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ISSUE
6

AG IN THE CLASSROOM
AG FOR LIFE

AGTECH

How Technology is Shaping the Future of Agriculture

Letter from the Editor

SINCE 2011, our mission at Agriculture for Life has been to deliver impactful, educational programs and awareness, connecting students of all ages to the "culture" of agriculture. Agriculture and food production are critical to every aspect of life, whether you are a city dweller, a canola grower, a rancher, or a backyard-garden tender. It is our mission to educate and inspire people of all ages to understand the integral role agriculture plays in society, the environment, and the economy.

Our goal with this series is to ignite curiosity and enable people to discover the world of agriculture and food systems, exploring areas such as health and safety, food security, nutrition, environmental impact, and sustainability.

This issue we chose to explore agricultural technology because it will help us reach new levels of efficiency. These innovations make it possible to grow and raise enough food for an increasing population, achieve sustainability, and save farmers time and money during production.

By creating content that engages students and empowers educators, we bring agriculture to life today, so that together we can enjoy a better tomorrow.

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AGRICULTURAL TECHNOLOGY

Technology and innovation are an important part of everyday life, and agriculture especially relies on technology within a land- and labour-intensive industry to create more efficient systems of production. These advancements tackle challenges such as feeding a growing population (9.8 billion by 2050),[1] economic success, and sustainability.

Annually, 20–40 per cent of crops are lost to pests or disease,[2] and technologies such as robotics, precision farming, and biotechnology can help make the food we grow or raise more resilient. Precision farming alone could reduce farming costs by $100 billion and save 180 billion cubic metres of water by 2030.[3] Other technologies like blockchain and Radio Frequency Identification (RFID) can improve traceability and create a safer and more reliable food supply chain. As technologies enter the market and advance the agriculture industry, new job opportunities are also arising. Jobs in machine maintenance and programming are beginning to replace more labour-intensive jobs, attracting a younger, more tech-savvy generation.

AUTOMATION AND ROBOTICS

The agricultural revolution from 1752–1900 radically changed North America with the introduction of machines. The cotton gin was patented in 1794, revolutionizing the industry by saving hundreds of man-hours and quickening the process of separating cottonseed from cotton fibre. The machine could produce as much as 50 lb. of cotton in a single day and was extremely cost saving.[4]

Another major development in machinery came with the innovation of putting steam engines on wheels in the early 1800s. This led to the first gasoline-powered tractor in 1892[5] and sparked a wave of advancements in farming devices and implements.

What is considered to be robotics today (the integration of computer science and engineering) was first introduced in the 1920s, with research on automatic vehicles continuing through the '50s and '60s. However, it wasn't until the 1980s that computers and Global Positioning System (GPS) technologies developed enough to give robots the vision and guidance they needed to make a large impact in the industry.[6]

Through the use of sensors, smart cameras, and GPS, machines can now avoid obstacles, as well as locate, identify, and detect changes in crops. This allows them to perform tasks such as monitoring plant growth, picking weeds, harvesting, sorting, and packing.[7]

Unmanned autonomous vehicles (UAVs), like drones, also take advantage of this technology, providing farmers with an aerial view of their land. By checking in on their fields from the sky, farmers can save on the gas and labour costs that would have been required to drive down to a problem spot and check it out on foot.

DID YOU KNOW?

Labour shortages due to COVID-19 could see agricultural robot sales increasing by 30% in 2021.[8]

Different types of camera sensors can be used on drones to provide farmers with a variety of information. Thermal infrared cameras, for instance, measure the temperature of the earth, informing the farmer how much moisture is in the soil. This data allows the farmer to determine where irrigation is most needed. Multispectral camera sensors detect four different bands of light: red, green, blue, and near-infrared that reflect off the fields. Healthy plants should reflect green light since this is what makes plants appear the colour green to our eyes. Near-infrared light, while undetectable to the human eye, also helps determine plant health as high reflectance of near-infrared indicates healthy chlorophyll levels in plants.[9] In the future, building completely autonomous drones can have them making runs and collecting data without the need for human assistance.

20%-40%

Crops lost to pests and disease each year[2]

Autonomous pickers can harvest crops like strawberries twice as fast as humans. A future where one robot can switch between multiple different kinds of crops will increase efficiency and pair better with best practices like crop rotations, when the type of crop planted in a field changes every growing season.[2]

Autonomous—"A device capable of operating with little or no human control."[10]

For complete automation to be possible, robotics need to be instilled with artificial intelligence (AI). AIs are the artificial brains behind the engineered equipment, allowing a robot to learn from its environment. Currently, AIs are used for image recognition, helping to spot drought, pests, or disease affected plants. Their detection accuracy is 98 per cent,[11] sending out immediate alerts to the farmer's smart device.

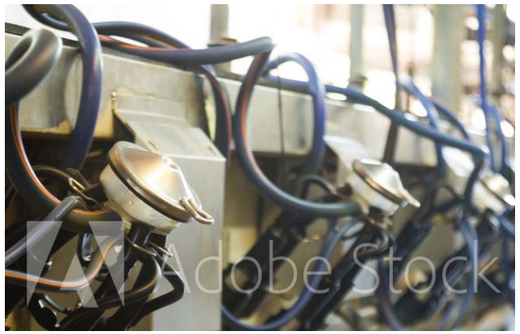
Robotics is also used within livestock farming. In the dairy industry, the first robotic milking system was invented in Europe and became available to the market in 1992. Modern robotic milking systems are now a voluntary process that allows cows to determine their own milking schedules. Cows are equipped with electronic collars that tell the robot which cow it is, whether or not she needs to be milked, and how healthy she is based on her milk production. The robot cleans the cow's teats, automatically attaches, and collects data on the quality and quantity of milk. Fewer interactions with humans allows the milking process to be less stressful for the cows and ultimately produces more milk with less labour.[12]

9.8 BILLION

Estimated population by 2050[1]

Other robots, like feed pushers, run along the feed alley found in freestall barns, pushing the feed closer to the cows. While the feed is originally dispensed close, as cows eat, the feed gradually gets spread out of reach, and a farmer has to come every few hours to push it closer. With robotic feed pushers, however, feed is always within a cow's reach, as the machine continues to run throughout the night. This saves the farmer up to 180 man-hours a year.[13] It is important cows are able to eat as much as they want, as it increases milk production.

From livestock farming to crop farming, there are many applications for robots in the agriculture industry. While some autonomous devices are still being implemented, the future will see even more robots in the field and barn as these systems become more affordable. The efficiency they offer in the long run boosts productivity and improves incomes, animal welfare, and sustainability. The agricultural robots market is expected to reach $20.3 billion by 2025.[14]



PRECISION FARMING

Farmers make about fifty key decisions every cropping season. These choices are vital to the efficiency of the farm, and one poor decision can cost farmers as much as $50 per acre.[15] Precision farming assists the decision-making process by gathering and analyzing crop data. This data informs decisions regarding what type of seeds to plant and where fertilizer or crop protection products might need to be dispensed. This saves the farmer labour and supply costs, decreases environmental impacts, and increases yields.

Inputs—"resources that are used in farm production, such as chemicals, equipment, feed, seed, and energy."[16]

The movement towards precision farming began in the 1980s with the introduction of Global Positioning System (GPS) technologies to the market.[17] The first satellite launched into space for agricultural purposes was the Landsat in 1972, but its poor quality and infrequent photographs did little for the industry. It wasn't until 1999 that the Moderate Resolution Imaging Spectroradiometer (MODIS) was launched, providing daily updates to farmers with better quality images.[18]

Handheld devices also took off in the 1990s, sparking advancements. These devices allowed farmers to map boundaries, pinpoint soil sample locations, and monitor their crops. To assist with the collecting and processing of data, new Internet of Things (IoT) devices, such as sensors, drones, and smart phones with the ability to communicate and share information through the internet, were later invented.[17] When these data management technologies were paired with precision agriculture, smart farming was born.[19]

When further applied to robotics, variable rate technology (VRT) became possible. VRT is an example of site-specific management, which measures differences within each field and then pairs the recorded information with technology to dispense a targeted and controlled amount of inputs. VRT can adjust the amount of inputs it spreads as it goes without having to pass over a field more than once. Currently, 15 per cent of North American farms use VRT, but this number is expected to drastically increase over the next five years.[20] This technology is most often used in fertilizer application. With the cost of fertilizer ranging between 35 and 50 per cent of variable input costs,[21] limiting its use to only what is necessary can make the application more cost efficient for farmers, and prevent excess run-off of inputs into the surrounding environment.

There are two different approaches to VRT: map-based and real-time (also known as sensor).[23] Map-based VRT uses previously collected data about the terrain and crop to create a multi-layered map called a prescription map. Yield-monitor and soil-sensor data, along with remote images from satellites or drones are input into a computer, where global information system (GIS) software is used to turn the data into a map. These maps show the current state of soil and plant health, alerting farmers to what sections of a crop require attention and treatment. If it is early in the season, the map can help determine which crops should be planted where.[24] The GPS in the farm machinery then interprets the maps and a controller is used to adjust the amount of input spread on the field.[23]

DID YOU KNOW?

In 2013, farmers produced 262% more food with 2% fewer inputs (such as seeds, labour, and fertilizers) than they did in 1950.[22]

Sensor or real-time VRT collects data as it goes, immediately coming to a solution based on its readings and dispensing a solution. Real-time VRT requires sensors to be incorporated into farm equipment like sprayers and seeders. As the machines move over the field, sensors detect the presence of weeds, pests, soil degradation, or drought, so the equipment and the farmer can make an immediate decision on what crop protection products or soil nutrients are needed. Alternatively, lasers can be used to zap weeds, replacing chemical inputs in both organic and conventional farming.

Sensors also assist the food supply chain in other settings, such as greenhouses and storage facilities like silos, grain bins, and refrigerators. The sensors monitor light, temperature, and humidity. Some sensors act as a switch, triggering when a certain threshold is breached, while others are more complex and can show continuous live readings. Should levels deviate from normal settings, alerts are provided with real-time information on the state of the commodities, allowing for quick action to solve a problem. This promotes crop health and produces higher yields in greenhouses while also preventing profit loss at the hands of spoilage when stored commodities like grain, produce, and meat aren't kept at correct temperatures.

Commodity—"staple crops and animals produced or raised on farms or plantations. Most agricultural commodities such as grains, livestock, and dairy provide a source of food for people and animals across the globe."[25]

Temperature sensors even have a place in tractors and other farming equipment. Some sensors detect overheating, while other sensors known as accelerometers catch changes in movement or vibrations, alerting the farmer to potential issues early.[26] This allows them to tune up equipment before it breaks down.

In the case of livestock farming, GPS sensors can track animals through special ID tags, keeping tabs on the movement of herds. With one on every animal, more advanced settings can even monitor health through the use of electronic collars.[27]

The future of precision farming will see a greater incorporation of autonomous robotics and artificial intelligence. AIs will become particularly useful in weather forecasting. Based on an intake of data, the algorithm can predict more accurately what weather farmers can expect. This includes temperature, precipitation, wind speed, and solar radiation.[11]

These predictions aid precision farming by allowing farmers to determine when to irrigate their crops and when they can count on the weather to keep them rain fed. This prevents unnecessary use of water resources, creating a healthier crop and a more sustainable farm. Weather information also assists farmers in determining the right time to harvest a crop before the first frost falls.

Precision farming is a growing movement, saving farmers money, protecting the environment, and helping produce enough food to feed a growing population. Soybean growers reported saving 15 per cent on input costs such as seed, fertilizer, and crop protection products through the use of precision agricultural technologies.[28] By 2025 the precision agriculture market is projected to reach $43.4 billion.[20]

BIOTECHNOLOGY

For thousands of years, humans have been selecting the best plants to breed, producing commodities that have more desirable attributes and are more useful to humans. Seeds from plants that performed well one year would be saved and used for the next. As the world developed, trade over long distances, food safety, and high appearance standards became increasingly important. Rising to the challenge, scientists found new ways to select for beneficial attributes in a commodity through the use of biotechnology.

Genetic engineering is one such biotechnology innovation that modifies the genetic material of a living organism like a plant or animal.[29] It plays a large part in creating sustainability and profitability in the industry. These modifications can make food more resistant to pests, disease, and drought, decreasing the need for crop protective inputs while increasing yields and farmer incomes. Alterations can also make food more nutritious and visually appealing so it doesn't go to waste if overlooked at the grocery store. By creating more efficient crops, genetic engineering can even help reduce food prices, as we're able to produce more with fewer input costs.[30]

The first genetically engineered food to appear on shelves was the Flavr Savr tomato. It was approved for sale in 1994 and was engineered to have a longer shelf life, suppressing the gene that causes tomatoes to soften after ripening.[31] Since then, genetic engineering has created new crops and even saved crops that were disappearing to disease.

In the 1990s, genetic engineering saved Hawaii's papaya industry when a scientist by the name of Dr. Dennis Gonsalves created a strain of papaya resistant to the ringspot virus that was devastating the region. The first round of genetically engineered seeds were given to farmers free of cost.[32]

11.2 MILLION HECTARES of GENETICALLY ENGINEERED CROPS were grown in Canada in 2019, including canola, soybeans, corn, sugar beets, and alfalfa.[33]

In Canada, approximately 11.2 million hectares of genetically engineered crops were grown in 2019. This included canola, soybeans, corn, sugar beets, and alfalfa.[33]

Genetically engineered animals have also started appearing on the market in recent years. In 2015, AquaBounty Technologies was approved to sell their AquAdvantage Atlantic salmon.[34] The salmon was designed to grow more quickly, borrowing a gene from the fast-maturing Chinook salmon.

Engineering animals can also have environmental benefits. For example, Science Advances published a study that identified gut microbes directly linked to methane production in cattle. If this gene is manipulated, it could lower methane emissions by as much as 50 per cent.[35] Less methane production from cattle can help curb climate change and make cattle ranching more sustainable.

The most recent innovation in genetic engineering is the CRISPR-Cas9 tool. Unlike other gene editing techniques (like recombinant DNA) that brought us genetically modified organisms (GMOs) like the Favr Savr tomato, CRISPR-Cas9 is more precise and efficient. It is also faster and cost effective.[36] Instead of introducing foreign DNA, it edits existing DNA. If you think of a cell like a little computer, instead of rewiring your computer every time it needs an update, CRISPR-Cas9 allows you to just reprogram the software.

CRISPR-Cas9 is a mechanism in a bacteria cell that acts like an immune system, detecting and destroying viral DNA. When a harmful virus invades a cell, it injects its DNA in the hopes of becoming a part of the host cell's genetic material. This can either kill the cell or spread the virus when the cell replicates. CRISPR's job is to discover the virus, destroy it, and store the DNA information of the threat, so the cell is prepared the next time the virus appears. The process is very similar to receiving a vaccine. The protein Cas9 uses a copy of this remembered information (RNA) to search the rest of the cell for any more signs of the virus. If it finds a match, Cas9 then cuts the virus out of the cell's DNA, allowing the cell to naturally repair the break by either gluing the two broken ends together, or rewriting genetic material to fill the gap.

This CRISPR-Cas9 mechanism has been harnessed by scientists and used to edit other organisms. They program CRISPR-Cas9 to search out specific parts in plant or animal DNA and either cut out that section of genetic code (ACGT) to turn off the gene or cut and replace it with a new combination of genetic code.[37] The CRISPR-Cas9 tool has been used to create fungus-resistant wheat, drought-resistant corn, and larger tomatoes, producing higher yields.[29] Food waste is lessened by developing damage-resistant apples, potatoes, and mushrooms that are more likely to survive the shipping process. This protects our climate from the harmful greenhouse gases food waste emits when it breaks down in a landfill. The nutritional value of food has also been enhanced by increasing omega-3 and vitamin A levels in produce.[18]

In the US they have used CRISPR-Cas9 to genetically engineer pigs against porcine reproductive and respiratory syndrome (PRRS), a disease that causes pigs to miscarry, and when at its worst causes losses of $600 million to the industry.[18] By using CRISPR-Cas9 to cut out the receptors where the virus attaches itself, scientists have made the piglets immune. As a result, pig welfare is greatly improved and farmers save money they would have had to spend on diagnosis and treatment. The hope is to approve the genetically engineered pigs for sale in the US and China by 2025,[18] and in the future reduce the likelihood that pigs will transfer viruses to humans, like in the case of the H1N1 outbreak of 2009.

DID YOU KNOW?

Scientists Jennifer Doudna and Emmanuelle Charpentier won the 2020 Nobel Prize in Chemistry for their research on CRISPR technology.[38]

While genetic engineering is still a fairly new process, twenty years of research has shown no difference between genetically engineered food and conventional food when it comes to safe consumption. In fact, over 1,700 studies, including the World Health Organization and hundreds of independent studies, came to the consensus that genetically engineered foods are safe to eat.[30]

Despite this fact, humans do not consume most genetically engineered crops. The majority of corn and soybeans produced go towards feeding livestock. Genetically engineered crops also have other functions outside of food. Worldwide, 80 per cent of all cotton is genetically engineered and can be used to make our clothing. Likewise, soybeans can be used to create biodegradable replacements for plastic. Along with corn, soybeans can also be used in biofuels, contributing to renewable transportation. Genetic engineering even improves the welfare of animals within the medical field. Where it used to take twenty-three thousand pigs to make 1 lb. of insulin, scientists can now make insulin in the lab—no pigs required.[30] In total, the CRISPR-Cas9 market is expected to reach $5.3 billion by 2025.[39]

DID YOU KNOW?

One bale of cotton can make 215 pairs of jeans.[30]

TRACEABILITY TECHNOLOGY

OnTrace defines traceability as "the ability to locate an animal, commodity, food product or ingredient and follow its history in the supply chain forward (from source to consumer) or backward (from consumer to source)."[40] Traceability and transparency in the food supply chain are important to maintaining consumer health and trust. Consumers want to know where their food comes from and what processes it went through along the way. Yet, while there is a multitude of data in the world, only 20 per cent of it is searchable, most of it hidden away within businesses and organizations.[41] Technologies such as blockchain and Radio Frequency Identification (RFID), if implemented in the food supply chain, can help make this information more readily available to both agri-food businesses and the public.

BLOCKCHAIN

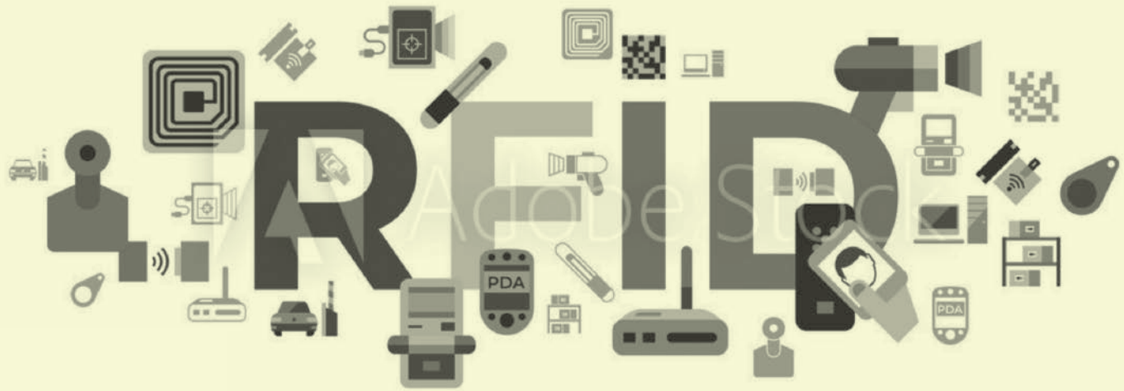
Blockchain was invented in 2008. Created by an unknown person or group calling themselves Satoshi Nakamoto,[42] blockchain technology has the ability to revolutionize the food supply chain through a new method of data verification and sharing. At each step from farm to fork, businesses can upload data to a network for all to see. Unlike a centralized system, where the uploader is the trusted source, the blockchain is decentralized and compares new uploaded data with other participants in the network. This is similar to the way Wikipedia operates, having multiple people fact-checking the same source.[43]

Unlike Wikipedia however, with blockchain a new block of information is only added to the shared network chain if the majority of participants check and agree that the information is correct. Verifying across multiple participants might sound like a long process, but in reality this automatic process is much faster and more reliable than the traditional centralized method. Authenticity checks are done by computers in mere milliseconds, and once a verified block is added to the shared network chain it cannot be altered. This prevents any one participant in the blockchain from dominating or dictating the process. It also cuts out any time-consuming middlemen and prevents the spread of false information.

By sharing information across a secure network, blockchain allows participants to build trust with one another, while providing insight into the industry. The technology assists operations managers, marketing companies, and food safety services in making informed business decisions that create a more profitable and safe food system. No one is left behind as commodity information becomes traceable through the supply chain with transactions recorded for everyone to see. Consumers can also rest well with the transparency this offers, knowing exactly where their food comes from, especially foreign foods travelling long distances. Although implementation is a slow process, blockchain has continued to gain momentum. Within the food and agriculture industry, the blockchain market is expected to reach over $1.4 billion by 2028.[44]

DID YOU KNOW?

The first blockchain transaction occurred in 2010, when two pizzas were bought for 10,000 bitcoins. Today, the worth of 10,000 bitcoins is $90 million.[45]



RFID TECHNOLOGY

Radio Frequency Identification (RFID) uses radio waves to wirelessly transfer data. When a tag is placed on an object, this allows the object to be identified and for information to be received about the history of that object. If you've ever used a remote garage door opener or paid with a card using the tap function, then you've used RFID technology.

Further implementing this technology into the food supply chain can improve traceability and efficiency within the agri-food industry. RFID tags can be placed on agriculture commodities or food products, much like a sticker is placed on an apple, and serve the same function as a barcode. Unlike barcodes, however, RFID tags can hold a lot more data about the product, can be encrypted or locked for security, and even rewritten and used again.

Also, direct contact does not need to be made with the product for it to be scanned and read.[46] With RFID, a simple wave of the scanner near any inventory and it will read hundreds of tags at once. RFID has an adjustable range of up to 150 metres.[47] This means no more counting inventory one by one! Improvements in inventory accuracy and management allow for more informed ordering and stocking decisions, and fewer labour costs. In fact, implementation of RFID technology has led to between 80 and 92 per cent gains in productivity.[47]

Scanning an item can tell an employee how many are in stock and even help them locate the item in the storage room. This ensures that shelves are full, sales increase, and waste from accidental over ordering is reduced, especially when it comes to perishable food like meat, dairy, and produce.

RFID technology also provides advancements in grocery store checkouts. Instead of scanning each item individually, a shopper can place their basket or cart near the scanner and it will read all the items automatically. The convenience makes for shorter lines and faster visits, boosting customer satisfaction and therefore economic success.

The moment a tag is placed on a food item to the moment it reaches the consumer, it can be traced with a single scan. Pairing this technology with blockchain-secured information can make available the record of a product, reaching all the way back to the production stage. This meets the consumer demand for information transparency and ingredient traceability. It also reduces waste and helps create a more sustainable agri-food industry. The desirability of this system has caused investment to surge. Currently, the food traceability market is expected to reach $26 billion by 2025.[48]

DID YOU KNOW?

NutriSmart, a food tracking system created by Hannes Harms, includes edible RFID tags that could be put onto food, providing consumers with nutritional information and complete supply chain traceability.[45]

IMPLEMENTING TECHNOLOGY IN PRECISION FARMING

How technology is helping farmers optimize their agricultural operations

BY: KIAH LUCERO

Although precision farming practices were introduced in the 1980s, they have since revolutionized the agricultural industry and spread across the globe.[49] Through the use of various technological tools—like GPS, drones, sensors, and automation, to name a few—precision farming helps farmers aggregate data in order to improve their overall farming operations.

With over thirty years in the agriculture equipment industry, Jim Wood, chief sales and operations officer at Rocky Mountain Equipment (RME), has experienced firsthand how precision farming has advanced the agricultural industry. "To me, precision farming is about putting the right amount of inputs, fertilizer, and chemical to get the maximum production out of your land," says Wood.

Technological advancements in precision farming lead to multiple benefits in all aspects of agriculture. From the perspective of the farmer, it can effectively increase a farmer's overall yield production while also minimizing redundancies in application inputs. "It is healthier for the environment, it's healthier for the land, but it's also about putting the right product in the right place on the land [to] increase production," says Wood.

RME provides farming equipment from companies such as Case IH, New Holland Agriculture, and Bourgault, which each integrate precision technology directly into their machinery. From seed drills and sprayers to tractors and combine harvesters, there are many different types of precision technologies built-in.

Take for example seeding—according to Wood, it is one of the most important times of the year for farmers. "If you think about it, in years prior to this horizon of new agriculture or new technology, farmers were seeding over the same piece of land twice because of lack of precision," Wood adds.

Both seed drills and sprayers are equipped with line sharing technology. Line sharing enables communication between the two seed drills in the field so they are not overlapping the same piece of land. Whether they are planting seed or applying fertilizer, this ultimately reduces costs for the farmer since fewer resources like seed, fertilizer, and chemicals are wasted. "They are very precise lines. They're spraying the right amount, at the right time, at the right place, and they're not overlapping," says Wood.

In addition to line sharing, seed drills and sprayers simultaneously gather data about farmers' fields and organize it into something called an "as-applied map." Otherwise known as precision mapping, the farming equipment keeps track of what seeds or fertilizers have been applied to which field. In terms of food traceability, this helps farmers accurately collect data and report it down the food supply chain.

Further improving data collection in precision farming is the implementation of remote sensors. With sensors, farmers can monitor the condition of their cropland situated 50 km away. "Farmers can tell if it rained on that piece of land last night; they can get satellite images of how their crop is doing. And so, they can make a lot of decisions without having to walk through the crop," says Wood.

Sensors and automation are also integrated directly into combine harvesters. As a combine travels through the field, it will simultaneously adjust its settings to produce the best yield based on factors such as crop conditions, moisture, and humidity. As precision farming continues to evolve, Wood says that in the future he expects to see more artificial intelligence out in the fields. "I think you'll see autonomous vehicles out in the fields, where you won't need an operator. It'll go out and do the job you've programmed it to do and make real-time decisions on what it's doing," says Wood.

Through a combination of various precision technology systems, precision farming works on overcoming numerous obstacles within the agricultural industry—saving time, money, and resources for farmers worldwide.

But precision farming can also address broader universal issues such as feeding a growing population while also attaining both economic and environmental sustainability.[50] "As far as feeding a global economy, I think precision farming assists in the fact that the yield increases—being more accurate and more productive. It helps meet the world demand because they're basically producing more," says Wood.

The technology also allows farmers to reduce inputs such as chemicals and fertilizers. Overall, this makes for a healthier environment."It helps get more production of the land while adding nutrients back into the soil. Actually, the land is probably healthier and that helps feed the world," says Wood.

FLYING SKY HIGH

How drones are changing agriculture in Canada—and around the world

BY: ELLEN COTTEE

Artificial intelligence, biotechnology, precision farming—innovations in agriculture help farmers save money, grow more crops to feed the world, and reduce the industry's impact on climate change. Who could imagine one of the most accessible and impactful tech additions to the farmer's toolbelt started as little more than a remote-controlled airplane with a camera?

Drones, also known as Remotely Piloted Aircraft Systems (RPAS), are not exclusive to agriculture—they are found in many industries including filmmaking, environmental conservation, and police departments. In fact, anyone interested in drones can pick up small, basic models at consumer box stores like Best Buy and Staples. These remote-controlled devices are able to fly above scenes, quickly observe the earth below, and collect images.

Markus Weber, president of Landview Drones in Edmonton, Alberta, says the simplicity of the technology combined with the ease of getting started makes drones a relatively easy tech choice for a producer. The biggest draw is what drones can do to simplify farm management.

"Drones give farmers an aerial view of their crop—when you're standing at the edge of a field, you can only see about twenty yards in," Weber says. "It doesn't require any more technology than just a camera in the air for a farmer to be able to understand what's going on with their crop."

Detecting issues such as drought, disease, or pest damage is key to producing a good crop. Drones, unlike manual inspection, allow farmers to map their fields quickly on a regular basis—giving them a better chance of solving any problems in the crop. Using drones instead of heavy field vehicles also minimizes soil compaction and plant damage that can affect healthy growth.

For one Saskatchewan farmer, using a drone to scout his canola field allowed him to better understand where kochia, a common weed, was taking root. Instead of applying herbicide to the majority of the field in hopes he cleared the problem, imaging from the drone allowed him to target problem areas—meaning he sprayed only forty acres instead of the usual four hundred.[51]

Drones are not just making jobs easier—they're also contributing to the fight

against world hunger. In the Philippines, typhoons can quickly destroy farmland, and assessing the damage manually to provide support takes days; a person can only inspect seven hectares in one day. Drones, on the other hand, are able to review two hundred hectares in only thirty minutes. This allows fast assistance, quick replanting, and minimal food loss.[52]

Imaging land is not where drone use in farming ends. Specialized versions of drones can be used to spray pesticides, fertilizer, and even plant seeds. Currently, regulations in Canada prohibit the use of drones for pesticide application—but not for long.

"We are still a few years away from spraying being an everyday practice, but it absolutely will be in the future," Weber says.

Weber says spraying with drones allows for targeted applications, using less of the product and only in the areas needed. Regions like Russia and the United Kingdom have already seen reductions in pesticide use, thanks to the precision application drones allow—meaning lower emissions of greenhouse gases that contribute to climate change.[53]

It is not just chemicals either; in Zimbabwe, where drought is common, drone irrigation systems allow for efficient coverage of the crops without wasting water through traditional irrigation.[54]

"The environmental and financial benefits really do go hand in hand—you're only applying the product where you need it. That works really well for the farmer's pocketbook, in addition to protecting the environment," Weber explains.

While regulations on drone use continue to lift around the world, the technology itself is on track to improve drastically over the next decade—leading to the possibility of even more sustainable farming applications. One of the most exciting advancements Weber sees in the future? "Five years from now, these systems will be completely autonomous."

Scan the QR code to fly sky high with real drone imaging.

BUILD A BRIDGE

CAAIN brings technology and agri-food businesses together to create solutions and growth in Canadian agri-food

BY: NATALIE NOBLE

Cutting edge technology is changing agriculture in ways Canadians barely dreamed of fifteen years ago. Finding ways to seamlessly integrate that technology into daily life can be a challenge, but that's what the Canadian Agri-Food Automation and Intelligence Network (CAAIN) is working towards. Bringing together technology and agri-food companies for innovative solutions and growth across the sector, CAAIN is working to be the connector for the industry.

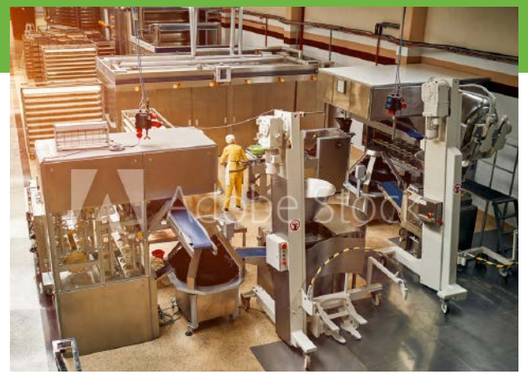
"CAAIN exists to bridge the gap between Canada's agricultural and technology industries," says Dr. Nicole Gaudette, a CAAIN program manager. "Essentially, we fund ideas that will help advance the agri-food sector. And while there are other organizations with similar goals, one thing different about us is our mandate to involve and help grow small businesses."

"The entire food sector, from farms to grocery stores, is embracing new technologies."

All this progress means growing career opportunities within the agri-food industry both here in Canada and around the globe. "The entire food sector, from farms to grocery stores, is embracing new technologies. That makes this an exciting area to be in right now and a great career choice for anyone trying to figure out what to study after high school.

"It's predicted that by 2050, the global population will hit [approximately] ten billion and that the world's demand for protein will jump by 70 per cent." Dr. Gaudette pauses, then adds, "How can we meet that need when there's less and less farmland and clean water? Working on the environment is one way. My expertise is in agri-food, and I can tell you we must also find technological solutions to make us better at growing, harvesting, processing, and distributing food. We have no choice but to find ways to produce more with less. There's a lot of opportunity for anyone looking for a rewarding challenge."

It's an ambitious target to say the least. So, just how can we move that needle? By leveraging the exciting, fast paced world of technology within agriculture of course. Dr. Gaudette breaks down two of the latest technologies moving agri-food into the future.



AUTOMATION & ROBOTICS: EASING THE MANPOWER DEMAND

Automation and robotics are playing a key role in alleviating some of the burden common to food processing today. "You have to appreciate the amount of manual labour that currently goes into food processing," says Dr. Gaudette. "The food we eat is directly handled by many people before it reaches our plates. That's not necessarily a bad thing. But what happens—and this is increasingly the case—when we can't find enough workers to get the job done?"

Dr. Gaudette sees robotics and automation as a way to create opportunities that replace entry-level jobs with skilled, highly technical positions. "So, we're reducing the entire food system's dependence on manual labour, and at the same time, opening doors to rewarding careers."

Whether in meat or dairy processing, or right on the farm, automation and robotics are reducing some of the pressure our food processing industry faces. "Over the past year, the fallout from COVID-19 has included a number of instances where food processing operations have been crippled, or even entirely shut down, by outbreaks. So, in addition to reducing the need for low-paying line work, automation has the potential to mitigate risk and improve safety throughout the food system," says Dr. Gaudette. "Necessity drives invention, and food processors are now seeing a need they have to address. That's part of what we're supporting at CAAIN—that search for tech that makes it easier to produce and deliver the food we eat."

BLOCKCHAIN: THE TRANSPARENT AND TRACEABLE JOURNEY OF OUR FOOD

One thing we all have in common, whether we work in agri-food or not, is the fact that we are all consumers. From the grocery store to the convenience shop or restaurant, the food we eat has been produced somewhere and likely has a long chain of activity. Planting, harvesting, processing, packaging, and shipping are all part of our food's journey before it makes its way into our homes.

"Supply chains are lengthy and complex. Canadians now want to know more about where their food comes from and who handled it along its journey from farm to plate," explains Dr. Gaudette. "That's where an amazing technology called blockchain enters the picture. Simply put, the term refers to a traceable string of data that grows with every touchpoint. Essentially, every interaction of a particular product is tagged with an encoded time and location stamp. That means that with the simple scan of a QR code, retailers and their customers can now know everything about the food on store shelves. This transparency and traceability build trust between consumer and supplier."

To further illustrate this concept, Dr. Gaudette recalls an incident from 2006. "There was an E. coli outbreak associated with some tainted spinach. The US Food and Drug Administration issued a recall that impacted the entire supply chain we just mentioned," she explains. "This meant that all spinach had to be pulled from store shelves until the primary source of contamination could be identified, which took weeks. In addition to the health implications, there were significant financial losses."

"If students are excited about technology, they should go into agtech because it's a place to grow and thrive."

Similar situations over the following years prompted retailers to seek solutions to reduce the effects of these events. "Blockchain is the answer," says Dr. Gaudette. "That same spinach situation would now be resolved faster and with greater precision, saving money, and more importantly, lives."

It's no surprise advancing technology is creating an incredible demand for young minds to help out. "If students are excited about technology, they should go into agtech because it's a place to grow and thrive," says Dr. Gaudette.

Satellite Scavenger Hunt

Using Google Earth, find each item on the list below and record the coordinates.
Hint: Some answers might require you to look outside of Canada.

CANOLA FIELD

CORN MAZE

FARM ANIMAL

TRACTOR

ONE OF AG FOR LIFE'S FOUNDERS
(AdFarm, Glacier FarmMedia, Nutrien, RME, TC Energy, or UFA)

IRRIGATION PIVOT

GREENHOUSE

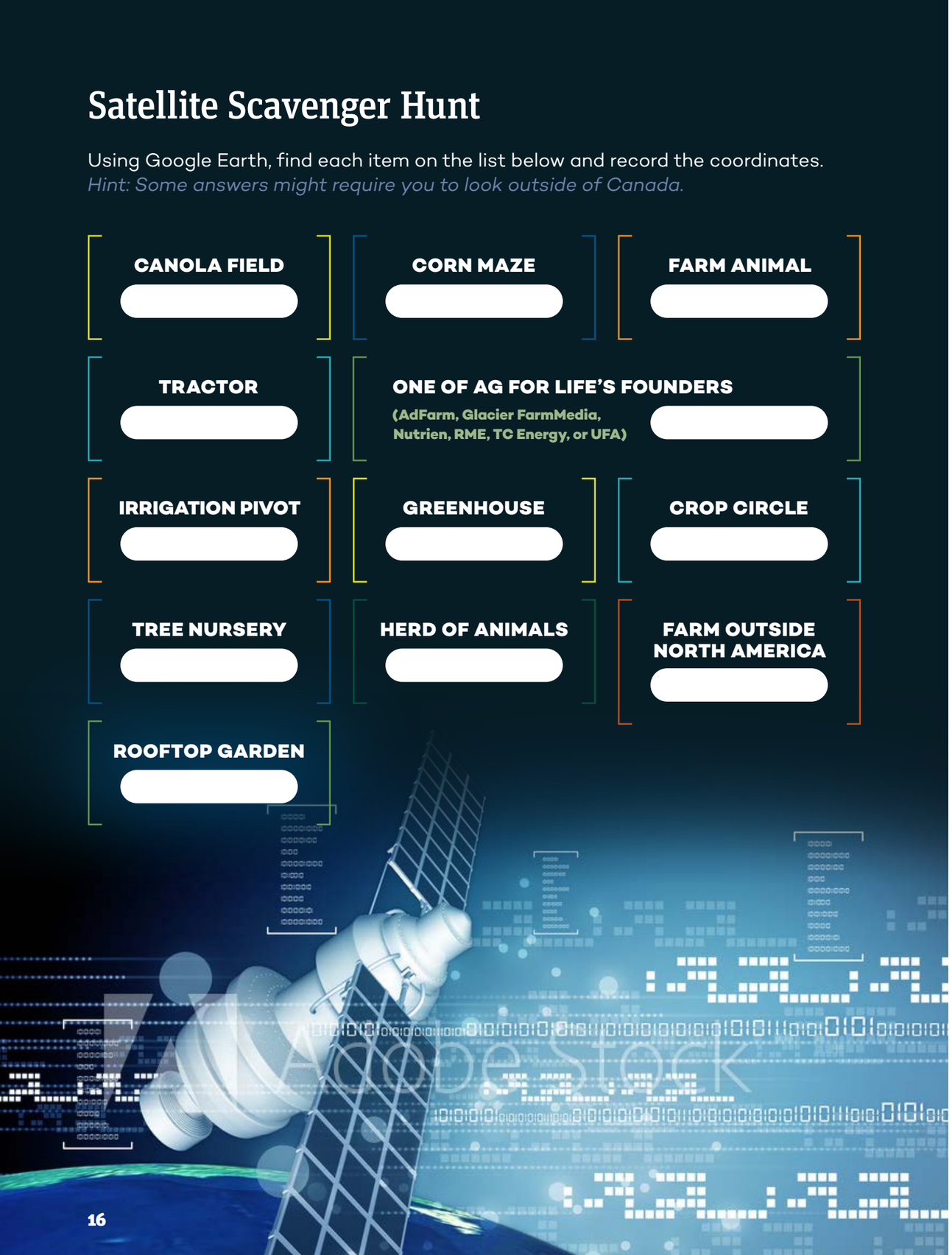
CROP CIRCLE

TREE NURSERY

HERD OF ANIMALS

FARM OUTSIDE NORTH AMERICA

ROOFTOP GARDEN



Agricultural Technology

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

Agriculture
Artificial Intelligence
Autonomous
BioTechnology
Blockchain
Camera
CRISPR
Data Management
Drone
Genetic Engineering
GPS
Internet of Things
Precision Farming
RFID
Robots
Satellite
Sensors
Smart Phones
Traceability
VRT

CHOOSE YOUR CHARACTER

ACTIVITY

THE INVENTOR

Technology continues to assist the agriculture industry. It improves efficiency, completing tasks faster and cheaper, all the while filling the labour gap. It allows us to produce more food with fewer resources. Achieving sustainability means we can continue to produce food for the present without compromising the future. The articles in this magazine highlighted only some of the many technologies in use today and there are still challenges in the industry that we haven't yet solved.

ASSIGNMENT: Invent a new technological device that can solve a current challenge in the agriculture industry. Pitch the invention to your classmates using a model or poster drawing.

CONSIDER: What is a challenge facing the agriculture industry today? How does your invention solve this problem? What does your invention do? How is it used? What does it look like? Why would someone working in the industry want to buy it?

THE TIME TRAVELLER

Technology has changed a great deal through the years. The equipment we use to produce food today doesn't look the same as it did a hundred years ago. It takes a lot of time, money, research, and testing for new innovations to enter the market, and the journey isn't always easy.

ASSIGNMENT: Choose a technology used in the agriculture industry and create a poster or PowerPoint timeline on how it's changed through the years and what you think it might look like in the future.

CONSIDER: Why was this technology invented? How has it improved through the years? What were the setbacks? Breakthroughs? How has this technology evolved to feed more people, cost less, or become more sustainable? What research is currently being done to improve this technology in the future?

THE DETECTIVE

Where does your food come from? The most popular trends in the agri-food industry today include transparency and traceability. People want to know where their food comes from and what processes it goes through from farm to fork. In a globalized food supply chain, this can be difficult to track and technology is evolving to help us achieve this consumer desire.

ASSIGNMENT: Pick a food product and trace one of its main ingredients back to its source. Create a web or chain using PowerPoint or a poster to show the farm to plate process.

CONSIDER: What technology did you use to find this information? What technology did the businesses in the supply chain use to make this information accessible to you? Was there any information you couldn't find? What future technology could make this investigative process easier? How would it work?

THE REPORTER

Some farms are big and others are small. Some farms raise livestock, while others grow crops. But every farmer uses slightly different methods, equipment, and technology. There are gains to be had from using technology but also challenges to implementation. There's a reason why farms operate the way they do and also ways in which we can help make them better in the future.

ASSIGNMENT: To better understand how technology works in the field, interview a farmer and write an article, record a podcast, or film a video that showcases the discussion.

CONSIDER: What technologies does the farmer use? Which technology is their favourite? Why? How does it work? What changes have they seen in technology over the years? Are there technologies they hope to incorporate into their farm in the future? Are there challenges to doing so? What is considered trendy technology right now? What challenges does the farmer face that technology could help solve in the future?

Sources

1 **UN**—World population projected to reach 9.8 billion in 2050, and 11.2 billion in 2100, 2017
https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html

2 **TDC**—The Future of Farming, 2017
https://www.youtube.com/watch?v=Qmla9NLFBvU&feature=emb_logo

3 **Fortune**—A.I. Gets Down in the Dirt as Precision Agriculture Takes Off, 2020
https://fortune. com/2020/10/05/a-i-precision-agriculture-deere/

4 **History—**Cotton Gin and Eli Whitney, 2019
https://www.history.com/topics/inventions/cotton-gin-and-eli-whitney

5 **Wikipedia**—Tractor, 2020
https://en.wikipedia.org/wiki/Tractor

6 **Wikipedia**—Agricultural Robot, 2020
https://en.wikipedia.org/wiki/Agricultural_robot

7 **Croptracker**—Robotic Technologies in Agriculture
https://www.croptracker.com/blog/robotic-technologies-in-agriculture.html

8 **International Federation of Robotics**—Case Studies, 2021
https://ifr.org/case-studies/service-robots/the-autonomous-way-to-industry-4.0

9 **DroneZon**—Multispectral Imaging Camera Drones in Farming Yield Big Benefits, 2020
https://www.dronezon.com/learn-about-drones-quadcopters/multispectral-sensor-drones-in-farming-yield-big-benefits/

10 **Oxford Languages**—Autonomous Definition, 2021
https://cutt.ly/ekhx73M

11 **Customer Think**—The Role of Artificial intelligence in Agriculture Sector, 2019
https://customerthink.com/the-role-of-artificial-intelligence-in-agriculture-sector/

12 **Michigan State University**—Robotic Milking
https://farm.kbs.msu.edu/pdc/robotic-milking/

13 **Lely**—Lely Juno
https://www.lely.com/ca/en/solutions/feeding/juno/

14 **Markets and Markets**—Agricultural Robots Market
https://www.marketsandmarkets.com/Market-Reports/agricultural-robot-market-173601759.html?gclid=CjwKCAiA9vOABhBfEiwATCi7GlJwr3mPDyPgcprgmdyQXcS2HOAjMHBfGK7uDd6olHwtyUcwYRF7thoCxrcQAvD_BwE

15 **Farmers Edge**—How Big Data Can Mean Better Profit-Focused Decisions, 2016
https://www.farmersedge.ca/big-data-can-mean-better-profit-focused-decisions/

16 **Teach Me Finance**—Farm Inputs
http://www.teachmefinance.com/Scientific_Terms/Farm%20inputs%20.html

17 **Global Market Insights**—Industry Trends, 2019
https://www.gminsights.com/industry-analysis/precision-farming-market

18 **MIT Technology Review**—The Food Issue, 2021
https://www.technologyreview.com/magazines/the-food-issue/#features

19 **MDPI**—From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management, 2020
https://www.mdpi.com

20 **AFN**—What is Precision Agriculture?, 2017
https://agfundernews.com/what-is-precision-agriculture.html

21 **Farmers Edge**—Variable Rate: Why It's Important Now, More Than Ever, 2020
https://www.farmersedge.ca/variable-rate-why-its-important-now-more-than-ever/

22 **Fact Retriever**—67 Interesting Farming Facts, 2019
https://www.factretriever.com/farming-facts

23 **Sugar Research Australia**—Variable-Rate Technology, 2014
https://sugarresearch.com.au/wp-content/uploads/2017/02/IS14017-Variable-Rate-Technology.pdf

24 **Geospatial Word**—How GIS is Enabling the Agricultural Sector, 2018
https://www.geospatialworld.net/blogs/gis-in-agriculture/

25 **Commodity.com**—Agricultural Commodities: Their Importance On The Global Market, 2020
https://commodity.com/soft-agricultural/

26 **Arrow**—Agriculture Sensors: Top 5 Sensors Used in Agriculture, 2020
https://www.arrow.com/en/research-and-events/articles/top-5-sensors-used-in-agriculture

27 **Arrow**—How to Make Herding Cows Easy with IoT
https://www.arrow.com/ecs/na/channeladvisor/channel-advisor-articles/how-to-make-herding-cows-easy-with-iot/

28 **Precision Ag**—Precision Agriculture: Higher Profit, Lower Cost, 2012
https://www.precisionag.com/institute/precision-agriculture-higher-profit-lower-cost/

29 **Parliament of Canada**—Research Publications, 2019
https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/201926E

30 **GMO Answers**—Welcome to GMO Answers
https://gmoanswers.com

31 **Biotechnology and Society**—Flavr Savr Tomato, 2015
https://biotechnologysociety.wordpress.com/2015/02/16/flavr-savr-tomato/

32 **ThoughtCo**—Genetically Modified Food, 2020
https://www.thoughtco.com/genetically-modified-food-how-did-we-get-here-375719

33 **USDA**—Canada: Agricultural Biotechnology Annual, 2020
https://www.fas.usda.gov/data/canada-agricultural-biotechnology-annual-3

34 **AquaBounty**—About Us, 2021
https://aquabounty.com/about-us

35 **Newsweek**—Cows Genetically Modified to Burp and Fart Less Could Cut Methane Emissions by Half, 2019
https://www.newsweek.com/cow-fart-burp-methane-genetic-modification-1447589

36 **SAIFood**—Gene Editing and Plant Breeding in Canada, 2020
https://www.saifood.ca/gene-editing-plant-breeding-canada/

37 **TED**—How CRISPR Lets Us Edit Our DNA, 2015
https://www.youtube.com/watch?v=TdBAHexVYzc&feature=share&fbclid=IwAR1pL-XE4xb5_vGVhrGpxGu9pLeD8IyFnZlo7NCqUEbgOyb6_Oi6rdcCIVE

38 **Synthgo**—Nobel Prize Awarded to Jennifer Doudna And Emmanuelle Charpentier For CRISPR Discovery, 2020
https://www.synthego.com/blog/gene-editing-nobel-prize

39 **AheadIntel**—CRISPR-Cas9 Tools: Global Market and Patent Landscape Report till 2025
https://www.aheadintel.com/product/crispr-cas9-tools-global-market-and-patent-landscape-report-till-2025/

40 **Food and Bioprocess Technology**—A Review on Agri-food Supply Chain Traceability by Means of RFID Technology, 2012
https://www.researchgate.net/publication/235352443_A_Review_on_Agri-food_Supply_Chain_Traceability_by_Means_of_RFID_Technology_A_Review_on_Agri-food_Supply_Chain_Traceability_by_Means_of_RFID_Technology

41 **IBM**—How Blockchain is Making Your Food Safer and Smarter, 2019
https://www.ibm.com/blogs/blockchain/2019/09/episode-7-how-blockchain-is-making-your-food-safer-and-smarter/

42 **Upfolio**—Blockchain Explained
https://www.upfolio.com/ultimate-blockchain-guide

43 **TED**—The Blockchain Explained Simply, 2016
https://www.youtube.com/watch?v=KP_hGPQVLpA

44 **Fortunly**—45 Blockchain Statistics & Facts That Will Make You Think: The Dawn of Hypercapitalism, 2020
https://fortunly.com/statistics/blockchain-statistics/#gref

45 **Engadget**—NutriSmart Prototype Embeds RFID Tags Directly within Food, Traces Your Lunch from Start to Finish, 2011
https://www.engadget.com/2011-05-30-nutrismart-prototype-embeds-rfid-tags-directly-within-food-trac.html

46 **Atlas RFID Store**—What is RFID? RFID Explained, 2018
https://www.youtube.com/watch?v=PwCqKvHWRNk

47 **The RFID Network**—How RFID Benefits Retail Fashion, 2011
https://www.youtube.com/watch?v=4eOr0PfwFgs

48 **Markets and Markets**—Food Traceability Market
https://www.marketsandmarkets.com/Market-Reports/food-traceability-market-103288069.html

49 **Agriculture and Agri-Food Canada**—Historical Evolution and Recent Advances in Precision Farming
https://www.ispag.org/files/Mulla%20and%20Khosla%202015.pdf

50 **Washington State University**—Precision Agriculture Technology for Crop Farming
https://bit.ly/390ktj4

51 **GrainNews**—Farmers weigh in on drone benefits, 2021
https://www.grainews.ca/features/farmers-weigh-in-on-drone-benefits/

52 **FAO**—FAO is using drones to help end hunger, 2018
http://www.fao.org/e-agriculture/news/fao-using-drones-help-end-hunger

53 **FAO**—How Drone Technology Is Bringing Environmental Benefits To Farms, 2017
http://www.fao.org/e-agriculture/blog/how-drone-technology-bringing-environmental-benefits-farms-1

54 **UAS Vision**—Drone Irrigation Technology in Africa
https://www.uasvision.com/2020/07/20/drone-irrigation-technology-in-africa/

Word Search Answer Key

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

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