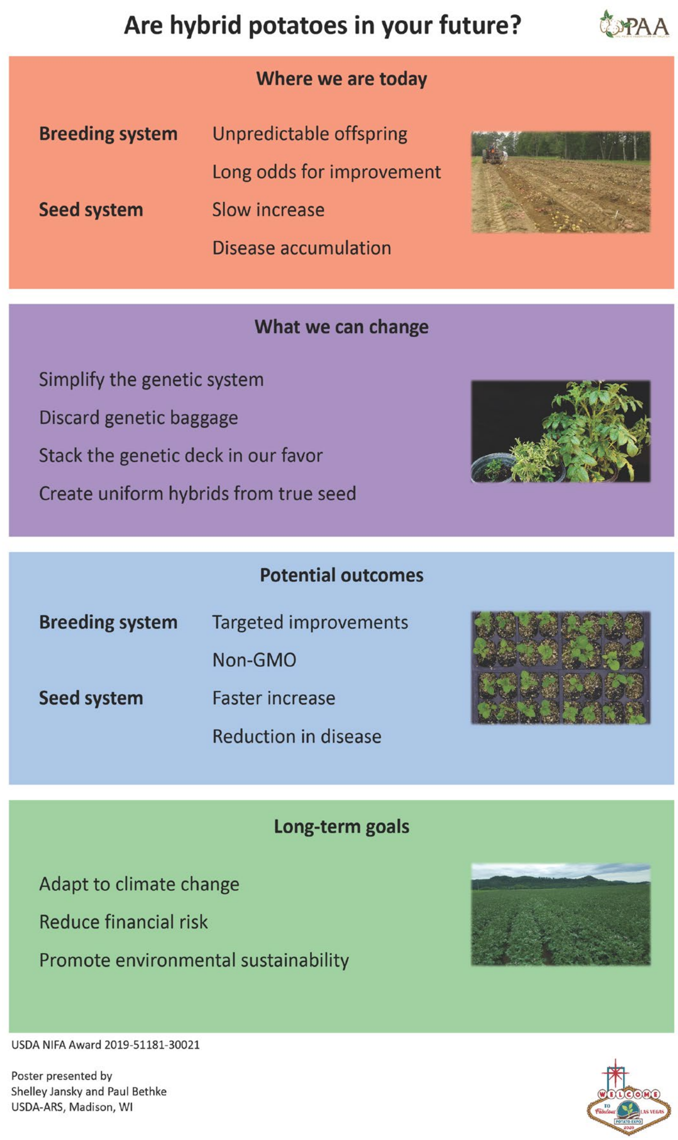

Where we are today. Potato is genetically complex. Every potato variety carries four copies of each gene, but in most cases the copies are not identical to each other. When a breeder makes a cross between two varieties, two of the four copies from each parent come together at random in each of the offspring. As a result, all offspring from a cross between two varieties are different from each other and we cannot predict which will carry the traits needed in a successful new variety. Breeders must sift through millions of these randomly generated genetic combinations to find the rare ones that are better than their parents. When a winner is found, it is a unique plant that is distinctly different from either parent and from all other potato varieties. Consequently, it takes years to learn how to manage a new variety. Another challenge is that seed must be increased through tuber pieces. When a potential new variety is identified as a seedling, the breeder must spend years producing enough seed for evaluation trials. Early trials are necessarily limited in number and scope due to low seed availability. In addition, minimizing the accumulation of pathogens during seed increase is a constant challenge.

What we can change. In the past decade, we have learned that we can simplify the potato genetic system, by creating plants with only two copies of every gene. These are called diploids. Surprisingly, diploids look like normal potato plants and can produce high yields of tubers. We can make a collection of diploid plants from each of our favorite varieties. Importantly, dysfunctional copies of each gene that were masked in the parent are revealed, as they have fewer normal copies to hide behind. Consequently, the diploid plants we produce from commercial varieties are highly variable and many have significant problems. The photo shows three diploid seedlings derived from Russet Norkotah. The first two seedlings inherited dysfunctional genes, leading to poor growth. The third seedling inherited normal genes. By throwing away the poor plants, we discard genetic baggage. At the same time, by keeping the vigorous plants, we are stacking the genetic deck in our favor; the third plant is enriched in beneficial genes. Eventually, we hope to create plants devoid of dysfunctional genes and uniform for functional ones. These plants, called inbred lines, will carry pairs of identical beneficial copies of its genes. When a pair of inbred lines is crossed, the hybrid offspring are genetically identical to each other and often superior to either parent. Consequently, hybrids planted from true seed are uniform in appearance and performance.

Potential outcomes. Once we have created a collection of diploid inbred lines, we will cross them in various combinations to determine which will produce commercially superior hybrids. We envision that, at least initially, the seed certification system will not change substantially; commercial acreage will still be planted from tuber seed. The only difference will be that the first step will start with true seeds rather than with tissue culture plantlets. Breeders could see a significant benefit, as they could increase seed for trialing much more quickly. A single hybrid potato plant can generate thousands of true seeds in a few months. Another major beneficial change from the current system is that breeders could incrementally improve inbred lines. That is, existing varieties will be improved rather than replaced. Using genomics technologies, we anticipate that breeders will be able to identify the specific genetic regions responsible for trait improvement and then add them into existing inbred lines. A new hybrid line produced from that inbred may be largely similar to its predecessor, but it has been improved for a commercially important trait. Consequently, extensive trialing across locations and years will not be needed to determine how to manage the new hybrid. Production knowledge gained from the previous variety will be sufficient in many cases. True seed does not carry most major pathogens, so disease load does not accumulate across seed generations.

Long-term goals. Members of the potato industry have told us that the three most significant constraints to success in their operations are *extreme and unpredictable weather events* resulting from climate change, *financial concerns* centered on the need to remain profitable with increasing demands from consumers, and expectations for *environmental sustainability* in a high input crop. The potato industry depends on new cultivars in order to respond to these challenges. Wild and cultivated relatives of potato carry genes that allow them to tolerate both disease and environmental stresses. The new diploid breeding system will enable us to systematically capture and integrate those genes into inbred lines and then hybrid varieties. Genes for traits that appeal to consumers, such as nutritional quality, appearance, and flavor, can also be introduced into new hybrid varieties. In addition to supporting large-scale production systems, we hope that a more nimble breeding strategy will lead to a steady stream of unique varieties that will capture the attention of consumers and keep them eating potatoes.