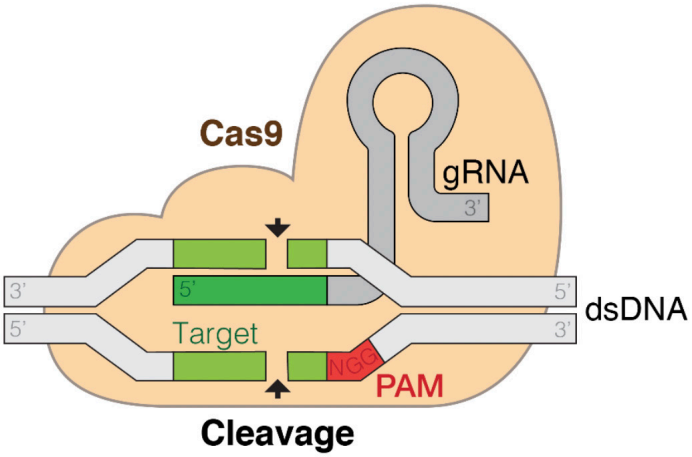
Topic Information: CRISPR-cas9

You may have heard about a new technology in the news. CRISPR-cas9 has taken biotechnology by storm as it allows for a more efficient and reliable way to make precise targeted changes to the genome of living organisms. CRISPR stands for “clusters of regularly interspaced short palindromic repeats”. Cas9 is the accompanying enzyme that works with CRISPR to act like a pair of molecular scissors. The CRISPR guides the cas9 to the correct site and cas9 snips the specific region.

The system comes from bacteria which uses the CRISPR system in order to protect itself. The spacers are taken from viruses that previously attacked the organism. This serves as an immune system for bacteria. When a virus tried to attack the second time the bacteria could fight it off with the help of the cas9 enzyme and the CRISPR DNA.

The cas9 enzyme binds to two RNA molecules called the crRNA (CRISPR RNA) and the

tracrRNA(or trans-activating crRNA). These two RNA sequences then guide the cas9 enzyme to the 20-nucleotide stretch that is complimentary to the crRNA (opposite base pairing from the primer) and the enzyme then cuts twice. The result is a double stranded break. In our biotechnology version we replace the tracrRNA and crRNA with one singular RNA known as gRNA (or guide RNA). dsDNA= double stranded DNA.



Source: Wikimedia

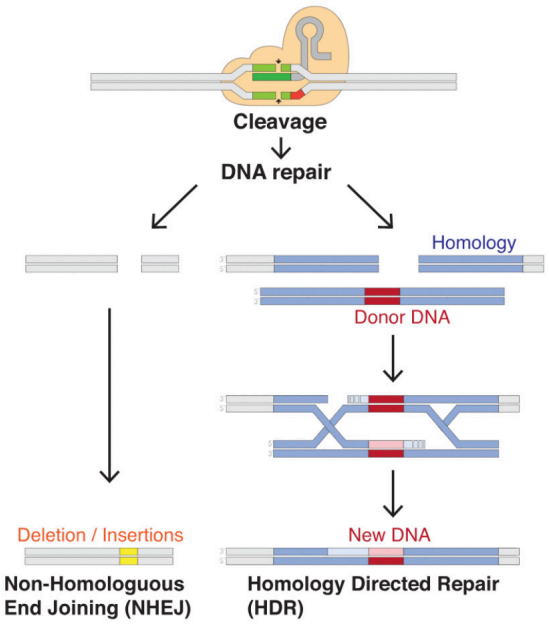
So how do scientists use this to do genome editing? First, we must say what we mean by gene editing. Gene editing refers to changing the genome which encodes for the instructions of the organism. The natural machinery of the cell repairs double stranded breaks in its own DNA. We can use this to trick the host cells DNA repair machinery to introduce the changes that we would like to see.

The changes can come in many forms:

- We can insert a gene of interest found in another organism (transgenic organism)
- We can make a copy of a protein of interest from that organism to amplify its effect
- We can delete a gene all together
- We can change the structure of an existing gene that may be non-functional due to a mutation
- Among others

As you can see CRISPR is a revolutionary change that has specificity beyond any other gene editing technology we have every created. In fact this technology is four times more efficient than the previous best genome-editing tool (called TALENS- Transcription Activator Like Effector Nuclease).

The technology is cheap and with that has also created opportunity. There is a lot that we do not know about the technology at this point. There has even been talk that this technology might be able to make designer babies one day, so it carries a problem. The real question is who gets to control technology and where is the limit.
However CRISPR has opened potential doors for the field of biotechnology and will continue to do so as time goes on. The following photo illustrates the process.



Source: Wikimedia

Advocacy vs. Activism

The final topic that we will discuss is the idea of the difference between an advocate and an activist. So what is the difference?

In short, an activist is someone who goes about a process to make a social or political change. An advocate on the other hand is someone who speaks on behalf of an industry, group or idea. While both can be very powerful, while both are very powerful, you should also understand what motivates or incentivizes their respective actions.

For example, many anti-GMO groups use activism to protest the use of GMO food in the public. Although there may be misinformation these groups are still able to get people on their side. It is important to know the difference while also understanding that both may be valuable tools

ACTIVITY #1 - DIGESTION AND LIGATION ACTIVITY

DO

Time: 25 minutes

Materials/Resources:

- Manual + pen/pencil

Instructions:

1. Members are presented with 4 sets of "Restriction Enzymes". These are references sections that you will take out of the sequence that is found below.
2. Here is the sequence that members will use the restriction enzymes for:

Restriction Enzyme 1: YZZGGG

Restriction Enzyme 2: YTZGQY

Restriction Enzyme 3: AABAAA

Restriction Enzyme 4 : QRTZYX

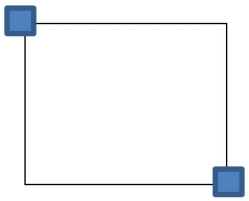
WYZZGGGHENSCIENTISTSARECREATINGMATERIALTOMAKETRANSGENICORG
ANISMSTHESCIENTISTWILLOFTENCHOOSEANORGANISMTHYTZGQYATHASTHE
DESIREDTRAITSTHATTHEYARELOOKINGFOR.THESCIENTISTWILLTHENTAKETH
EDNAOFTHATORGANISMANDUSEATECHNIQUECALLEDTHEPOLYMERASECHAIN
REACTIONAABAAA.THISTECHNIQUECOPIESONYZZGGGLYTHESPECIFICSEQUE
NCEANDDOUBLESTHENUMBEROFDNAMOLECULESFORTHATTARGETSEQUENC
EEVERYTIMETHEREACTIONTAKESPLACE.THISHASTHECAPACITYTOPRODUCEP
OTENTIALLYMILLIONSOFCOPIESOFTHEGENEOFINTEREYTZGQYSTTHATCANTH
ENBEDIGESTED.THISACTIVITYILLUSTRATESDIGESTIONWELL.

THEFIRSTPARTOFTHISACTIVITYHASYOUUSINGRESTRICTIONENZYMESTOFIND
ANDREMQRTZYXOVESEQUENCESOFDNA.THATISWHATHAPPENSINSCIENTIFICL
ABSALLAROUNDTHEWORLD.THEONLYDIFFERENCEISTHATWHENSCIENTISTSDI
GESTAGENEOFINTEREST,THEYALSODIGESTAVECTORORSOMEOTHERPIECEO
FDNA.AVECTORISANOTHERPIECEOFDNATHATHASAFUNCTION.INTHISCASEAVE
CTORCANINCLUDEACIRCULARPLASMYTZGQYIDORMAYINCLUDEANORGANISM'
SDNAIFTHECONDITIONSARERIGHT.BYUSINGANENZYMESCIENTISTCANPUTTHE
SESTRANDSBACKTOGETHERJUSTLIKEYOUHAVEDONEINTHISACTIVITY.AABAAA
THEYCANTHENEXPRESSTHEIRGENEOFINTERESTTOPRODUCETHEIRPROTEIN
ORDESIREDEFFECT.

DO	3. Get members to work together to come up with the decoded clue. Tell members that they can make straight vertical lines at the beginning and end of the words that they know. This will help them come up with the solutions to this puzzle that they may not know. 4. Once members have put it together get each member to read a sentence. The following lines up with the actual solution to this activity. When scientists are creating material to make transgenic organisms the scientist will often choose an organism that has the desired traits that they are looking for. The scientist will then take the DNA of that organism and use a technique called the polymerase chain reaction. This technique copies only the specific sequence and doubles the number of DNA molecules for that target sequence every time the reaction takes place. This has the capacity to produce potentially millions of copies of the gene of interest that can then be digested. This activity illustrates digestion well. The first part of this activity has you using restriction enzymes to find and remove sequences of DNA. That is what happens in scientific labs all around the world. The only difference is that when scientists digest a gene of interest, they also digest a vector or some other piece of DNA. A vector is another piece of DNA that has a function. In this case a vector can include a circular plasmid or may include an organism's DNA if the conditions are right. By using an enzyme scientist can put these strands back together just like you have done in this activity. They can then express their gene of interest to produce their protein or desired effect.
REFLECT	**Learning Outcomes:** For members to learn the basics about digestion and ligation in a fun and exciting activity. Members will also discuss more about other basic biotechnology methods.

APPLY	**Prompts:** • Were there words that you did not understand in this passage? • This simple biotechnology method was used to create the first bacteria produced insulin over 30 years ago. How do you feel about this type of technology being used in this way? • The passage mentioned at the end that the genes could be used to produce a protein or desired effect. Do you know what a gene is? o A specific region of DNA that codes for a protein or other product • The term desired effect is used. Why? o Not every gene encodes for a protein and some of these genes are regulatory in nature. They can turn off certain genes or control genes. These genes are not turned into protein and remain as RNA. These genes are referred to as RNAi or interference RNA.

ACTIVITY #2 - CRISPR/CAS9

DO	**Time:** 20 minutes **Materials/Resources:** • Sequencing Activity Sheet **Instructions:** 1. This game of tag will involve all members of the club. First order yourselves in terms of age. Set the boundaries so that they are very small by having each leader stand at an opposite corner (As can be seen in the diagram where the leaders are shown in blue squares and all the members are within the area). All youth must stay within the box that the leaders create. The game is tag but with an order.  2. The youngest member is it. They must tag the next member who is closest to age. Once this happens the leaders will take a step back and that person is it. As the time goes and more people are tagged the borders will expand. 3. As time goes on end the game at 10 minutes. Then ask the members the processing prompts.
REFLECT	**Learning Outcomes:** For members to discover the need for CRISPR based on the size of the genomes.

APPLY	**Prompts:** 1. CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats. Do you know what palindromic means? o DNA is double stranded. Palindromic means that the reading is the same both forward and backwards. In this case both the top and bottom are the same. An example of this is a famous quote by Napoleon who said the following: Able was I saw Elba. If you read that back what do you get? • Cas9 is in the second part of the name. What does it do? o CRISPR finds the target sequence using a guide while Cas9 is the protein that is responsible for cutting the sequence. • CRISPR has become of great interest as disease resistant genes could simply be removed from the host genome by CRISPR. When this happens the resulting products does not need to be marked as GMO as the product is simply the same product. Do you agree with this? Why would one remove disease resistant genes? Aren't they good?

ACTIVITY #3 - SENIOR MEMBER PROJECT- FARMACEUTICALS AND BIOPHARMING

Biopharming is the production and use of transgenic plants and animals that have been modified to produce a pharmaceutical substance or drug. In the past this was done by bacteria which have genes inserted into their genomes. The result is that these bacteria can then produce these important pharmaceuticals. The move to plants and animals could lead to reduced costs as these drugs could be made cheaper and allow for the plant or animal to be used in multiple ways.

DO	**Time:** 20 minutes Get members to review the following resources and to do their own research. Biopharming is an evolving field so there is always more information coming out. The senior members will be responsible for coming up with a presentation or game to explain the topic to the other members. Try and make the activity interactive. **Resources:** http://www.plantformcorp.com/history-of-biopharming.aspx https://fas.org/biosecurity/education/dualuse-agriculture/2.-agricultural-biotechnology/biopharming.html https://web.archive.org/web/20110718203226/ http://www.bio-pro.de/magazin/thema/00178/index.html?lang=en
PLAN	**Learning Outcomes:** The purpose of this activity is to allow senior members to teach a new development in the field of biotechnology.

APPLY	**Prompts:** For the senior members 1. How comfortable did you feel about the topic? 2. What did you learn through your research and your game? 3. Does this seem like an interesting topic to you? 4. When you used other sources did you find a lot of information? For other members? 1. Do you know the importance of biopharming? 2. Do you think biopharming initiatives could bring reduced costs to prescription medicine? 3. What do you think the effects would be on the agricultural industry if this technology was adopted? 4. Do you think there is a problem with these plants crossing into native plants? What technology did we learn about with the AquAdvantage Salmon that would prevent this? (Sterilizing the plants)

ACTIVITY #4 - ADVOCACY VS ACTIVISM

DO	**Time:** 10 minutes **Materials Needed:** None **Instructions:** • This is another split the room activity and a way to sum up the club. Ask members to move to the right (yes) or the left (no) according to their answer to the question. • To start who knows what the difference between advocacy and activism? o Ask those who are on the yes side what the difference between the two is o Then say that advocacy could be working within the system while activism is seen as working outside. Activism has a negative image in the public today, but both are valid in different means • Do you agree with the idea of advocacy (one side of the room) or more with activism (other side)? • Is it okay to be in the middle? Can you think of a something where both are important? o Think of a bill being introduced in the house of commons that limits your rights as a student to more gym time. Do you think there is a reason to work on both sides of the room? Work with your parents to oppose it while also working within the school system to oppose the change? • Can you think about anything that we talked about in this club that may require you to be a strong advocate? o Ask those who are on the yes side what they may have learned (hopefully they will all be on this side) o Ask those on the no side why this would not be something they would be willing to do • At the end of this club do you believe you have the tools to discuss the field of agricultural biotechnology?

DO	o Yes/no • Bring everyone back into the middle and ask members what they believe is the big take away from the club? o Ask each member individually and let them reflect
REFLECT	**Learning Outcomes:** For members to reflect on the club and to gain a better appreciation of the experiences. The point of this activity is also to sum up their experiences.
APPLY	**Prompts:** • • Why do you think some people have issues or concerns with certain agricultural biotechnology practices? o Get members to explain their reasoning for their thoughts o Do they think it is misinformation or the fear of the unknown? • Will you use what you learned in this club in the future? • Are there any other topics you would have liked to talk about? • Would you be able to have a conversation about GMOs with members of the general public or your friends? • Have you learned a very broad overview of agricultural biotechnology, DNA and GMOs? • We would now ask everyone to fill out a review for the club so that we can have your feedback for in the future when we run this club!

Note to Leaders

• This club is meant to be very educational in nature and teach members about biotechnology on a very general level. We ask that you try and organize at least one tour of a facility in your area that deals with some area of expertise. The Universities and Colleges will be more than happy to show you around and also to explain any burning questions the members may have.
• Ask the members early what they would like to do but if you think it might be interesting contact the venue and set up a tour! It will add a hands-on approach and learning experience to this club!