CANADA
4-H Ontario

www.4-hontario.ca

4-H ONTARIO PROJECT

Technology & the World Around Us

REFERENCE MANUAL

Credits

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,
my country, and my world.

The 4-H Motto

Learn To Do By Doing

CANADA
4-H Ontario

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4-H Ontario is pleased to be able to provide project resource reference manuals for use by volunteers in clubs. 4-H Ontario screens and trains volunteers to equip them with the tools to serve as positive role models for youth. With so many topics to choose from, 4-H volunteers are trusted to use these resources to provide safe and quality programming while using their judgement to assess the appropriateness of activities for their particular group of youth. By downloading any 4-H resource, you agree to use if for 4-H purposes and give credit to the original creators. Your provincial 4-H organization may have restrictions on the types of 4-H projects or activities which can be completed in your region.

Ontario

The 4-H program in Ontario is supported by the Ontario Ministry of Agriculture, Food and Rural Affairs.

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

The development of this project resource was generously funded by the Stanley Knapp Resource Development Fund and Agriculture & Agri-Food Canada (AAFC).

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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 Technology & the World Around Us Project!

The purpose of the 4-H Technology and the World Around Us Project is to create an understanding of the importance of technology in our every day lives and how the agri-food sector has embraced technology to feed an ever-growing world. This project focuses on technology that helps with productivity, profitability, animal welfare, environmental benefits and solutions to labour shortages. The technology featured in this project however, could be applied to and have multiple applications in many different industries.

Objectives

- Increase knowledge of what technology is, what benefits there are to adopting new technology and how technology is a part of our every day lives
- Gain an understanding and appreciation of the technology found in the agri-food industry
- Develop skills in identifying areas where new technologies could be developed
- Discover careers available that are associated with technology
- To start on a path of continual learning about technology by directing members to more in-depth information
- Expand skills in problem-solving, judging, communication and leadership
- To learn the proper use of parliamentary procedur

How to Use This Manual

The Reference Manual:

The reference book is laid out into 6 sections:

Meeting 1 – Technology & the World Around Us

Meeting 2 – Technology for Growing More with Less

Meeting 3 – Precision Agriculture Outstanding in its Field

Meeting 4 – Precision Livestock Farming – Animal Health & Reproduction

Meeting 5 – Technology in the Barn

Meeting 6 – Weather Monitoring - Food Processing, Packaging & Retail

There is more information in this project than what can be covered in 12 hours of a typical 4-H project. A member could take this project for multiple years and learn different content each year.

Each section can be used as a complete project, thus having six projects contained within this Reference Manual. A member could take this project for multiple years and learn different content each year. Each meeting contains Setting Objectives, Suggested Learning Outcomes, Roll Call questions, a suggested agenda, Topic Information, Activities and a Digging Deeper section. Activities should be used in combination with the discussion of topic information to teach members in a hands-on, interactive learning environment.

Table of Contents

Including STEM in the 4-H Technology & the World Around Us 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 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 Technology & the World Around Us Project, you will see STEAM integrated throughout the project within all of the activities provided. Examples of activities include 'Creating DNA, Design Your Barn, Seed Identification, Build Your Own Noodle Bot, Build an Eco-Bot Challenge! and Weather Monitoring' amongst many others.

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 could 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
- Adjournment

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 manual 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 dairy as the outcome is more about understanding the concepts of effective communication.

Electing Your Executive

Elections can be chaired by a youth leader, senior member or club leader. The person chairing the elections is not eligible for any positions.

Procedure:

1. All positions are declared vacant by the chairperson, who indicates this by saying "I'd like to declare all positions vacant."
2. The group decides on the method of voting (i.e. show of hands, ballot or standing).
3. The chairperson accepts nomination from members for each position being filled. Nominations do not require a seconder. Nominations are closed by motion or declaration by the chairperson.
4. Each member nominated is asked if he/she will stand for the position. Names of members who decline are crossed off.
5. Voting takes place by selected method and majority rules (i.e. member with most votes).
6. Announce the name of the successful member. Offer congratulations and thank all others that ran for the position.
7. If ballots are used, a motion to destroy the ballots is required and voted on.

Steps in Making a Motion

The motion is a very important key to having good meetings. Motions are a way of introducing topics for discussion and allowing each member to speak and vote. Any member can make a motion.

Steps in Making a Motion:

1. Address the chairperson (i.e. raise your hand).
2. Wait for the chairperson to acknowledge you.
3. Make the motion: "I move that…"
4. Another person seconds the motion: "I second the motion."
5. Chairperson states the motion.
6. Chairperson calls for discussion of the motion.
7. Chairperson restates the motion.
8. Chairperson calls the vote: "All in favour? Opposed?"
9. Chairperson announces the result of the vote: "Motion carried" or "Motion defeated."

Leader's Planning Chart

Mtg. #	Date/Place	Topics Covered	Activities	Materials Needed

As a club volunteer your responsibilities are to:

- Be a Volunteer in Good Standing by completing the volunteer screening process, attend a volunteer training session and adhere to the 4-H Code of Conduct.
- Notify the local association of the club, arrange a meeting schedule and participate in club meetings, activities and the Achievement program, assuring that all meetings and activities are accessible and inclusive for all participants.
- Review the project material in the Reference Manual 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.
- Ensure that members are registered for the club using the online registration system.
- Review the Participant Agreement Form (PAF) that members will have completed when registering online. 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.
- Adhere to the 4-H Code of Conduct at all times.

Achievement Program Ideas/Suggestions

- Have members create an exhibit or enter a float in the parade at a local fair/show.
- Have members make a presentation at school about the 4-H Technology & the World Around Us Project.
- Have members make a Tik Tok video that features technology from this project.
- Host an evening for your community with a guest speaker that highlights technology used in agriculture. Or, have 4-H club members do the presenting.
- Create a skit about technology and perform it at school, at a senior's home, at another organization's meeting, etc.
- Attend a local livestock or crops event that highlights new and emerging technologies

Special Projects/Digging Deeper Activities

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

- Create a display about a topic related to technology and display at a local fair or community event.
- Create a video about some aspect of technology in this project. Post on YouTube.
- Interview a farmer or someone who works with technology in the agriculture industry. Write a blog or an article for your local newspaper about a crop that they grow. (alternately, interview someone who works in a technology field not related to agriculture).
- Create a science experiment related to technology and enter the 4-H Canada Science Fair competition.
- Create a new technology that solves a problem in our society.

Tour & Guest Speaker Ideas

- Visit a farm that utilizes technology.
- Visit a farm machinery dealership.
- Have guest speakers attend meetings to supplement the material in the Reference Manual. Speakers could include an agronomist, seed salesperson, farmer, field crops researcher, meteorologist, custom sprayer, software developer, dairy equipment salesperson, geneticist, etc.
- Visit a food processing facility.
- Tour a farm machinery assembly plant.
- Tour a crop test plot – tour could include topics such as seed selection, soil fertility and crop protection.

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,
my country, and my world.

CANADA
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Technology & the World Around Us References/Resources

- 4-H Canada https://4-h-canada.ca/
- 4-H Ontario https://4-hontario.ca/
- AgCareers.com https://www.agcareers.com/
- AgScape https://agscape.ca/
- Bioenterprise: Canada's Food & Agri-Tech Engine https://bioenterprise.ca/
- Brainspire - Technology and Society: How Technology Changed Our Lives https://www.brainspire.com/blog/technology-and-society-how-technology-changed-our-lives
- Canadian Agri-Food technology – Sowing the Seeds for Tomorrow ((information and Communications Technology Council – Government of Canada) https://www.ictc-ctic.ca/wp-content/uploads/2021/11/canadian-agri-food-tech-2021.pdf
- Canadian Food Focus https://canadianfoodfocus.org/canadian-food-stories/
- Canadian Poultry https://www.canadianpoultrymag.com/
- Case IH https://www.caseih.com/northamerica/en-us/home
- Community Safety Knowledge Alliance www.cskacanada.ca
- CropLife Canada https://croplife.ca/
- Cyber Secure Canada https://www.ic.gc.ca/eic/site/137.nsf/eng/home
- DeLaval https://www.delaval.com/en-ca/
- Farm & Food Care Ontario https://www.farmfoodcareon.org/
- Fendt https://www.fendt.com/int/
- Food Safety Tech https://foodsafetytech.com/
- Future Learn https://www.futurelearn.com/
- GEA https://www.gea.com/en/index.jsp
- Get Cyber Safe https://www.getcybersafe.gc.ca/en
- Government of Ontario - Manure handling options for robotic milking barns https://www.ontario.ca/page/manure-handling-options-robotic-milking-barns
- Greenhouse Canada https://www.greenhousecanada.com/acceleration-by-technology/
- John Deere https://www.deere.ca/en/index.html
- Kubota https://kubota.ca/en/home
- Lely Canada https://www.lely.com/ca/en/
- Michigan State University Extension Agriculture https://www.canr.msu.edu/
- National 4-H Council https://4-h.org/
- National Cyber Threat Assessment 2020 – Canadian Centre for Cyber Security https://cyber.gc.ca/sites/default/files/publications/ncta-2020-e-web.pdf
- New Holland https://www.newholland.com/
- Oklahoma 4-H www.oklahoma4h.okstate.edu
- Ontario Genomics https://www.ontariogenomics.ca
- Ontario Ministry of Agriculture, Food & Rural Affairs http://www.omafra.gov.on.ca/english/
- Oxford Academics – Animal Frontiers https://academic.oup.com/af/article/6/1/53/4638795
- Progressive Cattle https://www.progressivecattle.com/
- Purdue University – College of Agriculture https://ag.purdue.edu/
- Robotics & Automation News https://roboticsandautomationnews.com/
- Science Focus https://www.sciencefocus.com
- Soil & Water Conservation – Agriculture Drainage, Past, Present & Future https://www.swcs.org/static/media/cms/75th_Book__Chapter_12_EF06D8EB17FCE.pdf
- Southern New Hampshire University – What is Cyber Security? https://www.snhu.edu/about-us/newsroom/stem/what-is-cyber-security
- Techjournal https://techjournal.org/
- The Canadian Centre for Cyber Security https://cyber.gc.ca/en/
- The Pig Site https://www.thepigsite.com/
- University of Guelph www.uoguelph.on.ca management. Proc. First North Amer. Conf. on Robotic Milking. pp. 18-32.

Meeting 1 – Technology and the World Around Us

Setting Objectives:

To create an understanding of the importance of technology in our every day lives and how the agri-food sector has embraced technology to feed an ever-growing world.

Suggested Lesson Outcomes:

- To understand what the word technology means
- To realize why technological advances are critical to everyday success
- To appreciate how technology affects our everyday lives
- To understand why the agriculture industry is continually adopting new technology
- To appreciate the importance of cyber security
- To discover careers related to the technologies presented in this meeting
- To start 4-H members on a path of continual learning about technology by directing members to more in-depth information
- To understand parliamentary procedure and how the election process works for electing the club's executive

Suggested Roll Call Questions:

- Name one piece of technology that you used today
- Name a piece of technology that helps you to do something better
- If you could invent a new piece of technology to help you complete a task, what would you invent?
- Name one piece of technology that you use that your parents/guardians wouldn't have had growing up

SAMPLE MEETING AGENDA Time: 2 hour 25 minutes

Welcome, Call to order, Pledge Review 4-H Code of Conduct		10 minutes
Roll Call		5 minutes
Parliamentary Procedure	Election of Officers	30 minutes
Topic Information, Discussion & Activities	**<u>Topic Information</u>** • Technology & the World Around Us ◊ What is technology? ◊ Technology in the agri-food system • Cyber Security ◊ What is a cyber attack? ◊ Why cyber security is important for the agri-food industry Acitivity #1 Technology & the World Around Us Wordsearch Acitivity #2 How Much Soil is there in the World? Acitivty #3 Technology in the News	30 minutes 15 minutes 20 minutes 20 minutes

At Home Activity	Cyber Crime in Canada	5 minutes
Wrap up, Adjournment & Social Time		10 minutes

Topic Information

Technology & the World Around Us

The future always feels like it's running late. Human imagination works faster than human enterprise, but at any given moment, scientists and engineers are redesigning future technology and the world around us in big and small ways. The rate of progress over the last half century has been extreme and staggering in fields as broad as computing, medicine, communications, food production and materials science.

Ancient and modern human civilizations have benefited from technological innovations, inventions and engineering applications used within societies to perform specific tasks. For societies to thrive and evolve, technological innovations have become necessary. As technological systems are invented by humans and reflect a population's needs and culture, human societies/civilizations and their technology have become inseparable from one another. Technologies change the way society behaves and operates which also affects and evolves economies, producing a potential greater need for more technology, resulting in a cycle.

No single piece of technology - even failed technology - has had zero impact on a human society. Since "necessity is the mother of invention," all invented technology has been created over the years to meet the needs of society.

DISCUSS IT

How has technology changed your life in the last 5 years? Has it made your life better or worse?

Debate It!

What one technology/innovation do you think has had the most influence and caused the most change for the agriculture industry?

This mutual relationship of co-influence and co-production has been the case from the beginning of history, resulting in two major forms of this beneficial relationship co-evolving, depending on the type of society in question:

1. **Agricultural Cycles**: The agricultural industry is based on the cycle of the season and has an agricultural, cyclical concept of evolution based on agricultural technologies. Since the technologies of an industry also help to determine the economy of a society, agricultural, technology and the economy are all intertwined.

2. **Progressive:** While also cyclical, the explosion of technology before and after the industrial revolution (mid 1700's to mid 1800's) has resulted in the world moving forward in social progress (via technology) which has resulted in more diverse markets and the development of new innovations, such as an interconnected world (e.g. the Internet) and globalization. The Industrial Revolution began when the agricultural industry became more industrialized and urban. The transcontinental railroad, the tractor, electricity and other inventions permanently changed society.

In 1892 in a tiny village in Northeast Iowa, John Froelich inveted the first successful gasoline-powered engine that could be driven backwards and forwards. The word "tractor" wasn't used in those days, but that's what it was. At the time Froelich invented this tractor, steam-powered engines were used to thresh wheat. Later that fall, Froelich shipped his "tractor" to Waterloo, Iowa to show some businessmen. Immediately, the men formed a company to manufacture the "Froelich Tractor." They named the company The Waterloo Gasoline Traction Engine Company. Unfortunately, efforts to sell the gasoline-powered tractor invented by Frolich failed. The Waterloo Company continued to build stationary engines while trying to improve the tractor.

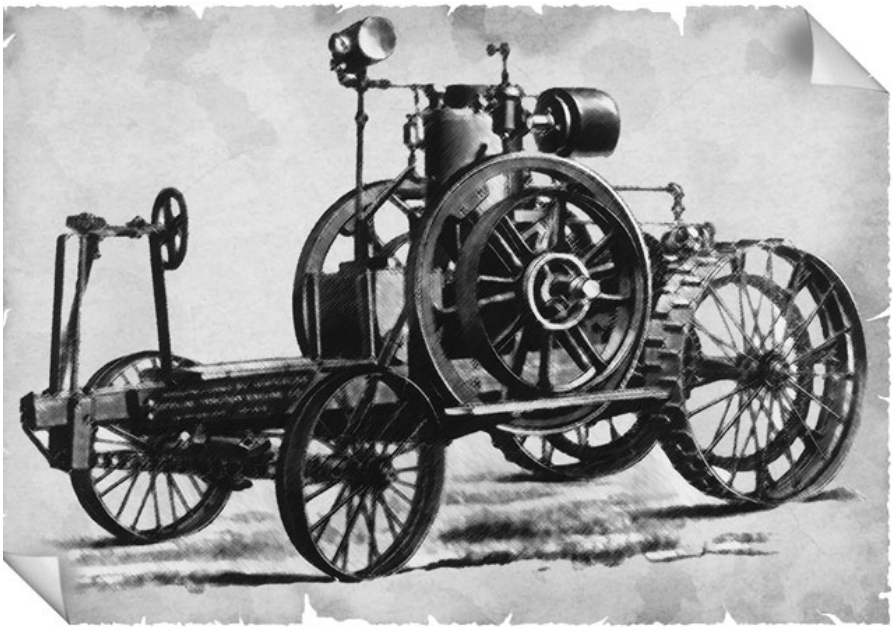


Image Credit: Farm Collector

Image Credit: Farm Collector

In 1914 the first Waterloo Boy Tractor, the Model "R" single-speed tractor, was introduced. Farmers liked it and within a year, sales reached 118. This tractor started with a hand-crank, had a two-cylinder engine and sold for $850. When the Model "N" Waterloo Boy with two forward speeds was introduced, that was also successful.

Share It!

Name a type of technology that was developed more than 100 years ago.

What is technology?

Technology is any application that is engineered or created using applied science and/or math to solve a problem within a society.

This can be agricultural technologies, computational technologies and health/medicine technologies, just to name a few – all of which are intertwined. Technology can encompass ancient technologies such as the calculator, compass, calendar, battery, ships, or chariots, or modern technology, such as computers, robots, tablets, printers, and cell phones. The technology of the future includes smart cities, more advanced smart devices, quantum computers, quantum encryption, advanced Artificial Intelligence and more efficient production systems.

Emerging technologies are changing the way we live, how we look after our bodies, are creating a more efficient food system and, could help us avoid a weather disaster.

Technology has made it easier to farm, more feasible to build cities, and more convenient to travel, among many other things, effectively linking together all countries on earth, helping to create globalization, and making it easier for economies to grow and for companies to do business. Virtually every aspect of human life can be carried out in an easier, more effective, and quicker fashion via technological solutions, resulting in less problems in one way, and more problems in another.

This project will look at various types of technology. Because the agricultural industry being so intertwined within the economy of any country, this project will have a focus on the technology used in the agri-food chain from the start of production on the farm straight through to food arriving in the retail sector ready for consumers. As you go through the meetings in this project though, keep in mind that the technology presented in this project could be used in many other industries and that technology is always evolving and changing.

CAREER ALERTS!

*Check out these exciting information **technology** careers!*

- *Computer Programming*
- *Computer Science*
- *Database Management*
- *Data Science*
- *Data Visualization*
- *Information Systems*
- *Network Security*
- *Software Engineering*
- *Web Development*

Technology in the agri-food system

Canada's agri-food sector spans many industries including primary agriculture, aquaculture and food and beverage processing. A sustainable, competitive food and agriculture system is critical to resilient economic growth for Canada. The United Nation's sustainable development goals (SDG's) make it clear that food is tied to almost everything we do including reducing inequality, achieving good health and well-being, responsible food consumption and production, building sustainable communities and protecting the environment. To ensure food security for the predicted population of 9.6 billion people by 2050 the FAO (Food & Agriculture Organization) predicts that food production must increase by at least 60 per cent to meet the demand. The global food and agriculture sector will need to produce more while reducing its environmental footprint.

Look It Up!

What is the current population of Canada and expected population in 2050? What is it for North America?

Because of the importance of increasing agriculture production globally, this project will look at various types of technology used within the agri-food industry.

Defining Agri-Food Technology

Agri-food technology encompasses any advanced technology used by the agri-food sector in food production, for instance, to make food production safer, more efficient or environmentally friendly, or to create novel types of food.

Given its expansive supply chain, the agri-food sector overlaps adjacent sectors including retail, health, ICT (information and communications technology) and manufacturing.

DID YOU KNOW?

The food and beverage processing industry is the largest manufacturing industry in Canada.

Mechanization of Agriculture

Ancient agricultural practices have seen a radical change with the mechanization of agriculture. Such mechanization simply means that machines and technological systems (including robots) have replaced ancient farming systems such as work animals and manual labour. This has resulted in more automated, highly efficient farm practices, producing far more abundant food resources for more people.

Experience It!

Visit an agriculture museum or someone who collects antique farm machinery to see farm machinery of the past. Find out what the oldest piece of equipment is and what it was used for.

The advances in agriculture are often referred to as precision agriculture. This can encompass both livestock and crop farming. Precision agriculture can be defined as:

A holistic and environmentally friendly strategy in which farmers can:

- vary input use and cultivation methods including application of seeds, fertilizers, pesticides and water; variety selection, planting, tillage and harvesting to match varying soil and crop conditions across a field as well
- vary input use with livestock including nutrition, veterinary, genetics and housing management to provide the most efficient, well-balanced system while also providing the utmost in animal welfare

The concept of precision farming has been around for a long time. Before the invention of farm implements, each seed was planted by hand and fertilizer was applied to each plant individually into many small fields. Cows, sheep and goats were milked by hand, animals were bred using livestock that lived closed by and medicinal care for livestock was basic. The mechanization and development of farm implements caused fields to expand in size and the blanket application of fertilizers, pest control products, planting, etc. The mechanization of livestock practices caused farms to be able to increase the number of head of livestock on farms, be able to breed livestock for more desirable traits and improve the health of livestock.

JUDGE IT!

There are many different types of technology that can be judged. Ask members in the club to set their cell phone out for everyone to see. Have each member explain why the features of their cell phone make it the best choice for a phone. As members give reasons for their cell phone, create a list of these reasons. Once everyone has had a chance to contribute to the list, have the group rank the reasons (criteria) from most important to least important.

If a member doesn't have a cell phone, have them explain what feature would be the most important to them if they were purchasing a cell phone (or which feature is the best feature on a parent or guardian's phone).

The general goals of precision agriculture include reducing costs, optimizing crop yields and quality, better management of resources, protection of the environment, energy conservation and improvements in animal welfare. The need for this technology is due to the increasing world population while the amount of crop ground is decreasing.

Cyber Security

Not all technologies involve computer systems, but many do. Technology is great and can be used to improve the lives of many but unfortunately not everyone has good intentions. Cybercrime is a growing concern especially with Canadian individuals and organizations increasingly relying on the Internet for daily activities. This trend enables Canadians to work, shop, and socialize remotely (especially important during the covid-19 pandemic). However, as more devices, information, and activities move online, they are vulnerable to cyber threats.

2018 Canadian Internet Usage
Source: 2018 Canadian Internet Use Survey by Statistics Canada, 2019 CIRA Internet Factbook and forecasts of the International Data Corporation – Canadian Centre for Cyber Security – National Cyber Threat Assessment 2020

Cyber threats pose a threat to the Canadian economy by stealing from individuals and organizations, notably through the theft of intellectual property and proprietary information.

DISCUSS IT

What kind of security do you use on your devices?

Cyber security consists of all the technologies and practices that keep computer systems and electronic data safe. In a world where more and more of our business and social lives are online, it's an enormous and growing field.

Data is now more valuable than ever because of the insight and knowledge that can be extracted from it. And it is very easy for cyber criminals to hack accounts and violate businesses once they collect this information. Cyber security for all connected devices is very important.

CAREER ALERTS!

*Check out these exciting **cyber** careers!*

- *Cybersecurity Engineers*
- *Director of security*
- *Security architect*
- *Network security engineer*
- *Security software developer*
- *Security systems administrator*
- *Technical director*
- *Security analyst*

Look It Up!

What has been the largest data breach in Canadian history? How did it happen? How many Canadians did it effect?

What is a cyber attack?

A cyber attack is an unwelcomed attempt to steal, expose, alter, disable or destroy information through unauthorized access to computer systems.

There are many reasons behind a cyber attack such as cyber warfare, cyber terrorism and even hacktivists. These actions fall into three main categories: criminal, political and personal.

Small businesses make attractive targets and are typically attacked due to their lack of security infrastructure. Small businesses are vulnerable for an attack for a number of reasons:

- Can't afford professional IT solutions
- Have limited time to devote to cyber security
- Don't know where to begin

DID YOU KNOW?

The Canadian Federal government networks blocked an average of 474 million hacking attempts per day over a 12-month period between July 2016 to July 2017.
Source: The Toronto Star

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

Experience It!

Invite someone who works in the computer industry who can speak about anti-virus programs and backing up data.

Why cyber security is important for the agri-food industry

Agriculture is key to Canadian prosperity and wellbeing, but it is under threat.

The agri-food system is a vital sector of the Canadian economy and our global position.

Farmers, as business people and entrepreneurs, are at the front lines of maintaining strong and resilient rural communities.

The food supply chain – from farm to fork – is essential to the health and wellbeing of every Canadian. Evolving food systems to be capable of supporting nine billion people in the face of climate change is one of the 21st century's big challenges. Digital technologies are helping agriculture to become more productive and efficient, and they can support sustainable food production practices.

Like other critical infrastructures, the agri-food sector is becoming a growing target for cyber attacks.

Digital technologies are changing how we produce food and how we distribute it

Next-generation equipment – along with agronomic and other data services – allows producers to manage each hectare of land and each individual animal in near real-time. These "precision agriculture" or "smart farming" technologies provide opportunities to boost productivity and profitability, and to enhance traceability.

Digitalization also can help farmers use inputs such as antibiotics or fertilizers more precisely, and lessen harmful outputs (emissions, waste and land disturbance), reducing agriculture's environmental footprint.

New technologies to address the food system challenges of the 21st century[1]

Digital Building Blocks

- New computing technologies
- The Internet of Things (IoT)
- Blockchain
- Cloud computing
- Big data and advanced analytics
- Artificial intelligence and machine learning
- Virtual reality and augmented reality
- 5G mobility

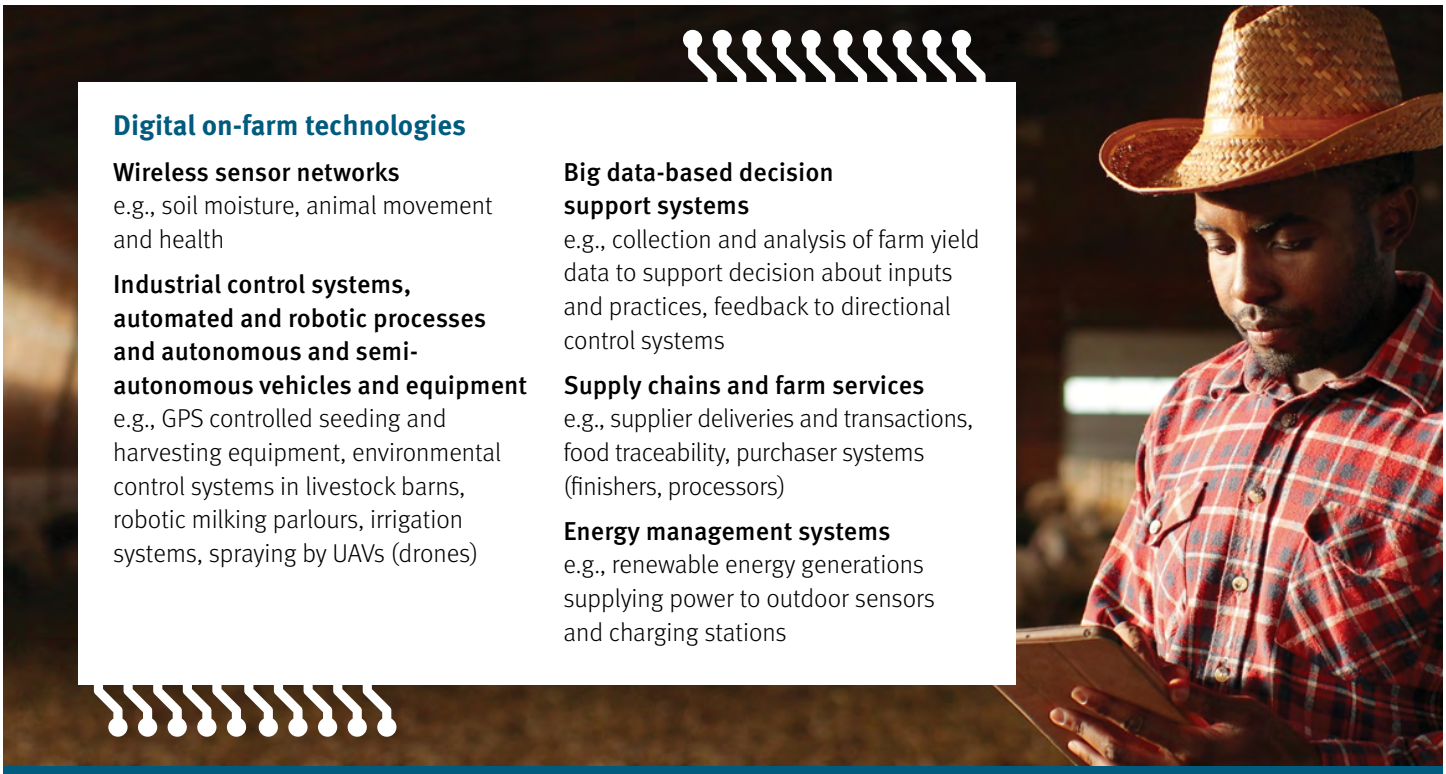
Advances in Sciences

- Next generation biotechnologies and genomics
- Energy creation, capture, storage and transmission

Reforming the physical

- Autonomous and near autonomous vehicles
- Additive manufacturing and multidimensional printing
- Advanced, smart robotics
- Advanced materials and nano-technologies

1. Adapted from World Economic Forum (2018)



Digital on-farm technologies

Wireless sensor networks
e.g., soil moisture, animal movement and health

Industrial control systems, automated and robotic processes and autonomous and semi-autonomous vehicles and equipment
e.g., GPS controlled seeding and harvesting equipment, environmental control systems in livestock barns, robotic milking parlours, irrigation systems, spraying by UAVs (drones)

Big data-based decision support systems
e.g., collection and analysis of farm yield data to support decision about inputs and practices, feedback to directional control systems

Supply chains and farm services
e.g., supplier deliveries and transactions, food traceability, purchaser systems (finishers, processors)

Energy management systems
e.g., renewable energy generations supplying power to outdoor sensors and charging stations

"There are two types of precision agriculture systems – those that have been hacked, and those that will be." [2]

New and important threats are developing

A series of ransomware attacks in Canada, the US and Australia in 2021 showed just how vulnerable the agri-food infrastructure can be. The attack on the Australian wool exchange system in February stopped trading for several days, resulting in millions of dollars of lost value and impacts on commodity prices. The attack on the world's largest meat producer in the summer threatened to cause disruptions to consumers on a global scale. And disruptions of two grain buyers in the United States at harvest time sent shock-waves through that sector. The attacks were attributed to cyber crime gangs based in Russia. One of these warned the agricultural sector in the fall of 2020 that it would be targeting it in the coming year.

Cyber disruptions can impact seeding and harvesting, affecting food availability and commodity prices. They can also affect animal health by: disabling milking systems; disrupting environmental controls in livestock barns; or interfering with biosecurity systems. Supply chain attacks can cause massive knock-on impacts on regional and national economies, animal welfare and local producers.

Cyber threats[3]

CYBER THREAT ACTOR	MOTIVATION	ATTACK FOCUS
Nation States	Geopolitical, economic and technological power	Disinformation, supply chain control, influence or interference, trade secrets, theft of intellectual property
Cyber Criminals	Profit/privateering for nation state	Financial data, personally identifiable information or ransomware, extortion
Hacktivists	Ideological causes inspired hacking	Sensitive business data, client and supplier data
Extremist Groups	Ideological inspired violence	Disruption of critical systems or data for physical effect
Hackers	Thrill seeking	Penetration and control of systems and devices
Insider Threats	Discontent/ retribution	Destruction/damage of business systems or profiteering of intellectual property

2. West (2018)
3. Adapted from Canadian Centre for Cyber Security (https://www.cyber.gc.ca/sites/default/files/publications/Intro-ncta-2020_e.pdf)

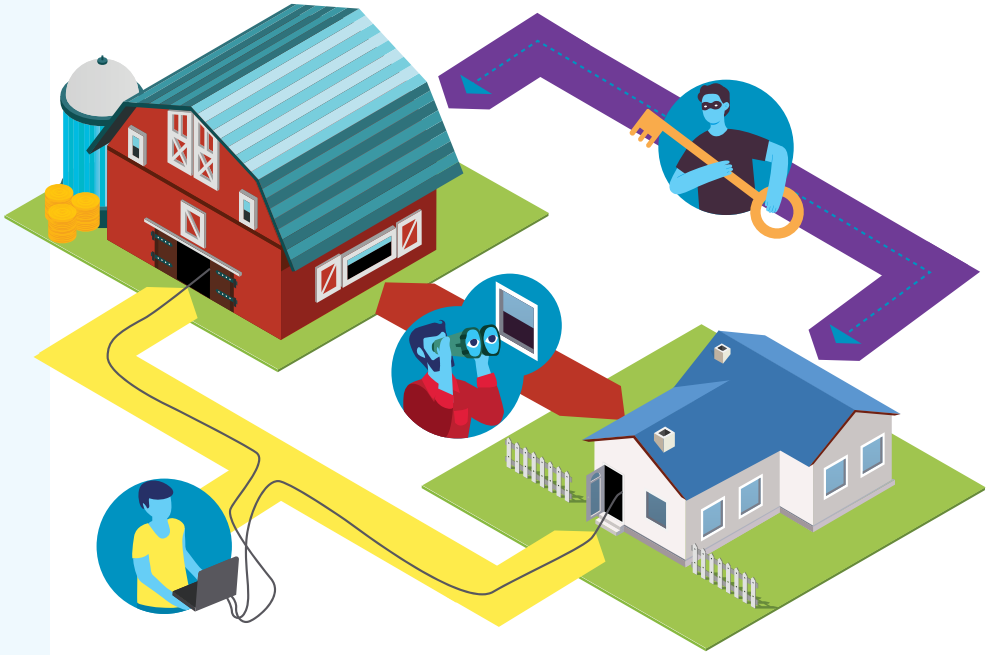
On-farm networks can be susceptible to attack

Farm network vulnerabilities[4]

Open Front Door
Common open ports - physical points of connection on computers that allow communication with external devices and to the Internet *(examples: for file transfer, for email retrieval and routing; for access to the World Wide Web; to allow connected applications to communicate with one another)*

Side Window
Using psychological techniques to get people to do things they shouldn't do *(examples: make a payment; click a link; or share confidential information)*

Locked Back Door
Sneaky methods for getting around normal physical and computer safeguards *(like user authentication or encryption in a computer or connected device)*



But Canadian producers are adaptable

Farmers are good risk managers. They:

- are good at noticing things that might involve risks and threats
- understand their operations and the ways the economic environment can impact their business (examples: commodity prices; the costs of inputs)
- can tolerate uncertainty and manage through disruptions
- are life-long learners
- make careful decisions to evolve their farming practices
- use information and experience to make practical decisions
- mentor and support family members and neighbours
- are self-reliant, and they also collaborate with one another ('barn-raising')
- are careful with their resources and stewards of their land and livestock
- plan for the future

4. After McCafferty (2020)

There are things farmers can do to minimize the risk of cyber disruptions, so they can continue to enjoy the business benefits of digital technologies

Take practical steps focusing on prevention, back-up and recovery:

- **Make sure hardware and software has been updated** by patches, and that they have basic physical and electronic safeguards in place (examples: locked server cabinets; strong passwords).
- **When on social media, consider** what kind, and how much, information about people and farming operations is shared.
- **Don't use public WiFi to check on farm systems when off the farm** – purchase and use a VPN (virtual private network) service for mobile devices if there's a need to monitor operations from public places OR connect monitoring apps to the cellular data service.
- **Make a sketch** of the devices, sensors, computers, servers, mobile devices, automated equipment, environmental control systems, financial systems, and other hardware that are connected within the on-farm networks – this helps to identify potential vulnerabilities.
- **List all the suppliers** whose services involve points of electronic contact with the on-farm systems.
- **Take time to understand what information is critical to the farm business**, where it sits and how it moves, and what would happen if it is corrupted or not available.
- **Consider how to get things up and running again following a disruption** – for example, pork and poultry operations have a very small timeframe to prevent big financial losses and animal welfare catastrophes if their environmental control systems go offline.
- **Back up your most important information regularly** and store it in a safe place.
- **Reach out to IT service providers and sector associations** to get technical help and to stay informed about new threats and how to manage them.
- **Most cyber attacks rely on human error or manipulation** – stay alert to the ways this can occur: don't click on un-verified links in emails or text messages; don't over-share information about operations and vacation plans; never reveal sensitive business or personal information to unsolicited callers – always check back with financial services or suppliers first – including IT service providers.

About this project

The *Cyber Security Capacity in Canadian Agriculture* project is a national, multi-year, initiative funded by Public Safety Canada's Cyber Security Cooperation Program that aims to strengthen cybersecurity capacity within Canada's agricultural sector.

The agricultural sector has increasingly become a target of cyber attacks in ways that can cause serious disruption to the livelihoods of rural communities, and to critical infrastructures, including supply chains. This project is aligned to efforts to strengthen and support domestic food security and wellbeing, rural economic development and resilience, and national prosperity.

For further information

CSKA Community Safety Knowledge Alliance

www.cskacanada.ca

Our National Farmer Survey is coming soon, in December 2021.

Additional resources

The Canadian Centre for Cyber Security (Cyber Centre) is Canada's authority on cyber security. It works to protect and defend the country's valuable cyber assets.
https://www.cyber.gc.ca/en/guidance/cyber-security-small-business
https://www.cyber.gc.ca/en/guidance/baseline-cyber-security-controls-small-and-medium-organizations

Get Cyber Safe is a national public awareness campaign created to inform Canadians about cyber security and the simple steps they can take to protect themselves online.
https://www.getcybersafe.gc.ca/en

CyberSecure Canada is a voluntary federal certification program designed for small and medium-sized enterprises and other organizations in Canada to help improve cybersecurity practices.
https://www.ic.gc.ca/eic/site/137.nsf/eng/home

JusTech is a privacy breach tool. In the event of a data breach, by answering a series of questions, business owners will be provided with multiple auto-generated documents: a completed Personal Information Protection and Electronic Documents Act (PIPEDA) breach reporting form, client notification, internal communication letter, a how-to-guide for breach reporting, and sample cyber policies. The process is easy to use and completely free for small businesses.
https://www.justech.ca

At Home Activity

Cyber Crime in Canada

Cyber crimes can cost millions of dollars each year to large companies. Find out how much money cyber crime cost companies in Canada this past year and be prepared to share your findings at the next meeting.

Digging Deeper

For Senior Members

Technology – the good, the bad and the ugly

Technology plays a huge role in our lives. It has the potential for great things but unfortunately has the potential to create things that are not good for society. Research to find a technology that has been created (now or years ago) that caused a lot harm or was used for a purpose not intended by the inventor.

Be prepared to share your findings with the group at the next meeting.

Activity #1: Technology & the World Around Us Wordsearch

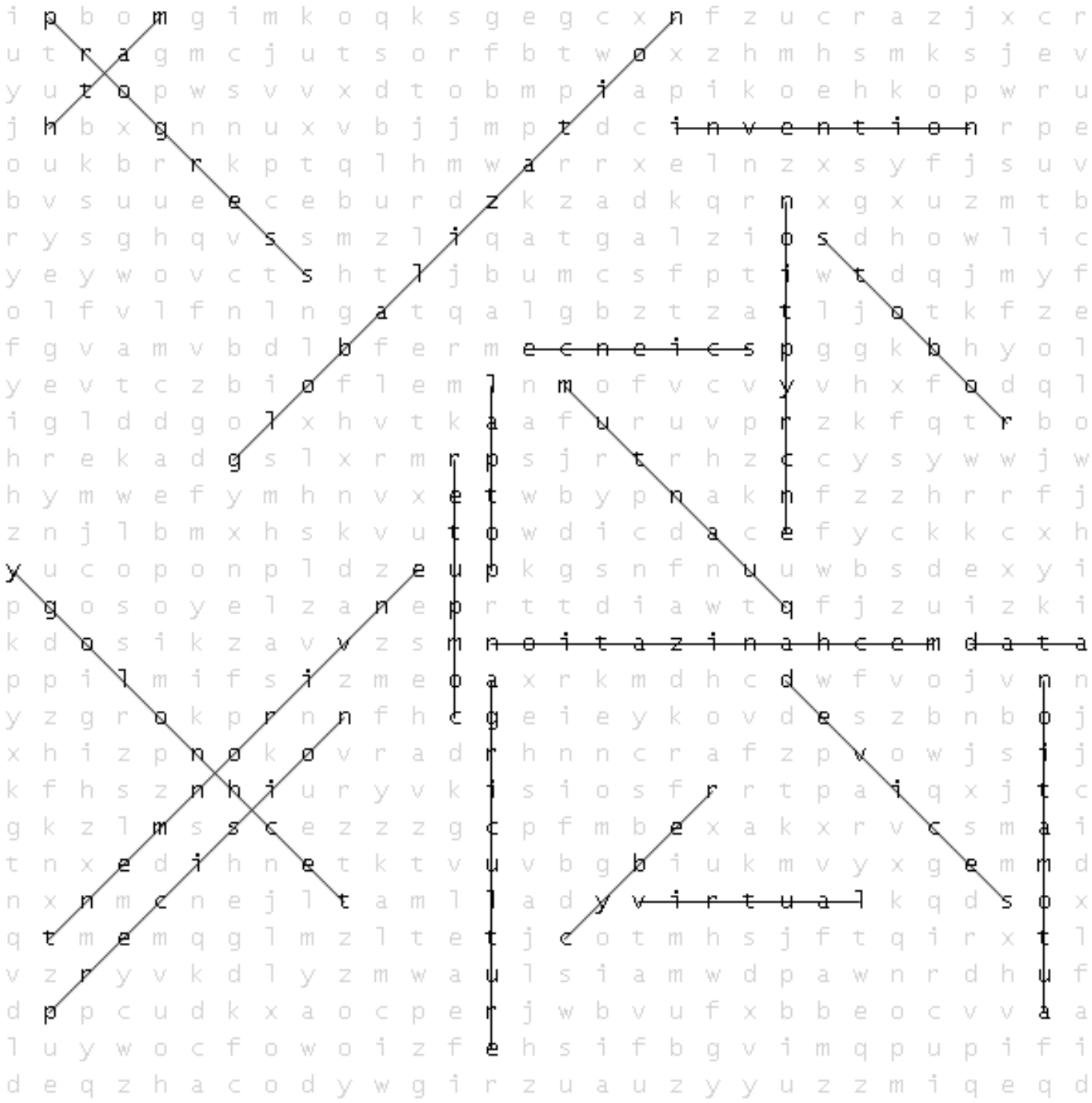
Do	Time: 15 minutes **Materials needed:** • Technology & the World Around Us Wordsearch (found on the next page) • Writing utensil **Instructions:** • Provide each member with a wordsearch. • Give members 5 to 10 minutes to find the words.
Reflect	**Learning Outcomes:** • The objective is to allow members to become familiar with words associated with technology.
Apply	**Processing Prompts:** • Was it easy or hard to find the words in the wordsearch? • Did any of the words surprise you that they would be included in a wordsearch about technology? • Are there any words that you don't know the meaning of?

Technology & the World Around Us Wordsearch

i p b o m g i m k o q k s g e g c x n f z u c r a z j x c r
u t r a g m c j u t s o r f b t w o x z h m h s m k s j e v
y u t o p w s v v x d t o b m p i a p i k o e h k o p w r u
j h b x g n n u x v b j j m p t d c i n v e n t i o n r p e
o u k b r r k p t q l h m w a r r x e l n z x s y f j s u v
b v s u u e e c e b u r d z k z a d k q r n x g x u z m t b
r y s g h q v s s m z l i q a t g a l z i o s d h o w l i c
y e y w o v c t s h t l j b u m c s f p t i w t d q j m y f
o l f v l f n l n g a t q a l g b z t z a t l j o t k f z e
f g v a m v b d l b f e r m e c n e i c s p g g k b h y o l
y e v t c z b i o f l e m l n m o f v c v y v h x f o d q l
i g l d d g o l x h v t k a a f u r u v p r z k f q t r b o
h r e k a d g s l x r m r p s j r t r h z c c y s y w w j w
h y m w e f y m h n v x e t w b y p n a k n f z z h r r f j
z n j l b m x h s k v u t o w d i c d a c e f y c k k c x h
y u c o p o n p l d z e u p k g s n f n u u w b s d e x y i
p g o s o y e l z a n e p r t t d i a w t q f j z u i z k i
k d o s i k z a v v z s m n o i t a z i n a h c e m d a t a
p p i l m i f s i z m e o a x r k m d h c d w f v o j v n n
y z g r o k p r n n f h c g e i e y k o v d e s z b n b o j
x h i z p n o k o v r a d r h n n c r a f z p v o w j s i j
k f h s z n h i u r y v k i s i o s f r r t p a i q x j t c
g k z l m s s c e z z z g c p f m b e x a k x r v c s m a i
t n x e d i h n e t k t v u v b g b i u k m v y x g e m m d
n x n m c n e j l t a m l l a d y v i r t u a l k q d s o x
q t m e m q g l m z l t e t j c o t m h s j f t q i r x t l
v z r y v k d l y z m w a u l s i a m w d p a w n r d h u f
d p p c u d k x a o c p e r j w b v u f x b b e o c v v a a
l u y w o c f o w o i z f e h s i f b g v i m q p u p i f i
d e q z h a c o d y w g i r z u a u z y y u z z m i q e q d

Agriculture	Laptop	Automation	Math	Computer
Mechanization	Cyber	Precision	Data	Progress
Devies	Quantun	Encryption	Robots	Environment
Science	Globalization	Technology	Invention	Virtual

Technology & the World Around Us Wordsearch – Answer Key



Activity #2: How Much Soil is there in the World?

Do	Time: 20 minutes **Materials needed:** • Apple(s) • One sharp knife (for leader demonstration) or plastic knives (for member participation) • Cutting board • Paper towels **Instructions:** • Pretend that this apple is planet Earth. Notice how its skin hugs and protects the surface. Cut the apple in quarters. Three of the four quarters represent how much of the earth is covered with water-- oceans, lakes, rivers, and streams. Set three of four quarters aside. • There is one quarter (25 percent) left, representing the portion of our earth that is dry land. Take this quarter and cut it in half. One of these halves represents land that is desert, swamps, polar, or mountainous regions where it is too hot, too cold, or too high for humans to be productive. Set this half aside. • The other half (one--eighth or 12.5 percent of the apple) represents where humans can live and grow crops. Slice this section lengthwise into four equal parts. Now you have four 1/32nds (3 percent each) of an apple. The first of these represents land too wet for food production. It isn't swamp land, but it may flood during the growing season. The second section represents land that is too rocky and poor to grow food. A third 1/32nd represents areas that are too hot. Set these three sections aside. • The last section (1/32nd or 3 percent of the apple) represents the area of the world developed by humans. Now, carefully peel the last 1/32nd section. This small bit of peel represents the portion of our planet that is soil on which humans depend for food production and similar uses.
Reflect	**Learning Outcomes:** • To allow members to learn the importance of soil as a limited, natural resource and how our food system is dependent on taking proper care of the soil so food can be grown to feed the world. • To have members to realize the importance of having technological advances in the agriculture industry to be able to produce more food with the limited amount of soil available for production.
Apply	**Processing Prompts:** • Does it surprise you that there is so little soil in the world to grow food? • All living things depend on soil to live. What are some of our important natural resources? Answers might include materials such as oil, water, coal, trees, animals and gold. All of those are important natural resources, but we often forget to mention one of our most important natural resources: soil. • What are some things that farmers do to take proper care of the soil?

Activity #3: Technology in the News

Do	Time: 20 minutes **Materials needed:** • Variety of newspapers and magazines • Markers of various colours **Instructions:** • Distribute newspapers and magazines amongst members. • Have members search through print media and have them circle articles that contain information about agriculture and the agri-food system. • Then, have members go back through the print media and, using a different colour of marker, circle the agriculture and agri-food articles that contain information about technology.
Reflect	**Learning Outcomes:** • To allow members to discover how many articles relate back to agriculture and/or agri-food production. • To help members come to the realization of how much technology there is within the agriculture and agri-food industry.
Apply	**Processing Prompts:** • Was it easy or difficult to find articles about agriculture and agri-food? • Were you surprised at how many agriculture and agri-food articles related to technology? • Do any of the articles discuss a problem/issue within agriculture that technology could help with?

Meeting 2 – Technology for Growing More with Less

Setting Objectives:
To allow members to discover and learn about the advancements in technology for the crops and horticultural industries.

Suggested Lesson Outcomes:
- To understand what genomics is and how it can change the environment, agriculture, human and animal health, our overall lives and more, all for the better
- To appreciate the importance of soil testing and learn about technology for analyzing soil
- To learn about new technologies for irrigation, drainage systems and carbon sequestration
- To discover what new technologies are available to the horticultural industry and why these technologies are important
- To understand what bioproducts are and discover the many new innovations being developed in Canada and abroad
- To discover careers related to the technologies presented in this meeting

Suggested Roll Call Questions:
- How much money did cyber crime cost businesses in Canada this past year? (from last meeting's At Home Activity)
- Name a crop that is grown now that wasn't grown 50 years ago in your area.
- Name a trait that is important in the seed that is chosen for a field crop.
- Name an item made from a crop grown in a field that is not used for food (e.g. crayons made from soybeans).

SAMPLE MEETING AGENDA Time: 3 hours 25 minutes

Welcome, Call to order, Pledge		5 minutes
Roll Call		5 minutes
Parliamentary Procedure	Minutes and Business	10 minutes
Topic Information, Discussion & Activities	**Topic Information** • The Science of Genomics ◊ What are GMO's ◊ Difference between conventional and GMO tech for plant breeding ◊ Science behind GMO plant breeding ◊ Gene editing ◊ CRISPR technology ◊ Why use GMO crops? ◊ Other types of GMO uses • Soil ◊ Soil Analysis – nutrient content ◊ Analyzing pasture/range lands ◊ Determining soil dryness ◊ Specialty Crop • Irrigation	40 minutes

	• Drainage Systems • Carbon Sequestration • Horticultural Technology ◊ Horticultural production ◊ Greenhouses ◊ Vertical farming • Bioproducts Activity #1 Cellular Agriculture Activity #2 Seed Identification Activity #3 The Story of the Carbon Cycle Activity #4 Design the Perfect Agricultural Crop	40 minutes 30 minutes 20 minutes 20 minutes 20 minutes
At Home Activity	Biofertilizers	5 minutes
Wrap up, Adjournment & Social Time		10 minutes

Topic Information

Innovative crop protection technologies and biotech crops help Canadian farmers grow more on less land using less water while protecting and caring for the environment. Innovative farming practices reduce fuel consumption and greenhouse gas emissions, preserve important wildlife habitats and improve soil quality (CropLife Canada https://croplife.ca/)

Soybeans in late summer in Ontario

The Science of Genomics

What are GMO's?

Genetically Modified Organisms, or GMOs, are crops developed using precise plant breeding to achieve benefits such as resistance to certain insects and diseases, herbicide tolerance, enhanced nutritional value and reduced food waste

Check It Out!

What is genomics? Watch this video titled 'Genomics 101' produced by Farm & Food Care Ontario and Ontario Genomics https://www.youtube.com/watch?v=oLe80yqx-FA

The difference between conventional breeding and GMO technology for breeding

Humans have cross-bred plants for centuries. Developing genetically modified organisms is a more targeted process. The goal of both GMO and conventional plant breeding is to produce crops with improved characteristics by changing their genetic makeup. GMO breeding achieves this by adding a new gene or genes to the genome of a crop plant. Conventional breeding achieves it by crossing together plants with relevant characteristics and selecting the offspring with the desired combination of characteristics, as a result of particular combinations of genes inherited from the two parents.

Both conventional and GMO plant breeding deliver genetic crop improvement

Soybean plant flowering

The science behind GMO plant breeding

In contrast to a plant created by modifying its DNA using traditional breeding methods, a GMO plant is created using a newer, more controlled method referred to as genetic engineering. This method changes plants by inserting a gene from another organism to add a useful trait to the recipient organism, such as disease or pest resistance. With genetic engineering, the DNA can come from organisms that cannot mate with the crop being modified, e.g., bacteria, fungi or another crop or unrelated plant. For example, one might move a drought tolerant gene from a drought tolerant plant to a corn plant.

With genetic engineering, usually only one gene from the donor, with a known role or coding for a known protein, is added or inserted into the current set of genes of a recipient plant. In contrast, traditional breeding methods mix many genes (from similar plants) in the mating process.

Soybean seed germinating, sprouting and emerging from the ground

Find Out More!

Check out the 4-H Ontario Agricultural Biotechnology Project to learn more about GMO technology in plant breeding.

DID YOU KNOW?

Canada gave canola to the world! Derived from rapeseed, canola was invented in the early 1970's by two Canadian researchers with the National Research Council, B.R. Stefansson and R.K. Downey, now known as the "Fathers of Canola".

CRISPR Technology – a method of Gene Editing

RISPR (pronounced "crisper") stands for Clustered Regularly Interspaced Short Palindromic Repeats, which are the hallmark of a bacterial defense system that forms the basis for CRISPR-Cas9 genome editing technology.

CRISPR is a technology that can be used to edit genes and, as such, will likely change the world. The essence of CRISPR is simple. It's a way of finding a specific bit of DNA inside a cell. After that, the next step in CRISPR gene editing is usually to alter that piece of DNA. However, CRISPR has also been adapted to do other things too, such as turning genes on or off without altering their sequence.

There were ways to edit the genomes of some plants and animals before the CRISPR method was unveiled in 2012 but it took years and cost hundreds of thousands of dollars. CRISPR has made it easier and more economical.

CRISPR technology also has the potential to transform medicine, enabling us to not only treat but also prevent many diseases.

Experience It!

Invite a crop breeder, crop scientist or a seed company representative to discuss changes in crop breeding techniques over the years.

Why use GMO crops?

When farmers plant their crops, they generally worry about three things that could prevent a good yield: pests, weeds and weather. Most of the GM crops grown around the world today address problems caused by insects or weeds (although some GMOs are currently being tested for enhanced nutrition). When it comes to insects, there are genetically modified plants that can repel only the very particular type of insect that feeds on it. With some crops, this has significantly lowered the need to apply pesticides. Other GM plants have been developed to be resistant to certain herbicides thus making weed control more straightforward and less expensive. farm staff.

DID YOU KNOW?

Genetic engineering helped to bring papaya back from the brink of extinction. Most of the papaya we eat in Canada is imported from Hawaii. Between 1993 and 2006, the papaya ringspot virus caused production of the fruit to drop by 50 per cent, so the Hawaii Department of Agriculture turned to genetic engineering to save it. Today, genetically engineered papaya accounts for over 90% of the fruits' production.
Source: CropLife Canada

Corn crop in Ontario mid to late summer

Some examples of traits that have been added to plants using genetic engineering include:

- Disease resistance
- Drought resistance
- Insect resistance
- Herbicide tolerance
- Improved nutrition

Corn crop in Ontario mid to late summer

Today, those who directly see the most benefits from GMOs are farmers and agricultural companies. Consumers probably don't perceive direct benefits just by picking the product up off the shelf (this may change in the future if the nutritional properties of plants are enhanced). However, with many GM crops there are secondary benefits that shoppers are unlikely to be aware of by glancing at items in the aisle, such as lower cost, less soil erosion (because tillage isn't as necessary for weed control), less pesticide application and others.

Other types of GMO uses

Plants aren't the only type of GMO that we use. GMOs are also used to produce many medicines and vaccines that help treat or prevent diseases. Before GMOs, many common medicines had to be extracted from blood donors, animal parts, or even cadavers. These medicines had a number of problems including the risk of transmission of diseases, inconsistent quality and unreliable supply. GMO medicines are more consistent and don't carry the same contamination risk.

DO IT!

Golden Rice has the potential to be life-changing for millions of people. Find out what Golden Rice is, why its important in developing countries and how GMO plant breeding is responsible for this innovation.

Source: Purdue University – College of Agriculture [https://ag.purdue.edu/ Career Alert – Check out these exciting crop science/technology careers!]

CAREER ALERTS!

*Check out these exciting **crop science/technology** careers!*

- *Farmer*
- *Crop scientist*
- *Crop production planning manager*
- *Seed production operations manager*
- *Crop consultant/advisor*
- *Landscape designers*
- *Crop analyst*
- *Agronomists*
- *Custom operators*
- *Commercial greenhouse managers*
- *Crop nutrients risk consultant*
- *Field or lab researcher*
- *Integrated pest management specialist*
- *Agricultural fertilizer and chemical retailers*
- *Research technicians*
- *Grain buyer/agent*
- *Feed and health regulatory agents*
- *Herbicide company representatives*
- *Technical agrologists*

Soil

Soil Analysis – Nutrient Content

Currently soil analysis is done using chemical methods. In Eastern Canada and US the most common method is Melhich3. Melhich was first discovered in the 1950's and Melhich3 became widely used for soil analysis in the early 1980's. Mehlich3 is a widely used extractant for evaluating plant available phosphorus (P) in soils and may be quantified using colorimetric or inductively coupled plasma (ICP) spectroscopic methods. It can be used over a wider range of soil pH than other soil tests.

Despite its strength and longevity, the problems with this method are numerous and well documented: reliance on proper handling of soil samples and chemical dosages by a lab technician, time consuming, reliance on various chemicals that must be discarded creating its own environmental dilemma, and inaccurate results at the edge of the detection spectrum for macronutrients such as Calcium. However, the most striking problem relates to precision agriculture. Conventional chemical labs originated at a time when samples were collected in hand labelled bags and forms, and results were mailed back to clients printed as a table on a piece of paper. Despite some changes and internet use, this process is still in place. It might even be argued that for composite sampling this is ok. But it is ill adapted for the speed and efficiency required to support the development of precision agriculture. More importantly however, chemical methods such as Melhich3 have a relatively wide margin of error and differences in results of up to 100% with the same sample sent to different labs. It is common to have a 25% standard deviation with results coming from the same lab on the same sample.

Precision Agriculture is quickly changing many of the current farming practices and to achieve the potential of this powerful technological revolution more sophisticated soil testing information will be required. To develop smaller management zones in a field, soil data needs to be generated that has accurate GPS sampling connected to accurate small sample soil analysis results. The smaller management zone soil data must then be integrated with Agronomic intelligence and provide direction to the planting equipment so that the potential of precision farming can be achieved through variable rate fertility, variable rate seeding populations and multi-hybrid planting field plans.

Technological advancements in soil testing, analysis and data management are long overdue and represent a major constraint to the farmer's adoption and profit realization of precision agriculture.

Logiag Inc is a Canadian company that is introducing a new soil data management system called LASERAG that

can help crop input suppliers, retailers and agronomists to provide farmers with the precise and accurate soil test results they need to take their field productivity to the next level.

The LASERAG system has four components:

1. Breakthrough Soil Analysis Technology
2. Cloud Based Soil Information Management Software
3. A Smart Phone GPS Application for the Soil Sampler in the Field.
4. The Soil Analysis Lab

Excerpts from Farms.com *https://www.farms.com/expertscommentary/laserag-the-next-generation-of-soil-testing-and-analysis-technology-97980.aspx#:~:text=Breakthrough%20Soil%20Analysis%20Technology%3A%20an,-temperatures%20of%20up%20to%2025000C*

Find Out!

Find out more about the LASERAG system, a Canadian innovation, by visiting their website. What makes this system beneficial for farmers and those in agri-business? Are there future agriculture applications that could be created using this type of technology?

Analyzing pasture/range lands

As technology improves and continually moves forward, more and more information can be gathered remotely to make informed decisions on farms and ranches. Remote sensing is the science of obtaining information about objects or areas from a distance, typically from drones, airplanes, or satellites.

Remote sensing programs use a combination of observed and forecasted weather, evapotranspiration, a normalized difference vegetation index (or NDVI, a land greenness value collected using satellite sensor data) and known relationships between historical weather data and grassland production to generate forecasts for predicted total plant biomass during the growing season. This provides a tool farmers can use to make data-driven estimates on plant production for the upcoming growing season to plan for critical drought decision dates, annual pasture stocking rates, grazing rotations.

These programs provide farmers opportunities to obtain information across their whole farm from the comfort of their office computer to better visualize, understand, and manage their pasture lands. With this information, producers can identify key areas to conduct more intensive pasture monitoring to determine how pasture plant communities compare with reference plant communities and how current management practices are affecting pasture health at specific locations.

Beef Cattle on pasture in Northern Ontario
Image Source: Beef Farmers of Ontario *https://www.ontariobeef.com*

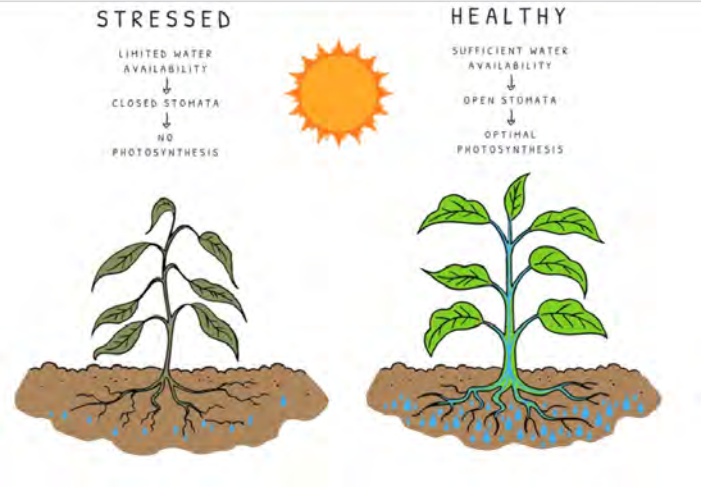
These programs are not meant to take the place of on-the-ground monitoring and management, but they provide tools for the farmer to assist in the management of pastureland.

Determining Soil Dryness

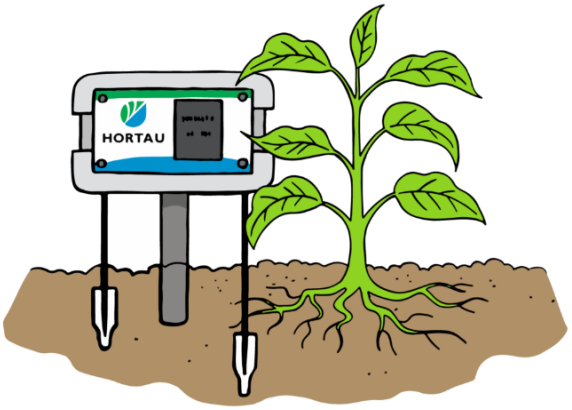
Monitoring soil moisture can help growers manage soil moisture. Choosing the right times and the right amounts to irrigate can lead to:

- higher yields
- better product quality
- improved plant vigour
- reduction in disease
- more effective use of water (water efficiency)
- reduced irrigation costs

With 70% of global fresh water used in agriculture, the United Nations predicts that by 2050 many areas of the planet may not have enough water to meet the demands of agriculture based on current patterns of use. One solution to this global dilemma is the development of more efficient irrigation. But, precision monitoring of soil moisture, allowing sensors to guide 'smart' irrigation systems to ensure water is applied at the optimum time and rate is required.



The right amount of water ensures maximum photosynthesis which will maximize growth, yield and quality.
Image source: Hortau Inc. https://hortau.com/technology/



Soil Monitoring System
Image Source: Hortau Inc. https://hortau.com/services/

Most soil moisture monitoring systems have a main gateway that collects, stores, and transmits the data. A soil moisture probe connects to this gateway, primarily through a cable, although some are wirelessly enabled.

Soil moisture monitoring can help growers efficiently use and apply water and nutrients. All soil moisture instruments provide data that help a grower make good decisions about how much water to apply and when to apply it. The right soil moisture monitoring instrument for the farm is one that suits the management style of the grower.

Research it!

What soil moisture monitoring systems are available in your area? What is the cost and how new is the technology?

Check It Out!

Watch this video at: https://www.youtube.com/h?v=g31agxATY2U&list=PLxmz9ERQlsZuqGYSGZglwIVFW9kV1Vjo2&t=23s to learn about soil monitoring systems. Video created by OMAFRA (Ontario Ministry Agriculture Food & Rural Affairs)

Irrigation

One of the most significant advancements to irrigation methods has been center pivot systems and technology. But the story doesn't end there. Just as precision agriculture opportunities continue to shape the ways farmers plant, harvest, and even scout their fields, technology is impacting the ways center pivot irrigation systems enable farmers to conserve water, operate more efficiently, and better irrigate crops for better yields.

Image Source: MVI https://www.mviwater.com/product/7000-series-center-pivot/

1. **Variable Rate Irrigation (VRI)**

Topography, soil data, adjacent waterways, crop type, and other factors make every field unique, thus, making the argument that every field should be irrigated to its individualized needs.

First invented to eliminate water overuse that's both bad for crops and wasteful, VRI allows farmers to customize water application per field based on numerous factors, defined by the farmer, entered into the irrigation system as a VRI Prescription. VRI can get so accurate, water application can be varied and controlled down to each square foot.

In general terms, VRI can be applied to most types of irrigation systems, including micro-sprinklers, drip, and subsurface drip irrigation. In center pivot technology, VRI works by combining hardware and software, along with customized preferences per each grower, to apply water only where it's needed and only the exact amount needed.

In addition to the biggest benefit of VRI, water conservation, the practice precision water application has been proven to result in better yields. Furthermore, growers can save time, labor, and costs attributed to fuel, chemical, and fertilizer by employing a VRI strategy.

2. **GPS Guidance**

GPS technology also lends itself well to irrigation. GPS solutions are being used for positioning on center pivots and linears, and guidance on corners and linears. The positioning capabilities accurately pinpoint the position of a center pivot or linear for further accuracy of precision irrigation, as well as fertilizer and crop inputs. GPS guidance on corners and linears uses satellite-based RTK to steer a machine along a programmed path, again, enhancing precision with both water and crop inputs. The technology can be used on end-guns to precisely reach ends of corners, and virtually eliminate water waste.

Furthermore, GPS guidance also lets farmers install corner and linear irrigation equipment in difficult areas or those typically too expensive. In the past, corner and linear guidance followed wire buried underground. Not only was this susceptible to rodents, a lightning strike could cause significant damage.

3. **Site-Specific Management**

Original control panels were developed in the early 1990's to work in conjunction with VRI systems. They allow a farmer to set the rate of application and adjust at any time from anywhere, without having to go into the field.

Modern control panels now enable variable rates across the same field; for example, one half receiving ½ inch of water, while the other half receives a full inch. They can also be programmed to auto-adjust the system based on temperature, set to allow the pivot to travel a specified number of degrees in a designated time period, and programmed months in advance, all directly from the panel or even a Smartphone.

Not just applicable to VRI, virtually every system on the farm, including pumps and sensors, can be monitored and managed through any device, from a Smartphone to a tablet to a desktop computer. Best of all, these systems record and store all the data they collect for future use and decision-making.

Excerpts from https://www.rdoequipment.com/resources/blogs/3-ways-technology-is-impacting-irrigation
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Excerpts from https://www.rdoequipment.com/resources/blogs/3-ways-technology-is-impacting-irrigation

Drainage Systems

Subsurface drainage will be part of the solution to the world's future food and water security needs. The growing global population, climate change, and declining soil quality have put unprecedented pressure on shrinking agricultural lands to increase productivity and resource use efficiency. Integrated design and management of irrigation and drainage will be critical components of future agriculture ecosystems. The shifting agricultural ecological zones under changing future climatic conditions will likely increase the need for installation of new or intensification of existing drainage. This means the drainage materials and installation technology will continue to evolve.

The application of autonomous robots and drones, or unmanned aerial vehicles (UAVs), mounted with multispectral sensors and GPS shows a great promise to the future of drainage-related assessments. Accurate assessment of the location and extent of drainage systems will become an important consideration for modeling and precision conservation planning. To date, drainage research has primarily focused on water quantity, quality, and water level control. New frontiers of drainage research will emerge:

- linking drainage water quality and ecological health
- assessing/modeling impacts of drainage on ecosystems
- integrating or stacking structural, behavioral, and ecological practices to mitigate negative impacts of drainage.

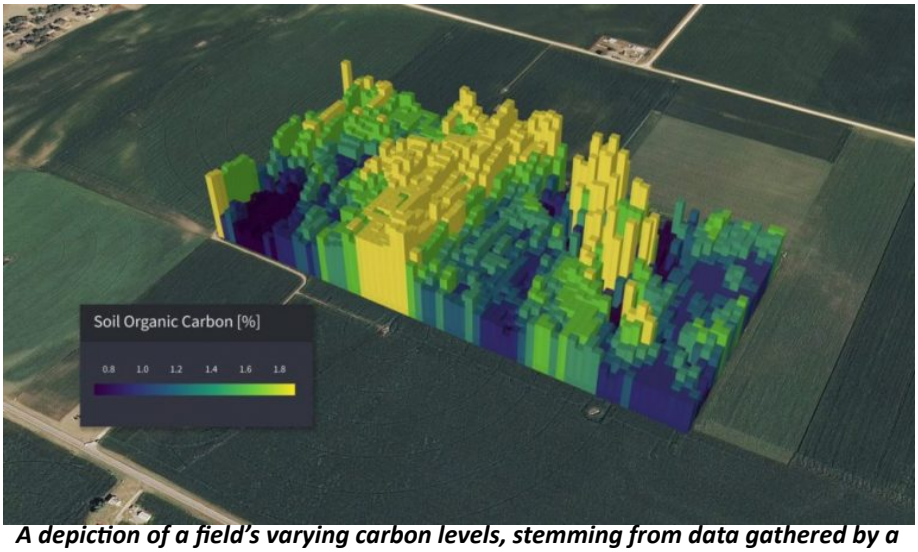
Advances in computer science, communication, and sensor technology have revolutionized the research capabilities of all fields of science, including those for drainage research. With availability of cheaper, faster technologies, high-frequency real-time monitoring and modeling of drainage systems has become possible.

Excerpts from Soil & Water Conservation – Agriculture Drainage, Past, Present & Future https://www.swcs.org/static/media/cms/75th_Book__Chapter_12_EF06D8EB17FCE.pdf

Carbon Sequestration

Farmland offers a benefit beyond food: carbon sequestration. Emerging regenerative agriculture practices have been experimenting with new ways to draw carbon from the air and store it in the soil and give farmers carbon credits (which could be worth a financial payback if a program were to be put in place in Canada for this). But until 2020, it was impossible to verify how much carbon is being sequestered without collecting soil samples and sending them to a lab, which is expensive, difficult to scale, and doesn't show how carbon levels vary across a field.

A company, based in Boulder, Colorado, has now developed a process to assess an entire field using hyperspectral imaging, invented by NASA. Specially equipped aircraft fly over a field twice a year—before planting and after harvest—to measure soil organic carbon. The technology can see whether soil is healthy or not and whether it's carbon rich and dense and dark brown versus if it's very crumbly. The technology has 300 times the power of the human eye.



A depiction of a field's varying carbon levels, stemming from data gathered by a hyperspectral image.

Image Credit: Cloud Agronomics

The technology can detect carbon levels to 30 centimeters deep, along with crop nutrients and agricultural runoff, all remotely. Growers can learn how regenerative practices such as no-till farming and animal grazing affect their soil carbon levels. The technology is now deployed on hundreds of thousands of acres in four countries.

Horticultural Technology

Horticultural Production

Horticultural crops require more direct attention and monitoring per plant than arable crops, to ensure any emerging pests and diseases are limited to an acceptable threshold. The establishment of this intensive but integrated management approach has paved the way for technological improvements that have automated and optimised farm operations that were previously performed manually, introducing more precision and reliability.

1. Automation for plant monitoring

Crop scouting is a crucial step in pest and disease management. It allows the farmer to make timely decisions and take preventative measures. It saves time and money, allows trends to be identified, and predicts future threats and potential problems. Traditional equipment for plant monitoring in a field or greenhouse includes a magnifying glass, plastic bag for plant samples, clipboard, marker, and camera. Today, sticky traps and mobile apps can give a far more accurate picture of the pests and diseases in a crop. Some apps even provide suggestions for possible solutions.

A recent innovation has been the development of digital scouting applications for mobile devices that provide a monitoring platform for the registration of diseases and offer biological solutions for horticulture. A scanner may count the insects on sticky cards using accurate image recognition, for example. In this way, you can scan the sticky traps in a crop, while the dashboard on a desktop/laptop gives a direct schematic overview of the results. The data can then be collated with other measurements and a broad analysis can provide suggestions for biological solutions. The app can also have machine or deep learning capability which allows it to improve its predictive power over time.

Pumpkin field in Ontario early fall

2.Use of drones for pest and disease identification and management

Check It Out!

Watch the video found at: https://www.youtube.com/watch?v=_QTDaIcCjco to view a digital scouting application for mobile devices.

Drones, or Unmanned Aerial Vehicles (UAV), that can identify pest and disease 'hotspots' in crops and then accurately disperse beneficial insects from the air, are now in use. Drones with sensor and imaging capabilities will be playing an increasingly critical role in identifying and reducing crop damage in the coming years. An innovative release mechanism designed for the aerial release of beneficial insects (biological organisms) can now be attached to a drone to disperse this biological solution exactly where it is needed most in the crop. Drones equipped with a scouting device can also be used to remotely locate and identify pests and diseases.

Specially adapted drones, that may have a wingspan of 1.5 m, can lift 15 kg, and fly over a 20-hectare strawberry field in an hour and disperse beneficial biological organisms, are more accurate than man-handled equipment and can target specific areas or 'hotspots' of pests or diseases.

What started out as military technology for observing and targeting specific enemy locations is now being used as a tool for sustainable agriculture.

3. Alternatives to traditional growth in soil

Technology is revolutionising the demand for natural resources such as water and land. In hydroponics, plants are grown in a small amount of solid matter, mainly sand and gravel.

A recyclable solution provides the exact amount of nutrients required by the plant, reduces water consumption by 90%, and results in reduced pest problems. The most popular crops grown in hydroponics are leaf lettuce, tomatoes, peppers, strawberries, and herbs.

4. Symbiotic organisms and plant defences: Biocontrol

Research is focusing on how microorganisms, often called bioinoculants, promoting plant growth can be applied from the start of the cultivation cycle. These can enrich the microbial composition of the environment around the roots of the plants. Beneficial microbes can activate the defence systems of plants and make them grow stronger. When they live on or near the root system they also compete for nutrients and space with pathogens (these are microorganisms that can cause diseases). Microbial pesticides that are designed to work on foliage pests invade the destructive organism (often at larval stage) and use its tissue as food.

Check It Out!

Watch the video found at: https://www.youtube.com/watch?v=YH4w-xIOxcs to learn more about hydroponic greenhouse production (note: video is from the United States).

The application of substances via a seed coating is an efficient way to apply beneficial microorganisms to crops. Biopesticides have also been developed in this way to support the plant.

There are three categories of microbial biopesticides.
1. Bacteria
2. Fungi
3. Oomycetes or even viruses.

Biopesticides provide a wide range of tools for non-chemical pest and disease control but are tightly regulated. All products have to be registered in the country of application.

Check It Out!

Watch the video found at: https://www.youtube.com/watch?v=XH-EFtTa6IU to view a precision weed control machine (note, video shows crops in Texas).

5. Precision agriculture for weed control, soil health and better yields

The need to produce more food in a sustainable manner has led to widespread adoption of 'precision agriculture'. This term describes a range of practices that use technology to provide crops with precisely (no more and no less than is necessary) the amount of nutrients and treatments needed for a high yield. Automation avoids over-application of agrochemicals which saves money and reduces spill-over to the wider environment (e.g. nutrient leaching). Predictive technologies can help customise crop varieties for improved performance.

Excepts taken from Future Learn https://www.futurelearn.com/info/courses/explore-how-farmers-produce-food-sustainably/0/steps/60773

Greenhouses

Modern technology in greenhouses is largely centered on controlling and creating optimal growing conditions for healthy plants, maximizing yield, speeding up production times, and minimizing environmental impact.

Access to data, and the software that organizes the information, is a driving force behind efficiency through technology. The data helps to make informed decisions when it comes to adjusting the temperature, monitoring the air, the light, the integrated pest management system and any environmental considerations a greenhouse may need to consider.

Technology and robotics play a significant role in automating major tasks related to harvesting, packing, labeling and palletizing.

The packaging automation machines in greenhouses, such as the one pictured to the left, use infrared technology to determine the size, diameter and weight of each mini cucumber and pack a perfect six-count tray using suction cups to move product from the line to the tray

Experience It!

Watch the video found at: https://www.youtube.com/watch?v=-rgdcVsF12g to view a time lapse video of tomatoes growing in a greenhouse from planting through to ready for harvest. Video was created by the Vineland Research & Innovation Centre located in Southern Ontario.

Automation of the produce sorting and packaging process is a key part of reducing labour needs and improving efficiency.

Image Source: Greenhouse Canada https://www.greenhousecanada.com/acceleration-by-technology/

Vertical Farming

Vertical farming is a related form of indoor agriculture, characterized by stacks of crop-laden shelves in an enclosed space.

Like greenhouses, vertical farms use a variety of technologies to grow crops, including irrigation lines, plant nutrition schedules, a variety of automation technologies, and more. But where greenhouses make use of sunlight for at least part of the crop production process, vertical farms do not.

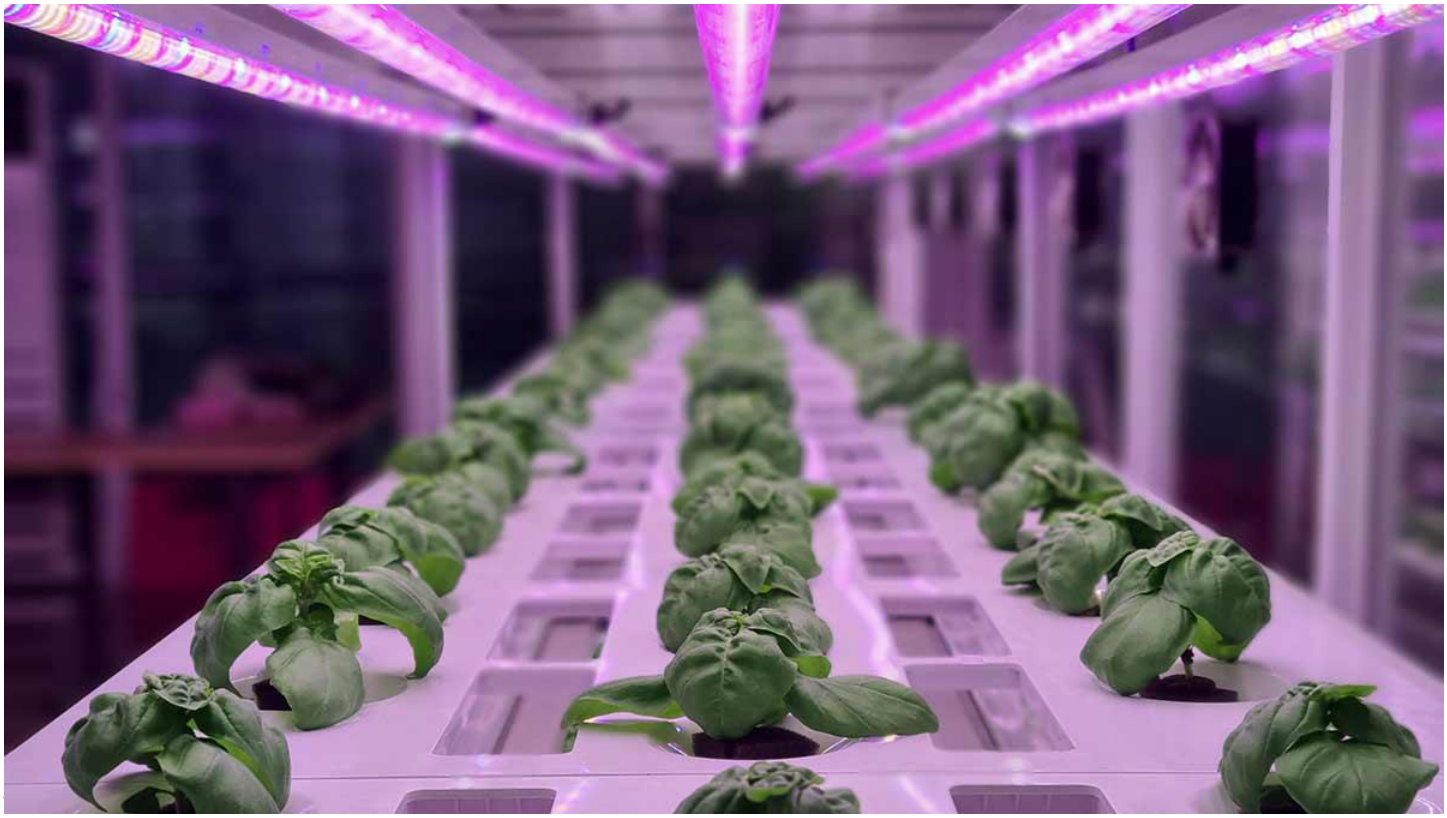
LEDs take the place of natural sunshine in vertical farms. Like greenhouses (LEDs are also used to supplement crop growth in greenhouse production systems) different coloured LEDs can be used for different crops, and for different growth stages.

Vertical Farming

Image Source: Robotics & Automation News https://roboticsandautomationnews.com/2019/05/03/top-25-vertical-farming-companies/22181/

Check It Out!

Watch the video found at: https://www.youtube.com/watch?v=zzpX-hxrMzg to view robotic automated harvesting system, developed at the Vineland Research & Innovation Centre (located in Southern Ontario).



Vertical Farming using LED lighting
Image Source: Robotics & Automation News https://roboticsandautomationnews.com/2019/05/03/top-25-vertical-farming-companies/22181/

the growing area completely enclosed and in optimal growing conditions means the crop is substantially less likely to be harmed by pathogens or insect pests. In turn, the need for crop protection products like fungicides can be significantly reduced. Organisms which can harm the crop can still get in, though, so following stringent biosecurity protocols is critical.

Producing fresh greens and vegetables close to growing urban populations – or remote communities – could help meet growing global food demands while reducing the carbon footprint generated by transporting food from far away.

The key technologies in vertical farming include:

- perception technologies – cameras and other sensors which can monitor for colour and other factors, such as disease
- artificial intelligence – which can process the data from the sensors and formulate solutions
- automated and even autonomous mechatronics – robots and other automated machines which pick the produce when it is ready for market, or apply cures to ailments during their growing

The above list is a very simple breakdown of the fundamental technologies that will be required to, basically, reduce to a minimum or even eliminate the need for human involvement.

If vertical farms were run like traditional greenhouses, there would be too much human input required and it probably would not be profitable. It's the new automation technologies that will make it work.

Experience It!

Tour a greenhouse or a vertical farm to see how they operate and what technology they use to produce their products.

Bioproducts

Bioproducts are products made with some component of biological or renewable materials. The bio in bioproducts relates to inputs derived from biological sources, including agriculture (e.g., crops and crop residues, dried distillers grains) and/or food processing (byproducts, residues and off-specification materials). Forestry is another potential source of biological materials.

Farmers in Ontario have traditionally produced food and feed crops that are often subjected to significant price fluctuations, overproduction and high input costs (such as fertilizer), resulting in marginal economic returns.

The emerging bioeconomy offers the potential to contribute significantly to the overall economies of both Ontario and Canada. The manufacture of bio-based products provides the opportunity to benefit all participants in the value chain, offering farmers and food processors additional markets for commodities and byproducts. In particular, primary producers may realize increased economic gains from bio-based materials derived from products that they generate, many of which have been considered waste materials in the past.

Typically, bioproducts are divided into three categories:

1. **bioenergy**
   - ◊ liquid fuels such as ethanol and biodiesel
   - ◊ solid biomass for combustion to generate heat and power
   - ◊ gaseous fuel such as biogas and syngas, which can be used to generate heat and power
2. **biomaterials**
   - ◊ bioplastics from plant oils and sugars
   - ◊ biofoams and biorubber from plant oils and latex
   - ◊ biocomposites manufactured from agricultural (e.g., hemp, flax, kenaf) and forestry biofibres, used, for example, in the production of automobile door panels and parts
3. **biochemicals**
   - ◊ industrial - basic and specialty chemicals and resins, including paints, lubricants and solvents
   - ◊ pharmaceuticals - antibodies and vaccines produced by genetically modified plant factories and natural source medicinal compounds
   - ◊ biocosmetics - soaps, body creams and lotions

Located at the University of Guelph, The Bioproducts Discovery and Development Centre (BDDC) is an interdisciplinary centre where plant biologists, chemists, and engineers converge to investigate and commercialize biomaterials. Established in 2008, the BDDC conducts leading edge research to develop greener bioproducts to substitute non-renewable materials in many manufacturing sectors (including automotive), consumer goods and services.

There are many exciting on-going bioproducts projects at the BDDC as well as at other facilities within Canada and around the world. A few examples of projects in the news includes:

Ford Automotive Using U of G Biomaterial Innovation

Made from coffee bean waste from McDonald's Corporation, bio-composite materials developed and tested at the University of Guelph's Bioproducts Discovery & Development Centre will be used for the first time to create vehicle parts made by Ford Motor Co, announced on December 4, 2019.

Fuel from flax: Saskatchewan-based start-up looks to produce biofuel from flax straw

Prairie Clean Energy from Regina, Saskatchewan, founded in March 2020, has developed a process for turning flax straw, which is often burned or trashed, into biofuel. There's about three-quarters of a million tonnes of flax straw per year that is burned in Saskatchewan. Farmers don't like burning it because they know it's not good for the environment and it's a fire hazard for the surrounding properties and communities.

GM Canada Using Renewable Landfill Gas to Power and Heat Propulsion Plant

As more emphasis is placed on fostering a green economy, large businesses are investing in new ways to power their operations with renewable sources. GM Canada is one such business. In August 2020, the company announced it had completed a $28-million cogeneration project that uses renewable landfill gas (LFG) from a local landfill to power and heat its St. Catharines, Ont., Propulsion Plant.

Toronto organics processing facility to convert food waste to Renewable Natural Gas

Ever wondered where your leftover food ends up? Well, in Toronto, that food waste will soon be turned into renewable natural gas (RNG). The City of Toronto, in collaboration with Enbridge Gas Inc., is installing equipment at its Dufferin Solid Waste Management Facility, which will upgrade the biogas produced from processing food waste into RNG. Through its partnership with Enbridge, the city will be able to inject the RNG into the natural gas distribution grid and potentially use it to power its waste collection trucks, among others, as well as heat city buildings and facilities.

CTK Bio Canada Develops Bioplastic Resin Designed to Break Down in Soil and Seawater

CTK Bio Canada has developed a new plant-based bioplastic resin designed to biodegrade by both industrial and home composting, as well as in unmanaged environments like soil and seawater, in order to reduce microplastic pollution. The company's materials are designed to overcome a critical barrier in the bioplastics space – the ability to degrade in water. While increased use of bioplastics are a positive sign for the environment, too much of it is still ending up in rivers and oceans where it can't easily biodegrade.

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

JUDGE IT!

There are many products grown in the field or greenhouses that can be judged. Choose 4 cucumbers and judge the cucumbers based on the scorecard for Fruits and Vegetables found in the 4-H Ontario Judging Manual. Other classes of fruits, vegetables and field crops can be judged at this meeting and/or future meetings. Scorecards for various classes can be found in the 4-H Ontario Judging Toolkit or the Ontario Association of Agricultural Societies' Judging Handbook.

At Home Activity

Biofertilizers

Much like ourselves, crops and livestock live in close relationship with an extraordinary ecosystem of micro-organisms such as bacteria, viruses, and fungi – collectively known as the microbiome. These organisms play vital roles in the health of our crops and livestock throughout their lifespan and altering the make-up of these communities can have outsized effects on health, production, and other traits important to agricultural producers and, therefore, consumers. DNA sequencing allows us to get a snapshot of what micro-organisms live in a particular community and what chemical processes the genes they express are contributing to.

One way in which the soil microbiome contributes to crop health is by promoting the uptake and storage of water. Applying a particular strain of bacteria to the roots of a plant (as a type of biological fertilizer) can help protect that plant against the stresses of drought by pushing that plant to take up more water than it would in normal conditions. Other microbes may instruct the plant to consume more soil nitrogen or atmospheric carbon dioxide, helping us reduce the levels of greenhouse gases in the atmosphere. However, it takes careful experimentation to uncover these plant-microbe relationships before even attempting to treat actual crops that will be consumed by people or animals. Technologies involved in these experiments include robots, mass spectrometers, DNA sequencers, and of course the various growing apparatuses needed to test thousands of plant-microbe combinations.

Information courtesy of Ontario Genomics

Research one of the technologies listed above (robots, mass spectrometers, DNA sequencers) to find out how these technologies are helping the agriculture industry improve soil health and ultimately crop health. Are there new and emerging technologies to help farmers improve the soil's eco-systems in their fields?

Be prepared to share your findings at the next meeting.

Digging Deeper

For Senior Members

Courtesy of Ontario Genomics

Introducing New Traits into Canadian Crops

Read through the projects below that are two of a number of projects that focus on introducing new traits into Canadian crops. Then, visit the Vineland Research & Innovation Centre's (VRIC) website or Platform Genetics' website to research an additional project that is currently being worked on. Be prepared to share your findings at the next meeting.

As part of its crop varietal development program, Vineland Research & Innovation Centre (and its spin-off company Platform Genetics) combine the latest techniques in crop mutagenesis (incorporating random mutations to create a library of potential crop varietals) with robotics-based automation and rigorous experimental testing to create elite crop varietals. VRIC has worked with many Canadian and international academic scientists to introduce new traits into Canadian crops. Two of these projects are described below, though other examples are also given on each company's website.

1. Tomato flavour profiles

Tomatoes are an economically vital crop to Canada, with strong national and international markets. However, imported tomatoes are often cheaper, making it difficult for Canadian farmers to maintain their crops' competitiveness. VRIC has worked with Canadian scientists to develop tomato varietals that are not only high-yield and disease-resistant, but also more flavourful. Flavour is an extremely complex trait, with dozens of chemical compounds contributing to sweetness, acidity, aroma, and texture. The metabolism of these compounds, in turn, requires the activity of dozens of different genes in the tomato genome. By combining both genetic and sensory testing of different tomato varietals, researchers and producers have been able to improve the flavour of common tomato varietals, making them more attractive to consumers and providing Canadian farmers with an advantage over their international competitors.

2. Broad-range disease resistance

Crop loss due to infectious disease can be crippling for farmers and others in the agriculture & agri-food sector, especially in greenhouses. However, the overuse of pesticides and other prophylactic treatments can be expensive, bad for the environment, induce antibiotic resistance in some infectious agents, or even be toxic to farm workers. Plants, much like animals, have evolved complex immune systems to protect themselves from bacteria, viruses, and fungi. Supporting this network of natural resistance to infectious diseases is an important way to protect crops without the need for further interference. By analyzing thousands of genetic mutants of popular greenhouse vegetables and attempting to infect them with various pathogens, researchers can identify mutations that confer resistance to a broad range of infectious agents. These mutations can then be inserted into established elite-growing varietals to create a crop that is both adapted to growing in the greenhouse environment and naturally protected from common disease. This benefits the grower, who can rely on a strong crop each growing cycle, as well as the consumer, for whom costs can remain low due to strong supply.

Vineland Research & Innovation Centre (https://www.vinelandresearch.com/) + Platform Genetics (http://www.platformgenetics.ca/)

Activity #1 - Cellular Agriculture

Activity Courtesy of Ontario Genomics

Do	Time: 30 minutes **Materials:** • Access to the Internet to download the report: https://www.candesyne.ca/cellular-agriculture (Executive Summary of the Report follows these activity instructions) **Instructions:** Cellular agriculture (the production of food and other traditional agricultural products like textiles through biological processes) is a relatively new, but rapidly expanding, field of science that brings together biology, chemistry, and engineering to supplement traditional agriculture. Funded by Ontario Genomics and Agriculture and Agri-Food Canada, Ontario Genomics, in partnership with the Food and Agriculture Institute at the University of the Fraser Valley, conducted a series of stakeholder consultations to explore critical considerations for Canada's emerging cellular agriculture industry. This report outlines opportunities for Canada to capitalize on this rapidly expanding global market, how this new field can transform Canadian agriculture and ready us for the future. • Discuss what cellular agriculture is. • Have each member read through the report. • Ask the group if they have any questions about the report and then discuss the pro's and con's of cellular agriculture.
Reflect	**Learning Outcomes:** • To allow members to discover what cellular agriculture is. • To allow members to think critically about the benefits (and drawbacks) of cellular agriculture.
Apply	**Prompting Prompts:** • What did you learn about cellular agriculture? • What are the benefits of cellular agriculture? • Was there information in the report that surprised you? • Do you think cellular agriculture has a place in our world? Do you think it will be successful?

Ontario Genomics

CELLULAR AGRICULTURE

CANADA'S $12.5 BILLION OPPORTUNITY IN FOOD INNOVATION

EXECUTIVE SUMMARY

November 2021

Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation - Executive Summary

Driven by an accelerating climate crisis, evolving consumer preferences, worsening global food insecurity, and the need to feed a growing global population, cellular agriculture presents an alternative and compelling route to produce proteins, ingredients and other food products[a] thereby augmenting global food systems. In recent years, the cellular agriculture industry has been exploding, with over US$9.7 billion in global investments and more than one hundred active companies worldwide. This is an industry that is flourishing with opportunities for current and new food producers across diverse and multi-sectoral public and private stakeholder groups.

Cellular agriculture encompasses several innovative approaches that use cell cultures, tissue engineering, or precision fermentation to make food products and other materials. Cellular agriculture is underpinned by the platform technology of engineering (synthetic) biology, a convergence of advanced biological, engineering and computational disciplines to create products for numerous sectors in new and sustainable ways.

The first-of-its-kind in Canada, the current report, *Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation* is based on extensive stakeholder engagement and builds on the landmark whitepaper, *Engineering Biology – a platform technology to fuel multi-sector economic recovery and modernize biomanufacturing in Canada*. Released in November 2020, by Ontario Genomics and the Canadian National Engineering Biology Steering Committee, this whitepaper highlighted the opportunity to use engineering biology as a platform technology for sustainable and innovative economic recovery and growth in three vertical pillars: Food Security, Low-Carbon Manufacturing, and Advanced Engineering Health Technologies.

The analysis presented here illustrates that the Canadian cellular agriculture landscape is rapidly evolving and shows tremendous promise to develop alongside and augment Canada's conventional agriculture and food industries, with Canadian start-ups already taking advantage of growing opportunities along the supply chain. As the fifth largest exporter of agricultural and agri-food products in the world and aligning with the ambitious vision of the Economic Strategy Table on Agri-Food's vision for Canada to become the favoured protein provider globally, Canada has unique advantages to drive leadership in cellular agriculture. This includes an extensive food and beverage industry, free-trade agreements covering 60% of global GDP, readily available feedstock, and world-class expertise across required disciplines. The report's economic analysis, by Dr. Michael von Massow, indicates that there is an enormous opportunity for Canada to capitalize on cellular agriculture. This includes the ability to

[a] In addition to food ingredients (such as proteins, enzymes, flavour molecules, vitamins, pigments and fats) that can be incorporated with existing products to create value-added hybrid goods, fermented products include dairy, eggs, chocolate, honey, while cellular/cultivated products comprise red meat, poultry, seafood, foie gras and pet food. Non-food cellular agriculture products cover textiles such as leather, wool, silk and cotton.)

diversify and create new product categories for domestic and international markets, supporting company creation and Canadian Intellectual Property generation, as well as an opportunity to address food security concerns in Canada and globally. Optimistic scenarios suggest a $7.5 billion a year industry and up to 86,000 jobs created by 2030, and longer-term Canadian revenues as high as $12.5 billion per year with the creation of up to 142,000 jobs; this is achievable and aligned with Canada's current share of the global market.

Funded by Ontario Genomics and Agriculture and Agri-Food Canada, Ontario Genomics, in partnership with the Food and Agriculture Institute at the University of the Fraser Valley, conducted a series of stakeholder consultations to explore critical considerations for Canada's emerging cellular agriculture industry. Based on these consultations and a review of literature and publicly available information, this report outlines inter-connected actionable opportunities for Canada to capitalize on this rapidly expanding and high-potential global market expected to approach US$100 billion in the next decade. To achieve success, Canada must:

1. *Develop a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term.* This is foundational to enable a growing domestic ecosystem and fully realize the benefits presented by this industry. An outcomes-driven national vision and strategy should be developed collaboratively, be inclusive of stakeholder requirements and include a clear plan for implementation in the short-, medium- and long-term.
2. *Establish a Clear and Transparent Regulatory Framework for Cellular Agriculture Products in Canada.* Canada is encouraged to proactively develop an agile, iterative, and innovative regulatory framework by building on existing processes to support the evaluation and approval of cellular agriculture products in a timely manner, in alignment with Canada's current rigorous regulatory process and excellent food safety standards.
3. *Provide Supporting Mechanisms for Research and Commercial Development.* Incentivization, through public and private investment and partnerships, and outcomes-driven networks, is critical for a thriving domestic cellular agriculture industry, with infrastructure support for research and development, training, company creation, scale-up and growth, leading to made-in-Canada product commercialization.

Canada's Actionable Opportunities for a Thriving Cellular Agriculture Ecosystem

Based on the input from our stakeholder consultations, along with a review of literature and other publicly available information, we articulate the inter-connected actionable opportunities to inform a policy framework and implementation plan for a thriving Canadian cellular agriculture industry worth up to $12.5 billion a year and creating up to 142,000 jobs.

1. Develop a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term to enable a domestic ecosystem that fully realizes the benefits presented by this industry. Founded on a clear value proposition and rationale, this strategy should be national in scope and developed collaboratively and cohesively by federal, provincial and territorial governments, industry (including large corporates, start-ups and conventional agriculture), academic and research institutions, not-for-profits, regulatory agencies, and policymakers.

The strategy should define a framework with concrete steps for implementing an action plan in the short, medium and long-term and have clear success metrics. Considerations for the value proposition and rationale include economic and export opportunities, environmental and ethical concerns, current and future domestic and global protein requirements, trade considerations, the changing food and agriculture employment landscape, opportunities in the sector, food security, resiliency in the face of climate change or other shocks, and alignment with Canada's strengths and priorities. In addition, promoting the integration of new production systems with existing conventional ones is critical, with ongoing monitoring to prevent undue disruption to either sector. The framework should include the strategy for government incentivization at both federal and regional levels. In the development of this Canadian-specific framework, models from currently leading cellular agriculture countries should inform pathways for incentivization and funding mechanisms that leverage government support for private sector investment.

Taking the value proposition into account, the action plan should specifically include steps for:

- Substantial and sustained investment in cellular agriculture for dedicated research and development;
- Support for start-up creation and growth through pilot scale-up to commercial-level production;
- Building a talent development pipeline.

The action plan should ensure coordination of and access to essential and existing infrastructure. Upfront investment is necessary to help Canada catch up with other jurisdictions currently ahead in this sector.

Broad communication and outreach are integral to the success of a national strategy. This needs to occur in parallel with technology development to ensure widespread uptake of cellular agriculture products and optimal return on investment. Critical consideration is required to understand consumer perspectives and use for

appropriate messaging to reach various people across different demographics - from children to the elderly, as well as those facing food insecurity - to articulate benefits, address concerns, and overcome potential barriers early.

2. Establish a Clear and Transparent Regulatory Framework for Cellular Agriculture Products in Canada. Canada is encouraged to develop an agile, iterative, and innovative regulatory framework by building on existing processes. The framework should be informed as early as possible by engaging industry stakeholders and other experts with the relevant regulatory departments and agencies (e.g., AAFC, CFIA, Health Canada and Environment and Climate Change Canada), and including cellular agriculture subject matter experts within regulatory bodies. This will ensure that any new policies and regulations have expert input and consider the perspectives of both regulatory agencies and the ultimate end users, and would help simplify and strengthen the Canadian process. A timely, reasonably priced and predictable regulatory process, and a smooth and transparent evaluation process with high approval confidence, can be achieved through an iterative approach. Early engagement between regulators and companies also allows issues to be flagged and addressed promptly. This will be crucial to attract and retain cellular agriculture companies in Canada while ensuring the domestic industry remains globally competitive under Canada's rigorous regulatory process and food safety standards. This process can be further fostered through continuous, clear, and comprehensive communication between the industry and regulators, as well as broad dissemination of positive engagements and success stories. A delineated regulatory pathway that is aligned with the industry's needs has shown much success in Singapore, the most advanced jurisdiction in regard to approvals of cellular agriculture product offerings.

To aid companies in navigating the regulatory process, a government program that appoints industry liaisons or "concierges" could be established. This would particularly benefit start-ups and early-stage companies that are navigating the process for the first time. It is anticipated that, before seeking regulatory approval, standardized safety testing of cellular agriculture food products could provide confirmation of product composition, nutritional profile, and (lack of) toxicity profile. Consideration should be given to an expedited review of products that have already been "passed" by an accredited, external standardized test. As the global cellular agriculture industry grows and matures, Canada will need to ensure its cellular agriculture standards align with emerging international standards to maintain its reputation as a producer of safe, high-quality foods and not impede exports. Currently, this is an underdeveloped area, and being an early mover in standardized safety testing will allow Canada to have substantial input into international standards as they progress. Cross assessment of regulatory processes with other jurisdictions (e.g., Singapore, Australia and New Zealand) should be continued and expanded, as appropriate.

Early development of regulatory guidance for the labelling of these products is also essential for transparency and to empower consumers to make informed choices. Cellular agriculture product labelling should be descriptive, communicate the nature of the product in clear and relatable language, while maintaining appeal as a food item. Labelling should differentiate cellular agriculture products from those in the traditional protein market while creating a positive impression and ensuring both types of products are on a level playing field and competitive in consumer markets.

3. Provide Supporting Mechanisms for Research and Commercial Development. Incentivization, through both public and private investment and partnerships, and outcomes-driven networks, is critical for a thriving domestic cellular agriculture industry, with infrastructure support for R&D, training, company creation, scale-up, and growth leading to made-in-Canada product commercialization.

Research and training the next generation of skilled workers

Early government investment would catalyze invention, help de-risk opportunities, and attract private sector investment while incentivizing innovation and driving company creation and entrepreneurship within Canada. Funding could support:

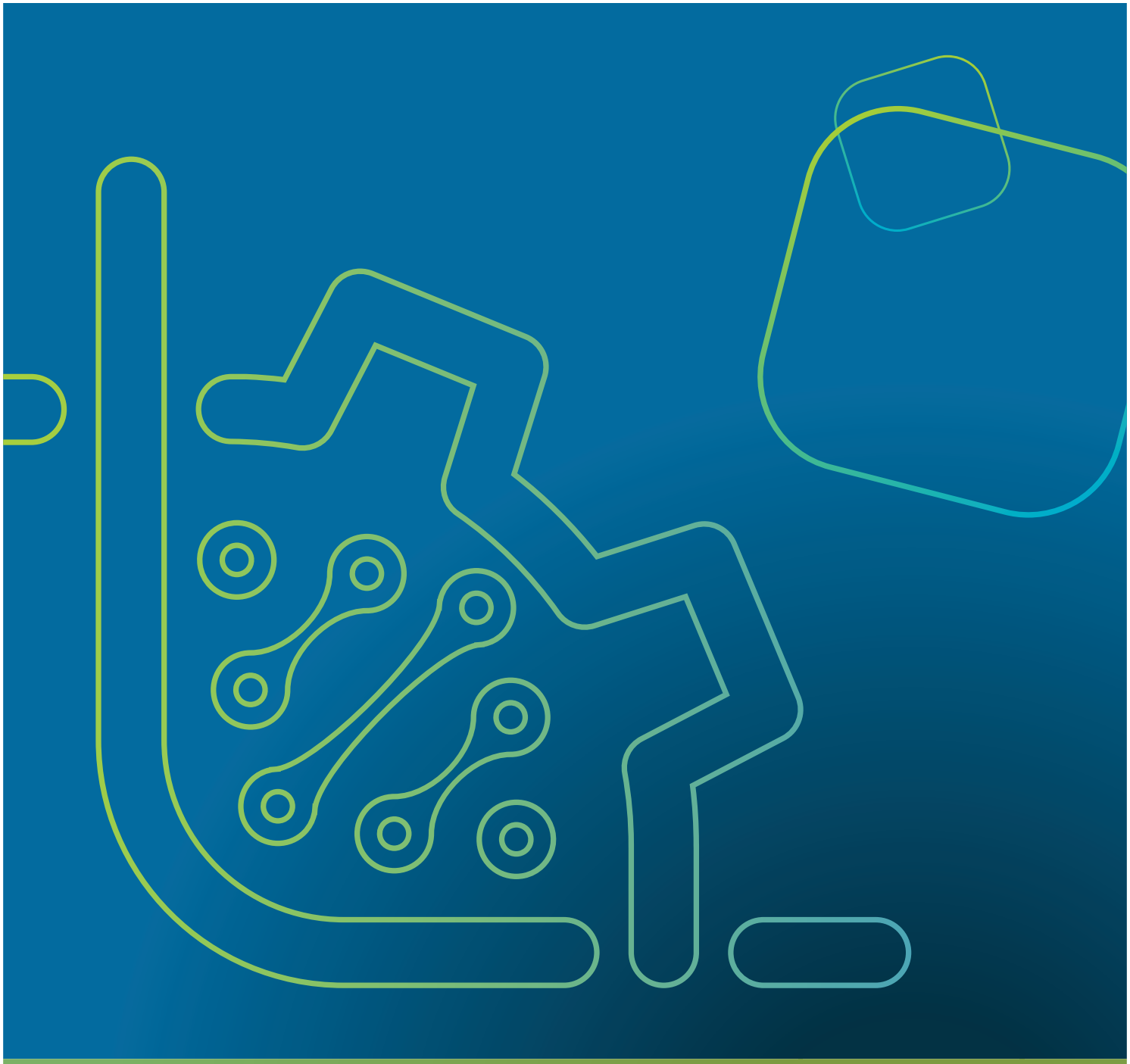
- Both fundamental and industry-driven research to ensure that the necessary and foundational tools and technologies are in place and that research is directed to industry needs.
- Open science to reduce redundancy and speed up product development.
- Alignment with strategic government focus areas or grand challenges, such as climate action, to encourage industry growth through sustainable practices and innovations.
- Key areas of multi, cross- and trans-disciplinary research (e.g., 'omics, engineering biology, AI, food sciences and others) for advancing cellular agriculture technologies that are also applicable to other business verticals (e.g., health, low carbon economy).
- LCAs, TEAs and other analyses that are objective and independent.
- Social sciences research playing a critical role in driving consumer engagement, addressing risk perception and public trust, and developing appropriate communication strategies.

New training programs that offer targeted and cross-disciplinary opportunities and industry placements related to cellular agriculture and engineering biology are critical. There are also opportunities to train and up-skill those with related expertise in other sectors. This would ensure that a domestic talent pipeline of skilled High-Quality Personnel (HQP) could fill the high-quality jobs that the cellular agriculture industry will create.

Growing the economy through start-up support, public private partnerships, and networks

Early start-ups require support in the form of lab space, facilities, and infrastructure, but also public and private seed funding for initial company growth. Canadian and international investors should be incentivized to invest in Canadian companies through clear and well-publicized government support for the industry. As seen in leading cellular agriculture jurisdictions, investment in public and private sector- partnered innovation hubs, including incubators and accelerators, can effectively support companies in their early stages. In addition to physical facilities, these hubs would need to include access to expertise, mentorship, and investment opportunities. While Canada has some capacity in Nova Scotia and New Brunswick, a lack of facilities for pilot/demonstration scale-up and at commercial scale is viewed as the most significant bottleneck globally, and is a primary reason for companies to leave Canada for other jurisdictions, such as the United States or Europe. The initial outlay to establish domestic scale-up capacity in localized ecosystems would be high, but fee-for-service operations could provide a global leadership opportunity to Canada, with potential to attract foreign companies. Such infrastructure can also be adaptable to serve different industries, such as to the production of vaccines in a health emergency or to bypass disruptions in the supply chain of critical materials to support a low carbon economy.

Supporting applied research and commercial development through industry and research collaboration is valuable to ensure the success of the domestic cellular agriculture industry. Partnerships between established companies and start-ups/academics (public-private partnerships) bridge the gap between research and translation, provide access to infrastructure, and create linkages and entry routes into the supply chain for B2B companies. The larger partner benefits from priority access to innovations, diversification and the creation of new product categories with strong market pull. Effective industry partnerships are vital to inform and drive policy and regulation and advocate with a common voice for a clear path to market for Canadian companies. On a larger scale, outcomes-driven networks are crucial to bringing together diverse stakeholders from industry, academia, government, and non-governmental organizations. Such networks should include diverse fields of multi-, cross-, and trans-disciplinary expertise and platforms and include regional, national, and international partnerships for interdisciplinary cross-pollination of ideas to breakdown silos between sectors and geographic regions and facilitate dialogue between disciplines. Network participants can benefit from and provide benefits to other sectors (e.g., health, low carbon economy) through knowledge exchange and parallel applications of novel technologies. These networks must include representation from the food production and conventional agriculture industries to foster mutually beneficial relationships, and transition or expansion to new food products market.



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Activity #2 - Seed Identification

Do	Time: 20 minutes **Materials:** • Closed jars with a different type of seed in each jar – have a number on each jar • Paper and a writing utensil **Instructions:** • Have members number their paper for the number of jars in this activity • Have members try to identify the seeds in the jars and have them write down their answers
Reflect	**Learning Outcomes:** • To allow members to discover what the seeds look like that crops are grown from. • To initiate a discussion as to the traits of these crops and which traits could be improved upon through genomics.
Apply	**Prompting Prompts:** • Was it easy or hard to identify the seeds? Were some seeds harder than others to identify? • Are all the seeds in this activity able to be grown in your area? • Have you seen any of these seeds planted as a crop? Do you grow any of these seeds on your farm? • What traits do these crops have that could be improved by gene editing?

Activity #3 - The Story of the Carbon Cycle

Activity Courtesy of AgScape

Do	Time: 20 minutes **Materials:** • The Story of the Carbon Cycle Worksheet (found on the next page) • Access to the Internet • Pen/pencil **Instructions:** • Have members watch the following video: TED-Ed: The Carbon Cycle – Nathaniel Manning: https://www.youtube.com/watch?v=A4cPmHGegKI&feature=youtu.be • Use images and words to create an artistic representation of how the carbon cycle works. Try to capture as many of the elements that contribute to the overall process as you can. Be sure to add in where agriculture fits into the cycle. • Discuss the Carbon Cycle with a partner or as a group and edit or add to your sketch as you share.
Reflect	**Learning Outcomes:** • To allow members to become more familiar the process of the carbon cycle.
Apply	**Prompting Prompts:** • Why is it important to know how the carbon cycle works? • Did anything in the video surprise you? • How does agriculture impact the carbon cycle and contribute to climate change? • How is agriculture impacted by climate change?

NAME: DATE:

The Story of the Carbon Cycle

Watch "The Carbon Cycle" by Nathaniel Manning. Use images and words to create an artistic representation of how the carbon cycle works. Try to capture as many of the elements that contribute to the overall process as you can. Then discuss the Carbon Cycle with a partner and edit or add to your sketch as you share.

Activity #4 - Design the Perfect Agriculture Crop

Do	Time: 20 minutes **Materials:** • List of traits (found on the next page) • Hat/bowl/bag • Paper • Writing utensil **Instructions:** • Print out list of traits. Cut into individual traits and put into a hat. • Have members choose three traits out of the hat. • Using those traits (and those traits only), they should draw and describe in words their 'perfect agricultural crop' and share with the others.
Reflect	**Learning Outcomes:** • To have members think about desirable traits in agricultural crops • To allow members to be creative when drawing and describing their crop • To continue to develop critical thinking skills
Apply	**Prompting Prompts:** • Why is it important to know which traits are desirable in agricultural crops? • Was it easy or difficult to create your perfect crop? • Did you like the traits that you picked from the hat? • Were there other traits you would have liked your animal to have?

Disease resistant
High yielding
Drought tolerant
Produce larger seeds
High germination rate
High germination rate
Cold tolerant
High # of heat units required
Tall stalk
Self-pollinating
Pest resistant
High yielding

Meeting 3 – Precision Agriculture Outstanding in its Field

Setting Objectives:

To discover an understanding of the various types of technology available for farm machinery and create an understanding of the importance of this technology for a more efficient and productive agriculture industry.

Suggested Learning Outcomes:

- To understand what the precision agriculture is
- To realize why precision agriculture is needed and how quickly it is advancing
- To appreciate the variety of data collection and field intervention tools available for today's field crop industry
- To discover what farm machinery of the future will look like
- To discover careers related to the technologies presented in this meeting

Suggested Roll Call Questions:

- Name one piece of farm machinery with new technology that is used on your farm.
- Name one piece of farm machinery that is used on the farm that wasn't used 50 years ago.
- If you could invent a new piece of farm machinery to do field work for you, what would it be?

SAMPLE MEETING AGENDA Time: 3 hour 15 minutes

Welcome, Call to order, Pledge		10 minutes
Roll Call		10 minutes
Parliamentary Procedure	Minutes and Business	10 minutes
Topic Information, Discussion & Activities	**Topic Information** • Precision Agriculture • Data Collection Tools Satellite Crop Monitoring Internet of Things (IoT): sensors & drones • Field Intervention Tools ◊ Variable Rate ◊ Precision steering & automated driving systems ◊ Remote Management & Diagnostics ◊ Isobus Protocol ◊ Future Prospects of Precision Farming Advantages of Precision Farming • Farm Machinery of the Future ◊ Electric Tractors ◊ Autonomous Tractors ◊ The Future of Automatic Farming	40 minutes

	Activity #1 Precision Agriculture in the Field Crossword Puzzle Activity #2 Build Your Own Noodle Bot Activity #3 Build An Eco-Bot Challenge!	20 minutes 30 minutes 60 minutes
At Home Activity	Impressive Farm Machinery Technology	5 minutes
Wrap up, Social time, and adjournment		10 minutes

Topic Information

Precision Agriculture

Precision agriculture, also called precision farming or smart farming, gives farmers the ability to use crop inputs including fertilizers, pesticides, tillage and irrigation water more effectively. More effective use of inputs means greater crop yield and(or) quality, without polluting the environment. Precision agriculture/"smart" farming is a practice that uses automated data gathering technologies, such as variable rate mapping, artificial intelligence, and digital imagery, to guide targeted farm management activities (e.g., seeding, input application, harvesting) to improve the sustainability, efficiency and productivity of agricultural operations. The benefits include lower input costs, increased yields, enhanced environmental sustainability and better-informed management decisions.

There are many tools available to precision farming, yet none of them can replace the professional experience of those working in the farming sector, as all of them provide valuable support to boost performance and results.

Some of the more popular instruments include semi-automated steered vehicles and variable dosage rates, but there are many more solutions that are constantly evolving. Cutting-edge technologies use integrated frameworks to collect data and put in place a series of actions to boost productivity. This project will take a look at some of the main date collection tools/technologies being used in today's agriculture.

Data collection tools

Monitoring the health status of crops requires a huge effort, especially when fields can extend over very large areas. Production in fields is hardly ever uniform. Some areas are far more productive than others. This can depend on the different quality of soil, the presence of parasites and fungi or irrigation problems. It is vital to be able to identify these causes in a timely manner, in order to remedy all and any situations that reduce productivity.

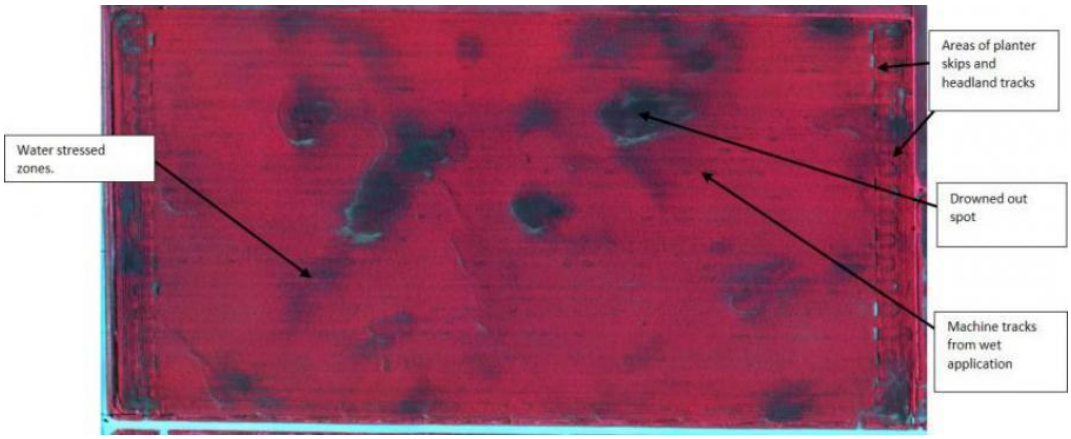
Discuss It!

If the health of crops isn't monitored closely, what potential implications does it have for the farmer? For livestock? For food for human consumption?

Satellite crop monitoring

Satellite crop monitoring is a tool that allows farmers to constantly monitor the health of their fields thanks to a multi-spectral imagery analysis of high-resolution satellite images It also promptly trigger any alarm bells.

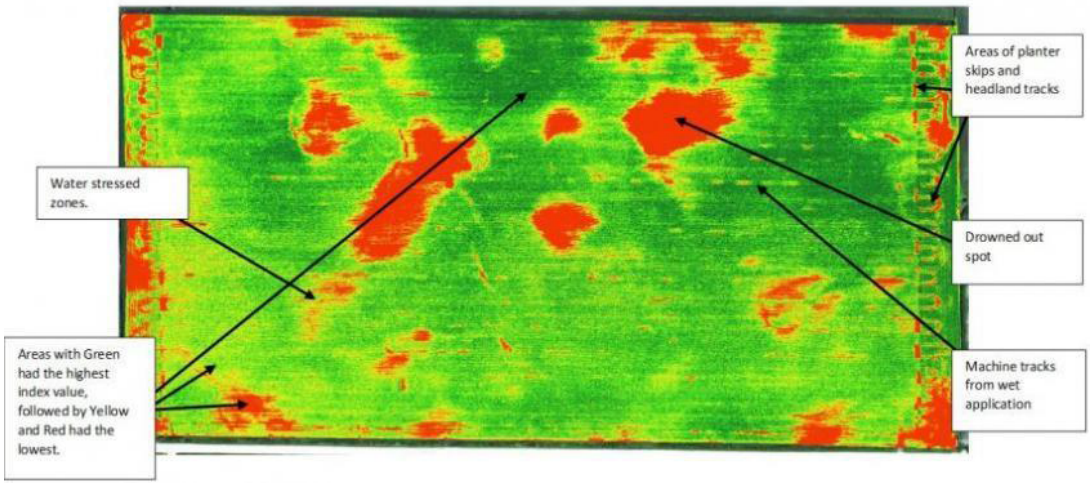
This is possible because the satellites are able to detect certain wavelengths of electromagnetic emissions such as visible and near infrared (NIR) bands. In practice, they have the ability to "photograph" sunlight reflected by the plants and soil to produce a sort of field imagery, providing information on key aspects such as vegetative development, humidity and temperature of the soil.



Near Infrared Imagery (NIR), also known as color infrared imagery, uses a false color composite to display information that would normally be invisible to the human eye. The NIR map shows areas of highly vigorous crops in bright red and weak crops or bare soil in grey.

Source: Iowa State University Crop Extension https://crops.extension.iastate.edu/cropnews/2016/05/choosing-right-imagery-best-management-practices-color-nir-and-ndvi-imagery

Among the most significant data is the health of the plants, which is measured with parameters such as the Normalized Difference Vegetation Index (NDVI), which helps to identify plants that are photosynthetically active and therefore healthy. Another useful parameter is the Normalized Difference Moisture Index (NDMI), which identifies the water stress of the plants by reading the moisture rate.



Normalized Difference Vegetative Index (NDVI) is a calculated index used to monitor crop health and photosynthetic activity. The higher the index value the greater the crop vigor. A color gradient is applied to make the image easier to interpret. A commonly used gradient is red to green; red being the low values and green being the high.

Source: Iowa State University Crop Extension https://crops.extension.iastate.edu/cropnews/2016/05/choosing-right-imagery-best-management-practices-color-nir-and-ndvi-imagery

Internet of Things (IoT): sensors and drones

Shown from left to right are examples of Color, near infrared (NIR), and Normalized Difference Vegetative Index (NDVI) images. The images were captured with a Rotary Platform small Unmanned Aerial System (sUAS).

- **RGB (color) imagery is similar to viewing a digital photograph taken from a plane.**
- **Near infrared (NIR) imagery provides a greater assessment of plant health than traditional photos by visualizing color bands outside of what the human eye can see.**
- **Normalized Difference Vegetative Index (NDVI) is a commonly provided index that assesses crop vigor based on a mathematical interpretation of color and near infrared data.**

Source: Iowa State University Crop Extension https://crops.extension.iastate.edu/cropnews/2016/05/choosing-right-imagery-best-management-practices-color-nir-and-ndvi-imagery

An alternative solution, which does not involve the use of satellites, is agricultural drones. Currently, they are mainly used for land mapping but the most advanced versions adopt infrared sensors and imagery systems to detect problems that cannot be detected by the naked eye, just as satellites do.

As was discussed in Meeting #2, another important instrument for precision agriculture, which does not involve any intervention from above, are the environmental sensors installed in the fields, capable of recording climatic data and information on soil water requirements. Unlike the monitoring performed with satellites and drones, which are particularly useful for large areas of land, the advantage of the sensors is that they can also be used in enclosed spaces such as greenhouses and nurseries.

Thanks to all this data collected by satellites, drones, and sensors, it is possible to generate interactive maps that photograph the health state of the field and highlight any differences between individual areas of crops clearly and quickly. This also allows irregularities to be discovered and report the need for any specific interventions.

There are many causes for the differences and potential problems in these areas: nutritional deficiencies, irrigation problems, localised parasitic attacks, damage due to hail or frost. To detect the reason for the decreased health of a field, it is necessary to conduct a field analysis which will be exceptionally well targeted thanks to all of the information available.

Once the causes of the different yields in these areas have been identified, it will be possible to put targeted actions in place, depending on the problem, to plant seeds or spread variable rate fertilizers, or increase irrigation in certain areas, or adopt the use of phytopharmaceuticals (medicines with pure active substances that come from plants or parts of plants) where necessary.

In the medium to long term, the information on differences and potential problems that repeat themselves each year, allows farmers to plan structural investments, such as irrigation management or soil interventions much more efficiently.

DISCUSS IT

Are there other applications that sensors and drones could be used for other than in agriculture?

The advantage of crop monitoring systems is that they allow farmers to accomplish constant control over very large areas or even fields that are very far apart from each other, by setting a series of automated interventions (for example, to receive notifications when a given event occurs) that allow them to intervene in a timely manner, immediately identifying stress factors that are otherwise difficult to recognise. Without forgetting that, in addition to highlighting problem areas, constant monitoring allows farmers to verify the results of corrective actions put in place over time.

Field intervention tools

Collecting data is the initial key pillar for precision farming and is used to understand where to intervene in a timely manner. The next step consists in the effective on-field interventions, and the new technologies provide essential support in this step too. This project will look at the main ones.

Variable rate: differentiated spreading of fertilizer and plant protection products

Precision farming technologies also include equipment capable of applying fertilizers and plant protection products in a specific manner on the field, according to the requirements of the crops. In this way it becomes possible to intervene in the right place and with the right amount of resources strictly necessary, optimising use and avoiding waste.

Variable rate technology requires accurate data on the actual requirements of each area of crops. Variable rate technology is based on 2 different modes to obtain this information:

- **sensors** that record data in real time relating to the health status of the crops, and chemical-physical characteristics of the soil which will be used to manage the operations

- **prescriptive maps** based on the previously collected data using imagery systems which are able to provide instructions to the machine concerning the distribution of the products. This second system also provides for the use of satellite geolocating technologies which can identify the position of the machine in the field and indicate the amount of the product to be distributed at any precise moment

Drones spraying plant protection products (pesticides) in targeted areas in the field.
Source: Bearing Tips

Precision steering and automated driving systems for tractors and agricultural machinery

The satellite steering and driving systems for tractors are some of the most renowned technologies in precision farming. These systems can improve work efficiency and boost productivity, reducing production costs, while saving time and fuel.

Thanks to a GPS or GLONASS satellite receiver, it is possible to localize agricultural machinery inside the fields. This prevents overlapping or by-passing of the consecutive steps in the spreading of fertilizers and plant protectors, with obvious advantages. If untreated areas see decreases in production or pathogen agent attacks, overlapping increases consumption and costs. Additionally, it is possible to replicate data in subsequent applications, which will become easier and faster to manage.

Auto-Steer in a tractor
Source: CropLife https://www.croplife.com/precision/autosteer-systems-continue-to-evolve/

Thanks to the prescriptive maps or sensors it is possible to adjust the variable rate distribution of products in real time.

There are various types of precision guidance and steering systems available, from the simple guidance bar systems to the more advanced precision guidance and semi-automated driving systems:

- **guidance bar systems** provide information to the driver via a monitor, to visually trace the most effective route and to report deviations from the set route, giving the operator the possibility to correct the route and carry out similar passages.

- **precision steering** includes the installation of a motorized actuator that acts directly on the steering wheel to adjust the route. This reduces the effort of driving the tractor so that the operator is free to focus on other aspects of the job such as controlling the equipment.

- **semi-automated driving** controls the steering of the vehicle by intervening on the steering column or directly on the hydraulic system. Thanks to state-of-the-art automated manoeuvring systems, the operator can still take control at any moment in time.

What are the advantages of these instruments? Faster and more accurate processing, reduced waste, and less stress for the operator who can pay more attention to other aspects of the job, such as controlling the equipment.

DID YOU KNOW?

GPS stands for Global Positioning System. GPS uses satellites that orbit Earth to send information to GPS receivers that are on the ground. The information helps people determine their location.

GIS stands for Geographical Information System. GIS is a software program that helps people use the information that is collected from the GPS satellites.

Remote management and diagnostics of the tractor fleet

One of the most advanced solutions to maximize productivity is remote fleet management and diagnostic tools.

Fleet management tools allow users to conveniently monitor a large amount of information from their office PC monitor such as travel, consumption, daily and monthly work.

Thanks to the use of geolocating systems and software to collect and process the information, tractors and equipment are able to transmit a large amount of data, providing indications used to draw up forecasts for future processing, aimed at optimizing costs and yields.

The information is exceptionally accurate: speed, engine rpm, work progress, hourly consumption, average consumption, and a variety of other data. In addition, it is also possible to outline the field areas very accurately and store the data relating to machine operations for the next passages.

Another key aspect is the possibility to carry out a real-time check-up on the health of the tractor, thanks to the remote maintenance and diagnostics functions, which allow the support service to intervene quickly and precisely, extending the working life of tractors while improving the performance of the fleet.

Isobus protocol: a universal language at the service of precision agriculture

To take advantage of all possibilities offered by precision farming technologies to the fullest, it is vital for the various agricultural machinery to be able to 'communicate' with each other. In order to solve the problems of compatibility between the various instruments, the Isobus protocol has been designed - a universal language that enables communication between tractors, software and equipment, even those from different manufacturers.

One single control display integrated inside the tractor cabin is used to control all the machinery and equipment which are part of an interconnected system.

This makes it possible to control Isobus certified equipment, effectively use automation systems and integrate all of the same with satellite precision systems and variable rate distribution of products, through to remote fleet management and tractor diagnostics systems.

Future prospects of precision farming

Some of the most recently developed technologies currently available and under development are state-of-the-art robots applied to agriculture, capable of managing crops more and more accurately with the possibility of collecting data on the state of health of the soil and automated seeding and harvesting, thanks to sensors that are able to detect the maturity of agricultural products and grippers which are able to handle fruits and vegetables without damaging them.

Excerpts from McCormick/Argo Tractors *https://www.mccormick.it/as/precision-farming/*

Research It and Share It!

Are there new farm machinery technologies that have been developed that aren't listed in this project manual?

DISCUSS IT

What types of fruit and vegetable crops would benefit from robots harvesting them?

Advantages of Precision Farming

Precision farming offers several advantages–economic, social, and environmental–over traditional methods:

- Increases ROI (return on investment), by reducing inputs use and increasing yield amounts and quality.
- Reduces soil, water, and air pollution by decreasing the use of chemical fertilizers and pesticides.
- Builds up soil biodiversity and supports wildlife outside farms.
- Makes farming sustainable by reducing reliance on resources and water.
- Reduces carbon emissions from the agriculture sector.

CAREER ALERTS!

Check out these exciting precision farming careers!

- *Agricultural Engineer*
- *Precision Ag Technicians (implement dealers)*
- *Crop Specialist*
- *Nutrient Management Specialist*
- *Precision Ag Department Managers*
- *Precision Agronomists*
- *Precision Farming Coordinators*
- *Robotics Engineer*

Farm Machinery of the Future (that's already here now!)

Electric Tractors

Electric vehicle technology has arrived for heavy machinery, thanks to breakthroughs in battery technology.

Many companies around the globe are now working on developing electric technology for heavy machinery in the agriculture industry, most often tractors. Most notably, two companies in California, Monarch and Solectrac Inc., have had success in developing electric tractors up to 70 horsepower. These tractors are now available for the commercial tractor market.

Monarch Electric Tractor, developed in California. This tractor is also designed to be autonomous.
Image Source: Bloomberg Green

The electric motor has only one moving part, unlike small diesel engines, which have over 300 moving parts. This helps to lower maintenance costs. Electric tractors do not use hydraulics. Instead, they use electric linear actuators. Linear actuators are a type of actuator that convert rotational motion in motors into linear or straight push/pull movements. Linear actuators are ideal for applications where tilting, lifting, pulling or pushing with pounds of force are required.

Solectrac Electric Tractor
Image Source: Sonoma County Farm Bureau

One of the biggest challenges with electric tractors is having a battery that will last throughout the day. Currently farmers with conventional diesel-powered tractors can typically run 10 to 12 hours without having to re-fuel, even when tractors are doing long, hard work. With small windows for planting and harvesting, farm machinery needs to be able to run long hours. To help with this challenge, both Monarch and Solectrac models have a replaceable battery pack. A quick exchange of a battery pack addresses the wait time for the machine to fuel up. The tractors

are advertised to have a battery pack run time of three to six hours, depending on the load of work placed on the battery.

Electric Linear Actuator
Image Source: Progressive Automation

Advantages of electric tractors:

- Save money on maintenance and fuel
- Less sound (improves communication while working)
- No exhaust - no more breathing in toxic diesel fumes or worrying about the long-term effects of inhaling these toxic fumes
- No carbon emissions/ more sustainable – reduces carbon footprint

Disadvantages of electric tractors:

- Cost (currently more than diesel-powered tractors)
- Battery technology - length of time the battery will last – if doing a high-powered task like tillage, the battery won't last as long

Experience It!

Invite a farm machinery salesperson or an agricultural engineer to your meeting. Find out what types of machinery, what technology these machines have and what types of technology this person thinks might be a part of farm machinery in the future.

Or, if possible, tour a farm machinery dealership to see the machinery first-hand.

Autonomous tractors (driverless tractors)

A driverless tractor is any autonomous farm vehicle that can manage its own speed, steering, braking, and navigation. This is achieved with the help of several additional systems such as GPS, lasers, cameras, and more. It is considered driverless because it can operate independently, without the need of a farmer or driver to run it.

Driverless tractors have since developed into sophisticated pieces of farming and technological equipment, which can carry out almost all of the functions of a typical field farmer autonomously, thanks to the several lasers, cameras, and sensors mounted on it.

Case IH is working on the development of an autonomous tractor with a cab with their Magnum AFS Connect series of tractors.

Case IH Autonomous Concept Tractor
Image Source: Case IH

In January 2022, John Deere revealed a fully autonomous tractor that's ready for large-scale production. The machine combines Deere's 8R tractor, TruSet-enabled chisel plow, GPS guidance system, and new advanced technologies. The autonomous tractor, featuring traditional diesel power, will be available to farmers later in 2022.

The John Deere 8R autonomous tractor has six pairs of stereo cameras, which enables 360-degree obstacle detection and the calculation of distance. Images captured by the cameras are passed through a deep neural network that classifies each pixel in approximately 100 milliseconds and determines if the machine continues to move or stops, depending on if an obstacle is detected. The autonomous tractor is also continuously checking its position relative to a geofence, ensuring it is operating where it is supposed to, and is within less than an inch (2.5cm) of accuracy.
To use the autonomous tractor, farmers only need to transport the machine to a field and configure it for autonomous operation. Using John Deere Operations Center Mobile, they can swipe from left to right to start the machine. While the machine is working the farmer can leave the field to focus on other tasks, while monitoring the machine's status from their mobile device.

John Deere Operations Center Mobile provides access to live video, images, data and metrics, and allows a farmer to adjust speed, depth and more. In the event of any job quality anomalies or machine health issues, farmers will be notified remotely and can make adjustments to optimize the performance of the machine.

John Deere 8R Autonomous Tractor
Image Source: John Deere

Changing the Face of Automatic Farming

A driverless or autonomous tractor offers huge potential for re-imagining the face of farming and making agriculture more automated than ever before. With vital functions of the farmer essentially being outsourced to these driverless vehicles and their sophisticated sensor sidekicks, which are all intimately connected through the Internet of Things (IoT), the global food system as well as individual farmers stand to gain a lot.

Check It Out!

Watch the video at: https://www.youtube.com/watch?v=QvFoRk4JsPc to see the John Deere 8R autonomous tractor in action.

For a more in-depth look at how the tractor operates, watch the video found at: https://www.youtube.com/watch?v=tSdIgGin_rk

1. **Lower costs of production**

One of the largest costs of any farming operation is generally labour, especially during harvest. Autonomous tractors would significantly reduce if not eliminate these costs for the farmer, as the vehicle would be able to manage entirely independently.

2. **More precise inputs and boosted productivity**

Autonomous tractors outfitted out with the latest agricultural sensors and systems will be able to not only map the field, soil, and crop data with extreme accuracy, but also apply various inputs in precise amounts, all without farmer intervention. Variable rate applicator (VRA) technology has been shown to skyrocket the productivity of a field simply because it treats different areas within a plot in a customized way best suited to its specific needs.

3. **More efficient use of farmer time**

Similarly to how early applications of GPS technology in tractors allowed farmers to focus on high-value activities like planting instead of low-value activities like steering in a straight line, these newer upgrades to autonomous driverless tractors will allow farmers to upgrade where they spend their focus, time and energy once again.

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

For example, instead of spending several hours per growing season driving through their fields, farmers could focus on tasks that are of yet not fully automated, such as business financials, strategy, marketing, and distribution.

4. **A tireless "workforce"**

Driverless tractors do not require a farmer to operate them. Consequently, this gives farmers a tool that could potentially run 24/7, without ever tiring. This is especially relevant for farmers with large plots of land, which would previously have relied on several manual labourers. Without the need for breaks for rest or food,

driverless tractors would massively increase the time- and cost-efficiency of several aspects of farming operations, such as tilling and harvesting.

5. **Reduced pressure to find new entrants to the agricultural workforce**

The average Canadian farmer is 55 years old. Global trends indicate that fewer and fewer people are entering the agricultural industry at all, spelling potential trouble for the world food supply in the coming years and decades.

Driverless tractors, in addition to other recent innovations in agricultural technology such as drones, robots, sensors, and IoT devices and equipment provide hope that there will be a decreased reliance on human labour in the future anyway, potentially mitigating any worries prompted by the lack of interest from younger generations of working the land for a living.

Check It Out!

Watch John Deere UK IE's video titled Autonomous Electric Tractor - Future of Farming, found here: https://www.youtube.com/watch?v=gMaQq_vRaa8

DISCUSS IT

What other industries could benefit from having autonomous vehicles? Do you think this is possible in your lifetime?

Autonomous & Electric - John Deere's autonomous tractor concept is a very compact electric drive unit with integrated attachment. The tractor has a total output of 500kW and can be equipped with either wheels or tracks. It has zero emissions.
Image Source: John Deere UK IE, 2020

The Future of Automatic Farming

Autonomous driverless tractors have come a very long way in the last five to ten years. With the growing market for smart precision agriculture devices, farms will continue to become more and more automated. We are on the path to a fully hands-free agricultural operation, even if it currently remains a little ways off into the future.

Excerpts from: https://stories.pinduoduo-global.com/agritech-hub/how-self-driving-tractors-are-making-autonomous-farming-a-reality

The first truly autonomous grain cart tractor in Canada was put to a farmers' test on September 8, 2021 when a group of about 50 farmers got together at Haggerty Creek Agricultural Services, the Raven dealer near Bothwell, Ont. Raven's OmniDrive is a real-life autonomous system for tractors and combines. It's programmed to automatically pick up the combine at optimal points in the field and shuttle the load to the road, all this without a driver.
Image Source: Farmtario (courtesy of Raven)

JUDGE IT!

There are many different types of farm machinery that can be judged. If possible, have 4 tractors (or 4 of a different type of machinery) on display for members to judge. If machinery is not available, use pictures instead. Have members create a list of features they think are important to have in a tractor (a list of criteria). Then, using this list have members rank (judge) the machinery and give their reasons for their placing.

At Home Activity

Impressive Farm Machinery Technology

Which piece of farm machinery technology impresses you the most? Why does it impress you? Learn more about this technology – when was it first developed, where was it developed, who developed it – and any other interesting information about this technology.

Be prepared to share your answers at the next meeting.

Digging Deeper

For Senior Members

Regulations for Flying Drones

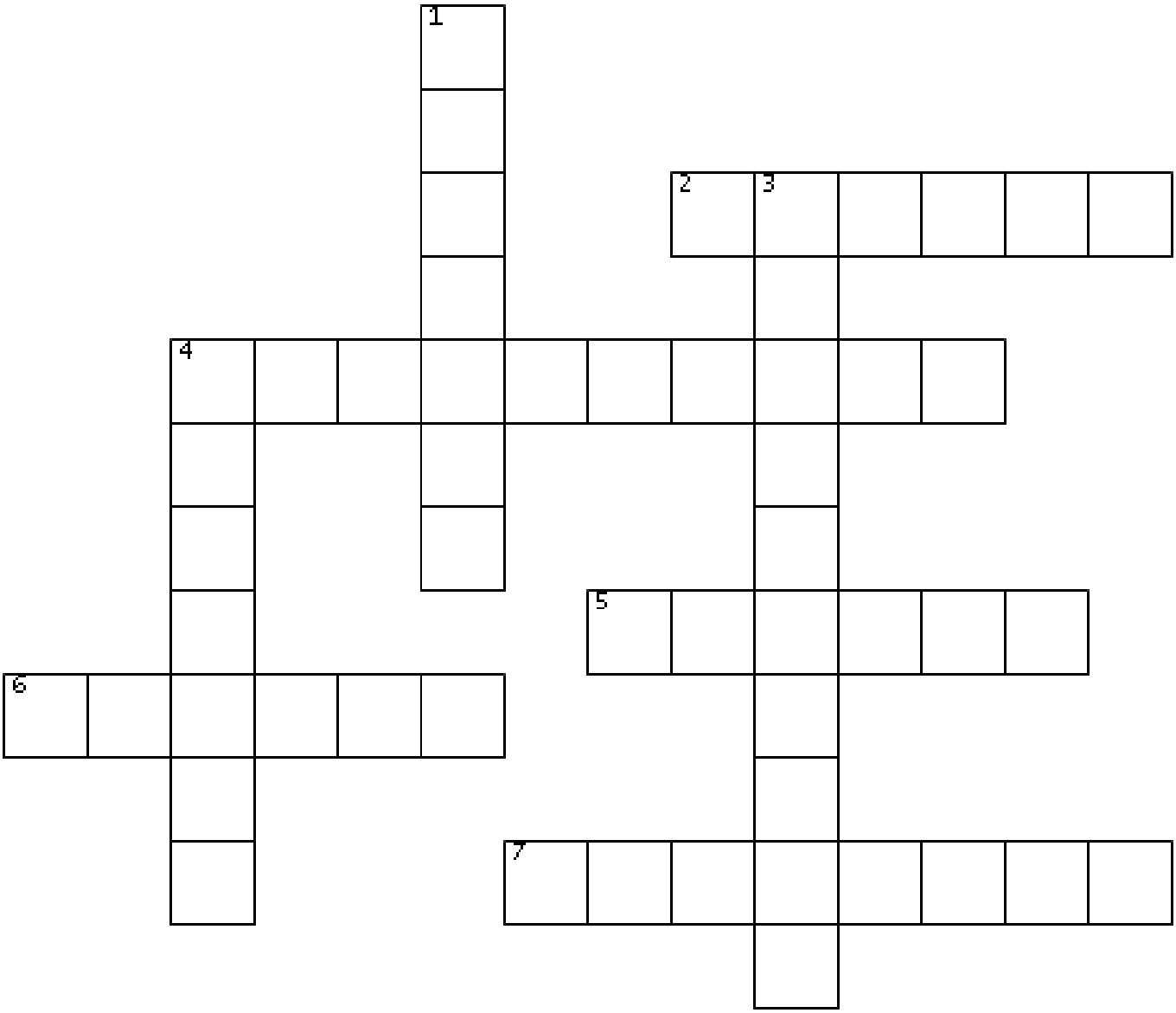
Flying drones over crop fields can give us a lot of information and some great pictures. But there are regulations when it comes to flying drones. Find out what the rules regulations are in your area.

Be prepared to share your findings with the group at the next meeting.

Activity #1 - Precision Agriculture in the Field Crossword Puzzle

Do	Time: 20 minutes **Materials:** • Precision Agriculture in the Field Crossword Puzzle worksheet (found on the next page) • Paper and a writing utensil **Instructions:** • Have members complete the Precision Agriculture in the Field Crossword puzzle worksheet • Review the answers to ensure everyone was able to complete the puzzle
Reflect	**Learning Outcomes:** • To allow members to review terms/vocabulary covered in Meeting #4
Apply	**Processing Prompts:** • Did you have to review the meeting material to find the answers? Did you find this activity easy or hard? • Were there any answers that surprised you? • Do you understand the definitions of each answer in this puzzle?

Precision Agriculture in the Field Crossword Puzzle



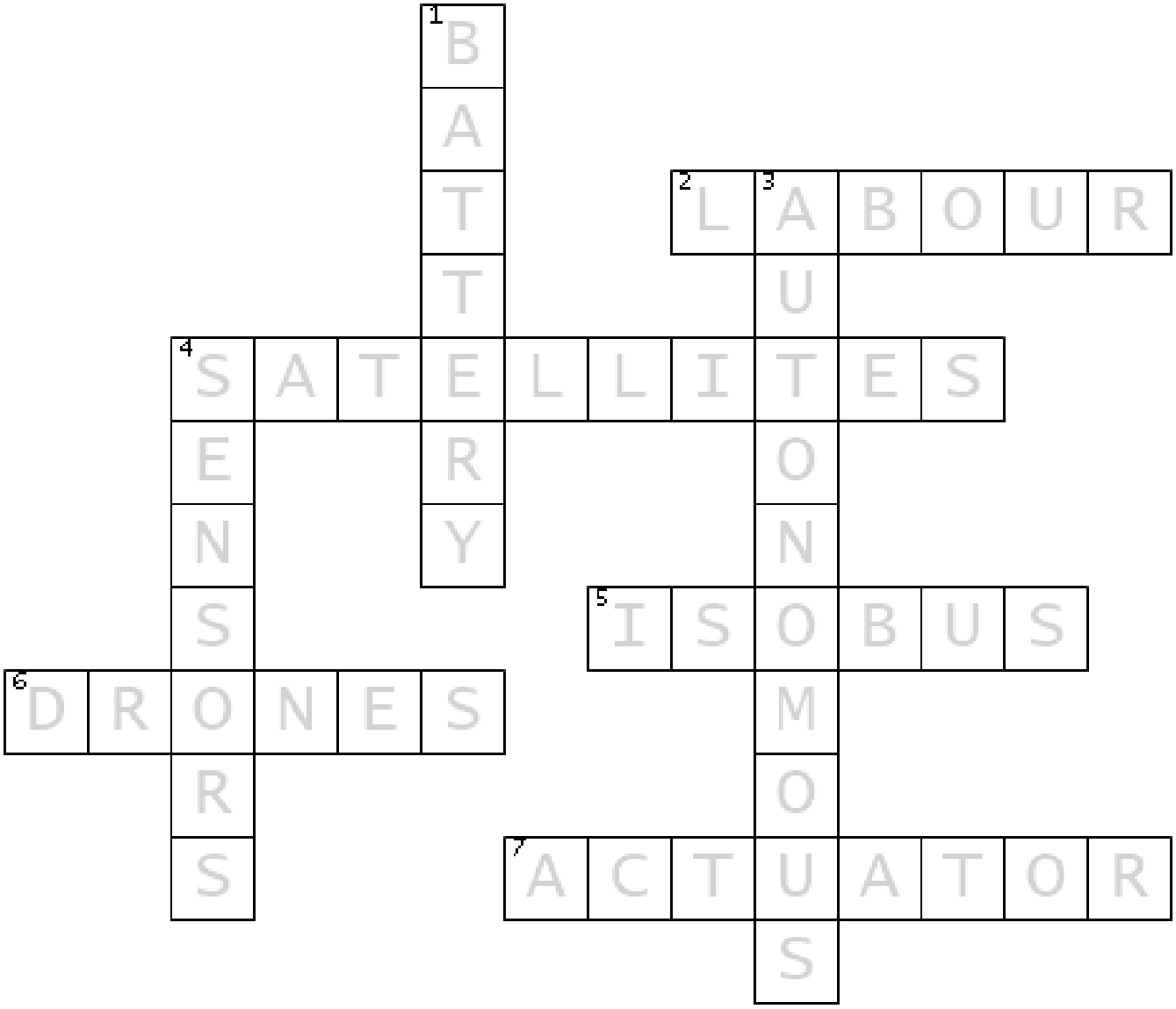
ACROSS

2. one of the largest costs of any farming operation
4. have the ability to detect certain wavelengths of electromagnetic emissions
5. a universal language at the service of precision agriculture
6. used for land mapping - the most advanced versions have infrared sensors and imagery systems
7. converts rotational motion in motors into linear or straight push/pull movements

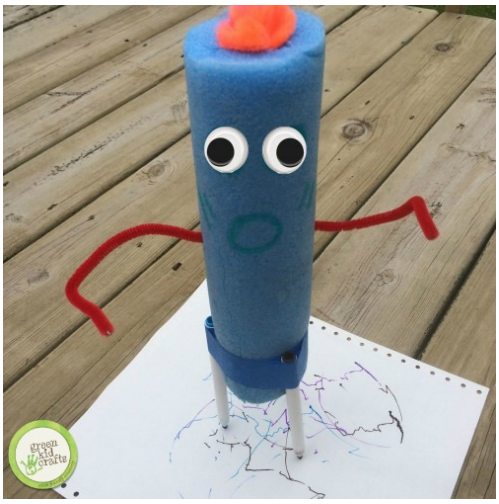
DOWN

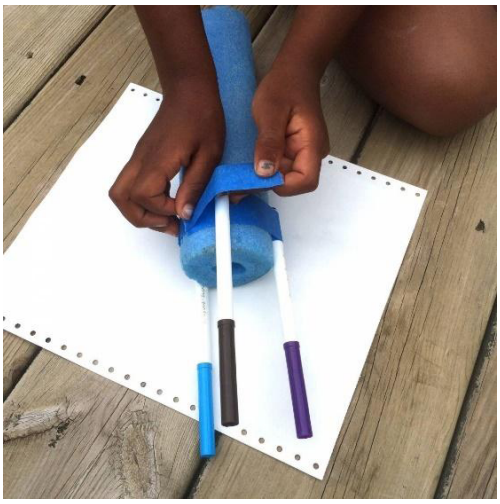
1. what an electric tractor runs on
3. another name for a driver-less vehicle
4. record data in real time relating to the health status of the crops

Precision Agriculture in the Field Crossword Puzzle - Answer Key



Activity #2 - Build Your Own Noodle Bot





Do	Time: 30 minutes **Materials:** • Pool noodle •Electric toothbrush (found in some dollar stores) • Markers • Tape • Decorations Instructions: • Cut pool noodle to a length that is slightly larger than the toothbrush (about 2.5cm longer). • Insert toothbrush into pool noodle. • Tape each marker to the noodle to create a 3-legged stool. It may be easier to also wrap the tape around the whole noodle to capture the markers more securely. • Decorate the pool noodle. Be creative! Pipe cleaners for arms, pom poms for hair and adhesive google eyes can be used. • Place the Noodle-Bot on some paper and turn on the toothbrush. Watch the magic happen!
Reflect	**Learning Outcomes:** • To allow members to create a basic robot. • To have members realize that they can build a robot using basic supplies.
Apply	**Processing Prompts:** • Was it easy or hard to make the bot? • Are there any modifications you could make to the robot to make it do a different task? • Is there anything else besides an electric toothbrush you could use to power the bot? • How can robotics be applied to farm machinery?

Activity #3 - Build an Eco-Bot Challenge!

Activity courtesy of the National 4-H Council
https://4-h.org/wp-content/uploads/2016/03/4H_ECO-BOT_FACILITATOR_GUIDE.pdf

Do	Time: 60 minutes **Materials:** • Manual toothbrush • 10mm pager vibrator with wires attached • 3 cm piece Scotch foam mounting double-side tape • 1 cm piece Scotch foam mounting double-side tape • LR44 1.5 volt button cell watch battery • Piece of 8.5 " x 11" copy paper • Piece of 8.5" x 11" cardstock • Scissors • Flexible straws (10) • 3 oz. paper cups (10) • One 27.5cm (11 inch) piece of masking tape • 2.5mL (tablespoon) of bird seed or rice •Timer **The Challenge!** Bailey Beach was the site of an unfortunate toxic spill and it is too hazardous for humans to clean. Your help is needed to establish a containment area to hold the toxic spill in place. Authorities are proposing that a special robot, called an Eco-bot, be used to solve this problem. Instructions: • Follow the instructions found on the Build an Eco-Bot pdf for Parts one, two and three of this activity (found at the end of this activity)
Reflect	**Learning Outcomes:** • To allow members to use STEM principles to build a robot that provides a solution to a societal problem • To create a robot that has real-life applications • To build a base of knowledge about robotics and the methodology used to create a solution to a problem
Apply	**Processing Prompts:** • After building the Eco-Bot, is there anything you would do differently next time? • Are there any different materials you could use to make the Eco-Bot work better? More efficiently? • Can you think of other tasks that the Eco-Bot could do? Other places the Eco-Bot could be used other than at a beach?

INTRODUCTION

Remind Youth of the Facts:

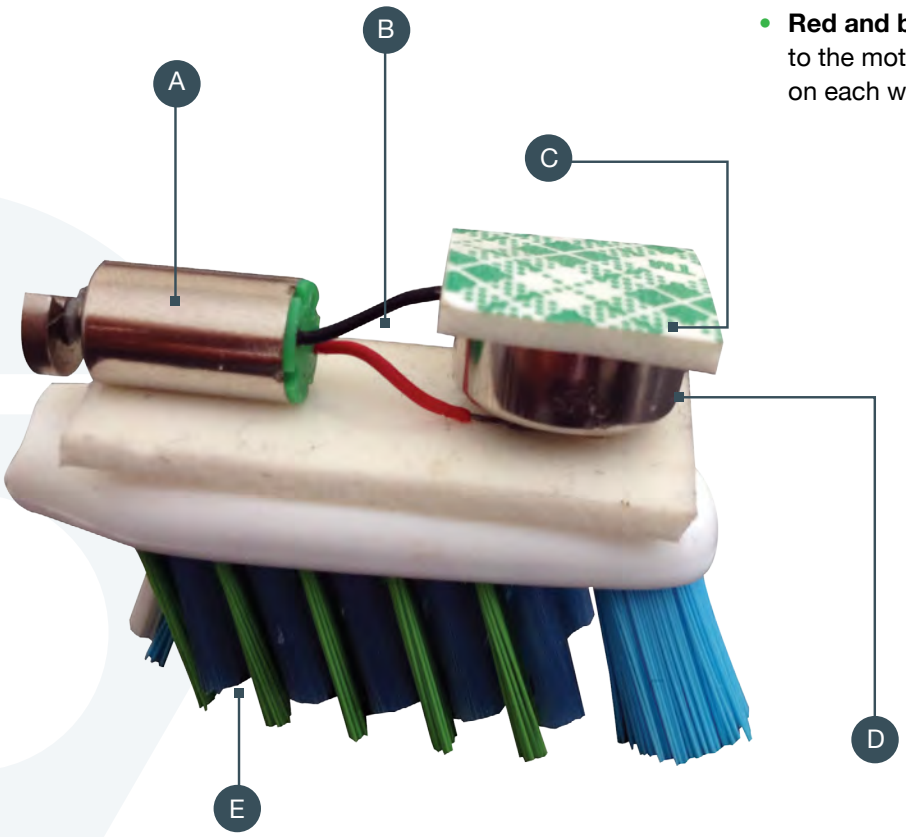
- Bailey Beach was the site of an unfortunate toxic spill and it is too hazardous for humans to clean.
- The EPA needs your help to establish a containment area to hold the toxic spill in place.
- They are proposing that a special robot, called an "Eco-Bot," be used to solve this problem.

As engineers who will program an Eco-Bot to clean a simulated environmental spill, it is important for participants to understand what an Eco-Bot is and what it can do.

Take the Lead: Know Your Parts

Using the Eco-Bot you built earlier, demonstrate how it works on a large table or open space on the floor. Explain that all Eco-Bots have the following parts, each one designed to perform a particular function:

- **Scrubber** – Also known as a toothbrush head, it will be used to "sweep up the spill"
- **Motor** – Controls the scrubber
- **Foam mounting tape** – Holds each of the parts in place
- **Watch battery** – Acts as the power source for the motor
- **Red and black wires** – Connect the power source to the motor (Note: For best results, the insulation on each wire should be stripped back to .5 cm)



Eco-Bot Assembly

A—Motor

B—Red and Black Wires

C—Foam Mounting Tape

D—Button Cell Battery

E—Scrubber

Understand How it Moves

A pager motor has an off-centered weight that unbalances the rotating part of the motor, causing it to vibrate. These vibrations pulse downward through the toothbrush's angled bristles, causing them to "push off" and move the Eco-Bot forward.

TALK ABOUT IT

How does the Eco-Bot work?

What parts are moving?

Which parts do you recognize?

Step 1: Bring Your 'Bot to Life.

Explain to the group that as robotic engineers, the first step is to build your Eco-Bot. Give each pair the supplies needed to build an Eco-Bot and explain how to put it together.

Eco-Bot Assembly

Remove the backing from one side of the 3 cm piece of foam tape and firmly stick it on the flat side of toothbrush head.

Remove the backing from the other side of the tape and gently push the motor on top of it with rotating part hanging off the back-end of toothbrush. This will allow the motor to spin without touching the tape. The wires should be positioned toward the head of the toothbrush.

Gently push the watch battery (+) side up onto the tape with the red wire underneath.

Turn the Eco-Bot on by pressing the black wire onto the battery with the 1 cm piece of foam on top.

Step 2: Observe What It Does.

Encourage participants to observe the action for 3-5 minutes and then ask everyone to turn off their Eco-Bots.

Explain that an Eco-Bot is an autonomous robot that is engineered to do only one thing — move forward. Its continuous forward movement is affected by touching the control surfaces. As the Eco-Bot encounters a control surface, it responds by turning, shifting position, or even falling over.

TALK ABOUT IT

What did you observe about how your Eco-Bot moves?

What problems did you encounter?

What controls the movements of your Eco-Bot?

What sort of tasks do you think the Eco-Bot could be used to accomplish?

LEADER NOTES

Establishing scientific habits of inquiry is essential, but requires practice and repetition. Make it fun, while promoting collaboration and communication within the group.

As the group works, be consistent in initiating discussions and encouraging them to ask questions.

Break from the activity regularly to give participants an opportunity to reflect on what they are doing, but keep the conversations short.

Good inquiry questions to ask include:

What happened when you _____?

Why did you choose to use that (technique, material, method)?

What would you do differently?

Part 2

THE GOAL IS CONTROL

Time Required: 30-45 minutes

OBJECTIVE

Working in pairs, use the engineering design process to create a set of control surfaces to optimize your Eco-Bot's performance in "sweeping up" the toxic spill on Bailey Beach.

MATERIALS YOU WILL NEED:

For each pair of participants you will need:
Challenge Mat for Bailey Beach

Suggested materials for testing environment:
Piece 8.5 x 11 in. copy paper

Piece 8.5 x 11 in. card stock

Scissors

(10) Flexible straws

(10) 3-oz paper cups

One 11 inch piece of masking tape

INTRODUCTION

In this experiment, we will create a "containment area" for the toxic spill. Control surfaces meant to contain the spill and direct the Eco-Bot are tested using straws, cardstock, and paper cups. The turning angles and the amount of friction and barriers that the Eco-Bot encounters are the variables participants can manipulate in programming the Eco-Bot to solve the simulated toxic spill challenge.

Take the Lead: The Role of Control

Before participants begin exploring how they might program their autonomous robot, initiate a conversation about control surfaces. Discuss what they are and what they can and cannot do.

Control Surfaces as Programming

All robots require programming or commands in order to complete tasks. One way that robots are programmed is through the use of control surfaces. **Control surfaces** are materials that restrict and redirect movements of a robot. They are a metaphor for the command structure of a computer program.

Autonomous robots have the ability to "sense" their environment (for example, through touch, sound, temperature or chemical changes). The robot's movement can be programmed by what it touches, hears or feels, and then adapt its behavior accordingly. The Eco-Bot is "programmed" through touch when it comes into contact with the control surfaces.

TALK ABOUT IT

How can we program our Eco-Bots to go where we want them to go?

What are the control surfaces that might be involved for a robot that is programmed to vacuum, mow the lawn or work in a factory?

How might autonomous robots work in toxic spill cleanup situations?

The Engineering Design Process in Action

Explain to the group they will apply the engineering design process to do a simulated environmental cleanup. Review the steps in the entire engineering design process BEFORE students begin to work.

LEADER NOTES

Consider using these tips to encourage successful inquiry:

Allow time after each of the engineering design process steps to allow for reflection, observation and questions.

There are no right or wrong ways to do things. Help participants see the choices they make and understand their reasons for making them.

Do not solve their problems or give explanations. Instead assist them by asking questions such as: What works? What doesn't? What have you tried and what happened? What has worked for other teams?

Step 1: Identify the Problem.

Show the group the Challenge Mat and revisit the details you presented earlier about the toxic spill on Bailey Beach.

TALK ABOUT IT

Where is the spill?

Why is it important to contain it?

What control surfaces will you use to program your Eco-Bot to cover the spill area?

What challenges do you have in containing the spill?

Step 2: Generate Ideas.

Encourage the pairs to brainstorm ideas for how to control the movement of their Eco-Bot by introducing control surfaces using straws, cardstock, and cups. This is an opportunity to test ideas using the materials, as time permits. Provide a few questions to help stimulate brainstorming:

TALK ABOUT IT

How can I "program" my Eco-Bot so that its movements will cover the entire area of the spill within the containment area?

Imagine what kinds of control surfaces you will design in order to program the Eco-Bot to cover this entire spill area.

How do the different materials affect the movement of the Eco-Bot?

Step 3: Evaluate and Compare Possible Solutions.

Ask each pair to choose their best ideas and create a plan for cleaning up the spill. Walk around and offer assistance and encouragement as each pair designs their plans.

Step 4: Build a Prototype.

Once they have sketched a drawing of their plan and you have approved it, give them a Challenge Mat, straws, cardstock, cups, a pair of scissors and a 11 inch piece of masking tape so that they can build their prototype. Remind them they can only use the materials they have been given.

Step 5: Test the Prototype.

Let the sweeping begin! Working in pairs, participants will determine how effective their materials are as control surfaces for their Eco-Bot. Place the Eco-Bot into the containment area and allow participants to observe the movements of the Eco-Bot and evaluate the success of their design.

LEADER NOTES

This is a good time to take photos of each pair of participants and capture their "solution" to the challenge.

Give each group 10 minutes to experiment. Remind them that they will have a chance to refine the design later in the engineering design process. Discuss the exercise as a group, recording any key observations and/or questions on a flip chart.

Step 6: Tell Your Story.

When it appears that most groups have built and tested a prototype, take a break. Gather everyone together to discuss their experiences and share their best ideas.

TALK ABOUT IT

How did you use the materials to create control surfaces?

What challenges did you experience?

What other materials would you like to try?

What questions do you have?

LEADER NOTES

Invite each pair or team to contribute their "best idea" and write it on a piece of newsprint. Encourage them to incorporate the ideas they like into their own designs.

Examples might include:
Use two straws to create higher walls so the Eco-Bot cannot "jump" over.

Create tunnels or mazes with cardstock.

Divide the containment area in two parts and use two Eco-Bots to sweep simultaneously.

Step 7: Refine your Design.

Using the design process, ask a new question like: How can we make our Eco-Bot move more efficiently over the toxic spill? Explain that the engineering design process is like a circle. It repeats over and over as you work to refine and make adjustments to solve a problem.

TALK ABOUT IT

How well does your design work?

What problem would you like to fix?

What could you do to improve the cleanup ability of your Eco-Bot?

Part 3

MAKE A CLEAN SWEEP

Time Required: 45-60 minutes

OBJECTIVE

How effective is your Eco-Bot? Can it clean up the toxic spill? Working in pairs, measure how much of the spill is "swept" by the Eco-Bots.

MATERIALS YOU WILL NEED:

Challenge Mat with control surface in place

(1) tablespoon of bird seed or rice

(2) Eco-Bots

Timer

Masking tape

Calculator (for calculating percentages)

LEADER NOTE

When youth have finished experimenting, consider the environment. Feed the birds your leftover birdseed or dump the rice in a compost pile.

INTRODUCTION

The Challenge Mat and Eco-Bot robot serve as **models** that are meant to show the appearance of something, and to help youth to understand the potential for using autonomous robots to cleanup a real spill.

Take the Lead

Participants will use birdseed to represent the toxic spill. When the Eco-Bot "sweeps" it out of the way, it can be assumed the spill has been "cleaned." The grid on the Challenge Mat will allow participants to use a ratio to measure the amount of spill that has been cleaned.

In this experiment, the only independent variable is the control surface. It can be manipulated to influence the robot's performance. The remaining variables are fixed variables that cannot be manipulated. In this way, as in real scientific experiments, participants will change only one variable at a time and compare the outcome.

Step 1: Set Up the Simulation.

Encourage participants to work in pairs and set up their testing area:

1. *Tape the Challenge Mat to a table or a flat surface.*
2. *Add one tablespoon of birdseed to the containment area within the control surfaces you created. Spread it evenly over each spot.*
3. *Decide who will be the **Eco-Bot Analyst** (the person who operates the timer and serves as the recorder) and who will be the **Eco-Bot Engineer** (the person who can "touch" and monitor the Eco-Bot).*
4. *Review the Rules for the Eco-Bot Engineer.*

Rules for the Eco-Bot Engineer

1. Only one team member can be an Eco-Bot Engineer.
2. If the Eco-Bot falls over, you must wait 3 seconds to pick it back up.
3. If the Eco-Bot gets stuck, you must wait 3 seconds to tap it or move it.
4. If the Eco-Bot leaves the containment area, you must wait 3 seconds to put it back.
5. You may only touch your Eco-Bot a total of 5 times during the 2-minute challenge.

LEADER NOTES

Explain that in this simulation, "touches" are considered "malfunctions." Discuss what these malfunctions might mean in a real-world situation:

An out-of-control robot

A timing delay

A need for human intervention

Extra costs

Discuss why a robot that experienced no malfunctions and cleaned 80% of the spill area might be a better prototype than a robot that cleaned 90% of the spill area but had three malfunctions. This could be viewed as a trade-off in reliability versus capacity.

Step 2: Start Your Eco-Bot!

Invite participants to begin testing their Eco-Bot:

1. *Place the Eco-Bot at any location on the Challenge Mat.*
2. *Set the timer for 2 minutes.*
3. *Turn on the Eco-Bot and start the timer.*
4. *Observe the movement of the Eco-Bot and follow the rules if it falls over, gets stuck or leaves the containment area.*
5. *Remove the Eco-Bot at the end of 2 minutes.*

Step 3: Measure Your Eco-Bot's Effectiveness

1. *Instruct participants to collect their data:*
2. *Count the number of times the Eco-Bot Engineer touches the Eco-Bot.*
3. *Count the number of black spaces that are "swept" or completely clear of the contaminant.*
4. *Use the following ratio to calculate the amount of the spill that was cleaned. This will give a percentage (a fraction or ratio with 100 as the understood denominator) that expresses the effectiveness of the Eco-Bot.*

LEADER NOTES

Expect some question or debate as to what is considered a "swept" space. Establish your own rules for determining swept spaces or use the following:

If a space is about half-swept, count 2 half-swept spaces as one.

If there is only a small portion of a space is swept, don't count it.

If a space is mostly swept, count it as one.

$$\frac{X}{125} \text{ (x) } 100 = \_\_\_\_\_\% \text{ of effectiveness}$$

- X = number of black spaces free from birdseed after 2 minutes.
- 125 = approximate number of spaces that are in the containment area.

Step 4: Repeat, Repeat.

Ask participants to repeat the Steps 1-3 two more times. Encourage participants to switch roles, allowing everyone the opportunity to be an Eco-Bot Analyst and an Eco-Bot Engineer.

Step 5: Average It Out.

Compute the average of the percentages and the number of malfunctions.

Step 6: Share the Results.

Test 1 _____%	Test 2 + _____%
+ Test 3 _____%	divided by 3 = _____%

Collect the results from all of the pairs or groups and calculate an average group percentage.

TALK ABOUT IT

Discuss the amount of "touches":

How do these touches represent malfunctions?

Were the touches necessary due to the design of the robot? Or the control surface?

How could you reduce the amount of touches/ malfunctions?

Examine the most successful designs. What do they have in common?

Collect ideas for next steps. What other tests could be done?

LEADER NOTES

If you plan to do the Experiment Extension (page 20), now would an appropriate time to introduce the exercise.

Step 7: Review Your Performance

Encourage participants to share what they observed, what they learned and what they would do differently. This is also a great time to revisit the various lists and brainstorming the group created at earlier stages in the experiment. Discuss and explore how their thinking and understanding of robots has changed and evolved throughout the process.

TALK ABOUT IT

What changes would you make to your control surfaces?

What characteristics/abilities does an autonomous robot need in order to complete a task like this one?

In what ways in this a realistic simulation? What makes it unrealistic?

How did the engineering design process help you when completing this challenge?

What role did you play during this activity that was particularly interesting to you? How could this be related to a future career or area of interest?

INTRODUCTION

Meeting 4 – Precision Livestock Farming – Animal Health & Reproduction

Setting Objectives:

To create an awareness of what precision livestock farming is and the technology that has been and continues to be developed for this sector.

Suggest Lesson Outcomes:

- To understand what precision livestock farming is
- To appreciate the advancements in technology for the livestock sector
- To understand how genomic selection pertains to livestock
- To appreciate the technology used for animal identification
- To understand what sensor technology is and how it is used to monitor animal health
- To discover what technology is available for livestock transportation
- To discover careers related to the technologies presented in this meeting

Suggested Roll Call Questions:

- Which piece of farm machinery technology impresses you the most? (At Home Activity from Mtg. #3)
- Name one health issue that a farmer needs to monitor for in their livestock.
- What do you think is the greatest technological development in the animal health field?
- Name one trait in animals that you would want to breed for in order to replicate that trait in other animals

SAMPLE MEETING AGENDA Time: 2 hours 10 minutes

Welcome, Call to order, Pledge		10 minutes
Roll Call		5 minutes
Parliamentary Procedure	Minutes and Business	10 minutes
Topic Information, Discussion & Activities	**Topic Information** Precision Livestock Farming • Livestock Genetics & Reproduction ◊ Innovation & Technology in Animal Breeding ◊ Genomic Selection ◊ How does genomics work? • Other Tech & Advancements in Livestock Breeding • Animal Identification ◊ • Sensor Technology that Monitors Animal Health ◊ Why use animal sensors ◊ Recent Advances ◊ Wearable Technology ◊ Applications of Wearable Technology • Livestock Transport	

	Activity #1 Creating DNA Activity #2 Societal Thoughts and Pressures Affecting Technology Development Activity #3 Design the Perfect Livestock Breed	20 minutes 20 minutes 20 minutes
At Home Activity	Livestock Transport Regulations	5 minutes
Wrap up, Social time and adjournment		10 minutes

Topic Information

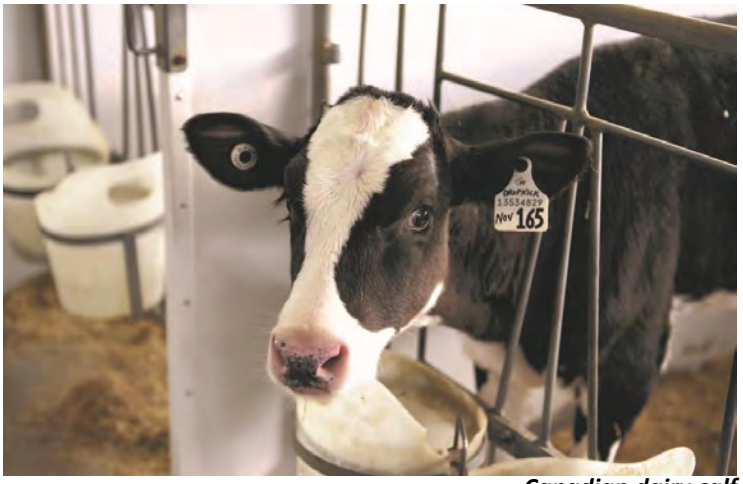
Precision Livestock Farming

As part of precision livestock farming (PLF), managing livestock is one of the current challenges for agriculture.

PLF uses a combination of tools and methods to measure different variables from each animal with high precision, supporting farmers to make decisions concerning the livestock production systems. Decisions are often based on the acquisition, collection, and analysis of quantitative data obtained by continuous real-time from animals and the environment. These tools include sensor technology cameras, microphones, wireless communication tools, Internet connections, and cloud storage, among others. However, the application of the existing tools for PLF can be challenging under extensive livestock management because this occurs on large farms and natural pastures that are large, heterogeneous, and highly dynamic environments. The main purpose of PLF is to enhance farm profitability, efficiency, and sustainability by improving on-farm acquisition, management, and utilization of data management and the utilization of data, in order to enhance the nutritional and other management aspects from distinct species of animals. PLF can also deliver additional food safety, traceability, welfare, and environmental benefits. In addition, PLF aims the management of crop processes to create synergy with livestock feeding.

Livestock Genetic & Reproduction

The classic example of a biotechnological revolution in animal breeding is the introduction of artificial insemination (AI) in dairy cattle breeding programs in the 1960's. Originally, AI was primarily introduced to prevent the passing on of infectious diseases via natural service. However, it was soon understood that AI, especially in combination with cryopreservation, has some major benefits compared with the conventional breeding system:



Canadian dairy calf
Image Source: Christa Ormiston

- the number of offspring per sire is substantially increased. While a bull used in natural service can sire hundreds of direct offspring during his lifetime, the most widely used AI bulls have more than one million direct offspring.

- mating a cow to a certain bull has become independent of the physical presence of the bull.
- the mating of a bull has become independent of time, especially so when cryopreservation is used.

Innovations and Technology in Animal Breeding

Animal breeding is technology driven. There are four criteria though that must be met in order for new innovations in animal breeding to be fully and successfully implemented:

- they must be suitable for daily use
- must provide an added breeding value
- should be cost efficient
- society must accept their application in the food chain.

If one of these criteria is critically missed, there is a high risk that a technology may fail.

Genomic Selection

Genomics is the study of all of a person's or animal's genes (the genome), including interactions of those genes with each other and with the person's environment.

Animal genomics can be defined as the study of looking at the entire gene landscape of a living animal and how they interact with each other to influence the animal's growth and development. Genomics help livestock producers understand the genetic risk of their herds and determine the future profitability of their livestock. By being strategic with animal selection and breeding decisions, genomics allows farmers to optimize profitability, efficiency and improve health of livestock herds.

Over the past decade, genomics has had tremendous impact on livestock breeding through genomic selection, which allows genetic gain based on available phenotypic records to be improved by leveraging information contained in a phenotype across all animals at an early age, rather than only across close relatives.

A phenotype is an individual's observable traits, such as height, eye color, and blood type. The genetic contribution to the phenotype is called the genotype. Some traits are largely determined by the genotype, while other traits are largely determined by environmental factors.

How does Genomics work?

An organism's complete set of DNA is called its genome. Virtually every single cell in the body contains a complete copy of the approximately 3 billion DNA base pairs, or letters, that make up the human genome.

Marker Assisted Selection

Marker-Assisted Selection (MAS) is a used for indirect selection of superior breeding animals. Marker-assisted breeding uses particular DNA sequences (markers) that are close neighbours to sequences that cause differences in the traits of individual organisms. By only looking for these markers, instead of having to sequence the whole genome of every organism we want to breed, we can improve these traits more quickly and economically. If there are many traits that we want to breed for at once, we can either increase the number of markers to be sequenced or sequence the whole genome!

Experience It!

Invite an AI Technician to your meeting to discuss the latest in breeding technology for use with livestock.
If possible, visit a Genetics facility that has animals on-site for semen collection.

Check It Out!

View the video titled Genomics solutions for the agriculture sector in Ontario, created by Ontario Genomics. It can be found at: https://www.youtube.com/watch?v=1wRMWgI-Cr-0&t=1s

Genomic Sequencing

Genome sequencing is a laboratory method that is used to determine the entire genetic makeup of a specific organism or cell type. This method can be used to find changes in areas of the genome. These changes may help scientists understand how specific diseases, such as cancer, form.

Two methods, whole exome sequencing and whole genome sequencing, are increasingly used in healthcare and research to identify genetic variations. Both methods rely on new technologies that allow rapid sequencing of large amounts of DNA. These approaches are known as next-generation sequencing (or next-gen sequencing). These methods are also used within the livestock industry to help make breeding decisions.

INNOVATION HIGHLIGHT

Make better cows and cool the planet.

That's the dual goal of a University of Guelph-led, international project intended to reduce climate-warming methane emissions from dairy cattle. The team is using genetics and genomics tools to breed cattle with enhanced health and fertility that process their feed more efficiently. Improve a cow's feed efficiency, and you can reduce the animal's methane emissions – produced mostly from burping out the gas – in the process.

Up to nearly one-third of a cow's feed efficiency is dictated by its genes. Genomic selection provides an elegant way of breeding cows that are more resource-efficient. They eat less but are just as healthy, just as fertile, and they produce just as much milk, but they do it with less resources.

Excerpts taken from: https://news.uoguelph.ca/2021/11/u-of-g-researchers-are-committed-to-reducing-global-methane-emissions/

Why is Genomics and Gene Transfer Important?

Gene transfer is a relatively rapid way of altering the genome of domestic livestock (also referred to as transgenic livestock). The use of these tools will have a great impact toward improving the welfare of animals as well a multitude of other benefits including:

- **Enhanced Nutrition for Humans** - Transgenesis allows improvement of nutrients in animal products, including their quantity, the quality of the whole food, and specific nutritional composition. Transgenic technology could provide a means of transferring or increasing nutritionally beneficial traits. The production of lower fat, more nutritious animal products produced by transgenesis could enable improvements in public health.

- **Nutrigenomics** – How nutrition impacts gene expression gives us the information to create the opportunity for precision nutrition. What and when a cow eats can affect how genes impact its health, immunity and growth rate. For example, it was previously believed cattle should be fed free-choice minerals and supplements, focusing on maximizing intake. But nutrigenomics has proven supplementing animals with specific levels of nutrients at specific times encourages the body to use those nutrients more efficiently, thereby increasing productivity and, ultimately, profit.

- **Reduced Environmental Impact** - Over the last few years, livestock production has been under attack as being harmful to the environment. However, the production of transgenic livestock has the potential to dramatically reduce the environmental footprint of animal agriculture. Increasing efficiency and productivity through transgenesis could decrease the use of limited land and water resources while protecting the soil and ground water. Improved production efficiencies of milk and meat would decrease the amount of manure, slow the direct competition for human food, decrease the amount of water required for the animals and the production facilities, and decrease the land necessary for livestock operations.

- **Enhancing Milk** - Advances in transgenic technology provide the opportunity either to change the composition of milk or to produce entirely novel proteins in milk. he improvement of livestock growth or survivability through the modification of milk composition involves production of transgenic animals that: (1) produce a greater quantity of milk; (2) produce milk of higher nutrient content; or (3) produce milk that contains a beneficial 'nutraceutical' protein

- **Enhancing Growth Rates and Carcass Composition** - The production of transgenic livestock has been instrumental in providing new insights into the mechanisms of gene action implicated in the control of growth. It is possible to manipulate growth factors, growth factor receptors, and growth modulators through the use of transgenic technology. Another aspect of manipulating carcass composition is that of altering the fat or cholesterol composition of the carcass. By altering the metabolism or uptake of cholesterol and/or fatty acids, the content of fat and cholesterol of meats, eggs, and cheeses could be lowered. There is also the possibility of introducing beneficial fats such as the omega-3 fatty acids from fish or other animals into our livestock. In addition, receptors such as the low-density lipoprotein (LDL) receptor gene and hormones like leptin are potential targets that would decrease fat and cholesterol in animal products.

- **Enhanced Animal Welfare through Improved Disease Resistance** - Genetic modification of livestock will enhance animal welfare by producing healthier animals. Animal welfare is a high priority for anyone involved in the production of livestock. The application of transgenic methodology should provide opportunities to genetically engineer livestock with superior disease resistance. One application of this technology is to treat mastitis, an inflammation of the mammary gland, typically caused by infectious pathogen(s). Mastitis causes decreased milk production. Transgenic dairy cows that secrete lysostaphin into their milk have higher resistance to mastitis due to the protection provided by lysostaphin, which kills the bacteria Staphylococcus aureus, in a dose-dependent manner. Lysostaphin is an antimicrobial peptide that protects the mammary gland against this major mastitis-causing pathogen.

DID YOU KNOW?

Research is utilizing genetics to turn off the small receptor that allows the Porcine Reproductive and Respiratory Syndrome (PRRS) virus to develop in pigs.

DID YOU KNOW?

Progress in research has produced prion-free and suppressed prion livestock. Prions are what cause bovine spongiform encephalopathy (BSE) or 'mad cow disease' in cattle and in Creutzfeldt-Jacob disease (CJD) in humans.

Check It Out!

Animal welfare is important to all, but especially to farmers and scientists who study genomics. In this video, you'll learn how genomics is helping the pork industry in Canada breed pigs that are more resilient and less susceptible to stress. Watch the video titled 'Genomics and Animal Welfare in Canadian Agriculture' created by Farm & Food Care.
https://www.youtube.com/watch?v=IvLo81_wMRg

- **Improving Reproductive Performance and Fertility** - Several potential genes have been identified that may profoundly affect reproductive performance and fertility. As examples, introduction of a mutated or engineered estrogen receptor (ESR) gene could increase litter size in a number of diverse breeds of pigs. A single major autosomal gene for fertility, the Boroola fertility (FecB) gene, which allows for increased ovulation rate, has been identified in Merino sheep.

- **Improving Hair and Fiber** - The control of the quality, color, yield, and even ease of harvest of hair, wool, and fiber for fabric and yarn production has been another area of focus for transgenic manipulation in livestock. The manipulation of the quality, length, strength, fineness, and crimp of the wool and hair fiber from sheep and goats has been examined using transgenic methods. In the future, transgenic manipulation of wool will focus on the surface of the fibers. Decreasing the surface interaction could decrease shrinkage of garments made from such fibers.

Excerpts from: Transgenic Animals in Agriculture, Matthew B. Wheeler (Departments of Animal Sciences and Bioengineering, University of Illinois at Urbana-Champaign)

Other Technologies and Advancements in Livestock Breeding

Sexed Semen

The technology in current use for sexing sperm represents remarkable feats of engineering. These flow cytometer/cell sorters can make over 30,000 consecutive evaluations of individual sperm each second for each nozzle and sort the sperm into three containers: X-sperm, Y-sperm and unsexable plus dead sperm. Even at these speeds it is not economical to package sperm at standard numbers per inseminate. However, with excellent management, pregnancy rates in cattle with 2 million sexed sperm per insemination dose are about 80% of those with conventional semen at normal sperm doses. The main application is for dairy heifers to have heifer calves, either for herd expansion or for sale as replacements.

Estrus Detection

Using leg pedometers to detect estrus in cattle
Image Source: Conception – Animal https://www.conception-animal.com/en/detection-chaleurs

Various products are on the market using wireless technology and include boluses that send information from the reticulum of the cattle as well as ankle/neck pedometers. Both systems send information wirelessly to a computer or Smartphone. The systems also detect early warning signs of possible health and welfare conditions (lameness, abortions, etc.).

JUDGE IT!

Choose 4 dairy animals of approximately the same age (or 4 of any other type of livestock) and judge the animals based on the appropriate scorecard found in the 4-H Ontario Judging Manual. If livestock are not available, use pictures instead. Have members rank (judge) the livestock and give their reasons for their placing.

Frozen Storage of Oocytes and Embryos

An oocyte is an immature egg (an immature ovum) that has not been fertilized. An embryo is an oocyte that has been fertilized.

The biochemical and metabolic activities of living cells are virtually stopped at ultralow temperature and they enter into a suspended state of animation. Cryopreservation is the method for preserving living cells at ultralow temperature at genetically and physiologically stabilized state. Cryopreservation of oocytes and embryos is an integral part of the assisted reproductive technologies with many potential applications. Cryo-banking of oocytes and embryos derived from genetically superior animals is promising for enhancing the outcome of planned breeding programs and conserving biodiversity of endangered animal species. Cryo-banking can also ensure steady supply of oocytes and embryos for many downstream applications of assisted reproduction such as in vitro embryo production, embryo transfer, production of stem cells, and genetic engineering. Tremendous advancements have been made in this field over the past 5 decades and several methods have been established for cryopreserving oocytes and embryos in different species.

In Vitro Fertilization and Embryo Culture

In vitro production (IVP) of embryos and associated technologies in cattle have shown significant progress in recent years, in part driven by a better understanding of the full potential of these tools by end users. The combination of IVP with sexed semen (SS) and genomic selection (GS) is being successfully and widely used in North America, South America and Europe. The main advantages offered by these technologies include a higher number of embryos and pregnancies per unit of time, and a wider range of potential female donors from which to retrieve oocytes (including open cyclic females and ones up to 3 months pregnant), including high index genomic calves, a reduced number of sperm required to produce embryos and increased chances of obtaining the desired sex of offspring. However, there are still unresolved aspects of IVP of embryos that limit a wider implementation of the technology, including potentially reduced fertility from the use of SS, reduced oocyte quality after in vitro oocyte maturation and lower embryo cryotolerance, resulting in reduced pregnancy rates compared to in vivo–produced embryos. Nevertheless, promising research results have been reported, and work is in progress to address current deficiencies. The combination of GS, IVP and SS has proven successful in the commercial field in several countries assisting veterinarians and cattle producers to improve reproductive performance, efficiency and genetic gain.

Excepts from Cambridge University Press

Nuclear Transplantation

Nuclear transplantation is a method in which the nucleus of a donor cell is relocated to a target cell that has had its nucleus removed (enucleated). Nuclear transplantation has allowed experimental embryologists to manipulate the development of an organism and to study the potential of the nucleus to direct development. Nuclear transplantation, as it was first called, was later referred to as somatic nuclear transfer or cloning.

Research It & Debate It!

Dolly the Sheep was created as a result of a Nuclear Transplantation experiment in 1996. This sparked a lot of debate and controversy about cloning. Find out why this experiment was so controversial and discuss/debate the pros and cons of nuclear transplantation.

Animal Identification

RFID tag for beef cattle

Radio Frequency Identification (RFID) is the wireless non-contact use of radio frequency waves to transfer data. RFID systems usually comprise an RFID reader, RFID tags, and antennas. Tagging animals with RFID tags allows farmers to automatically and uniquely identify livestock.

Within the Electromagnetic Spectrum, there are three primary frequency ranges used for RFID transmissions – Low Frequency, High Frequency, and Ultra-High Frequency. Livestock tags use Low Frequency transmissions.

An RFID tag in its simplest form, is comprised of two parts – an antenna for transmitting and receiving signals, and an RFID chip (or integrated circuit, IC) which stores the tag's ID and other information. RFID tags are affixed to items in order to track them using an RFID reader and antenna.

RFID tags transmit data about an item through radio waves to the antenna/reader combination. RFID tags typically do not have a battery (unless specified as Active or BAP tags); instead, they receive energy from the radio waves generated by the reader. When the tag receives the transmission from the reader/antenna, the energy runs through the internal antenna to the tag's chip. The energy activates the chip, which modulates the energy with the desired information, and then transmits a signal back toward the antenna/reader.

RFID tags are mandatory in many types of livestock in Canada including cattle, sheep, pigs, bison and cervids (farmed deer). The tags are important for both identification and for animal movement and traceability.

Sensor Technology that Monitors Animal Health

Sensor technology for animal health monitoring is becoming an essential component of agricultural technology that is continuously being explored. Scientists have created sensor technology for animal health monitoring - a wearable sensor gadget for animals that can monitor vital indicators such as pulse rate, heartbeat, and respiration in animals through their fur/hair. As was mentioned briefly above in the Estrus Detection section, animal sensors can be used for estrus detection and much more.

Why Should We Use Animal Sensors?

There are various sorts of sensor technology for animal health monitoring that is currently in use for efficient monitoring systems, whether for people or animals. An animal sensor is a device that detects physiological or behavioral factors that are associated with the cattle's health or ovulation and permits you to take control of these factors. These animal sensors also detect on-farm shifting in this state which is connected to several health conditions also including illness. Moreover, this sensor technology for animal health monitoring necessitates the intervention of farmers, for instance, the treatment of livestock for their illnesses.

CAREER ALERTS!

*Check out these exciting animal **health/technology** careers!*

- Farmer
- Artificial Insemination Technician
- Livestock Veterinarian
- Veterinary Surgical Technician
- Emergency and Critical Care Veterinary Technician
- Zoo Veterinary Technician
- Veterinary Pharmaceutical Sales Rep.
- Livestock Transporter
- Animal Nutritionist
- Animal Behaviourist
- Animal Research Scientist
- Animal Technician
- Laboratory Technician

Experience It!

Invite a guest to your meeting that sells animal health sensors.

Recent Advances in Wearable Sensors for Animal Health Management

Image Source: techjournal.org

Recent advances in wearable sensors for animal health management and their use is becoming essential these days. If these types of equipment are constructed properly and utilized appropriately, these animal sensors can enable timely identification of illnesses in animals; ultimately, it will reduce economic damages. These gadgets are especially beneficial on dairy and poultry farms. On-site monitoring sensors are more beneficial rather than entirely depending on a farmer's instincts and knowledge. These animal sensors can give trustworthy data regarding the physical state of the animals.

Because of their improved performance of Wearable technology for animals, Livestock monitoring sensors and Biosensors for animals have the potential to create a revolution in farming activities and have the opportunity to be one of the most influential and realistic in the sensor technology for animal health monitoring.

Recent advances in wearable sensors for animal health management are being developed to address the requirements of livestock, animals, and pets. Medicinal fixes, monitoring collars, and digital saddle modification are being acquired at a larger rate and leveraged for the healthy raising of domestic animals. This Wearable technology for animals is versatile and effective. Also, permitting pet owners to accomplish more achievements in less period.

This sensor technology for animal health monitoring can be implanted in animals to identify their sweat contents, their body temperature, behavioral activities and movement of animal, stress level of the animal, analyze sound level, measure pH level, help in the prevention of disease, identify analytes, and indicate the existence of infections and pathogens in their blood. Wearable technology for animals assists farmers in detecting illness at earlier stages and therefore preventing animal fatalities. By using these predictions, farmers may also remove sick animals early in time and avoid disease spread in entire cow herds.

This sensor technology for animal health monitoring is classified into two types:

- *Attached sensor technology for animal health monitoring*:

Recent advances in wearable sensors for animal health management can be known as on-cow attached animal sensors, which are attached to the exterior of the livestock's body such as implanted sensors and rumen bolus.

- *Non-attached sensor technology for animal health monitoring*:

Recent advances in wearable sensors for animal health management of this type of sensors are also known as off-animal sensors that are capable of measuring the health of cattle by their movement, how they pass by, or through them. Further, there are non-attached animal sensors available which include In-line livestock monitoring sensors and online livestock monitoring sensors. In-line livestock monitoring sensors detect the production of milk from the cow in real-time. The dairy edge is the sole accessible choice for in-line Livestock monitoring sensors measurement. Online livestock monitoring sensors automatically collect a sample such as milk that is then examined by the Livestock monitoring sensors.

Wearable Technology for Animals

Recent advances in wearable sensors for animal health management are being developed to address the requirements of livestock, animals, and pets. Medicinal fixes, monitoring collars, and digital saddle modification are being acquired at a larger rate and leveraged for the healthy raising of domestic animals. This Wearable technology for animals is versatile and effective. Also, permitting pet owners to accomplish more achievements in less period.

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Applications of Wearable Technology for Animals

The sensor technology for animal health monitoring helps in various sectors, and there are various applications of Wearable technology for Animals. Among all applications of sensor technology for animal health monitoring; Wearable technology for Animals few are going to be listed below:

- ***Analyzers for Sweats***

Sweat analysis can provide important information regarding the health of animals of an individual. Wearable sweat monitors have yet to enter the commercial market; it is not introduced in the market yet owing to size restrictions of a device. Although, there are experiments of low-budgeted robust designs that are going on to produce such sensor technology for animal health monitoring. Iontophoresis, which uses an electrical current to push a pharmacological stimulator into the skin of an animal, is one way for gathering sweat.

But there is a requirement of such sensor technology for animal health monitoring that does not only acquire the sweat of an animal but also analyze it and maintain perspiration during the day or as needed. Recent advancements in sensor technology for animal health monitoring, such as sweat monitors, seek to reduce the device's size so that it is wearable and convenient to use. Reusable potentiometric patches coupled with microfluidic microchips have been created for real-time sweat sodium monitoring, and they are linked to a small wireless device to monitor sodium intake in sweat. In addition, assessing different electrolytes at the same time is more helpful.

Image Source: techjournal.org

Biosensors For Animals

Aside from accumulating valuable information about animal care and overall farm surveillance, it can be made much easier and more credible by using biosensors for animals incorporated with mobile phones and portable devices rather than traditional methods like taking notes, maintaining a farm journal, or using minimal recent advances in wearable sensors for animal health management without information capabilities.

A variety of solutions for smartphones and portable devices have been created to decrease the burden of physical record keeping. Data can be automatically collected by solar-powered sensors installed on animals and sent to a centralized computer. The finished data may be readily seen on a bespoke display or workplace PC, making this technology extremely useful for farmers.

A device that consists of biosensors for animal monitoring that connects to the ears of livestock and measures their body temperature currently costs approximately $100,000 that can be used for around 10,000 cattle.

DISCUSS IT

What other uses can you think of for biosensors outside of the agriculture industry?

These recent advances in wearable sensors for animal health management, biosensors for animal wristbands are easily available in the market and these animal sensors can also be utilized for cattle to identify estrus. A new robotic feeding system employs electronic ankle bands that communicate with sensors put on the animal to capture data on the eating and milking behavior and patterns of an animal.

Applications of Biosensors for Animals

The sensor technology for animal health monitoring helps in various sectors, and there are various applications of Biosensors for animals. But nowadays, the application of biosensors for animals is currently restricted in the field, because the sensing element is impacted by a variety of factors, including ambient conditions and the kind of molecules. Furthermore, the size of the sensor technology for animal health monitoring might impact the effectiveness and functionality of a biosensor for animals. Among all applications of biosensors for animals few are going to be listed below:

- ***Provide Safe Meat***

To fulfill the rising worldwide need for processed poultry and meat products. To get safe meat, it is a major issue to produce high-quality meat. As increased demand arrives, this becomes more sensitive to animal health. Sensor technology for animal health monitoring, biosensors for animal health monitoring devices that may be incorporated within an animal's body, patched beneath its skin, or stay in its stomach provide important information to animal owners about their behavior and medical problems. These recent advances in wearable sensors for animal health management are intended to be utilized for animal health, monitoring the heating and cooling requirements for animals.

- ***Identification of Antibiotics***

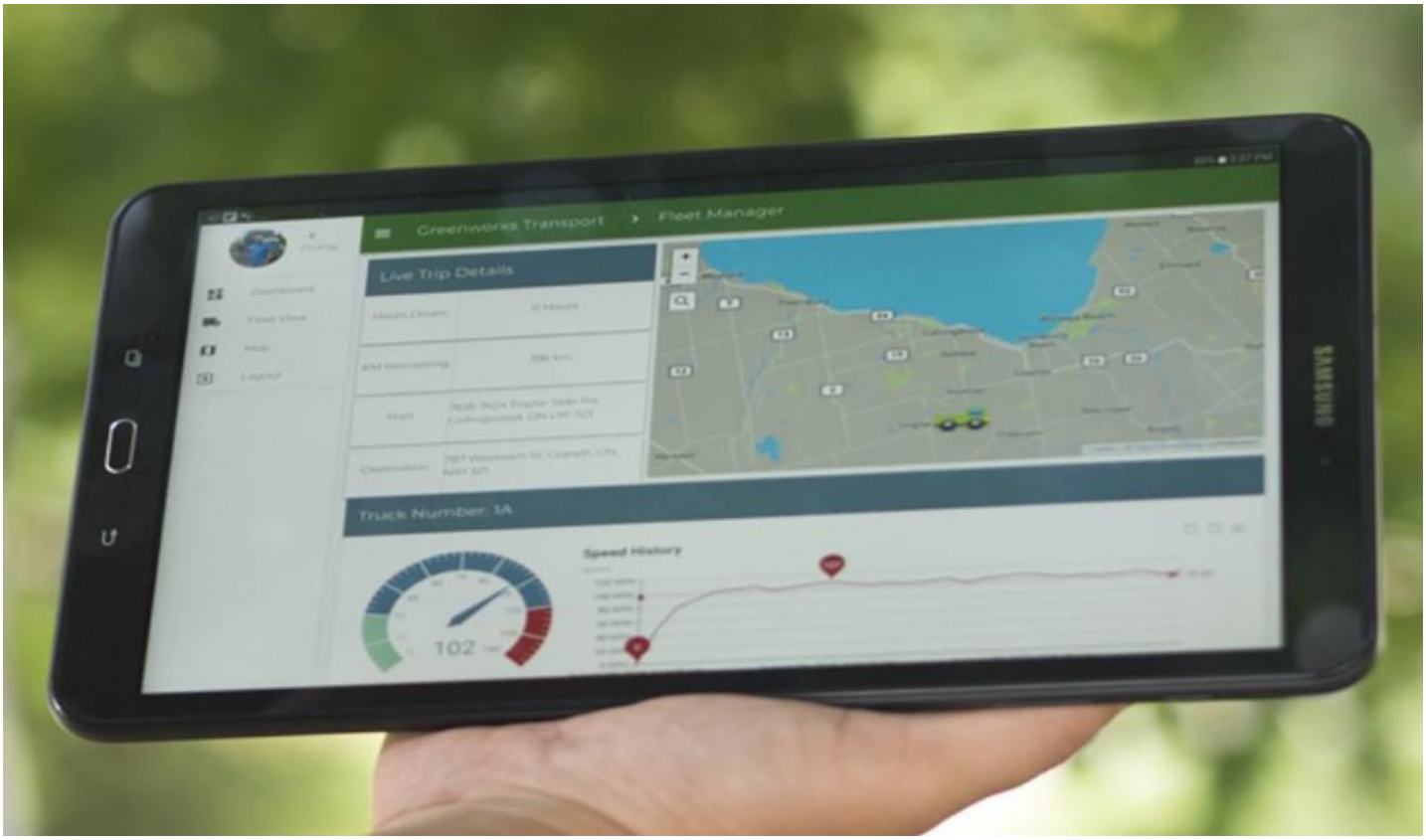
Another significant application of sensor technology for animal health monitoring; biosensors for animals are antibiotic identification. Antibiotic resistance is becoming a serious concern to farmers as a result of the unrestricted and regular use of medications in the livestock sector. Farmers urgently need to adopt these types of substitutes to prevent animals from growing immune to intravenous antibiotics.

- ***Microfluidics Detection***

Microfluidics allows the fast identification of analytes, and this seems to be another innovation that is gaining popularity. The monitoring of analytes is critical in many areas, which include food security, and this technique has shown to be useful in this respect. Microfluidics technology allows for the use of tiny samples that can be identified rapidly and result in minimal reagent waste. Furthermore, the use of microfluidics technologies in POC operations has proven effective since it decreases the danger of cross-infection significantly. The usage of documented and thermoplastic microchips has changed the development of disease diagnostic systems.

Currently, paper-based chips eliminate the requirement for sample preparation. On the other hand, these thermoplastic microchips are practical since they are recyclable and economical.

Excerpts taken from techjournal - How to Use Sensor Technology For Animal Health Monitoring



Transport Genie monitoring screen
Image Credit: Transport Genie

Livestock Transport

Farmers are concerned with the welfare of their livestock and that concern doesn't end once their animals are in transit. Technology like Transport Genie, developed by Canadian agri-tech company Transport Genie Ltd., based in Burlington, Ontario, enables farmers and truckers to effectively monitor animals in transit to ensure their welfare needs are being met.

Transport Genie monitors microclimate conditions inside livestock trailers and uses blockchain technology to store and share that information with truck drivers and other users along the supply chain in a secure, tamperproof way. The sensors can be configured to monitor variables such as temperature and humidity, as well as CO2 levels and a wide range of other factors, including driving conditions and driver behaviour such as braking and acceleration. They can also be used to control devices such as cooling fans, misters and drinkers to keep animals comfortable and hydrated. The system provides accurate real-time data to drivers who can then make adjustments to resolve any issues without stopping the vehicle.

Experience It!

Invite someone from the livestock trucking industry to your meeting to discuss the latest technology advances for transporting livestock.

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

At Home Activity

Livestock Transport Regulations

The regulations for transporting livestock have increased in recent years. Find out what the current regulations are for transporting livestock from (long or short haul). How is/could technology help to meet these regulations?

Be prepared to share your answers at the next meeting.

Digging Deeper

For Senior Members
Courtesy of Ontario Genomics

Emerging Technology in the Livestock Sector

Read through the projects below that are two of a number of exciting projects that focus on improving the livestock industry in a variety of ways (environment, reproduction, animal welfare). Are there more new and emerging technologies that have been developed that either add to the work being done below or that address another issue in the livestock sector? Be prepared to share your findings at the next meeting.

Cattle Genetics

Beef and dairy cattle are key livestock for the Canadian agriculture sector, contributing tens of billions of dollars to the economy each year. There are many ways in which science and technology, and especially genomics, are contributing to ensuring that our cattle industry remains profitable while mitigating its effects on the environment and promoting animal welfare. A few projects related to this are:

1. Decreasing methane production / improving feed efficiency

Livestock are both affected by, and contribute to, climate change. One of the ways in which cattle contribute to climate change is through the production of methane. Methane is a biproduct of digestion and can be modulated through changing a cow's feed or by creating cattle who are more efficient digesters. As with many of the traits listed below, how efficiently a cow converts its feed to energy is at least partly regulated by that cow's genes. By analyzing the genomes of many cattle, using DNA sequencing, and then analyzing how much methane they produce when given an optimal feed, scientists can select for cattle that produce less methane. This requires the help of many pieces of technology, including feed bins with integrated scales to determine exactly how much a cow is eating in a given time, methane sensors which can accurately measure the cow's emissions over time, and of course the equipment needed to sequence each cow's DNA.

2. Use of sensors to track fertility and climate-related stress

Dairy cow performance (such as growth, milk production, and reproduction), as well as animal welfare and health, can be strongly influenced by air temperature, humidity, and other climatic factors. This is especially important in the age of anthropogenic climate change when fluctuations in weather are becoming more prevalent. Genetic selection plays a key role in breeding livestock that can better cope with changing climate, and more specifically, tolerate extreme temperatures and humidity and changes thereof. By integrating phenotypic data collected using automated sensor technologies (think FitBits for cows!) with high-throughput genotypes of dairy cows through application of artificial intelligence algorithms, scientists can select robust dairy animals which are resilient to environmental stressors, such as extreme hot/cold temperatures, while maintaining health, production, and reproductive efficiency.

Activity #1 - Creating DNA

Do

Time: 20 minutes

DNA is an abbreviation which stands for deoxyribonucleic acid. DNA is present in all living things. Also, the structure of the DNA molecule is the same in all living things. When isolated from a cell and stretched out, DNA looks like a twisted ladder (double-helix). The sides of the DNA ladder are called the backbone and the rungs of the ladder are pairs of small chemicals called cases.

There are 4 chemical bases in DNA:
Adenine (A)
Thymine (T)
Guanine (G)
Cytosine (C)

A always binds with T and G always with C.

Materials Needed:
Strands of licorice
Colouring mini marshmallows (for a healthier alternative, use fruit)
Toothpicks
DNA code (found on the next page)

Instructions:
Using the code on the page following this activity, create one DNA strand by attaching the marshmallows with a toothpick to one licorice piece using the DNA code given on the next page (place toothpicks into the licorice, then push the marshmallow onto the toothpick close to the licorice, leaving enough room for the second matching DNA strand to be attached).
Add the matching base pairs.
Complete the DNA model by attaching the other backbone (licorice) so the model looks like a ladder.
Carefully twist the DNA model so that it looks like a double helix.

Reflect

Learning Outcomes:
To allow members to become familiar with how DNA is structured

Apply

Processing Prompts:
• Why is it important to know what the structure of DNA looks like and how it functions?
• Was it hard to create the DNA strand?
• How does DNA fit with the study of genomics?

DNA Challenge!

Create the following DNA strand:

T A C G T A T G A A A C

Remember!

A always binds with T, and G with C

Guanine (G) = Green

Cytosine (C) = Pink

Adenine (A) = Yellow

Thymine (T) = Orange

Activity #2 - Thoughts and Pressures Affecting Technology Development

Do	Time: 20 minutes **Materials Needed:** • Paper and a writing utensil for making notes **Instructions:** • Have members read the following: *For years, our understanding of genetics has been used to improve agricultural practices and food production. Conventional plant and livestock breeding have shaped many of the food products we enjoy today. More recent advances in biotechnology are allowing us to address agricultural issues that were inconceivable with standard genetic technologies. One such advancement is the development of gene-editing technologies that may be used to improve the welfare of farm animals, potentially benefiting farmers and broader. However, people have also expressed concern about the use of biotechnology in food production. This concern — as well as supply chain constraints — can lead to resistance to adopting these technologies by producers, processors, retailers, food service, and other supply chain stakeholders. Research is ongoing to focus on an understanding of perception, trust and adoption among all interested groups from farmers to consumers.* *The introduction of genetically modified foods was largely met with mistrust and skepticism. We must therefore ask: What factors affect societal acceptance of these technologies?* *Taken from GenomeCanada: https://www.genomecanada.ca/en/barriers-and-opportunities-commercialization-gene-edited-beef-and-dairy-products* • Have members work in small groups to come up with a list of factors that will help society accept new genetic technologies • Have each group present their list • If time permits, divide the group in two. Have one group debate why all genetic technologies should be accepted by society with the other group takes the stance that genetic technologies should not be trusted or accepted
Reflect	**Learning Outcomes:** • To have members realize that not all new genetic technologies will be readily accepted by society. • To have members critically think about factors that will help society to accept new genetic technologies.
Apply	**Processing Prompts:** • Was it easy or difficult to come up with a list of factors? • Are you surprised that some new genetic technologies are not readily accepted by society? Why are you surprised? • Can you think of a new technology that was never accepted by society and was never developed any further? • Was it difficult to defend the side you were on for the debate?

Activity #3 - Design the Perfect Livestock Breed

Do	Time: 20 minutes **Materials Needed:** • List of traits (found on the next page) • Hat/bowl/bag • Paper • Writing utensil **Instructions:** • Print out list of traits. Cut into individual traits and put into a hat. • Have members choose three traits out of the hat. • Using those traits (and those traits only), they should draw and describe in words their 'perfect livestock animal' and share with the others.
Reflect	**Learning Outcomes:** • To have members think about desirable traits in livestock animals • To allow members to be creative when drawing and describing their perfect animal • To continue to develop critical thinking skills
Apply	**Processing Prompts:** • Why is it important to know which traits are desirable in livestock? • Was it easy or difficult to create your perfect livestock animal? • Did you like the traits that you picked from the hat? • Were there other traits you would have liked your animal to have?

Livestock Traits

Good mothering ability
High milk production
Nutritionally efficient
Ease of birthing
Efficient rate of gain
Disease resistant
Structurally sound
Longevity of life
Tall stalk
Protective of offspring
Short gestation/multiple births per year
Produces low rate of methane
Good fertility
Calm and docile temperament
Good muscle growth

Meeting 5 – Technology in the Barn

Setting Objectives:
To learn what technologies are available for animal husbandry for various types of livestock.

Suggested Learning Outcomes:
- To understand what technologies are available in barns and on pasture for various types of livestock
- To gain an appreciation of how quickly various technologies are being developed and adopted for commercial use in barns
- To consider how these technologies could be used in other industries
- To discover careers related to the technologies presented in this meeting

Suggested Roll Call Questions:
- How can technology help truckers and farmers to meet livestock transport regulations? (At Home Activity Mtg #4)
- Name one piece of technology that farmers use in the barn
- What is one thing farmers do to ensure that animal welfare is a high priority in the barn?
- Name one advantage to having video surveillance in a barn
- Name one piece of technology used in the barn that wouldn't have been used 50 years ago

SAMPLE MEETING AGENDA Time: 4 hour 35 minutes

NOTE: this meeting has a lot more content than what can be covered in a two-hour meeting. It is suggested to choose one type of livestock to focus on for a meeting. Some technologies presented in this meeting are for all types of livestock housing but some technologies are specific to each commodity.

Welcome, Call to order, Pledge		10 minutes
Roll Call		10 minutes
Parliamentary Procedure	Minutes and Business	10 minutes
Topic Information, Discussion & Activities	**Topic Information** • Barn, Feedlot & Pasture Technology ◊ Alarm systems, video systems in barns, augmented reality • Tech in Cattle Barns & Pasture ◊ Temperature-controlled barns, robotic feeding systems, robotic feed pushers, herd management software ◊ Dairy Specific » Robotic milkers, parlor milking, tie stall milking, tech in the milk house, manur management, robotic cal feeders	120 minutes

	◊ Beef Specific Technology » Sensors, GPS trackers, drones, artificial intelligence, robotic cattle driver • Tech in Pig Barns ◊ Artificial intelligence, robots, sensors, drones, IoT, automated individual feedings, temperature & environmental control • Tech in Poultry Barns ◊ Robots, 3D printing prosthetics, drones, sensors, artificial intelligence, virtual reality, IoT • Tech in the Sheep Industry • Tech in the Goat Industry Activity #1 Breakthrough Technologies Activity #2 Technology in the Barn Word-search Activity #3 Design Your Own Barn	 30 minutes 20 minutes 60 minutes
At Home Activity	Introducing Technology	5 minutes
Wrap up, Social time and adjournment		10 minutes

Topic Information

Barn, Feedlot and Pasture Technology

Alarm Systems in Barns

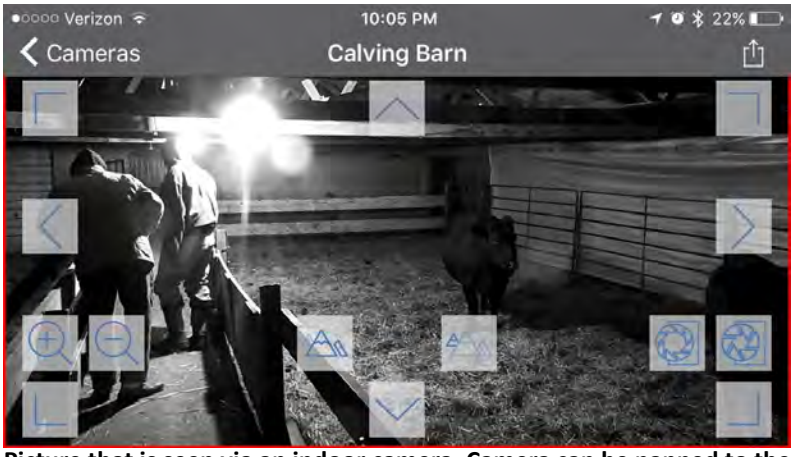
Remote sensors, alerts and alarms can aid in quickly and reliably detecting power outages for failures, dangerous temperatures, feed system malfunctions and water supply problems. An advanced network of wireless sensors integrates with the equipment in the barn and allows the farmer to monitor the barn from any computer, cell phone or tablet. Systems can be customized to receive alarms via text message, e-mail or phone.

Find Out More!

What companies are in your area that sell sensor technology for livestock barns? Do they specialize in one type of livestock barn? Choose one type of livestock barn and find out what it would cost for sensor technology for the barn.

Video in Barns

Labour is one of the most valuable resources on a farm and farmers often try to utilize their time wisely to decrease hours spent on certain tasks. Producers can potentially decease time spent in certain areas of the farm with the use of modern video technology thus allowing them to multitask. Cameras are beneficial both inside the barn and outside in pasture fields as well as in farmyards for security.



Picture that is seen via an indoor camera. Camera can be panned to the left and right, up and down, as well as zoomed in.
Image Source: Conception – Christy Mogck, South Dakota State

Barn and pasture cameras need to be able to:

- transmit the image to a remote device such as a computer, cell phone
- have clear night vision
- have a weather resistant design

Most video systems use WiFi capability although there are systems that have other options. The 4G wireless cameras for barns are designed to work without WiFi and Internet. They operate on a 3G/4G mobile network and allow for live viewing from anywhere and anytime on a cell phone.

Outdoor camera image, allowing producers to watch cows not penned in a barn for calving activity.
Image Source: Conception – Christy Mogck, South Dakota State
tate University Extension

DISCUSS IT

What other types of businesses could use video surveillance? What advantage could it provide to these businesses?

Augmented Reality Smart Glasses
Image Credit: https://www.queppelin.com/augmented-reality-in-agriculture/

Augmented Reality (AR)

A newer concept, augmented reality combines real-world observations with virtual-world information by using only a pair of glasses or your cellphone, allowing users to enhance their vision to make better management decisions.

For example, one new farming technology projects images of 3D objects from architectural drawings, allowing producers to see a new feedlot projected around them before they ever build it. Another possibility is being able to walk through the feedlot or barn for any type of livestock and immediately see health statistics for each animal through augmented reality goggles.
AR can add information to what the viewer sees with their eyes and can use light spectra that the human eye cannot. Examples for use include

enhanced decision making by production workers, machine repair or for certification and inspection during auditing processes. Similar to AI (artificial intelligence), errors can be caught faster, reducing processing hazards before they become dangerous. In the processing plant AR allows the opportunity to see potential food borne illness concerns, such as bacteria on food, and avoid food scares.

Discover It!

The world of augmented reality is changing quickly with more concepts and tasks that can be done using augmented reality being developed every day. Make a list of tasks that can be completed using augmented reality.

Technology in Cattle Barns and Pasture

Most technology is created for the dairy industry and then adapted for the beef industry. Many types of technology are developed for the cattle industry, however because of economical reasons, the beef industry tends to be slower than the dairy industry to adopt technology.

Check It Out!

Visit https://www.youtube.com/watch?v=SqiP804BIeo&t=15s to see how robots are being used in Dairy Barns. When watching the video, keep in mind that some of the robotic technology in the video can also be used in Beef Barns.
Video credit: Canadian Food Focus.

For this section, we'll look at technology that can apply to both the dairy and beef industries. Further into the meeting, we'll look at technology that is specific to each sector.

Cattle Industry Technology

Temperature-Controlled Barn

Ventilation systems are intended to provide optimum living conditions for cattle. A well-managed, functioning, and efficient ventilation system has a significant effect on productivity and animal welfare. Cattle that are comfortable and not affected by heat stress produce more milk (dairy); will gain weight more efficiently (beef), have lower respiration rates, higher conception rates, and better health.

The three most common types of ventilation in cattle barns are all-natural, mechanical/natural and all-mechanical.

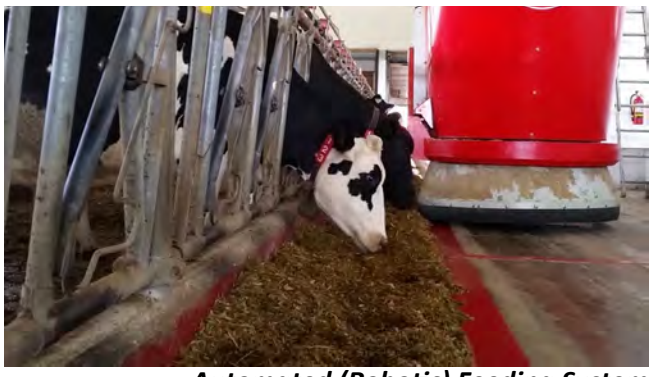
Sensors in barns can control lights, fans and curtains to maintain a comfortable environment for livestock when using a mechanical/natural or all-mechanical system of ventilation.

Sensors can also collect data about the climate in and around the barn, the health of the animals and the smell emissions. Various sensors measure the inside and outside temperature, CO2 (carbon dioxide) and ammonia levels, water consumption, air pressure and humidity. Via the dashboard on a phone, PC or tablet farmers have direct insight in the form of graphs, alerts and summaries

Robotic TMR (Total Mixed Ration) Feeding System

A number of different automatic (robotic) feeding systems are currently available on the market. These can be combined and used to meet individual farm requirements. There are three different stages that the robotic feeding system performs:

- Stage I: Filling Mixer
- Stage II: Mixing
- Stage III: Distribution



Automated (Robotic) Feeding System
Image Source: Conception – Canadian Food Focus

Automatic feeding means that cattle are fed with precision.

Farmers can define exactly the right ingredients needed to feed each group of animals, including beef cattle. This has a positive influence on feed efficiency, and the development and production of the animals.

Experience It!

Visit a dairy barn that has implemented some (or all) of the technologies listed in this meeting. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

Feeding more frequently stimulates eating, so it benefits animal health, fertility and production. Eating several times a day keeps the pH value of the rumen constant and allows cattle to make better use of the ration they eat. Animals become more active. Dairy cattle visit the milking robot more often, resulting in an increased output of milk.

Feeding more frequently ensures there is always enough fresh feed in the manger. The robot senses when it is time for a new feeding round. The mixing and feeding robot measures the feed height of a specific section to determine when the ration needs to be supplemented, so there is never too much or too little feed in the manger.

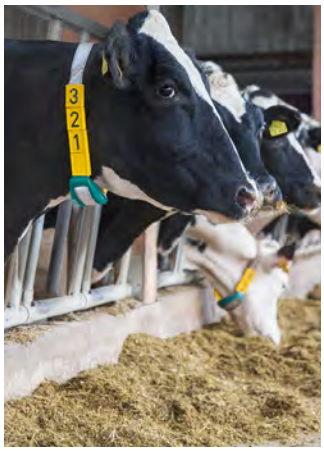
Robotic Feed Pusher

Cows can get a little messy with their food. Just like a Roomba spins through your house, this automated feed pusher keeps feed within reach of cows so they never go hungry.

Robotic Feed Pusher
Image Credit: https://settje.com/

Herd Management Software

Various types of technology are available to monitor individual cow health and activity. This technology can come in the form of neck tags, collars or ear sensors. It monitors the herd 24/7 in any situation and is a tool for continuously monitoring the fertility, health, nutrition and location of the herd, receiving real-time information on to a smartphone and/or other devices.



The neck collar is used for heat detection, health monitoring and cow location.
Image Credit: GEA

Dairy-specific Technology

Robotic Milkers

With robotic milking (also called AMS – automatic milking system), cows are able to walk up to a robotic milking machine to be milked, whenever they want to. These machines can also function to give feed or supplements to the cows, as well as track body weight, milk yield, temperature, and more to help with health and wellness tracking.

Each cow wears a collar that tracks all kinds of data, from how much milk she gave, to her digestive activity, to her temperature. The collar also helps the robot decide whether it's time for her to be milked.

Check It Out!

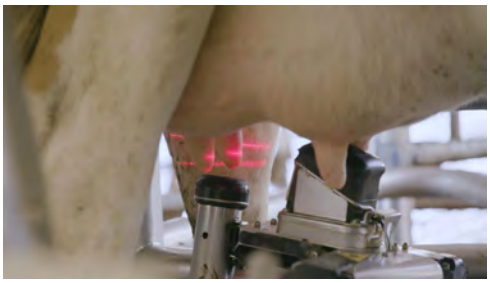
Watch this video produced by the Dairy Farmers of Canada which gives an overview of the technology used in the dairy industry and why its important to have this technology. https://www.youtube.com/watch?v=pUNnD24M4LY&t=77s

If it isn't time, the robot won't start when she walks up to it. If it is, the robot will drop grain, close a pen around her, and go to work.

A robot arm comes around to brush and clean the teats and stimulate her to drop her milk down. There are two ways it knows where to put the teat cups. On top of the unit, there is a camera that's shining down on the cow to see where she is positioned in the robot. The computer knows the coordinates of where the teats are from memory of the last time it milked her. Then the laser will shine on the teats and identify exactly where it is to go up on it.

Robot brushing the teats to clean them and stimulate the cow to let her milk down
Image Credit: Robotic Milking 101 – Cabot Creamery

Robotic (Automatic) Milking System (AMS)
Image Credit: Progressive Dairy: Canada



The laser on the robotic milker searches out the teat on the cow to find where to place the milk cup.
Image Credit: https://www.opb.org/

Robotic milking (AMS) in action.
Image Credit: https://www.independent.ie/

Cow leaving the robotic milking system after the automatic gate opens.
Image Credit: GEA Group https://www.gea.com/

Once there is milk flow detected in all four quarters, the cow milks successfully and once the milk flow starts to decline and gets to a certain level, it will take the cup off. It takes the cup off each quarter separately. A teat spray (disinfectant) is then applied to the teats. The exit gate opens, the cow walks out, and then the entry gate opens for the next cow to come in.

Debate It!

There are three different types of milking systems – tie stall, parlour and robot. All three systems have their benefits and challenges. Divide the club into three groups with each group choosing one type of milking system and creating a list of benefits. Have each group present their list to the rest of the club. Be prepared to defend why your system is a good system.

Check It Out!

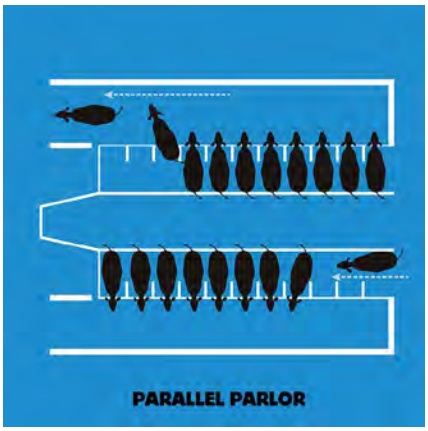
Watch the video produced by Farm & Food Care Ontario that features a parlour milking system in the video titled 'How Dairy Cows Are Milked.' It can be found at: https://www.youtube.com/watch?v=hAWVXG-e2pI

Parlour Milking

The four main designs of milking parlors used by dairy farmers are:

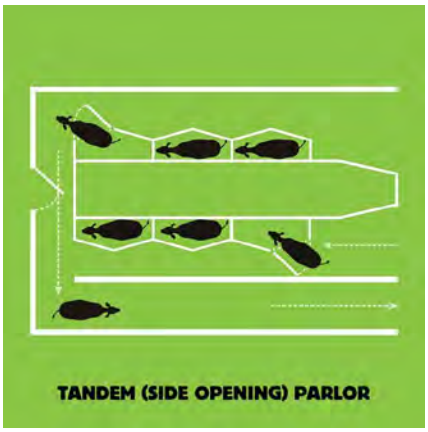
1. **Parallel**

As the name suggests, cows stand parallel to each other in this design. So, if the cows are standing side to side, that only leaves one access point for the milker to reach the udder: the rear end. In parallel parlors, milking doesn't begin until all cows are in their stalls, and they are all released from the parlour at one time. Milking only takes about 10 minutes per group.



2. **Tandem**

Tandem parlour designs are not all that different from tandem bikes, in that the cows stand nose-to-tail inside individual stalls. This gives the milker a side-on vantage point of the udder. Cows can be released one at a time, too, so if one cow is moving a little slowly, all her friends don't have to wait for her to finish.

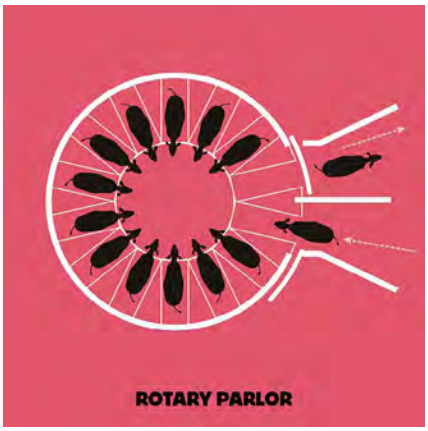


3. **Herringbone**

Herringbone parlours are the most common design used on dairy farms with smaller herds. The cattle stand at a 45-degree angle. This design offers the milker a different access point to the udder than the parallel or tandem designs, and also allows access for different types of equipment to be used.

4. **Rotary**

Rotary parlours are like carousel rides for dairy cows. The milking stalls are arranged in a large circle on a platform that rotates slowly. Cows can walk in, and depending on the size of the platform, finish milking by the time they've completed a lap or two. Rather than the milker having to walk around the parlour to attach the milking equipment to each udder, they can stay in one place and let the cows come to them.



Excerpts and images from https://www.dairydiscoveryzone.com/

Research It!

Do a search on the Internet for a video for each of the four types of milking parlours to see them working. As you are watching each video, create a list of the technologies needed to make each system work. After watching the videos, rank each system based on the pros and cons of each one as well as your personal preference of what you would want to see in a milking parlour. Be prepared to explain your ranking.

Challenge!

Research to find out what the largest size of rotary parlour milking system exists in the world. If possible, find out what the cost was to the farmer to purchase the system.

Tie Stall Milking

The majority of dairy farms in Canada are tie-stall barns although the number of free stall barns (which include parlour and robotic milking barns) is increasing each year.

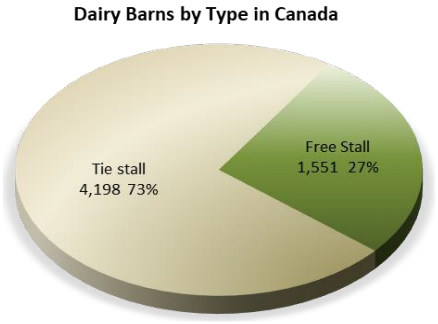
Surge bucket milker, circa 1956
Image Credit: Surge Milker

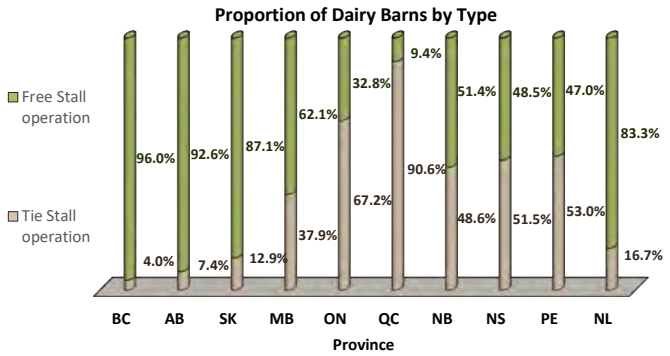
Agriculture and Agri-Food Canada

Canada

DAIRY BARNS BY TYPE IN CANADA [1]
2020

Province	Tie Stall operation			Free Stall operation			Unrecorded		Total Number of barns
	Number of barns	%	Herd Size	Number of barns	%	Herd Size	Number of barns	Herd Size	
BC	7	4.0%	54.1	166	96.0%	215.1	-	-	**173**
AB	18	7.4%	85	226	92.6%	176.3	1	76	**245**
SK	8	12.9%	96.6	54	87.1%	233.3	-	-	**62**
MB	33	37.9%	87.7	54	62.1%	242.3	2	146	**89**
ON	1,314	67.2%	61.5	642	32.8%	141.8	1	37	**1,957**
QC	2,687	90.6%	65.9	280	9.4%	142.4	61	109	**3,028**
NB	36	48.6%	61	38	51.4%	170.8	9	-	**83**
NS	50	51.5%	60	47	48.5%	139.5	4	-	**101**
PE	44	53.0%	69.9	39	47.0%	103.7	4	61	**87**
NL	1	16.7%	249	5	83.3%	205.6	1	-	**7**
Canada	**4,198**	**73.0%**	-	**1,551**	**27.0%**	-	**83**	-	**5,832**





[1] Based on Herds Enrolled in Milk Recording Program
Source: Lactanet
Compiled by Agriculture and Agri-Food Canada, Animal Industry Division, Market Information Section

2020 Statistics Agriculture & Agri-Food Canada

Current tie-stall milking in action
Image Credit: USAgNet.com

Even though tie-stall milking systems have been in existence for over 80 years, the technology used within this system has changed over time. Gone are the days of the milking claw (the unit attached to the cow) putting milk into a bucket under the cow which was then transferred to the milk cooler in the milk house. Today's systems use pipelines to take the milk away from the milk claw. Today's milk claws are also more advanced with electronics to measure the amount of milk coming from each cow, each time she is milked.

CAREER ALERTS!

*Check out some exciting technology careers in the **dairy** industry!*

- Dairy Robot Technician
- Installation Specialist
- Agricultural Engineer
- Dairy Specialist
- Equipment Salesperson
- Structural Engineer
- Structural Engineer
- Feed Nutritionist
- Veterinarian
- Software Engineer/Software Architect
- Microbiologist
- Marketing & Sales
- Mechanical Engineer
- Farm Management Support
- Electrical Engineer
- Laboratory Technician
- Animal Research
- Farm Manager

Technology in the Milk House

The room in the dairy barn where the milk is cooled and stored until the milk truck picks it up is referred to as the milk house. Over the years the technology in the milk house has changed dramatically to now include remote monitoring. A cloud-based interface reports the status of milk cooling systems to dairy producers including milk volume, milk temperatures, equipment alerts, and more. Systems also include fully programmable wash and cooling control. Real-time updates through smartphones let farmers keep an eye on their farm when they need to be away.

Milk Cooler equipped with a monitoring system for optimal reporting capabilities.
Images Credit: Paul Mueller Company

Farmers can download real-time tank-temperature history via the USB port on the monitor or directly on the dashboard using their computer.

Manure Management Systems in Robotic Milking Barns

It is important to maintain clean and dry cow alleys in a milking barn. Cows will drag manure from dirty alleys onto their free-stall bed, which can result in unhealthy udders and feet.

Automatic Alley Scraper
Image Credit: Progressive Dairy: Canada

Free-stall barns where cows are milked robotically require different cleaning strategies than barns where the cows are milked in a parlour. Since the free-stall area of a robotic barn is never free from cows, cleaning with a tractor or skid steer is not recommended. The layout of many robotic barns makes it difficult to clean the barn using traditional alley scrapers, because barn layouts make use of large open areas in front of the robotic milkers and often have larger cross-overs than in parlour barns. As a result of these layouts, some robotic milking barns have slatted floors for better manure removal.

Manure Management in Slatted Floor Robotic Milking Barns

Slatted-floor barns originally were designed with narrow alleyways that concentrated cow traffic to push the manure through the slats. As interest in cow comfort increased and lying times in stalls lengthened, reduced cow movement in the alleys resulted in a greater build-up of manure in the alleyways. The most effective way to deal with this manure build-up is to use some form of scraper to push the manure down through the slats. There are two methods of scraping manure in a slatted floor robotic barn.

Automatic alley scrapers are effective in pushing manure through slats, but they still involve cables or shuttle arms that have to be maintained as well as corner wheels or other drive mechanisms that have to be installed outside the cow area so as not to be a hazard to cow traffic, adding to the size of the barn. A disadvantage of automatic alley scrapers is that they cannot remove manure from cross-overs and holding areas.

Robotic Slat Cleaners
Image Credit: Lely (left) and DeLaval (right)

Robotic slat cleaners address the disadvantages of automatic alley scrapers. They do not require cables or drive wheels and can deal with cross-overs and any large open areas adjacent to robotic milking units. They can be programmed to scrape the areas in the barn where manure builds up the most, such as next to the free-stall curb, more frequently than other areas of the barn. This keeps the slats and, consequently, the cows cleaner.

Robotic slat cleaners are not intrusive. They do their job quietly and have little effect on cow behaviour. In fact, the only time cows become concerned is when the robotic slat cleaner is not moving. If a robotic slat cleaner encounters a cow lying in the alley or some other obstacle, it will either try to go around or try several times to push it out of the way. If the cow or obstacle still will not move, the robotic cleaner will shut down and wait for the producer to take action.

Dry manure stuck on slats can be difficult for robotic slat cleaners to remove. Hot, dry weather and summer cooling fans in barns can dry out the manure on the slats. When this happens, it can be more difficult to push manure down through the slats, and the tires may spin on the dry manure, causing the robotic slat cleaner to lose its position, as the revolution count on the wheels no longer represents distance travelled. To address challenge, both units have a water spray system.

Excerpts taken from https://www.ontario.ca/page/manure-handling-options-robotic-milking-barns

Manure Management in Solid Floor Robotic Milking Barns

A revolutionary manure robot designed to clean solid barn floors is now available to dairy farmers. The machine collects the manure rather than scraping it around the barn. This not only results in a cleaner floor, but also prevents cows from standing in manure up to their dew claws, as is the case when a manure scraper is used.

This robot is specifically designed for barns with solid floors and takes a revolutionary diverse approach when compared to traditional manure scrapers. The robot does not push manure but vacuums it. This makes the build-up of manure a thing of the past. This not only makes for a cleaner floor. It also ensures the cows' hooves remain cleaner. This improves both cow health and the well-being of the animals.

The robot uses a vacuum pump to collect the manure in its tank. At the end of a route the robot releases the manure above a dumping location.

Lely Discovery 120 Collector working to vacuum up manure in a sand-bedded barn.
Image Credit: Jennifer Betzner, Farmtario

Check It Out!

Look at the websites of companies that provide the dairy industry with robotic technology for videos on how their products work. One video that demonstrates the robotic vacuum technology for collecting manure can be found at: https://www.youtube.com/watch?v=_dgf_V3Htxw

Robotic Calf Feeders

Automatic (robotic) calf feeders are an efficient and effective method to achieve intensive calf feeding. The feeder can be set up in both group and individual pen scenarios. Automatic calf feeders offer the ability to manage and track the feeding program of each animal. Benefits of using automatic calf feeders include:

- Labour savings
- Calves growing faster
- Healthier calves
- Control over feeding cost and calf feeding operation
- Lower mortality and morbidity rates
- Earlier reproduction

Automatic calf feeder in action
Image Credit: GEA Automatic Calf Feeder - Dairy Lane Systems

The automatic calf feeder will supply the correct portion and concentration of feed spread over the day, resembling the natural behavior of the calf. The small accurate portions spread over the day will substantially enhance the development of the digestive system of the calf. Calves are weaned gently by gradually reducing their milk portions. Slowly reducing the amount of milk available compels calves to increase their intake of roughage.

The calves are prepared from the beginning for a milk producing life with a milking robot. From a young age, calves are raised knowing to get their milk. This makes them assertive. They also become accustomed to automatic feeders and the noises they make.

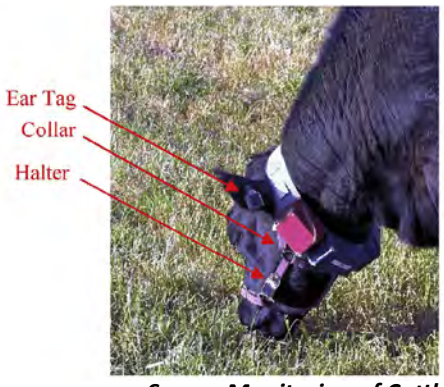
With a push of the button a farmer can see how much milk a specific calf is consuming and adjust their mix if necessary. Furthermore, farmers have the ability to check data on their calves remotely and intervene in the event of an alarm.

Beef-specific Technology

Sensors

Like the dairy industry, cattle producers can track virtually anything within their herds using sensors. Monitoring individual animal health and comfort can prove costly and time-consuming if done manually. With wearable sensors (typically on the leg, the neck or as an ear tag), beef producers can monitor general animal health – as well as rumination, illness and lameness – efficiently and more accurately. Sensors can also be used to create virtual fencing for livestock.

Sensor Monitoring of Cattle
Image Credit: IceRobotics Ltd.



Sensor Monitoring of Cattle
Image Credit: Research Gate Systems

GPS Trackers

Similar to sensors, GPS trackers are one of the more widespread technologies available for extensive or low input cattle systems. Each animal wears a GPS unit — neck or feet are popular locations — that keeps track of its location, as well as being able to monitor its body temperature, daily movement rate, and how often it has eaten, gone to the waterer or taken mineral licks. GPS tracking systems can also help with security by providing alerts when animals move outside of designated areas.

CAREER ALERTS!

*Check out some exciting technology careers in the **beef** industry!*

- Installation Specialist
- Agricultural Engineer
- Beef Specialist (Barn & Pasture)
- Equipment Salesperson
- Structural Engineer
- Feed Nutritionist
- Veterinarian
- Software Engineer/Software Architect
- Farm Management Support
- Marketing & Sales
- Mechanical Engineer
- Animal Research Technician
- Farm Manager

In-rumen Bolus Monitoring

Cattle Scan Monitoring Bolus
Image Credit: Cattle Scan, Guelph, ON
https://www.cattlescan.ca/bolus-monitoring-system

In-rumen monitoring, which can also be used for dairy cattle, lets producers track rumen temperature and pH, as well as drinking activity and heat detection. It's a device that doesn't need to go in every animal but can be used on a "one per pen" basis to serve as an indicator of something that could be affecting a group of animals, like acute or subacute ruminate acidosis. Farmers can look at daily variation and it will send them an alert to their phone that tells them what the data says.

Drones

These small, air-bound robots allow producers to more easily manage feedlots and ranches. Drones can check fence lines, water troughs and gates, and manage pasture more effectively through aerial images and video.

Artificial intelligence

Livestock producers face the challenge of growing animals to meet market and consumer specifications and timing. Artificial intelligence – particularly machine vision – can use digitized camera images to analyze each animal's depth, size and even fat content to accurately predict that animal's market potential.

3-D images are analyzed using artificial intelligence algorithms to provide accurate body condition scores for each animal. Different measurements, such as muscling, are given a mathematical description and assigned a value that can be used to estimate a cow's condition based on the 3-D shape the machine "sees."

Excerpts from Progressive Cattle

Experience It!

Visit a beef barn that has implemented some (or all) of the technologies listed in this meeting. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

Robotic Cattle Driver

A robotic cattle driver than can minimize worker injuries when moving cattle has been developed and is being tested in cattle processing facilities. Wearing lacrosse helmets and chest pads, the workers who herd the cattle in these processing facilities look more like baseball umpires than plant employees. As the herd clears from each pen, the gates close and the workers move outside a series of rails; waving plastic bags tied to sticks and calling out commands to help push the cattle forward until the next gate can be closed. When herding live animals, they can turn on you, run you over, kick you, hurt you. The robotic cattle driver takes away some of the risk for workers.

Robotic Cattle Driver in action

Image Credit: Cargill https://www.cargill.com/story/meet-the-cowboy-robot-thats-making-cattle-herding-safer

The body is made out of metal. The wheels are designed to move agilely along the trampled and sometimes muddy ground. A blower gives ability to press the cattle forward without actually touching the animals. Wiry waving arms with plastic bags tied to the ends whip back and forth, mimicking the sound and motion of the workers waving theirs. The machine also has a recorded voice to help prompt the animals.

The robot is operated via remote control by a worker standing on catwalks that overlook the pens. While people still need to be inside the pens, closing the gates off as the cattle travel toward the plant, the robot allows them to keep a greater distance from the animals.

Check It Out!

Visit https://www.youtube.com/watch?v=Aehth3w9h04&t=98s to see a robotic cattle driver in action.

Challenge!

Find out how much a robotic cattle driver would cost. Is this something you think could be implemented on beef farms and ranches in Canada?

Technology in Pig Barns

Digital technologies have the potential to transform pig production. Swine producers and consumers can both benefit from these technologies that offer the opportunity to improve processes, increasing productivity and efficiencies while making the animal production process safer for both humans and animals alike. Technologies allow pork producers to address the mega trends: our growing global population with an increasing middle class, the continued interest in pork as a healthy protein, the demand from consumers for safer food and the need to demonstrate approved animal welfare practices.

Artificial intelligence (AI)

Facial recognition of pigs may sound far-fetched, but it is already a reality thanks to AI. AI uses algorithms to mimic human decision making. Often used in conjunction with hardware technologies which collect data, such as robots, sensors and machine vision. Recognition systems track individual pigs in the pen, monitor feed & water intake, movement, etc., identifying and even suggesting the ideal feed program for pigs. To address smothering sows, several companies have designed technologies to alert producers or even prompt the sow to move (SwineTech) should she be suffocating her babies. Other companies use machine vision and 3D cameras to monitor a pig's tail posture which can indicate potential for increased tail biting, allowing producers to act preventatively.

Check It Out!

Watch this video titled 'Canadian Pig Farm Tour' created by Farm & Food Care Ontario for an inside look into a pig farm. https://www.youtube.com/watch?v=E7SijUQBGfM

Artificial intelligence (AI)

Robotic Feeder for Swine
Image Credit: Pig Progess

Facial recognition of pigs may sound far-fetched, but it is already a reality thanks to AI. AI uses algorithms to mimic human decision making. Often used in conjunction with hardware technologies which collect data, such as robots, sensors and machine vision. Recognition systems track individual pigs in the pen, monitor feed & water intake, movement, etc., identifying and even suggesting the ideal feed program for pigs. To address smothering sows, several companies have designed technologies to alert producers or even prompt the sow to move (SwineTech) should she be suffocating her babies. Other companies use machine vision and 3D cameras to monitor a pig's tail posture which can indicate potential for increased tail biting, allowing producers to act preventatively.

Robots

Robots can improve animal welfare, safety and production in swine production. They don't tire, can do heavy work and do so 24/7.

The robotic machine for feeding pigs uses linear feeders which dispense the exact amount of feed needed for each meal.

The Boar Bot robot helps the boar check for sows that are in heat.
Image Credit: Swine Robotics

The robot reduces the presence of humans on the pig farms and generates data that helps improve overall herd management. The robot offers the farmer the opportunity to adjust his production according to market variations and input costs and helps to make the swine farm more competitive.

Robots cleaning facilities improve conditions and address environmental and societal concerns such as reducing odour, emissions and animal welfare and improve sanitation.

From a processing standpoint, robots can vastly improve safety by replacing the more dangerous roles in meat processing and packing and use AI to cut the meat in the most efficient manner increasing profitability.

The Bumper Bot is the latest technology to protect workers while moving pigs. The variable speed, variable width Bumper Bot can move any size or number of pigs with the push of a remote control button, reducing injuries to both people and pigs.
Image Credit: Swine Robotics

The Evo Cleaner is a control system that makes it possible for the robot to do two motions at the same time in order to pressure wash barns.
Image Credit: Swine Robotics (item made by Envirologics)

Check it Out!

Watch the video found at: https://www.youtube.com/watch?v=W4Zqvemqhmk to see the Boar Bot in action.

Check It Out

Watch the video found at: https://www.youtube.com/watch?v=tz7YVhUdl8g to see the Evo Cleaner for barns in action.

Sensors

Sensors similar to 'Fitbits' in the form of wearables are creating a lot of interest in the pig industry. They can provide one of the primary pieces of the data collection puzzle, allowing farmers to track animals on an individual basis and monitor health in real time. Sensors can alert farmers to illness concerns, heat cycles, food and water intake, anything that is critical to productivity. Sensors can also be placed on sows with young piglets to help stop baby piglets from being crushed.
Aside from wearables, fixed sensors can record house ammonia levels, dust, humidity and temperature.

Sensor for continuous temperature logging
Image Credit: https://www.pig333.com/

Protecting Pigs - a sow wears a SwineTech patch, which works with the device hanging on the farrowing stall. Designed to prevent baby pigs from being crushed to death, the system sends a vibration to the sow to move.
Image Credit: Farm Progress

Drones

Drones are greatly beneficial in many agricultural applications, particularly crop production. There isn't as much opportunity for their use in the pig industry at present. The primary opportunities would be with outdoor pig systems, potentially checking herds and relaying status of their location or health.

Internet of things (IOT)

This is the technology that connects all others, allowing for robots and sensors to transmit data and machines to alert farmers if there are malfunctions. While much of pig farming is still rural, therein lies the struggle with these technologies. Fortunately programmes such as the EU's funded project ALL-SMART-PIGS are preparing to use IOT connect the swine industry. The ALL-SMART-PIGS project looked at connecting various pieces of technology (e.g. as cameras, sensors and robots) and the challenges this brings such as internet and power connection, fly feces on camera lenses, cable biting by rodents (or pigs), integration issues between the hardware providers, measurement dispensed feed, data acquisition and data quality.

Excerpts taken from Nine digital technologies transforming pig production, Emily Houghton, https://www.thepigsite.com/articles/9-for-19-digital-technology-for-the-pig-industry

CAREER ALERTS!

*Check out some exciting technology careers in the **swine** industry!*

- *Installation Specialist*
- *Agricultural Engineer*
- *Swine Specialist*
- *Equipment Salesperson*
- *Structural Engineer*
- *Feed Nutritionist*
- *Veterinarian*
- *Software Engineer/Software Architect*
- *Farm Management Support*
- *Marketing & Sales*
- *Mechanical Engineer*
- *Electrical Engineer*
- *Microbiologist*
- *Laboratory Technician*
- *Animal Research Technician*
- *Farm Manager*

Automated Individual Feedings

The outcome of production and cost relies greatly on the feedings pigs receive. Pigs need to be fed the right amount of food at the right times to give farmers the best results.

Automated feeding for swine helps control expenses. An automated feeding system incorporates both feeding and weighing. Each pig wears a unique identification (RFID) tag that identifies the animal in the feeder. The automated feeder then dispenses the exact amount of feed needed for each animal, helping manage ever-rising feed costs. The weighing components record the pig's weight as they feed, and the data can be analyzed for making real-time management decisions. With an automatic pig feeding system, more pigs can be managed with less labour.

Automated Feeding System for Swine
Image Credit: https://osbornelivestockequipment.com/news/automatic-pig-feeding-systems-bottom-line/

Temperature and Environment Control

Another important factor in pig farming is keeping pigs warm. That's where temperature and environment control come into play. Technological advances in pig farming have made it possible to provide optimal environmental conditions for the pigs as they grow.

There are specific temperatures required for farming pigs. These ideal temperatures ensure that the pigs grow happily and healthy. However, the temperature of the pigs' environments is most important for farrowing and managing the nursery.

When farrowing, the pigs need to stay warm to ensure that they grow strong. These advances in climate control also have systems that create mist while regulating temperatures, creating a comfortable environment for all the pigs and piglets.

Experience It!

Invite a pig farmer that has implemented some (or all) of the technologies listed in this meeting in their barn. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

Technology in Poultry Barns

Chicken consumption is increasing faster than any other meat in the globe. As of 2022, chicken is the most consumed meat in the world, surpassing pork consumption which has held the title for many years. Every year, billions of chickens are produced in Canada, the United States, South America, Africa, and other countries. Egg consumption continues to grow as well because eggs are inexpensive, mild-tasting and are easy to process and include in other foods. Universal acceptance by almost all cultures and all religions ensures that poultry will continue to prosper.

With an increasing world population, poultry farmers need to continue to harness new digital technologies and information to improve efficiencies and respond to the growing requirements of consumers.

Use of Robots in Poultry Barns

The following list showcases many of the robotic advances in the poultry industry. The use of brand names is to assist with finding more information online about these technologies as well as new similar and emerging technologies in the poultry industry.

Check It Out!

To see a turkey barn in action, watch this video titled 'How Turkeys Grow' which was produced by Farm & Food Care Ontario. https://www.youtube.com/watch?v=pM3EGqhjflM

Cleaning robots

In Cholet, France, robotics pioneer Octopus Robots has designed two robots specifically for poultry production. The first, Octopus Poultry Safe, sanitizes and decontaminates large buildings by delivering liquid disinfectants and sanitizers, working autonomously until the entire targeted area is saturated. The robot collects data while working, such as temperature, humidity rate and carbon dioxide levels. It also gathers data on sound and light levels.

Octopus Poultry Safe autonomously sanitizes and decontaminates large buildings while collecting environmental data.
Image Credit: Octopus robots

Poultry Safe is equipped with a second module called the Scarifier, which also has the ability to work as a standalone robot. The Scarifier is designed to aerate litter in presence of poultry. It is capable of dealing with all types of substrates, turning and ventilating litter to prevent the onset of aspergillosis (a disease caused by Aspergillus fungus), pododermatisis (inflammation of the foot pads) and hock and breast injuries. Regular litter aeration is also known to inhibit the fermentation process in soil and dramatically reduce the level of ammonia in barns.

France-based company Tibot Technologies designed a similar robot for aerating litter. The Curiosity runs along the poultry house floor, running prongs through the litter to keep it aerated. In doing this, it prevents moisture from accumulating and keeps ammonia levels down.

The Curiosity robot in action.
Image Credit: Agriculture Connectee Magazine

The Curiosity robot runs on lithium battery that lasts for 10 hours. It can be programed to work all over the house, has six speeds and has a four-wheel drive system, making it possible to handle varying terrain in the barn. Although the robot is still in development, the company says it will be commercially available in the spring of 2019 for a cost of about $10,000.

Showcased at Space 2018, an agricultural trade fair in Rennes, France, a high-pressure washing robot called Lavicole won the highly coveted Innov'Space award. Designed specifically for cleaning poultry houses, the robot is track-mounted and fully radio-controlled.

Lavicole high-pressure washing robot for poultry barns
Image Image Credit: Rabaud

In order to ensure thorough cleaning, the robot is equipped with three washing devices. A directional ramp mounted on an articulated arm and equipped with five rotating nozzles that can reach 4.5 metres high make it easy to clean ceilings and walls. Lavicole also has a washing system designed to clean feeders, a manual high-pressure cleaning lance and a foam gun to apply detergent. The French company Rabaud designed Lavicole.

Robots as Data-collecting tools

EyeNamic is not actually a robot, but a behaviour monitor that captures the movement and activity of animals, alerting farmers to problems that could become welfare issues, like improper distribution, crowding, feed and water intake and piling.

EyeNamic Behaviour Monitor
Image Credit: WATTAgNet

Farmers find it important to know, for example, why birds are crowding in one area, but not going to another. Maybe the litter is too wet. Maybe the ventilation isn't working properly. Or maybe the water line has shut off. Whatever the problem, being able to monitor from a distance at all times allows farmers to quickly respond to abnormal behaviour.

Another monitor, ChickenBoy, is a lightweight device that travels slowly (10 cm/second) on rails overtop of the flock, gathering three datasets as it goes. It collects information on ambient conditions, welfare and health, and watches over installations.

ChickenBoy monitoring system in action.
Image Credit: The Poultry Site

As ChickenBoy moves along the rails, it gathers data on climate conditions, including humidity, temperature, airspeed, and carbon dioxide levels. For now, it does not come equipped with an ammonia sensor.

ChickenBoy also takes thermographic images that can distinguish between chickens that are dead or alive. What's more, it assesses dropping colour, alerting the farmer when it is off. Some thermographic imaging tools even alert famers when flock health status changes. By looking at the colour you can see which ones are not well and which ones are healthy. Farmers can predict disease two to three days earlier through excrement analysis.

Although the cost is not yet established for Canadian buyers, it costs European clients around €15,000 (about $21,500 Canadian) for the device.

Task-oriented robots

In open aviary systems, training hens to lay eggs in nesting boxes can be a difficult task. For farmers, it means regularly walking through barns and manually moving birds to deter them from laying on the floor. It's a time-consuming job, and one that farmers can now pass on to a robot.

Spoutnic, designed by Tibot Technologies, has been designed to move around the barn in random patterns. As it travels, it gently forces hens to keep moving, which keeps them from laying eggs on the floor.

Reducing the number of eggs on the floor reduces the amount of time farmers have to spend stooped over, picking up eggs. Internal studies show that Spoutnic helps increase feed consumption, which leads to increased growth of 300 grams per bird. Barns where Spoutnic works also show a three per cent decrease in mortality.

Spoutnic robot working in a poultry barn.
Image Credit: Poultry News

> ***Check It Out!***
>
> *Watch this video at: https://www.youtube.com/watch?v=Hwo1kbcVJEw&list=PLeW-xid_mQQXZopHeVSXIL2BBQnxg8Z8v&t=27s to see the Spoutnic in action in a broiler barn.*

If Spoutnic isn't available, poultry farmers could always employ a poultry-bot to collect floor eggs.

The robot eliminates the one to two hours that farmers spend collecting eggs in cage-free housing systems. Collecting eggs may be its main task, but this robot can also track data, like humidity and temperature, and keeps an eye out for sick and dead birds.

PoultryBot collecting eggs
Image Credit: Canadian Poultry Magazine

3D printing prosthetics

One of the more inventive ways in which 3D printing can affect the poultry industry is through life-saving techniques. Reproducing feet, legs and even beaks has already been applied for pet birds. One example includes researchers from the University of Calgary, who created prosthetic feet for Foghorn the rooster after he lost both of his feet, most likely an unfortunate result of severe frostbite. Then there's Dudley the duck, who received an entire prosthetic leg (including the knee joint) from the combined efforts of a 32-year-old mechanical engineer and architect who worked with Proto3000, a 3D printing company based out of Ontario. Looking forward to the future, there is an opportunity for preserving high-value breeding poultry stock such as parents, grandparents or great-grandparents, where continuing the genetic line is critical.

Wyandotte chicken with a prosthetic leg created by a 3D printer
Image Credit: https://www.myminifactory.com/object/3d-print-prosthetic-chicken-leg-for-hopalong-90916

Drones protecting the flock?

The opportunity for drones in chicken houses may seem a little farfetched. There is concern that the drone could make the flock nervous and cause undue stress. To this point, an experiment by Georgia Tech in 2015 showed the birds were not yet ready for this technology, compared to robots, which are probably better suited for indoor tasks anyway.

Free-range or yard-kept chickens and turkeys that roam fields freely would be a better application for drone technology, which could herd, protect and monitor them. Adaptation of avian species to drones would probably require training but could succeed outdoors.

Chicken wearing a backpack sensor
Image Credit: Popular Mechanics

Sensors for individualized monitoring

Sensors are designed to measure ammonia, a common problem in many poultry barns. Sensors are also used to regulate and control the climate in the barn, including ventilation, temperature and carbon dioxide monitoring, which can reduce the negative effects high carbon dioxide concentrations can have on layers and breeders, resulting in significant cost savings. A unique lighting system using sensors and LED bulbs to create a consistent lighting environment that stimulates better growth efficiencies in birds and also reduces costs.

From a wearable sensor perspective, researchers and farmers can gain a lot of insight into the health and well-being of broilers, layers, turkeys and ducks. Fitted with RFID tags, poultry can be observed in a more natural environment, giving researchers the opportunity to learn from the animals. This information can be evaluated to determine everything from natural behaviors to inefficiencies in diet, greatly increasing the opportunity to help with production efficiencies. Studies conducted at the University of Michigan have used sensors to analyze how chickens use space in their pens in order to better understand how to design non-cage systems for the comfort and well-being of the hens.

Artificial intelligence (AI) in the barn

AI is used to monitor and control the environment of the poultry barn. Sensors collect the information, software tracks it and AI adjusts the conditions of the barn or alerts the farmer if there is a potential issue, such as an ill bird. All this information can be transferred to the farmer's iPad or smartphone. This is all done in real time and can curb concerns and small issues before they become disastrous to the entire flock. Aside from saving humans from doing these tasks, there are opportunities for cost savings, such as optimized feed consumption and climate control, increased production through healthier flocks because of cleaner water and better systems management. All of this information can be stored and analyzed to increase uniformity in production, which will ultimately increase performance and overall flock health.

CAREER ALERTS!

*Check out some exciting technology careers in the **poultry** industry!*

- *Installation Specialist*
- *Agricultural Engineer*
- *Poultry Specialist*
- *Equipment Salesperson*
- *Structural Engineer*
- *Feed Nutritionist*
- *Veterinarian*
- *Software Engineer/Software Architect*
- *Farm Management Support*
- *Marketing & Sales*
- *Mechanical Engineer*
- *Electrical Engineer*
- *Microbiologist*
- *Laboratory Technician*
- *Animal Research Technician*
- *Farm Manager*

Artificial intelligence (AI) for grading eggs

A form of AI, machine vision, has been used to grade eggs as well as determine defects such as cracking or internal blood spots. It can also be used in assessing infertility in incubation by scanning eggs and learning which are fertile and which are not. An algorithm is then created, enabling the machine to determine the accuracy of fertility by over 98 percent by day five of incubation.

Artificial intelligence (AI) for identifying male and female eggs

AI technology has allowed a significant challenge within the layer industry to be overcome. Layers, of course, are designed to produce eggs for consumption. To replace laying hens, farmers have to incubate some eggs, but they cannot tell until they are hatched which are male and which are female. Using terahertz spectroscopy, the system can identify male eggs immediately after laying and the farmer can sell them as unfertilized eggs, allowing for significant cost savings within the layer industry.

Chicken wearing a virtual reality headset which simulates a free-range world for the chicken.
Image Credit: http://www.theaustinstewart.com/secondlivestock.html

Virtual reality (VR)

An eccentric option is to give a virtual reality experience to the chickens. Created by professor Austin Stewart at the University of Iowa, Second Livestock is a conceptual company that allows chickens to enjoy the free-range experience while remaining contained within the safety of the poultry barn The idea is that chickens are equipped with a virtual headset and see through a screen projection using goggles. In this way, chickens can be raised anywhere, even in urban areas, and feel the freedom of their virtual world, free from predators. While this company may not actually be producing these products, it is important to recognize that the technology is there and is on its way to becoming increasingly more affordable.

Experience It!

Invite a poultry farmer that has implemented some (or all) of the technologies listed in this meeting in their barn. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

Internet of things (IoT)

The internet of things is the technology that connects all the others. IoT connects many of the sensors in a poultry barn to a smartphone, iPad or other devices. Software programs on the market offer packages to track and trace all elements of the farm, including information gathered from sensors, but also potentially from various sources, from robots to veterinary activity and upstream supplier information. This overall management of the entire chain offers incredible advancements to traceability, which is becoming increasingly important to all food production worldwide.

Excerpts from Poultry Industry News

Technology in the Sheep Industry

Some of the technology already mentioned in this meeting can also apply to the sheep industry. In addition, five futuristic technologies that the sheep industry may expect to see on the market in the next decade appear on the following pages.

Experience It!

Visit a sheep farm that has implemented some (or all) of the technologies listed in this meeting. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

IN THE CHUTE TECHNOLOGY

Five futuristic technologies that the sheep industry may expect to see on the market in the next decade.

1 ROBOTIC SHEARING

Modern robotics are being developed to tackle labour shortages and reduce physical strains in the shearing industry. Powered by electric motors and computer programing, these mechanical armed robots are testing on 3D printed sheep to mimic real life movements during shearing. The robotic system is designed to work in conjunction with manual shearers to:

- REDUCE FATIGUE
- REDUCE BACK STRAIN
- IMPROVE POSTURE

SHEEP HERDING DRONES 2

Drones are quickly becoming an effective piece of farm equipment - taking root in the ag-industry's automation era to herd and monitor livestock. Applied heavily to crop agriculture for field mapping and crop scouting, drones are now being designed to mimic the bark of a dog as an aid in sheep herding and monitoring to:

- MOVE LIVESTOCK FASTER
- REDUCE SHEEP STRESS
- MONITOR FLOCK & PASTURES

3 SMART TAGS

Radio frequency ID tags are not a new technology, but they are becoming more sophisticated and used for real time automated tracking, monitoring and assessment of a flock. Designed to be low cost and long lasting, Smart tags come as ear tags or temporary collar tags for use on pre-weaned lambs. Large sums of individual animal information can be captured by the device over an animal's lifetime including:

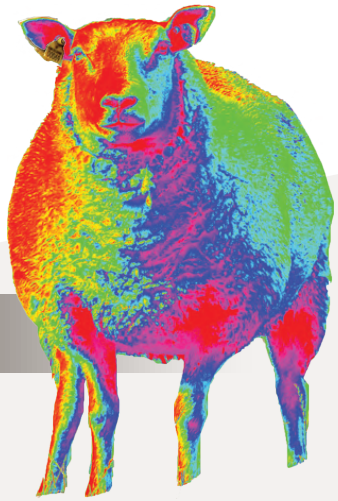
IDENTIFY LOCATION

ESTABLISH MATERNAL PEDIGREE

MONITOR ACTIVITY

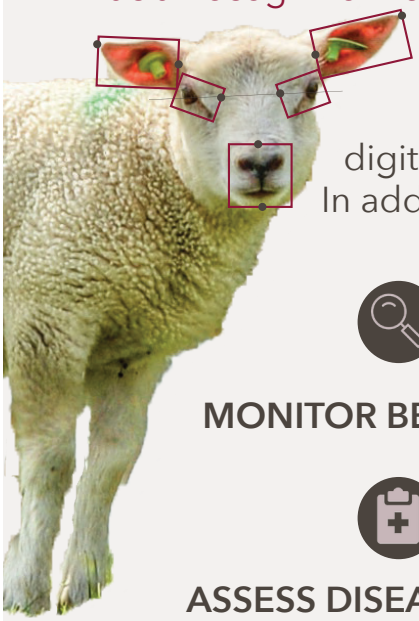
INFRARED RADIATION THERMOGRAMS 4

Thermal imaging (TI) is not a new concept, but it is finding a new place in early detection of disease and injury in livestock. TI trials have been able to accurately diagnose respiratory illness weeks before clinical symptoms appear. Early detection of ailments by TI is proving to improve overall flock health with the potential of:



Lower vet costs | Reduced antibiotic use | Less mortality

5 FACIAL RECOGNITION



Facial recognition technology may one day replace the use of electronic IDs. Through a machine-learning model, sheep can be identified individually by their unique facial features, and data captured can be linked to other digital systems to better understand and track behaviour. In addition to identifying animals, this futuristic technology will also:

MONITOR BEHAVIOUR

TRACK LOCATION

ASSESS DISEASE STATUS

ESTIMATE WEIGHT & PARENTAGE

This project is funded by the Ontario Ministry of Agriculture, Food and Rural Affairs

Ontario

(pages courtesy of the Ontario Ministry of Agriculture, Food & Rural Affairs (OMAFRA)

Technology in the Goat Industry

Some of the technology already mentioned in this meeting can also apply to the goat industry as well. To see technology in the goat industry in action, view the following video: https://www.youtube.com/watch?v=_3X966BoJxw which features a farm in Europe.

Check It Out!

To see goats being milked watch this video produced by Farm & Food Care Ontario. https://www.youtube.com/watch?v=sy3g-HSdHRs

Experience It!

Visit a goat farm that has implemented some (or all) of the technologies listed in this meeting. Find out what the advantages (and any disadvantages) are of having this technology in the barn.

CAREER ALERTS!

*Check out some exciting technology careers in the **sheep & goat** industry!*

- *Dairy Robot Technician*
- *Installation Specialist*
- *Agricultural Engineer*
- *Sheep & Goat Specialist*
- *Equipment Salesperson*
- *Structural Engineer*
- *Feed Nutritionist*
- *Veterinarian*
- *Software Engineer/Software Architect*
- *Farm Management Support*
- *Marketing & Sales*
- *Mechanical Engineer*
- *Electrical Engineer*
- *Microbiologist*
- *Laboratory Technician*
- *Animal Research Technician*
- *Farm Manager*

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

JUDGE IT!

Choose 4 items/pictures one type of technology featured in this unit. Have members create a list of features they think are important to have in this type of technology (a list of criteria). Then, using this list have members rank (judge) the technology and give their reasons for their placing.

At Home Activity

Introducing Technology
Activity Courtesy of AgScape

Scenario:

In your recent travels you came across a remote farming community that has been cut off from the rest of the world for generations. You are a farmer from Ontario who has been incorporating various advanced and emerging technologies into your work. Based on your understanding of the positive and negative impacts of these technologies, what types of technology would you choose to introduce to this remote community? On what did you base your decision?

Be prepared to share your answer at the next meeting.

Digging Deeper

For Senior Members

Robot Design

Activity courtesy of AgScape

Select a type of production agriculture and design a robot (to do a task other than what is listed is this project) that will help the people who work in that industry do their job.

Draw and label the robot and write a paragraph about how their invention could have a positive impact on the quality of life for a farmer. End the paragraph by predicting whether the robot will be accepted by the industry and society.

Be prepared to share your findings with the group at the next meeting.

Activity #1 - Breakthrough Technologies

Do	Time: 30 minutes **Materials:** • Breakthrough Technologies document (found on the next page) **Instructions:** • Have members read through the list of breakthrough technologies. • Have each member (or have members work in groups) choose at least two breakthroughs listed and research online to see if there has been any progress on the technology. • Have members present their findings to the group.
Reflect	**Learning Outcomes:** • To allow members to see what emerging technologies are being introduced to the agricultural industry. • To allow members to think critically about the technologies presented and the implications these technologies will have for agriculture.
Apply	**Processing Prompts:** • Were you surprised by any of the information you found about the progress/update of the technology? • Do any of the technologies seem too far-fetched to work in the agriculture industry? Seem impractical? • How do you think these technologies might change the way farmers operate their farms? • Can you think of other applications for the technology listed? Any other industries that could make use of this technology?

Breakthrough Technologies That Support Sustainable, Efficient Livestock Industry

As consumers continue to demand better animal welfare and improved sustainability across the livestock sector, new innovations are emerging that enable producers to monitor herd health in real time, prevent disease outbreaks, and optimize nutrition. Thirteen of these breakthrough technologies were spotlighted at the Animal AgTech Innovation Summit in San Francisco on March 16, 2020. Solutions ranged from a nonantibiotic treatment for bovine mastitis to autonomous livestock monitoring.

The Start-Ups

Armenta (Israel). This company has developed the first nonantibiotic treatment for bovine mastitis using acoustic pulse technology (APT). Mastitis causes annual losses of over $6 billion in the U.S. and Europe. Infected cows treated with APT have shown 70% cure rates and consequently 10% increase in milk yield.

BinSentry (Canada). An agricultural IoT company, this start-up is solving a 40-year-old problem in the animal feed industry – reliable inventory monitoring of on-farm feed bins. BinSentry's IoT sensor enables feedmills and vertical integrators to realize significant cost savings by enabling dramatic increases in operational efficiency.

CattleEye (Ireland). This start-up has created the world's first autonomous livestock monitoring platform, which will improve the lives of farmers as well as their livestock. Its deep learning AI platform is designed to interpret visual imagery of livestock from web cameras and extract valuable insights about those cows.

FarrPro (USA). This start-up was founded to change the way the world rears pork. Its Haven platform reduces piglet mortality, saves energy, and improves sow welfare by creating a microclimate environment for piglets to stay safe, warm, and healthy. The platform is the first step in the company's roadmap to bring traceability and automation to the pork industry and provide the insight and control required to prevent disease outbreaks, rapidly develop vaccines, and safeguard the pork supply chain.

General Probiotics (USA). This company is developing innovative cellbots and antimicrobial probiotics that eliminate harmful pathogens in livestock, enable the production of safe food, and reduce the current dependency on antibiotics. Its core competency is the precise engineering of advanced probiotics using synthetic biology and artificial intelligence.

H2OAlert (The Netherlands). This start-up has created the first uniquely wireless IoT real-time water control management system for dairy and beef cattle. The quality and quantity of the cattle drinking water is checked in real time, 24/7, for pollution and possible malfunctions in the water supply. In this way, the H2OAlert system and the data obtained will result in a direct contribution to animal welfare plus milk and meat production.

Hencol (Sweden). In order to give producers an optimized decision support system, this company is developing the next level of precision livestock farming with its big data and AI algorithms. Hencol enables digitalization of the entire value chain with significant benefits for all.

Jaguza Tech (Uganda). This company has developed an offline and cloud-IoT-based livestock management system, which features animal healthcare monitoring and recordings of IoT sensors, farm management systems, and animal livestock identification as well as utilizing animal smart tags and QR code readings via wireless technologies.

Moonsyst (Hungary). The smart monitoring system this start-up has created for progressive dairy and beef producers collects different parameters of livestock. This real-time data helps producers increase productivity and detect disease, stress, and heat.

Nextbiotics (USA). This company's goal is to leverage cutting-edge synthetic biology tools and bacteriophage technology to provide unique solutions to the antibiotic resistance crisis. It offers solutions to destroy pathogenic (bad) bacteria. Its first product is a feed additive for animal producers to enhance animal nutrition and significantly reduce the use of antibiotics.

Roper (USA). This start-up is revolutionizing beef production with a solar-powered, GPS ear tag and companion mobile app. Roper's technology provides geolocation and health monitoring of cattle in a pasture, which enables producers to cut management time by 30% and maximize fertility and nutrition, sustainably manage grazing, and pinpoint sick or distressed cattle.

Simple Ag Solutions (USA). A B2B, software-as-a-service company, this start-up is bridging the gap between animal health and production. Its platform was developed for livestock and poultry producers to help manage antibiotic use, optimize production, and facilitate audits.

Source: https://www.agriculture.com/news/livestock/13-breakthrough-technologies-support-sustainable-efficient-livestock-industry

Activity #2 - Technology in the Barn Wordsearch

Do	Time: 20 minutes **Materials:** • Technology in the Barn Wordsearch (found on the next page) • Paper and a writing utensil **Instructions:** • Have members find the words listed in the wordsearch. • Discuss what each technology listed is and which type of livestock barn/pasture it might be found in.
Reflect	**Learning Outcomes:** • To allow members to discover and review various types of technology found in livestock barns and pasture.
Apply	**Processing Prompts:** • Did you recognize each piece of technology listed and which livestock barn/pasture it can be used in? • Have you seen any of these types of technology in use? • Are there other industries that could use this type of technology? • Are there ways this technology could be adapted for other uses besides its original use?

Technology in the Barn Wordsearch

c b s a y l b p e y c v u k l a t e s y j e s q d l s c q b f x v m f e k w w v
o r y u g y r b v p a i c i t a m o t u a a f g h l a c h i w w x p t c u p c t
z e e t o t j h e q t d a d x o n c r j c z f f p b a d j i f s e z o p w s h w
y x k o l k b m t f t e c v d a p n g n r b w g i x f o q e c k l t u e c j b d
h p r n o v u z g w l o h e a l t h o i i t o u o c h a k r b k s k s b x y x z
a p u o n k g c x z e k d o h e i j q j w h p u l b i q u g z e e u c k b q k p
z y t m h n q k i z a k z x q z p t b f n a i s m i q e x r v o r n g r q f e e
c b j o c o y m z c d o m r q u n n o f h i b t w c t z n i s o j e s l m a e h
m a h u e i y c s j y b z s h q c m b j j m c o b j b p l c b c d a s y o x z w
o q c s t s i i z r z u u b k e l k x r n y r b t m i s o o y t k a y d w l i o
f e u n t i y t z j x s n o i t a v o n n i e l c g u v t u d t e f e n a l q s
d f j n c c s e y r t r u u k s s n v m j u i l s x z i k g t w s s o c w r g w
t i v k e e y c g a a m w w j m b n x d d g f e c v c b a i t l a e e c r w a p
f t f g b r r h i y c c p u o z g w a j o n r c i m z k n p l y g g f c y u c v
o k e g f p p n w s y h r g m o i a y n u p u a y h j u q j k w i i s o m w y o
y w s k e g a i v r t q n c u s r m k s y k s p d v t i l i f f k p o v e e a m
b p u f k b u c y p k a k c f z r y h u e a a s l p m r w d y r e u a q j h p n
w r f k i l g i s a x p o d d n w i k j r c i r s b f r x t n r o d k u i d m z
x h n l g i m a o h n z m g a r u e e d g n w m c e l v n y u r k k f s r d o l
e f i m s n y n u o v v f w h r t y w q q v d m d w n c g t s a c d d f b v y r
m t a i c h u w g q q a e r o w y s r o s n e s i l l o a l e k l k b g y x t c
y w i y u g i t a n h h b u t z k d k j v w y u y q b r r n q u l a v v c l j e
m r g o c t h d r d i g i t a l i z a t i o n y v l e b g d o l q w r x n a p y
w e e v p e e h s i e r m g i h o j b q q d s k k p o i r o a t o s r m s g h l
s d l g w j i e b c t w o e j q b y n u r w e g m w n o y v l y z l n c s u p n
s s z r a l b z b u q i e t d y l h b h n c t e h e l j u w x p s t o c y z f m
l o f a o m b s t k s o o a i c l c x s a g t a e a c r o n e e d i o h b x h w
w l n s t l i b o e c c k n h n j f y z l x p r u w w i a q a t m x w f d w a f
w f a v e h l j w j v s g n e p o o w h k a v t x k p d t x d g l g e z e l f d
j f e y b p i q n k e u a g e u u m r x w r r x v u a z a i z y c q d m m p o e
y w o k q b y p p t x r h y b f b n t u v i t v w s g u p b c m l e p x i v v v
c h d t t w z n z a n g f u v s l c r i v e u f a l f a q e n r w v r z b f d r
z r j x m o u t t y l e d t b e i u g o c o u z i d p r m e b w u c z j a k j d
y e s o j m d q r h g z d w r v q v p p u s n b v b e l o k g z z c p p y v v d
x w f t a i d i a z u l g a o c p d h s v d x d n o b r a a u w w m s u v p z d
e n v i r o n m e n t g o v l x c y i i g h t z h m u g p j x p y h i a m i u a
y u t a j v f p r h c m p g p w a g i d w i r u m p a u h l w a d s s o x j e m
x g z l u o m m l u z r n l x n u o p r f u g p e x i q t f k s v x e w j d y l
t a z v o y a i g p a r e e r y z s g m z y h g o u x c s w n k c m k u e u j i
f p i d g u j q r d u e u i f a u w q u z e w h t e s r r t o p w l q h y i k a

alarms automatic autonomous cattle cellbots

chickens digitalization drones efficiency engineer

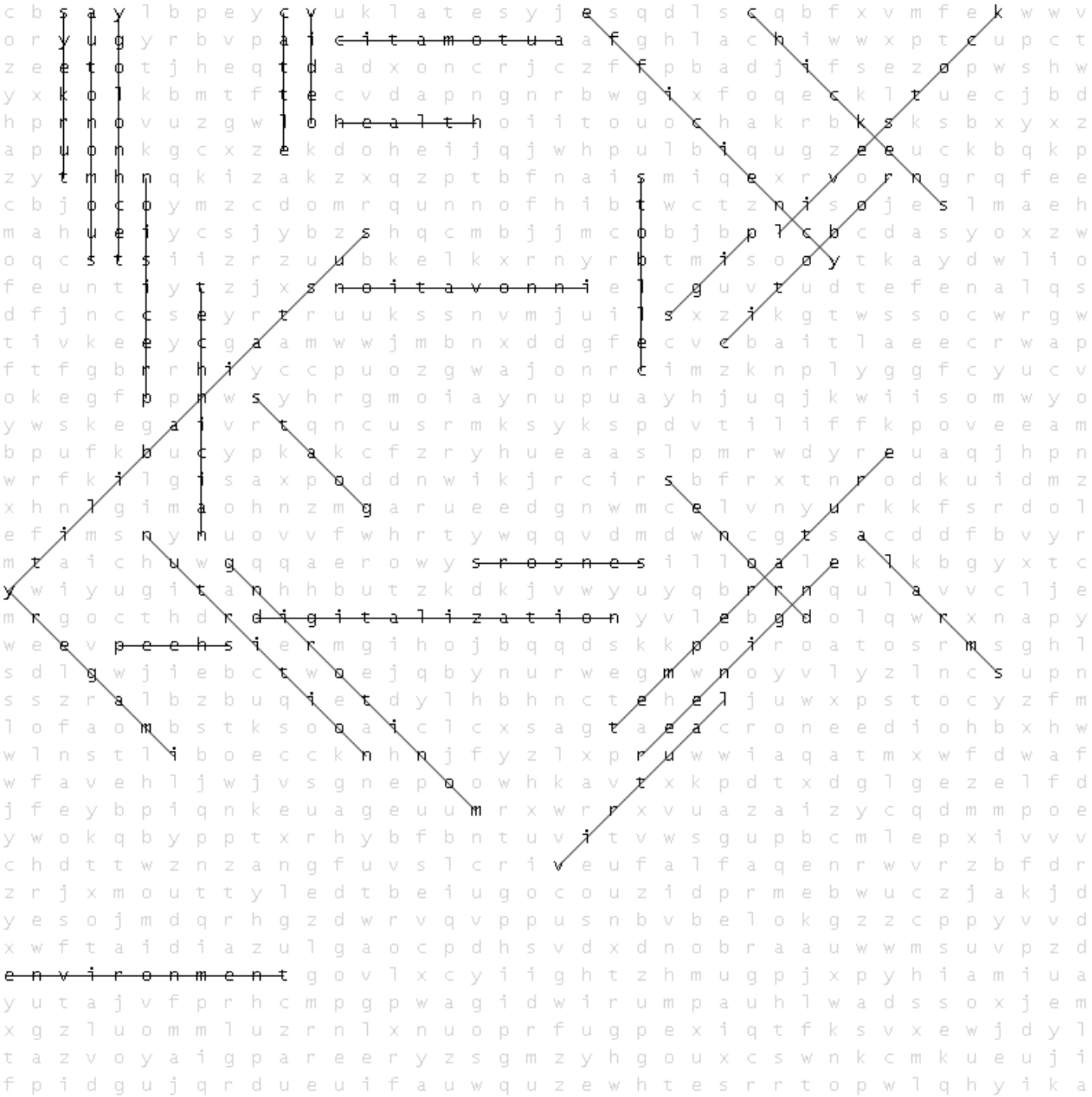
environment goats health imagery innovation

livestock monitoring nutrition pigs precision

robotic sensors sheep sustainability technician

technology temperature turkeys video virtual

Technology in the Barn Wordsearch Answer Key



Activity #3 - Design Your Own Barn

Activity courtesy of AgScape

Do	Time: 40 to 60 minutes **Materials:** • Computer/online device with access to the Internet **Instructions:** • Have members set up their TinkerCAD account: https://www.tinkercad.com/. Then have them visit https://www.tinkercad.com/learn/ designs to explore the program and learn the basic design functions before moving on to the activity. • Members should then design barn or feedlot in TinkerCAD (or an equivalent coding/building program or using hand-held manipulatives) incorporating at least one technology mentioned in this meeting. Consider spacing, ventilation, access to the outdoors/fresh air (if its an option depending on the type of livestock), safety, food and water access and other points that are important for animal welfare. • Members are to create a presentation to highlight the barn they have created. • In addition to the barn design, have members visit https://www.agcareers.com/career-profiles/ to explore careers related to the farm/barn style they've created. The presentation should include a minimum of 5 key careers that are related to the specific animal health and welfare-related elements included in the barn design. • All of the research is to be put together in a short presentation to share with the group. Various forms of media (audio/visual/video) could be used in the presentation.
Reflect	**Learning Outcomes:** • To allow members to become familiar with the software used in designing barns (and other structures). • To have members use critical thinking skills to decide which elements need to be included in their barn design. • To discover careers related to the barn/type of livestock that was designed.
Apply	**Processing Prompts:** • Was it easy or hard to learn a new computer program? • Were you able to design your barn the way you wanted or did the computer program have limitations? • Now that you have your barn designed, are there any changes you would like to make? • After seeing designs from other members in the club, are there any changes you would like to make to your design? • Did any of the careers you heard in relation to each barn that was designed surprise you? • Are there any careers you want to find out more information about?

Meeting 6 – Weather Monitoring - Food Processing, Packaging & Retail

Setting Objectives:

To create an awareness of the technology available for monitoring weather.
To create an understanding of the technology becoming available for food production beyond the farm.

Suggested Learning Outcomes:

- To learn why weather monitoring is important
- To appreciate emerging technologies used in food production
- To realize why advancements in packaging are needed for food products
- To understand what new technologies are being used within the retail sector
- To realize that technology can help advance agricultural education in new ways
- To discover careers related to the technologies presented in this meeting

Suggested Roll Call Questions:

- Which technologies would you introduce to a remote agricultural community that has been cut off from the rest of the world? (At Home Activity from Mtg #5)
- Name one piece of weather data that is important for farmers to know.
- Name one source of weather data (e.g. The Weather Network, Accuweather, radio).
- Name one reason it is important for retailers to be concerned about the type of packaging being used for food products.
- Name one thing you have learned in this project that you didn't know before taking this project.

SAMPLE MEETING AGENDA Time: 1 hour 55 minutes

Welcome, Call to order, Pledge		10 minutes
Roll Call		5 minutes
Parliamentary Procedure	Minutes and Business	10 minutes
Topic Information, Discussion & Activities	**Topic Information** • Weather Monitoring Technologies ◊ IoT Sensors ◊ Satellite data & hardware stations ◊ Artificial Intelligence & machine learning • Technology in Food Processing ◊ Artificial Intelligence ◊ Automation ◊ Virtual Reality	30 minutes

	• Technology & Innovations for Food Packaging ◊ Internet of Packaging ◊ Biodegradable Packaging ◊ Active Packaging ◊ Edible Packaging ◊ Nanotechnology • Technology in the Retail Sector ◊ 3D Printing ◊ Blockchain • Technology in Agricultural Education ◊ Virtual Reality Activity #1 Find Your Purpose-Driven Career (Careers in Agriculture & Food) Activity #2 Food Packaging Design Challenge	 20 minutes 30 minutes
Wrap up, Social time and adjournment		10 minutes

Topic Information

Weather Monitoring Technologies to Help Save Crops and Pasture Land from Mother Nature

Unpredictable and sometimes severe weather is a critical issue to address. No one can change the weather but monitoring and predicting it can save a lot of money for agribusinesses. This is where predictive weather analytics and weather tracking technology in agriculture can help.

The idea of building a weather forecasting solution for agriculture looks more than promising. Such a solution needs to mitigate the effects of climate change by predicting uncommon weather that harms crops. Predicting weather changes will empower agribusinesses to optimize resources, save crops, and automate decision-making on growing and harvesting periods as well as contribute to the concept of climate smart agriculture.

Almost every solution for smart weather monitoring relies on data. And not just for forecasting extreme weather like floods but for regular weather conditions in the field that impact crops day to day. Thanks to technologies like IoT weather stations, weather collection data, and AI weather prediction, agribusinesses can store and process countless data sets to be prepared for weather changes, react to them fast, and promote climate change management initiatives.

The most critical weather data for agriculture:

- **Rainfall** – Analyzing historical data on rain over defined periods provides bold observations and serves as valuable input for future predictions based on artificial intelligence algorithms.
- **Temperature** – Tracking changes in temperature during the day, month, and year gives an outlook at conditions for crops and inputs for further analytics on conditions determining weather changes.
- **Wind** – Wind direction and speed can warn farmers of a coming storm.

- **Air pressure** – This is one of the most important measurements for predicting weather changes.
- **Humidity** – This metric is critical, especially with regard to preparing for rain and using water smartly.

All these data sets can be gathered into a unified platform for weather monitoring and made available from any device. Farmers may customize dashboards to monitor the most critical data and visualize analytics for better decision-making. On a smart weather dashboard, farmers also can:

- set the number of measurements collected over a defined period (hours, days, weeks, months, years)
- track all historical data or choose a period to display
- observe community data from other farms as open-source information
- locate all sensors across fields to know where weather changes may already be impacting crops
- correlate metrics to build forecasts accounting for all potential hazards and get suggestions for protecting fields

A typical application for agriculture weather forecasting technology

Image Credit: Intellias

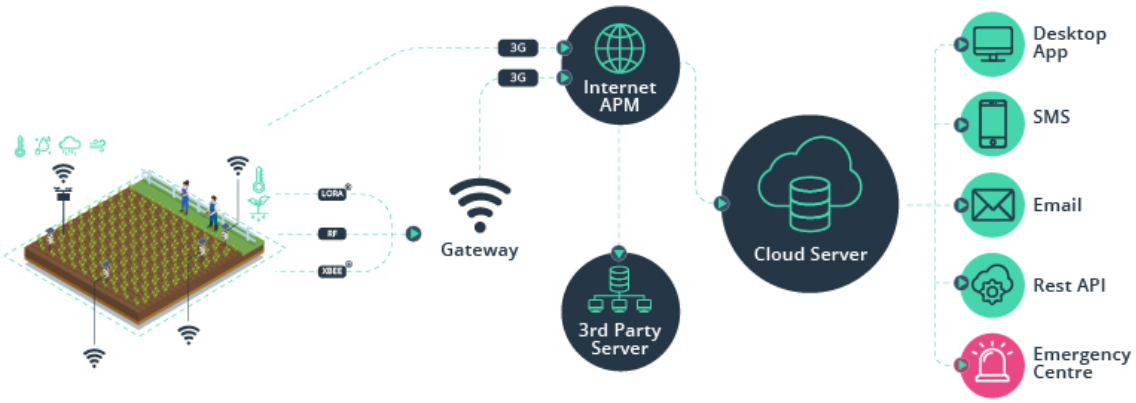
Experience It!

Invite a meteorologist, climatologist or an agronomist to speak at your meeting about the importance of weather monitoring for agriculture.

Applying real-time data on weather conditions relevant to the current location and season helps farmers take care of soil and crops and manage all weather-related risks. When it comes to selecting technologies for weather forecasting, agribusinesses should consider a mix of agricultural tech solutions that complement each other. The three main technologies that contribute to the development of intelligent weather monitoring for agriculture are smart IoT sensors to collect and analyze data, satellites and weather stations, and AI and machine learning systems for weather predictions.

IoT sensors for weather monitoring

IoT sensors lay the foundation for a bigger connected system for weather tracking in agriculture. These systems rely on a network of connected sensors that collect data in the field. Cloud computing platforms then process the collected data to provide alarms and notifications on potential weather hazards affecting crops.



Connected system of IoT sensors for weather monitoring
Image Credit: Intellias

Using IoT systems, farmers can get real-time access to information on the environment and soil to plan actions ahead of weather changes. When a system receives disturbing data from weather sensors, it can send a notification on upcoming frost or rainfall.

- Advantages of IoT solutions for weather condition monitoring:
- Reduce risks to crops by monitoring severe weather conditions
- Help farmers optimize use of resources and protect crops
- Increase the quality of products by suggesting the best time for harvesting
- Send notifications to multiple devices and platforms in real time
- Collect reliable data in the field that's relevant to a farm's location and the current season
- Integrate with third-party services and access community data

CAREER ALERTS!

*Check out some exciting technology careers for **weather monitoring** that can assist agriculture!*

- *Meteorologist*
- *Climatologist*
- *Storm Chaser*
- *Environmental Scientist*
- *Graphic Designer*
- *Software Developer/ Engineer*
- *Information Technology Specialist*
- *Electronics Technician*

Satellite data and hardware stations used for weather forecasting technology in agriculture

Farmers can adopt satellite data for various purposes and use aerial images to observe crop yields and perform weather forecasting in agriculture. Satellites can be used in two ways:

1. a source of data for farmers' weather forecast apps
2. as transmitters of data collected from agricultural weather stations on Earth.

The second way satellites can be used (transmitter of data collected from agricultural weather stations) is a bit expensive however, as transmission of data via satellites costs a lot — nearly $1,300 (Cdn.$) per kilobyte (as of the year 2021). Agriculture weather predictive technology allows farmers to use satellites to access geospatial and meteorological data to prepare fields for uncommon or severe weather.

Agribusinesses are also using satellites for weather forecasting to monitor global climate changes and predict weather disasters like fires and floods. Most often, satellites are controlled by government organizations and therefore aren't flexible enough for custom use cases. Still, they provide the overall picture of weather conditions in an area. Collecting satellite images and data empowers applications to assist in predicting crop yields based on weather conditions and field monitoring. It also helps in planning smart irrigation based on weather changes that can spread potentially dangerous herbicides across the terrain.

AI and machine learning to predict weather events

The application of AI and machine learning to weather forecasting is the most recent and promising technological advancement for agriculture. As with any AI solution, weather forecasting requires a huge amount of data to teach machine learning algorithms. This data can be crowdsourced from connected sensors, satellites, and local hardware weather stations to create accurate localized weather predictions. These predictions require great computing power to process large data sets, and capable storage is required to save this data for future use.

As deep learning algorithms rely most on the quality of training data, data quality and labeling is critical for accurate predictions. Sorting data and recognizing weather patterns should help to extract accurate insights on determining weather conditions following training of a deep learning model.

The increase in accurate data sources plays a big role in successful weather prediction. There are more than 1,000 weather monitoring satellites currently orbiting the Earth, and there are thousands of weather stations on the Earth's surface. The most recent addition is IoT-connected sensors installed by individual farmers in their fields. All of these provide enough inputs to teach algorithms how to distinguish between cloud patterns, recognize the consequences of the smallest temperature and humidity changes, and detect potential hazards based on changes in wind direction that may bring weather fronts from other terrains.

Excerpts from Intellias https://intellias.com/weather-monitoring-technologies-to-save-crops-from-mother-nature/

Experience It!

Climate change is a significant issue for everyone, including farmers. Learn how genomics is helping Canadian agriculture breed more resilient plants and animals that can stand up against the effects of climate change. Watch this video titled 'Genomics and Climate Change in Canadian Agriculture' created by Farm & Food Care. https://www.youtube.com/watch?v=IVVaAW5DveE

DISCUSS IT

How could weather monitoring technologies help outside of the agricultural industry? Who could this technology benefit?

Technology in Food Processing

Artificial intelligence (AI) in processing

AI technologies have become the backbone of many other technologies. Robots, for example, use AI in processing plants to improve efficiencies. Through a collaboration of efforts, iPoultry is a high-tech automated processing system. Automating a procedure such as chicken deboning requires recognition of the shape and size of each chicken and individual adaptation. Artificial intelligence is the perfect technology for this application. A computer can analyze the difference in density and structure of meat versus bone, thereby making the most precise cut possible. This is a great example of combined technologies: robots perform the work that AI instructs them to do based on the data that sensors collect. Some robots can debone a chicken in two to three seconds, replacing up to 30 human operators. JBS (Canada and USA), one of the world's largest meatpacking firms, deploys robotic butchers within its plants. The robots are used to slice more challenging meats, which reduced workplace injuries.

Automation

Automation stands alongside AI and advanced robotics, even incorporating those technologies to create a streamlined system. Many systems are designed to replace or enhance repetitive tasks, boosting their speed and accuracy, to significantly improve output, without incurring a loss in quality. It's not just about hardware, like swapping a human labourer for a robot. It's also achieved through software. Think supply chain management solutions that help plan for various events and experiences without human input.

When many of these technologies are used side-by-side, it strengthens their application and usability. As is true of advanced robotics, for example, AI can also be used to create more intelligent automation platforms. Instead of carrying out repetitive or simple tasks, they can be programmed to react and engage through any number of parameters. The system might slow production, for instance, based on a decrease in product demand. Or it might swap to an alternate component or ingredient because of a shortage somewhere.

With the right controls and support, automation technologies are game-changing. With the global population growing and demands increasing more with each year, food manufacturers will look to streamline their operations and boost output in any way possible, and automation will be a go-to.

Virtual reality (VR) training in production

The most obvious application for VR in the food processing industry is training, particularly processing. It could teach line workers in the processing plant the ideal way to trim meat from birds. Applied to free-range layer houses, it could teach employees how to walk through the house without frightening the birds, find errant eggs and check on hens. This technology is, however, expensive, and implementation is likely to be slow.

CAREER ALERTS!

*Check out some exciting technology careers in **food processing**!*

- *Food Technologist*
- *Equipment Technician*
- *Food Safety Specialist*
- *Microbiologist*
- *Electrical Engineer*
- *Software Developer*
- *Microbiologist*

Technology and Innovations for Food Packaging

The packaging industry is adopting smart and sustainable solutions to make product packaging more consumer, brand, and environmentally friendly.

Internet of Packaging

The internet of packaging brings technological disruption to traditional packaging and allows consumers to better connect with brands. Smart packaging leverages technology such as QR codes, smart labels, RFID & Near Field Communication (NFC) chips. These cutting-edge technologies offer value-added benefits of security, authentication, and connectivity, making the product packaging a data carrier and digital tool. AR packaging gives companies an opportunity to better engage with customers by introducing them to a range of product content, discount codes, and video tutorials. Further, the internet of things sensors and devices allow brands to integrate diagnostic and indicator functionalities in their packaging. This helps customers to know in real-time the product's condition.

Food Consumption Tracking

British startup RightMash Technologies builds an IoT-based real-time food consumption tracking platform. The food item is placed on an NFC-enabled RightMash sensor which tracks minor weight changes in the food item or container. Then, the RightMash platform uses big data to provide consumption patterns and inventory analysis. In the event of low stocks, reorder, or expiring products, RightMash automatically triggers an alert. The startup provides businesses in the food industry with the technology to increase their revenues by helping businesses reduce losses incurred due to spoilage, wastage, mishandling, or manual error.

Biodegradable Packaging

Plastic is the most commonly used packaging material since the early 20th century, however, its slow decomposition rate causes widespread environmental problems. As consumers become more aware of the negative consequences of single-use plastic packaging, they demand eco-friendly packaging. Biodegradable packaging and films gain traction and are suitable alternatives to traditional plastic packaging. For example, starch, cellulose, PLA, polyhydroxybutyrate (PHB), and polyhydroxyalkanoates (PHA), as well as other biopolymers, find applications in the packaging industry. Apart from this, plant-based packaging from sugarcane, coconut, hemp, and corn starch also replace plastic packaging. These innovations are economical for businesses to adopt and reduce their impact on the environment.

Corn-based Foil Packaging

Bulgarian startup LAM'ON produces 100% biodegradable and compostable lamination film and foil packaging. They produce PACK'ON, a packaging foil made of polylactic acid (PLA) derived from corn. The use of silver nanoparticles as antibacterial additives in the foil and its oxygen barrier properties make the solution suitable for food packaging. The film and foil break down in natural materials such as water, carbon dioxide, and composite. The polymer threads of the product are biaxially oriented and, hence, make it durable and less prone to tearing. Moreover, PACK'ON indicates no migration of oils and other elements which makes the product safe for packing of food and cosmetics.

Active Packaging

According to the Food and Agriculture Organization (FAO), one-third of all the food produced for consumption is wasted globally. Food waste is a big challenge to be addressed as companies often incur huge losses because of the same. Active packaging is a growing packaging industry trend, which is used with the goal of increasing the shelf life of the product and has applications in the food, beverage, cosmetic, and pharmaceutical indus-

tries. For example, modified atmospheric packaging uses oxygen or ethylene absorbers and moisture regulators to keep food fresh. Another example of active packaging releases antimicrobial agents to prevent bacterial growth in the product.

INNOVATION HIGHLIGHT

Active Packaging Films & Containers

SoFresh is a US-based packaging startup that develops food-saving packaging. The startup develops techniques for infusing food-grade natural extracts into film or containers that release controlled active vapor in the food item. Mold spores absorb the vapor, slowing down their metabolism to the point that they struggle to survive. SoFresh's packaging products include standard and custom bread and bakery packaging, over-wrap films, lid stock materials, and barrier laminations. Its technology is tested with food items such as bread, cheese, and berries hence is well suited for companies selling these eatables. SoFresh's active packaging solution enables companies to extend food travel life, shelf life, and consumption time so as to mitigate spoilage and wastage.

INNOVATION HIGHLIGHT

Compostable Active Packaging for Fish

Canadian startup Impactful Health R&D develops a packaging solution to prolong the shelf life of fresh fish. The startup offers an active film-based technology with naturally derived anti-bacterial components. Their packaging is 100% biodegradable and is compliant with the Food and Drug Administration's (FDA) oxygen transmission rate requirement. Further, the film is useful in skin or vacuum packaging applications and preserves the texture of the fish. The startup's solution is capable of increasing the shelf life of fish by a considerable amount of time. This helps fish sellers, re-sellers, and fish farming industry to minimize losses

Edible Packaging

Packaging follows the use-dispose model, and so largely contributes towards solid waste and ends up either in landfills or in water bodies. This is why over the last decade, both businesses and consumers are moving towards sustainable packaging. The challenge for businesses is to opt for packaging that satisfies this basic functionality and also reduces or eliminates solid waste. Edible packaging is a revolutionary packaging industry trend that addresses the challenges and also closes the loop for packaging. A good example is packaging made from milk protein used as casein film around food products. These films are better at keeping food fresh, compared to plastic. Also, startups making edible spoons, straws, or other cutlery items provide restaurant chains, cafes, or ice cream parlors with options other than plastic.

INNOVATION HIGHLIGHT

Edible Packaging Material

Decomer Technology is an Estonian BioTech startup that is innovating a plant-based edible and water-soluble packaging material. The startup's material is tasteless, transparent and hypoallergenic, and is used for packaging in industries like food, detergent, pharmaceutical, and agriculture. Their product, HoneyDrop, is honey packaged in edible packaging material. BlenDay is another product by the startup, a blendable plant-based superfood pillow pack, which is consumed by blending into smoothies as-is. The outer layer of BlenDay packs is made of pectin and colorful superfood powders.

INNOVATION HIGHLIGHT

Edible Cutlery

Kulero is a Germany-based startup that produces edible cutlery. Kulero meets the demand for disposable cutlery with its edible and sustainable cutlery alternatives. The edible cutlery is made from multi-grain flour, salt, and water. In addition, spices, herbs, or cocoa powder are used to add flavors. Their vegan spoons are durable and last 30 minutes in hot liquids or soups and 60 minutes in cold meals. Already, the startup has managed to replace 5 million plastic spoons. It currently offers a range of products including edible spoons, edible straws, and cups, as well as compostable bowls and plates.

Nanotechnology

From packaging material, product safety, authentication, and tracking; nanotechnology has applications at various phases of the packaging supply chain. The use of nanoparticles mixed with polymer chains in packaging enhances barrier properties and tensile strength. The use of nanomaterials in packaging enables tracing and anti-counterfeiting for brands and packaging companies. Nanotech also has a big impact on the food packaging industry by addressing the rising concern of food safety. Also, nanocoatings are applied on the packaging surface to keep it safe from dirt, dust, and stains. Lastly, several types of nanosensors are useful to monitor the freshness of the food and detect any chemical changes.

CAREER ALERTS!

*Check out some exciting technology careers with **food packaging!***

- *Software Developer/Engineer*
- *Information Technology Specialist*
- *Electronics Technician*
- *Graphic Designer*
- *Environmental Scientist*
- *Microbiologist*
- *Consumer Scientist*

INNOVATION HIGHLIGHT

Cellulose-based Materials

CelluloTech is a Canadian nanotechnology startup that focuses on cellulose-based materials. The startup's solution replaces plastic coatings for different types of packaging with a fully renewable mono-material alternative. To replace plastics, waxes, and other non-biodegradable material used in packaging with cellulose, they use their proprietary technology to make cellulose packaging-fit. CelluloTech's green-chemistry process, CHROMATOGENY, makes any cellulose-based material, such as paper or cotton, permanently hydrophobic.

INNOVATION HIGHLIGHT

Invisible Inks for Connected Products

Canadian startup Arylla develops smartphone readable invisible ink to make products traceable. Its proprietary invisible ink uses nanotechnology and is completely undetectable by sight and cannot be felt. Label suppliers use the ink to print unique identifiers or tags with Arylla's low-cost, small-footprint inkjet stations. The startup's tag platform integrates with third-party software to offer personalized customer experiences, fight counterfeit, and improve traceability. The ink is printable on different materials including woven labels, packaging, hand tags, and patches. The technology is used in luxury items to ensure authentication and prevent counterfeiting.

Excerpts from Top 10 Packaging Industry Trends & Innovations in 2021, StartUs Insights

DO IT!

Research to see if there are any other types of new packaging that aren't listed in this project.

Technology in the Retail Sector

3-D printing

A new world of food processing is becoming a reality with 3-D printing. Cakes and pizzas may be the currently popular 3-D foods, but using 3-D printing, the food industry could eventually produce new types of food by utilizing low-value meat cuts, creating new opportunities to increase carcass value and putting more money in the pockets of farmers and ranchers.

3-D printing can also shorten the time needed to replace machine parts and even has veterinary applications.

Blockchain

Now more than ever, consumers are demanding complete transparency when it comes to purchasing food products. Lack of knowledge of origin and concern over foodborne illness has left consumers distrusting food labels. Blockchain could be used to reinstate confidence in food products by offering traceability of products along the entire supply chain, from producer to retailer

Blockchain in production safety

Blockchain's opportunity in the poultry industry is its ability to resolve food safety and transparency issues. Walmart, Unilever, Nestlé and other food giants are working with IBM using blockchain technology to secure digital records and monitor supply chain management, ensuring traceability of the poultry products sold in stores. Blockchain can be used to monitor all aspects of the food supply chain, from farmers and producers to processors and distributors. This is Walmart's third experiment with blockchain and seeing the increasing interest of other large food conglomerates demonstrates the unique capabilities of this technology.

Recently, Cargill announced it would enable customers to trace their Thanksgiving turkey back to its farm of origin. Blockchain technology is what makes this possible. Consumers can enter a code from the package onto the company's website and learn where the turkey was bred and grown. This is a big step toward offering traceability and understanding where food comes from, something that is becoming of increasing concern for consumers.

ZhongAn Technology has launched a technology incubator to develop blockchain technologies, citing that there is an expectation of specific applications within the poultry industry. The Chinese consume about 5 billion chickens a year but prefer dark meat rather than the breast meat favored by American consumers. Recently, the country has been allowed to export cooked chicken to the United States, and blockchain could be a way to alleviate any concerns about sourcing and production methods, eventually opening the way for raw exports.

Apart from the benefits for farmers or processors, consumers may be the key to implementation. Transparency is becoming critical, as is having the ability to know where and how food is produced. Australian-based CHOICE offers all iPhone and Android users a free app that allows consumers to scan a code on the egg carton and download detailed information on where the eggs are from and information relating to their welfare conditions.

CAREER ALERTS!

*Check out some exciting technology careers in the **retail sector**!*

- *Food Technologist*
- *Equipment Technician*
- *Food Safety Specialist*
- *Microbiologist*
- *Electrical Engineer*
- *Software Developer/Engineer*
- *Analytics & Data Managers*
- *IT Technicians*
- *Social Media Managers*

Experience It!

Have a guided tour of a grocery store, guided by the owner/ manager. See what various technologies the store has in place that benefit the store and/or the consumer.

Technology in Agricultural Education

Virtual reality

Virtual reality is the next step beyond augmented reality (discussed in Meeting #5) because while it is also a 3-D, computer-generated environment, in virtual reality, the entire visual is virtual.

This technology can be used to demonstrate farm life to the public, increasing consumer awareness without inhibiting production or endangering animals or consumers. People don't have to be on the farm to hear and see how the farm operates. Virtual reality can be used to engage and educate the consumer to address common misconceptions and help them relate to farm life.

A similar concept is being used for pre-sale auctions as well, allowing farmers to view and purchase stock using a 360-degree pre-sale auction inspection video experience. Potential purchasers navigate around the auction forum from their computer or smartphone within a headset.

Excerpts from Progressive Cattle

DO IT!

Remember, with any tour that you might take during this project that you are a guest. Be polite, respectful and grateful to the host(s) that have opened up their facility/fields for your 4-H club to tour.

JUDGE IT!

Choose 4 different types of packaging for food. Have members create a list of features they think are important to have for food packaging (a list of criteria). Then, using this list have members rank (judge) the packaging and give their reasons for their placing.

Digging Deeper

For Senior Members

Weather Monitoring

Over the course of a month, track the weather. Record information such as:

- Total amount of rainfall/snowfall
- High temperature of the day
- Low temperature of the day
- Wind speed
- Air pressure (if that information is available)
- Humidity (if that information is available)

Create a graph that charts each of the above pieces of information, using a different colour for each line. Do you notice any correlations between precipitation, temperature, wind, air pressure and humidity?

Keep the graph in your Record Book.

Activity #1 - Find Your Purpose-Driven Career (Careers in Agriculture & Food)

Do	Time: 20 minutes **Materials:** • Computer/table/device and access to the Internet **Instructions:** • Visit the thinkAG website: https://thinkag.ca/en-ca/ • Follow through the steps listed on the home page for the careers quiz, exploring agriculture and food careers, learning about careers in Canada's food supply chain and viewing scholarship and post-secondary opportunities that are available.
Reflect	**Learning Outcomes:** • To assist members in discovering their career interests and talents. • To allow members to think about a career they not have previously considered.
Apply	**Processing Prompts:** • Did the results of the careers quiz surprise you? • Are you thinking of a career that you may not have previously considered? • Where are skills needed in Canada's food supply system? • Is there more information you would like to research about certain career paths?

Activity #2 - Food Packaging Design Challenge

Do	Time: 30 minutes **Materials:** • Computer with access to the Internet or craft supplies **Instructions:** • Have members work in small groups to create a food package design for a new kind of homemade-style soup. Have members keep the following in mind while creating the packaging: ◊ Environmentally friendly/biodegradable ◊ Consumer/eye appeal ◊ Messaging on the packaging (nutrition, where it's made, etc.) ◊ Suitability to the type of food being sold ◊ Ease of opening the packaging ◊ Food safety concerns *Alternate activity* – have each small group choose a different type of food to design a package for.
Reflect	**Learning Outcomes:** • To allow members to be creative while also keeping many other factors in mind when designing packaging for food.
Apply	**Processing Prompts:** • Were you able to consider all factors when designing the packaging? • Is the packaging practical for the type of food it's designed for? • Would the packaging you designed be easy to produce in mass quantities? • Is the packaging environmentally friendly? • Is there a way to make the packaging tell you if the food inside is safe to eat?