Building on Success

Today's plant breeding methods rely on the innovations and advances that came before them. The science of plant breeding is ever-evolving, and access to new technologies allows researchers to innovate at an unprecedented rate.

AS EARLY AS 8,000 B.C. to 5,000 B.C., Mesoamericans were working to domesticate corn, and by 700 B.C., Assyrians and Babylonians were hand-pollinating palm, shares Todd Wehner, a cucurbit breeder at North Carolina State University. It seems as though man has been altering the genetic makeup of plants since the beginning of time.

During these early years, they were simply selecting plants that showed faster growth, larger seeds or sweeter fruits, adds Sarah Ward, an associate professor of genetics at Colorado State University. Plant breeding was a popular activity in the 1700s and 1800s; however, there was little understanding of the science behind it.

To formalize the creation of new plant cultivars and plant breeding, Louis Leveque de Vilmorin, of the Vilmorin family of seed producers, founded the Vilmorin Breeding Institute in 1727. At the time, Vilmorin was working to lay the foundation for improved size, shape and sugar content of sugar beets. According to "Principles of Plant Genetics and Breeding," it was there that the progeny test was first used to evaluate the breeding value of a single plant.

About a century later, Captain Robert FitzRoy asked Charles Darwin to join him on the five-year voyage as a naturalist aboard the HMS Beagle, setting sail on a five-year voyage, surveying the world. It was during this expedition that Darwin observed similarities among plant species all over the globe, along with variations based on specific locations.

Early Controversy

This observation led him to believe humans had gradually evolved from common ancestors, yet it wasn't until 1859 when he published his controversial theory of evolution. Yet, biologists, botanists and plant scientists took note.

At the turn of the century, three scientists were working on breeding problems and discovered a paper written decades earlier by Gregor Mendel.

"Mendel's paper detailed pea experiments, demonstrating the role of invisible 'factors,'" says Sarah Ward, an associate professor of genetics at Colorado State University. "These invisible 'factors' were dominant and recessive alleles, or genes, that could produce the traits we see and could be passed to offspring,"

Darwin's theory of evolution and concept of natural selection, combined with Mendel's work on heredity, became the foundation of plant breeding and selective breeding, says Sam Eathington, vice president of global plant breeding for Monsanto.

Since the publication of Mendel's paper, plant breeding began to evolve and has never been the same.

First the came the concept of crosses, which led to what is known as improved hybrid vigor in the early 1900s. But the first commercial hybrid corn wasn't produced until the 1920s.

Mutation breeding was introduced in the 1930s, according to the Food and Agriculture Organization of the United Nations. It can be used to accelerate the process of trait development and

does not involve gene modification. Furthermore, it broadens biodiversity. It uses the plant's own genetic resources to mimic the process of spontaneous mutations — something that happens all the time in nature.

Around the world, plant breeders such as Norman Borlaug put their newfound knowledge to use, developing more productive, higher-yielding hybrids across a number of crop species including wheat and rice.

The period from the 1940s to 1960s became known as the Green Revolution, when agricultural output significantly increased, saving billions of people from famine and starvation. Borlaug's work with wheat in Mexico led the country from only supplying half it's needs to being self-sufficient. When leaders in Pakistan and India adopted his work, output increased fourfold.

Then there's the discovery of the DNA structure by James Watson and Francis Crick, which helped explain how hereditary information is coded and replicated. This was one of the most significant discoveries of the 20th century, and helped advance molecular biology to this day.

Then scientists began to apply tissue and cell culture technologies to create genetic variability and increase the number of desirable germplasms available to the plant breeder.

In 1983, scientists developed the first plants using biotechnology to introduce a trait from nature to help them better survive their environment. Since then, this technology has been used in a number of crops but not without great controversy.

This was followed by marker-assisted selection (MAS) and genomic selection. MAS is the indirect selection process where a trait of interest is selected based on a marker linked to a trait of interest. It essentially, minimizes the wait-and-see time, as the plants DNA is the same as when it's a seed to when it's mature and the fruit is ready for harvest.

Genomic selection is a form of MAS in which genetic markers covering the whole genome are used, according to the National Center for Biotechnology Information.

As the sciences and technology progresses, the range of tools available to plant breeders to develop more productive, higher-yielding varieties expands.

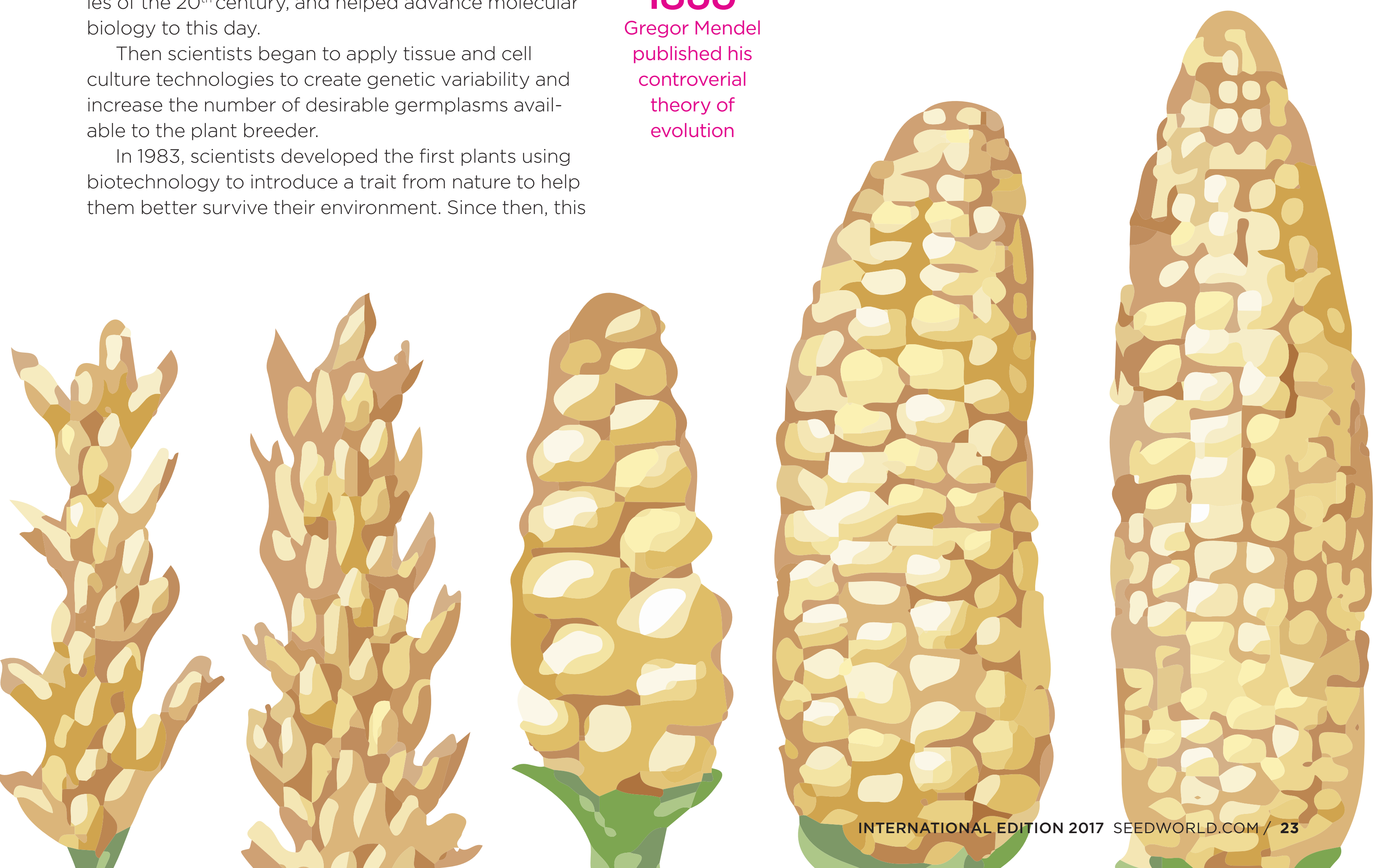
1940s
when Norman Borlaug kicked off the Green Revolution

9.7
billion people expected to inhabit the earth in 2050

1859
Gregor Mendel published his controverial theory of evolution

Building on a Strong Foundation

"Plant breeding is an ongoing practice," says Andy LaVigne, American Seed Trade Association president



and CEO. "It's an evolving science, whether you go back 10,000 years ago when man was selecting plants that were strong and met the local needs, or all the way back to the 1900s with cross breeding and hybridization and mutation genesis and cell culture. Plant breeding builds upon itself."

He says plant breeders don't just "Eureka" moment and come up with a new way of doing things.

"Our understanding develops each year, because we are getting better at mapping genomes and better at bioinformatics," LaVigne explains.

That brings us to another milestone of plant breeding, gene editing — the umbrella term for a number of tools and methods.

LaVigne says opportunities will come into play, but stresses the importance of new learnings and methods that will emerge and evolve in two years, five years and 10 years.

"The domestication of the plant was arguably the single most important technological advance in our history, and allowed us to develop into the highly complex civilization we have become," says Nino Brown of the University of Georgia's Institution of Plant Breeding, Genetics and Genomics. "As technologically advanced as we might be, we are still as dependent on plants as we have ever been. It could be argued, that with the current population and rate of growth, we are more dependent on these crops than ever."

"It's this relationship between plant genotypes and the environment that will continue to drive genetic improvements for future generations."
— Sam Eathington

According to the United Nations, there were 6.1 billion people on earth in 2000, and that number is expected to reach 9.7 billion by 2050.

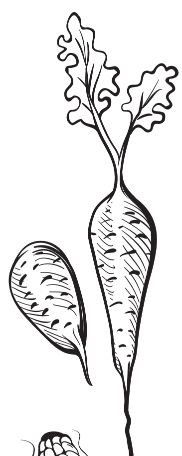
Brown says that's a lot of mouths to feed, but LaVigne and Monsanto's Eathington are optimistic.

"We are at an amazing time in agriculture right now when it comes to really understanding what plants do, and how we look at characteristics favorable to crop production as it relates to the challenges farmers face with weather, pests and disease," LaVigne says. "But how do we deal with those not-so-favorable characteristics and minimize those in the breeding process?"

That's the question plant breeders and researchers labor over.

"Today, plant breeders still rely on classic methodologies to develop top-performing products," shares Eathington, adding that modern technologies help optimize the predictability of how certain plants will grow in a variety of environment conditions. "It's this relationship between plant genotypes and the environment that will continue to drive genetic improvements for future generations." **SW**

EXPLORE THE EVOLUTIONS



Almost everything we've ever eaten has evolved and changed through generations of breeding. Some of the most popular fruits and vegetables originated from plants that would be almost unidentifiable today:

Carrots: Originally, carrots were yellow and purple. In the 1600s humans started breeding them to be white and orange, and then in 1700s they were bred to be red. Purple carrots are still grown in Europe and Asia, and red carrots are grown in China and India.

Watermelons: 5,000 years ago they were only two inches in diameter and tasted bitter. Nothing like the sweet-tasting fruit we eat today.

Bananas: About 6,500 years ago humans started breeding Musa acuminate, the banana's forefather. That plant was crossed with Musa balbisiana and produced plantains, a relative of the modern banana.

Corn: About 10,000 years ago humans discovered Teosinte, which was a plant with small, thin "cobs" that were only two or three inches long and had kernels so hard they could crack your teeth. Over thousands of years of selection, Teosinte was adapted to produce the 12-inch ears of today.

Cauliflower, broccoli, cabbage, Brussels sprouts, and kale: These common vegetables descended from the common Wild Mustard plant about 10,000 years ago.

POLICY ROUNDTABLE

Travel around the world and explore the policy and regulatory environment associated with plant breeding innovation. Countries opt for different approaches, but the international seed industry remains hopeful these policies will not only be consistent, but will also foster innovation.

PROVIDING EDUCATION AND resources around plant breeding innovation is one of the biggest priorities for the International Seed Federation (ISF) this year and for years to come.

There are a number of reasons for this, says Bernice Slutsky, who serves as co-chair for ISF's Plant Breeding Innovation Working Group, which operates under the remit of the Breeders Committee.

"These are methods we hope will be available to plant breeders to use across all crops," Slutsky says, noting these methods are fairly accessible and relatively inexpensive. "Through methods such as CRISPR-Cas, plant breeders are taking all their collective knowledge gained over the past 20-30 years and using it to create more genetic variability to provide growers more solutions and give consumers more options."

One of the biggest concerns plant breeders and those in the seed industry have is whether they'll be able to use the latest breeding methods. A social stigma and burdensome regulatory barriers could limit their use.

Harry Klee, a tomato breeder from the University of Florida, says they are taking a wait-and-see approach.

"We love gene editing but we haven't actually put anything out there yet," Klee says. "We are still being cautious as to how consumers will respond.

"For example: By knocking out the expression of a single gene, I can make the lycopene levels go up by 25 percent, and we know consumers really like those deep red tomatoes with high lycopene. We can do that with very simple gene editing and very quickly. I can do it with traditional plant breeding, taking two to three years per variety, or I can do it with gene editing and get it within six months."

The timing for ISF's work is critical as policymakers and governments around the world discuss plant breeding innovations, and if and how they should be regulated. Argentina, Australia, Canada, the United States and Europe are all in very different stages and are taking different approaches.

Argentina is the only country (at the time of writing) that has legislation written and signed into law. Canada doesn't regulate products based on process. Australia is reviewing its legislation, while both Europe and the United States are working to make revisions.

Argentina: Signed into Law

In 2015, Argentina announced that it had signed legislation into law stating that gene-edited plants would not be regulated as GMOs.

"The regulation is very clear in its definitions, and non-transgenic products can be excluded from regulation," says Juan Kiekebusch, Seed Association of the Americas (SAA) senior adviser on biotechnology. "The caveat is that companies, before making a big investment in research projects, should make an appointment to consult with the national biosafety commission, which then makes the determination if it's GMO or not."

Kiekebusch explains that not all countries agree with this approach, but it is one approach that sets a pathway, and it's aligned with the Cartagena Protocol on Biosafety.

Canada: Product, Not Process

Canada does not distinguish between a GMO and non-GMO when evaluating products for registration. It considers plant breeding innovations to be covered by its domestic legislation and regulation.

"Canada has a huge advantage over other nations in that it truly doesn't regulate the breeding process, but rather the product itself," says Allen Van Deynze, who grew up on a small Manitoba farm and now serves as director of research at the Seed Biotechnology Center, University of California, Davis. "We have a truly logical process, but there are many forces at work trying to change this. …

"If everyone would adopt and objectively implement the Canadian system, there would be a lot more things happening in plant breeding as far as products coming out, and everyone could use the tools to help create them."

Australia: Technical Review Underway

In Australia, the Office of Gene Technology Regulation (OGTR) is conducting a technical review of the regulations around gene editing with the goal of improving clarity regarding the most recent plant breeding methods. According to the OGTR, the technical review will focus on scientific aspects to ensure they keep pace with technological change and might result in proposals for inclusion, or exclusion, of techniques or organisms from regulation.

At this time, no amendments relating to recent plant breeding methods have been drafted.

Although technical changes can be made, the definitions of what is and what is not a GMO in Australia are contained within the gene technology legislation.

"There is a general view … that there's a range of new science and new development getting caught up in the regulatory system," says Matthew Cossey, CropLife Australia chief executive. "What's important is that you have a system that consumers have absolute confidence in. That it has safety but also allows for research to flourish and for new innovations to make it to the farming sector."

U.S. Proposes Non-Regulation

The U.S. Department of Agriculture (USDA) determined in April 2016 that it would not regulate a mushroom and a new type of corn genetically modified with the gene-editing tool CRISPR-Cas9. These were the first CRISPR-edited crops to be approved by the U.S. government.

Regulated by both the USDA and the Food and Drug Administration (FDA), the federal agencies were asked to review how they handle products derived from biotechnology, as well as recent breeding methods.

In January, USDA released its rule-making notice in tandem with FDA, whereby FDA acknowledged in its Request for Information that some applications of gene editing result in plants that could be developed through more traditional breeding methods.

USDA proposed a regulatory program in which it first assesses GE organisms to determine if they pose plant pest or noxious weed risks. If the department concludes that a GE organism does not pose a plant pest or noxious weed risk, then it would not require a permit for the importation, interstate movement and environmental release of the GE organism. However, if it is determined, based on risk analysis that controls on movement are needed, the department will work with the requestor to establish appropriate permit conditions to manage identified risks to allow safe movement.

"We're pleased that USDA's proposal recognizes that some applications of gene editing result in plant varieties that are essentially equivalent to varieties that are developed through more traditional breeding methods, and treats these varieties accordingly," says Andy LaVigne, American Seed Trade Association president and CEO.

> "What's important is that you have a system that consumers have absolute confidence in. That it has safety but also allows for research to flourish …"
> — Matthew Cossey

Europe: Uncertainty Prevails

In October, France recommended the European Court of Justice regulate all organisms created through all methods of mutagenesis. On the flip side, in 2015 Sweden had decided that the technical and legal issues associated with plant breeding innovation favored non-regulation and Finland followed suit.

But the broader European Parliament (EP) seems to be at a stalemate. In June 2016, the EP voted on an initiative put forward by its Committee for Agriculture.

The initiative received broad backing from the Agriculture and Rural Development Committee, but the plenary vote significantly altered the final text by suppressing proposals related to a more supportive and enabling regulatory framework for plant breeding and crop protection innovations.

"It is fair to say that we are rather disappointed," says Garlich von Essen, European Seed Association secretary general.

The plenary voted down a number of elements that had called upon the EU to facilitate the development and deployment of innovative plant breeding methods by a supportive and enabling regulatory framework.

Von Essen says: "To some extent, the EP has missed the point and an important opportunity."

Pro Innovation Policies Needed

The fact is that regulatory policy will determine the methods used across companies and across crops. Policies that place an overly high regulatory burden on new plant breeding innovations will limit use to only the largest companies and only the highest value crops, such as corn and soybeans.

While countries around the world chart new territories in determining how plant breeding innovations should be handled, the international seed industry hopes policymakers will create frameworks that give legal certainty to plant breeders and developers, foster innovation and ensure safety.

"A recent study shows that more than 80 percent of current and future productivity and sustainability gains are derived from plant breeding," von Essen says.

In moving forward, Slutsky says the goal is to adopt a set of consistent criteria for how a product should be evaluated, and thus regulated. ISF, through its Plant Breeding Innovation Working Group, developed a document outlining such criteria.

"If we can get the scientific community to agree on a set of parameters, then we can build a path minimizing political and 'off science' disruptions when we approach regulators and policymakers," Kiekebusch says.

That's why in mid-November, SAA hosted a meeting with academic representatives from the U.S., Mexico, Paraguay, Colombia, Argentina, Uruguay, Peru, Chile and Brazil to discuss concepts for consistent criteria when it comes to how, and if, these innovations should be regulated.

"We want to be proactive from both a policy and communications point of view," Slutsky says, "so at the end of the day, scientists can take advantage of these plant breeding innovations."

These innovations are seen as part of the solution to helping farmers increase crop yields and better manage disease, pest and abiotic pressures in a sustainable manner. **SW**

Take the Challenge: SPEAK UP

The International Seed Federation invests in communications tools and encourages those in the business to start telling their plant breeding innovation story.

TODAY, THE WHOLE environment the seed industry is working in has changed, shares Michael Keller, who serves as secretary general for the International Seed Federation (ISF).

He's referring to the social dynamics at play, how policymakers reach decisions and the rapidly advancing science and technologies researchers and plant breeders have access to.

"The environment has changed. The topics have changed, and how we engage has changed," Keller says. "It's no longer just the seed industry talking to itself and working with governments. We are required to work more broadly and engage all stakeholders across the value chain."

This requires speaking up and telling the seed industry story, your story. It's an effort the entire agricultural community has undertaken. Industry leaders have concluded that if you don't stop and take the time to tell your story, others will and it won't necessarily be the story you want.

Politicians are making decisions based on what society thinks, and that's why we need to be engaged and active on social media, Keller says. That's why ISF, in partnership with Seed World, encourages you to take the challenge and speak up. The Plant Breeding Innovation Working Group's communications subgroup created a communication toolkit to help with both messaging and terminology.

"To truly speak with one voice, consistency is key — both in terms of the messages we deliver and the words we choose to convey them," says Jennifer Clowes, ISF communications manager. To help build member's confidence and capabilities, ISF is hosting media training as part of the 2017 World Seed Congress in Budapest, Hungary. Following the event, attendees are encouraged to put their new skills into practice at the Seed World Media Center where publisher Shawn Brook will film participants' responses to a series of questions about plant breeding innovation.

"This is something we are really excited about," says Keller, "as it puts the training straight to use with a trusted source and personal coaching. We have to proactively engage and be vocal, visible and present. We have to go out and tell our story, but it's important to realize we aren't just talking for the sake of it. We have specific key messages that we need to get out there in order to tell our story."

These key messages hone in on the benefits of plant breeding innovation, methods of plant breeding innovation and public policy for products of plant breeding innovation. The communications toolkit is for ISF members to use and proactively engage with opinion leaders and influencers in breeding, academic institutions, policymakers and governments, Clowes explains. The toolkit currently includes a discussion guide, two infographics and a global presentation.

"When talking about GMOs, many in the seed industry have had negative experiences, as they were automatically on the defense," Keller says. "But plant breeding is a continuum, and it's evolving. It's up to us to show that we are a responsible industry; we have nothing to hide and can unlock a tremendous amount of potential if we have access to the latest methods.

So what are you waiting for? Start speaking up. **SW**

What EXACTLY is Plant Breeding Innovation?

Plant breeding innovations comprise a number of methods that plant breeders and researchers use to more precisely and quickly improve crops for farmers. Here, you'll find a breakdown of the methods being used and a brief description of how they work.

TODAY'S SCIENCE USES advanced tools, techniques and methods, giving plant breeders much more control of the end product. This allows them to reach their endpoint in a much more efficient and timely manner and will allow farmers to have access to improved varieties at a much faster pace to meet their ever-changing needs. Below is a list of seven of the eight methods (grafting on GM rootstock not included) being used by plant breeders.

Site-Directed Nucleases

Site-directed nucleases include three main methods: Meganucleases, Zinc-finger nucleases (ZFNs) and Transcription Activator Like Effector Nucleases (TALENs). These technologies rely on biological molecules that have both a DNA-binding domain that recognizes a specific DNA sequence (the site direction) and a DNA cleavage activity (the nuclease), which, when added to a plant cell, results in a specific, predetermined break in the plant's DNA. The plant's natural DNA repair mechanism recognizes this break and repairs the break using enzymes naturally present in the cell.

The goal of SDN technology is to take advantage of the targeted DNA break and the host's natural repair mechanisms to introduce specific small changes at the site of the DNA break. The change can either be a small deletion, a substitution or the addition of a number of nucleotides. Such targeted edits result in a new and desired characteristic, such as enhanced nutrient uptake or decreased production of allergens.

SDN applications are divided into three techniques (SDN-1, SDN-2 and SDN-3). All three take advantage of a double stranded break in the genome. The differences are that SDN-1 and SDN-2 do not use recombinant DNA and do not lead to the insertion of foreign DNA. However, SDN-3 introduces genetic material to the plant by means of a template containing a gene or other sequence of genetic material.

Oligo-Directed Mutagenesis

Nucleotides are organic molecules that form the basic building blocks of DNA, an organism's genetic material. ODM makes use of oligonucleotides, or short molecules, to produce a specific single base change within the DNA of a plant. The technique relies on the introduction of an oligonucleotide into a plant cell; the inserted oligonucleotide is identical to part of the plant's genetic material, except for the presence of one intended change. The oligonucleotide acts as a template for the plant's natural DNA repair mechanism, which detects the mismatch between the template and the endogenous genetic material and copies the intended change into the plant's DNA. In this way, a desired specific change in the plant's genetic material is produced. The oligonucleotide itself is not inserted into the DNA of the plant; it remains in the plant cell only for a short period of time before it is degraded.

In practice, ODM consists of mixing pant cells with oligonucleotides, obtaining the desired change in the plant's cells and letting those cells develop into mature plants using regular tissue culture methods. The genetic improvements for useful traits, such as disease resistance, drought tolerance and higher nutritional value occur without altering the plant's overall genetic makeup or introducing any foreign genes. ODM produces results similar to the natural breeding process, only four times faster and in a controlled precise manner, as the desired trait is the only change generated and no further breeding has to be undertaken to obtain the desired plant.

Agro-infiltration

Also called "*sensu stricto*," Agro-infiltration places plant parts in contact with cells of the bacterium *Agrobacterium tumefaciens*, which has the capability to transfer and integrate a part of its own DNA into the genome of the plant. This natural capability has been exploited to transfer viral genetic material to a plant cell. The transfer mimics a viral infection required to identify plants carrying a viral resistance gene. Resistant plants identified through Agro-infiltration can be used to produce progeny, which is used to develop commercial varieties. Agro-infiltration is applied very locally on a plant; as a rule, the genetic material is not stably incorporated in the germline and therefore not transmitted to progeny.

Cisgenesis

As a technique, cisgenesis is very similar to conventional breeding, but allows for a more specific transfer of genes between closely related crossable plant species. With this technique, a specific trait, such as disease resistance, is transferred from a same or closely related crossable plant species to another, without altering the plant's overall genetic makeup. Cisgenesis allows the natural breeding process to occur up to four times faster and in a controlled manner, as the desired trait is exclusively introduced and no further breeding must be undertaken to eliminate unwanted characteristics in the new plant variety. As with conventional breeding, the donor plant must be crossable with the recipient plant, and the genetic transfer could also occur naturally as a result of crossbreeding.

Reverse Breeding

Reverse breeding allows production of new hybrid plant varieties in a much shorter timeframe and ambient numbers compared to conventional plant breeding techniques. In reverse breeding, an individual plant is chosen for its elite quality. By suppressing normal genetic recombination, homozygous parental lines are derived from this plant. Upon crossing, these parental lines can reconstitute the original genetic composition of the selected elite plant, from which the lines were derived. During reverse breeding, a genetic modification step is employed to suppress genetic recombination; however, the final selected variety and their parental lines do not contain this genetic modification.

RNA-directed DNA Methylation

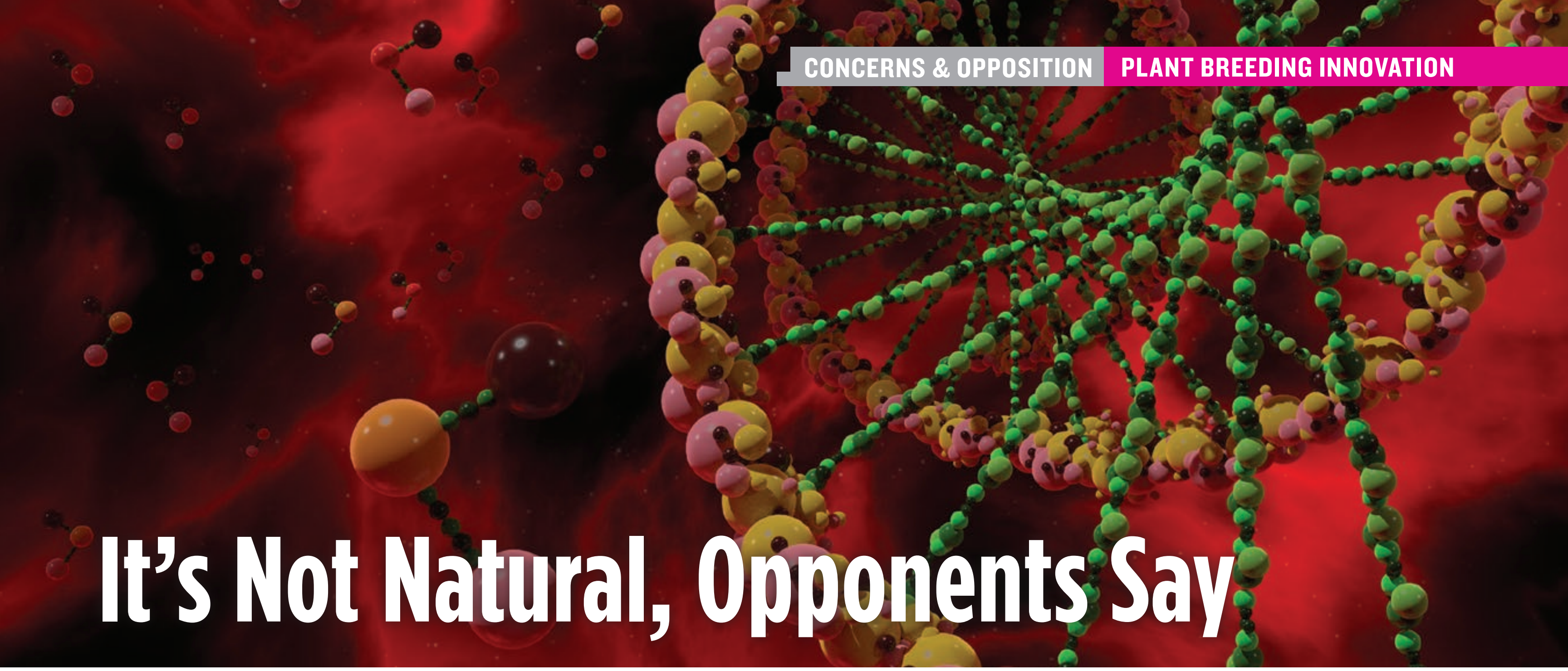
In the process of RNA-directed DNA methylation, short double-stranded RNA molecules (dsRNA) with homology to a target site in the plant genome are introduced into plant cells. This dsRNA is subsequently recognized by the plant's natural defense mechanism, which recruits an enzyme called DICER, which breaks the dsRNAs down into smaller RNA molecules called small interfacing RNAs (siRNAs). These siRNA molecules then direct the plant's defense mechanism to methylate the DNA of the target site through a DNA methylation pathway.

Referred to as an "epigenetic" modification, the plant's nucleotide sequence is left unchanged. Rather, the chromatin structure (a complex of nucleotide sequences and proteins) is altered, resulting in decreased activity or even silencing of a specific gene. The resulting plant has no change in its genetic material compared to the starting plant material. In most cases, these changes are passed from generation to generation in the absence of the original trigger.

The production of the small double stranded RNA molecules used in RdDM can be achieved in different ways. For example, with Virus Induced Gene Silencing (VIGS), the plant is infected with a plant virus that is engineered to produce the dsRNA. Alternatively, it is possible to introduce a transgene that leads to the production of dsRNA.

After silencing is achieved, the methylation is maintained, resulting in the gene being silenced in future generations, but the genetic material coding for the RNA is lost. In the case of VIGS, the original viral genetic material containing the sequences for the production of dsRNA is lost during meiosis; in the case of introduction of a transgene, the gene is removed by crossing with plants that do not possess the transgene. As a result, the final selected variety (the "product") is not genetically modified since there is no introduction of genetic material into the plant and there has been no alteration of the plant's nucleotide sequence compared to the starting material. The only difference is the specific methylation of a certain stretch of DNA resulting in the desired trait; a common characteristic of all methods of RdDM used for plant breeding. **SW**

Source: NBTPlatform.org.



It's Not Natural, Opponents Say

While science shows that the latest methods used by plant breeders are safe, opponents say these methods "are not natural" and should be regulated.

TODAY THE AVERAGE person is three to four generations removed from the farm, with little to no understanding of agriculture. However, consumers have never been more curious about their food, where it comes from, how it's grown and the nutritional value.

Agriculture is heavily driven by science and technology, and it has been adopted from seed developers, to the farm, all the way to the grocery store. Yet, consumers have a hard time believing that technology is a good thing when it comes to the production of their food.

But they aren't the only ones. Some scientists and non-governmental organizations also have concerns.

Michael Antoniou is one such person. He serves as genetic engineer and head of Kings College Gene Expression Therapy Group in London, England.

Antoniou believes the risks of deregulating gene editing outweigh the benefits.

"Although the changes are more targeted through gene editing, there are still a number of areas that you are not in control of and that calls for regulation," he says. "It all depends on the biochemistry that gets altered, and you won't know that in advance."

But Antoniou is not alone. Friends of the Earth has an active campaign against the use of the most recent plant breeding methods, specifically gene drives. Proposed as a solution to Zika-carrying mosquitos, as well as eradication of pigweed, one campaign spokesperson says there are unintended consequences of permanently changing a species.

Dana Perls, a senior food and technology campaigner, is passionate about the impact of off-target and non-target effects, as well as the potential for misuse.

"[When] driving a specific trait through a population, plants or other organisms could also lose the natural diversity that enables survival and adaptation in different environments and under different environmental pressures," she says.

But it's not just activists or lone scientists who are opposed to the use of the most recent breeding methods. Policymakers are uncertain too, but they are looking for answers.

"We are at a crossroads," says Christoph Then, of Testbiotech — a nonprofit organization, independent of the biotech industry, that aims to provide information and scientific expertise on the risks associated with plant breeding innovations. "The new methods known as genome editing have huge potential for radical changes of the genome.

"We do not have the experience to declare these products safe. If these new techniques are not regulated, there will be no transparency, no choice for farmers and consumers as well as no possibility of safeguarding human health or protecting the environment as required by EU regulation."

Testbiotech's Then urged the European Commission to make a clear position statement that "these new technologies will not escape EU regulation."

While those in the seed industry share that most of these plant breeding innovations are similar to traditional breeding in that they can be achieved through traditional breeding methods, the EU law defines a GMO as "an organism … in which genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination."

Understanding different viewpoints can be challenging, but it's important to understand alternative thoughts. According to the Harvard Business Review, when trying to influence, don't start by trying to pull others to where you are. Instead, got to where they are by asking: Who is this person? What is their situation? Am I offering options that can help this person move forward? This, the authors say, is not only a great way to achieve results, but also strengthens relationships. **SW**

Paving the Way for Innovation

For researchers and plant breeders to take advantage of the latest plant breeding methods, they need reassurance that their product will be accepted by consumers and that it won't interrupt international grain trade. Industry leaders hope that by developing a set of criteria for governments around the world to adopt, international markets will align.

LEADERS RECOGNIZED EARLY on that if plant breeders were going to have access to the latest innovations and methods, they had to take the lessons they learned from the 80s and 90s with GM technology and apply them today.

Due to the regulation and the costs associated with bringing a GM product to market (eight years and an estimated $135 million), public plant breeders have been priced out of the market, and that's true for smaller developers as well.

Another lesson learned is around policy. Bernice Slutsky, who co-chairs the International Seed Federation's (ISF) Plant Breeding Innovation Working Group, says that for GM products, countries set up special pre-market approval processes for products of genetic modification.

"We are asking, 'when is it justified to include a product under these GM regulations?' Most new plant varieties are regulated around the world," she explains. "It's not a question of whether they should be regulated, or should they not be regulated, but should they be subject to the same special pre-market approvals that were set up for GM."

But Slutsky cautions this isn't just about gene editing or another technology. "This is about the seed industry and agriculture's ability to innovate," she says. "If we always go back to GM as the dampening point, that is a huge hindrance to the industry."

Therefore, ISF and its members have been working proactively to take the lad on this issue, shares Secretary General Michael Keller.

Laying the Groundwork

"When we first initiated our efforts in this area two years ago, ISF had to clarify its role and focus via the working group," says Keller. Consequently, three key objectives were identified:

1. To facilitate policies across countries that don't impede, but rather enable the adoption of new technologies and foster harmonized regulations across countries.
2. To communicate with ISF members and other parts of the value chain.
3. To create alliances with stakeholders, public plant breeders and research institutes.

As co-chair of the International Seed Federation's Plant Breeding Innovation Working Group, Bernice Slutsky knows the next year to two years are critical in terms of paving the path ahead.

When the working group started, members focused first on policy. "That's where we felt the core of it was, and we also knew that our policy efforts would take the longest and generate the most work," Slutsky says.

The working group started by hosting off-the-record meetings, designed as an information exchange, with individuals from key countries. Slutsky says these were people who often wouldn't meet to discuss the issue, but they were asked: "What could be done to facilitate consistent science-based policies across countries?" This led to some very good discussions, Slutsky says.

From there, the Plant Breeding Innovation Working Group developed a concept paper to foster discussion and serve as a road map for national seed associations and ISF members when working with governments and stakeholders. The paper provides a detailed background on plant breeding and the tools and technologies available today.

"Essentially, if you can reach the same product endpoint with traditional plant breeding as with the new technologies, then we believe they should be governed the same as products derived from traditional breeding," Slutsky summarizes.

The paper, which has been translated into Chinese, Korean, French and Spanish, with more languages to come, outlines criteria to help governments determine if products should fall within the GM regulatory framework, or out of the GM regulatory framework.

"Our hope is that if governments follow the criteria provided, there will be consistency among countries," she says.

Meanwhile, the communications subgroup of the Plant Breeding Innovation Working Group has been developing a communication toolkit, currently comprising infographics, presentations and a complete discussion guide on how to talk about the topic.

"These tools are designed to support our national and regional seed associations in their communications with their public stakeholders, policymakers and members," explains Jennifer Clowes, ISF communications manager, who is coordinating this project.

The Road Ahead

But the Plant Breeding Innovation Working Group isn't done. There's still a lot of road ahead. The communications subgroup will be developing a frequently asked questions document based on the most common questions asked throughout the process.

The primary working group will expand its reach by reaching out to more countries to get input and collect feedback.

Additionally, the working group will begin talking about the importance of plant breeding innovation as part of other international meetings. These include the Food and Agriculture Organization of the United Nations (FAO), Organisation for Economic Co-operation and Development (OECD) and the Asia-Pacific economic community.

"These are places where governments are already meeting," Slutsky says. "We are trying to get on the agendas to talk about the concept paper and discuss the importance of plant breeding innovation. In some cases, we'll even look to host a side event."

FAO hosted a meeting on agricultural innovation, while OECD convened in Canada on gene editing, and the Asia-Pacific Economic Cooperation held a two-day workshop last June on plant breeding and the use of gene editing.

Now ISF is encouraging its members to start communicating with their governments and to proactively engage in conversations with their partners and downstream stakeholders in the value chain.

"It's important that our conversations don't just focus on the technology of gene editing," Keller says. "In fact, gene editing wouldn't be useful at all if we didn't have the accumulation of knowledge such as genome mapping, marker-assisted selection and many others.

"Rather, this technology allows breeders to use that cumulative knowledge. Gene editing is one tool of many that breeders can use. We are not going to feed the world because of gene editing, but because plant breeders have access to all the tools available."

"Our focus is clearly plant breeding innovation. It's the No. 1 priority for the entire industry — all players and all crops. It affects everyone."
—Michael Keller

Drive for Consistency

Consistent policies are not only important for seed trade, but also other parts of the value chain, particularly commodities and the grain trade, both of which depend on uninterrupted trade.

"We are all familiar with the issues of asynchronous approvals," Slutsky points out. "From that perspective, we have to work with downstream partners on the end goal, as farmers want an array of technologies available. "

But farmers need reassurance that they will have a market for their product. "From a grain trade perspective, consistency is most important," Slutsky says. "They don't want inconsistent government policies that hinder their ability to sell their product. The other half of the equation is innovation."

But consistency isn't the only criteria important to the seed industry. "The important piece is that the policies put in place shouldn't be unnecessarily burdensome, and they should foster innovation," she says.

Adrian Percy, global head of research and development for Bayer, says he favors a harmonized regulatory system. "Of course, it has to be a reasonable regulatory system that encourages innovation and one that allows us to support sustainable agriculture," he says.

Global Oversight

With so much at stake and the importance of plant breeding innovations to agriculture's ability to provide the feed, food, fiber and fuel needed in a sustainable way, researchers need access to all the tools in their toolbox.

"We hope to reach an endpoint such that we don't have policies or processes across governments that impede commodity trade, research collaboration or seed movement," Slutsky says.

The next year-to-two are going to be pivotal, Keller notes.

"Governments are actively discussing this topic, and it's been in the press a great deal," he says. "We need to stay ahead of the curve.

"Our focus is clearly plant breeding innovation. It's the No. 1 priority for the entire industry — all players and all crops. It affects everyone." **SW**