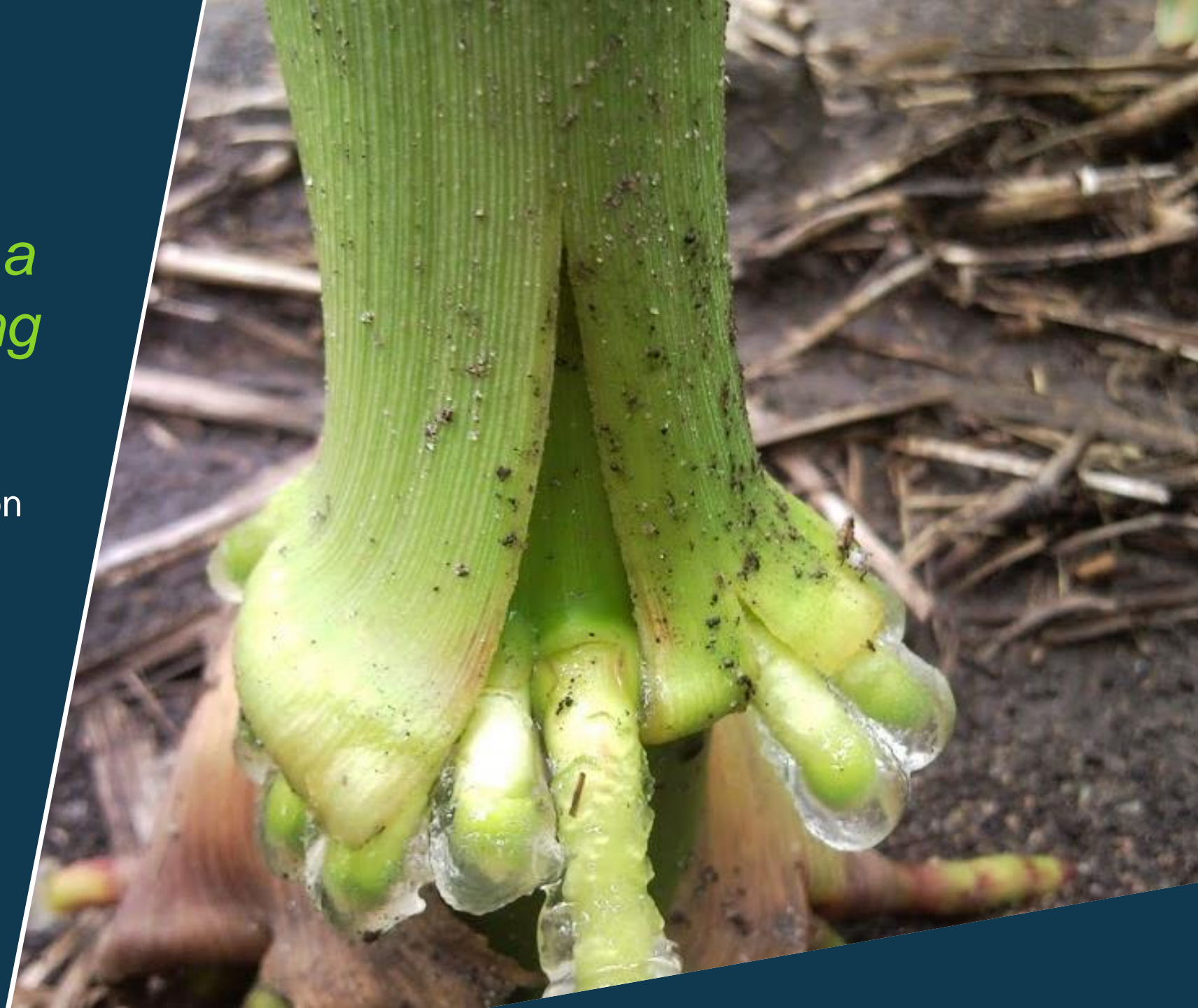# Decision making in a commercial breeding program

What works routinely in the industry with maximum return on investment?
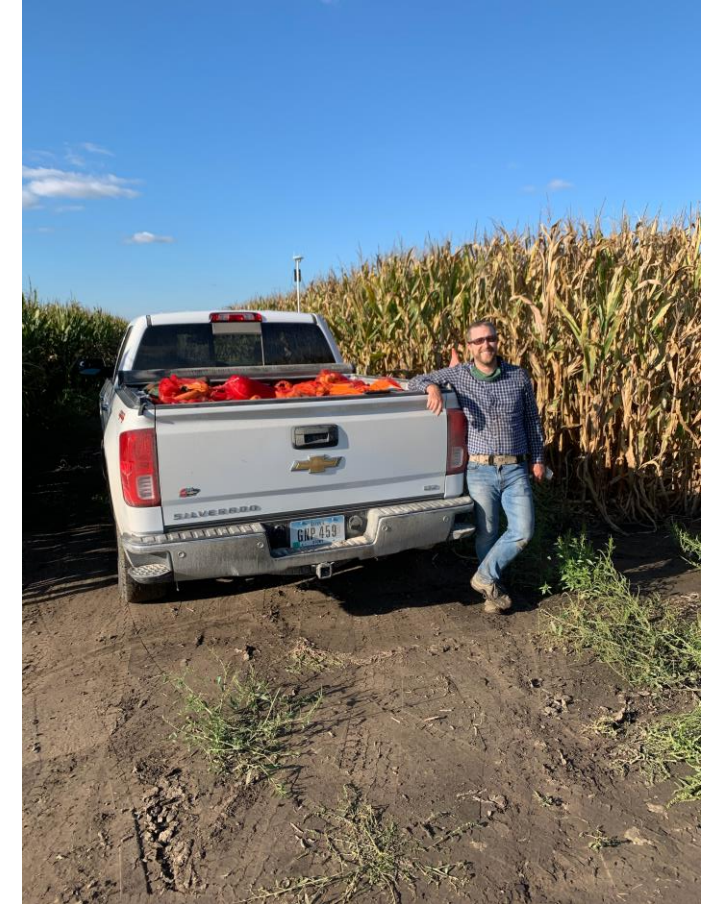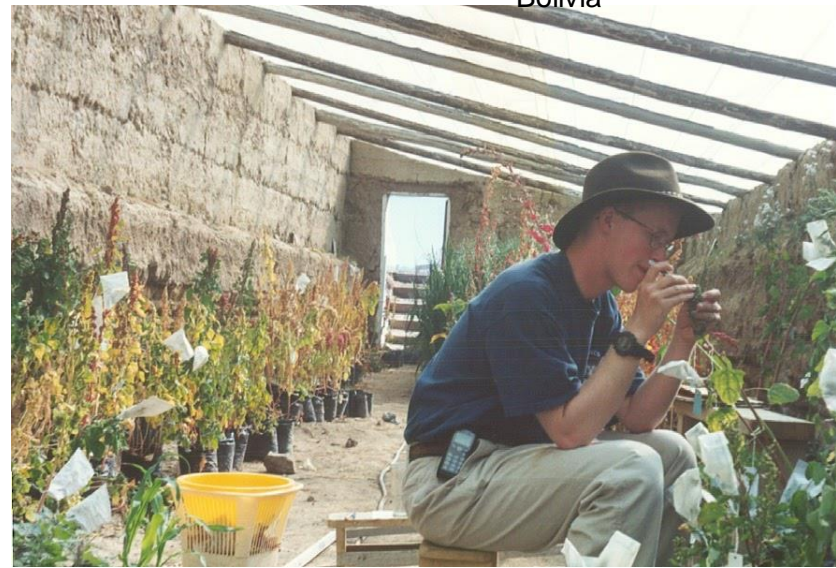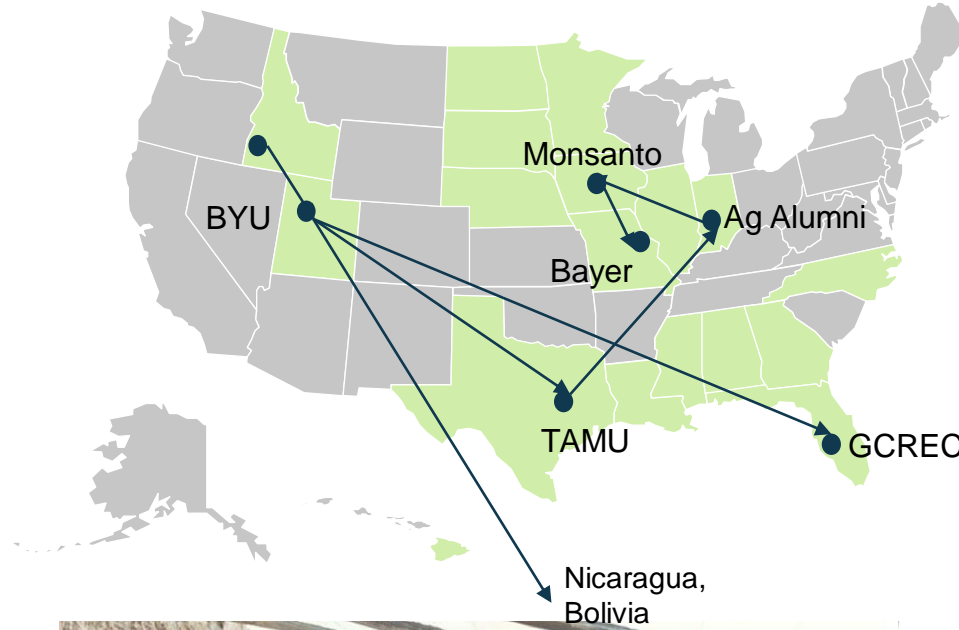
Brian Gardunia – Bayer

Brian Gardunia – My history and experience

Managing complexity while keeping focus on customers

Decision making in a commercial breeding program

When // Stages of breeding with increasing accuracy to predict performance for customer and competition

What // Advancement to next stage of testing and cascading decisions for population development. Incorporating genetic markers, nursery and testing observations, seed quantities, and plans for future.

Who // Team of teams – expansion of decision-making teams to include breeders, data scientists, geneticists, testing, commercial, sales, and production agronomists

How // Change is eternal – Innovation and continuous improvement: Software, databases, analytics, organization, strategy.

When: The road to develop tailored solutions for growers

|	
Breeding	1,000,000's of possible combinations
Trait Integration + Integrated Field Testing	1,000's of possible combinations
Seed Production	100's of hybrids & varieties
Field Scale Trials	10's of hybrids & varieties
Commercialization	1-3 products

Example of US Regional Brands

Example of US National Brands

When: Stages of breeding with increasing accuracy to predict performance for customer and competition

Product Design

Genomic prediction

Parental cycle

Product Development

Commercial Cycle

Commercial
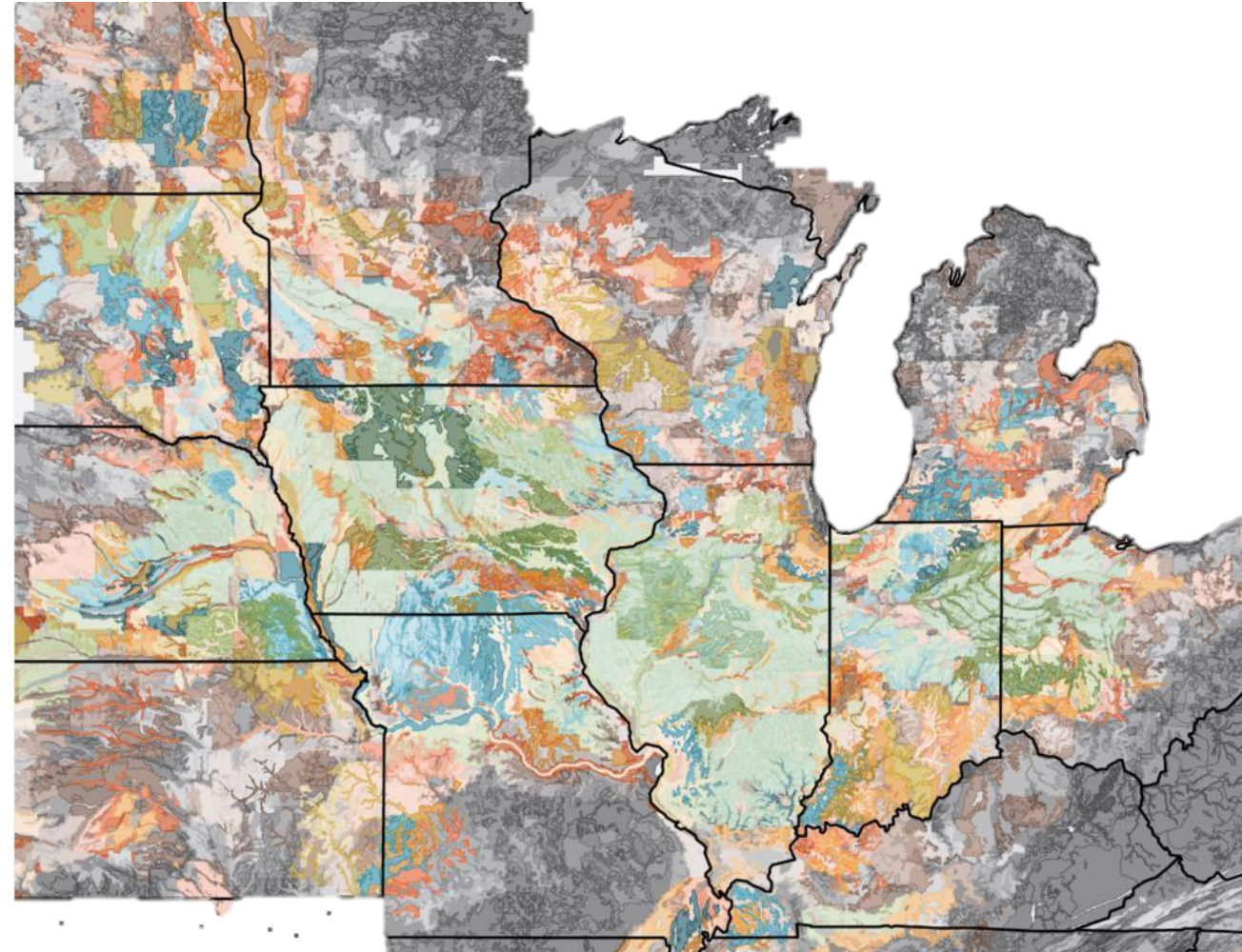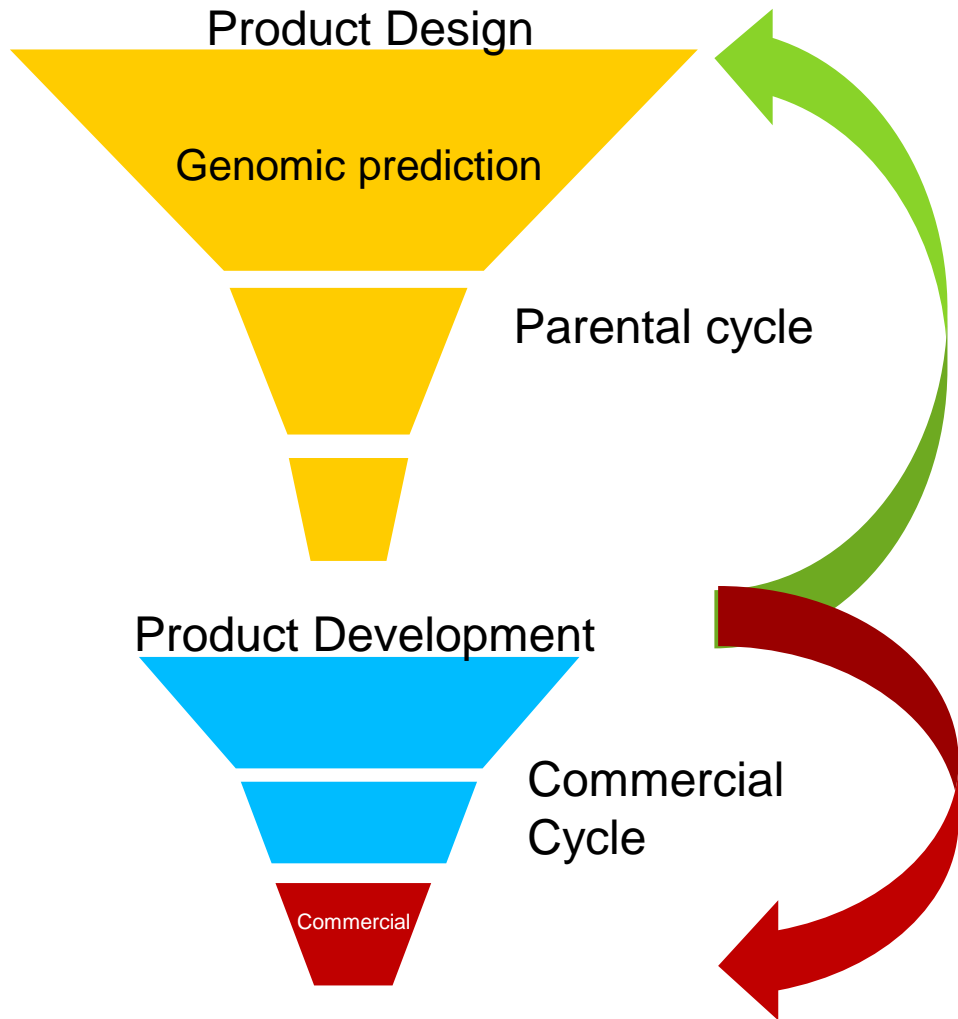
When: Stages of breeding with increasing accuracy to predict performance for customer and competition
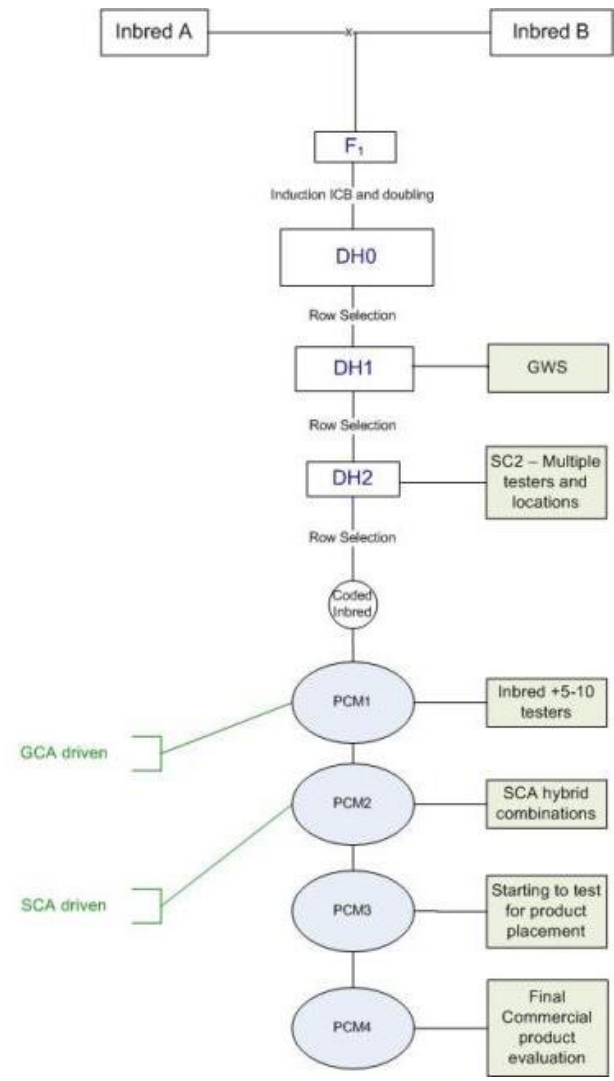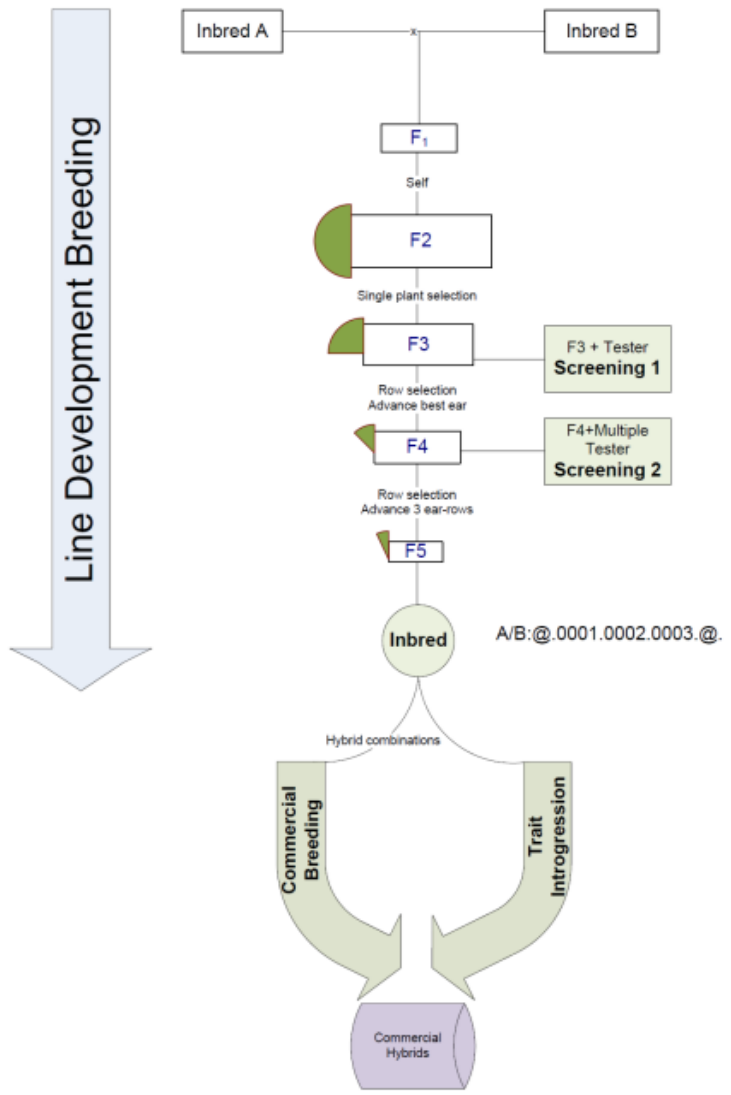
1. Testing cycles vs nursery cycles

2. Testing vs breeding seed

3. Calendar

   a. Time between harvest and advancement

   b. Cascade decisions to next stage

   c. Global connections

What: Traits to measure

Example from corn – what traits to observe for selection
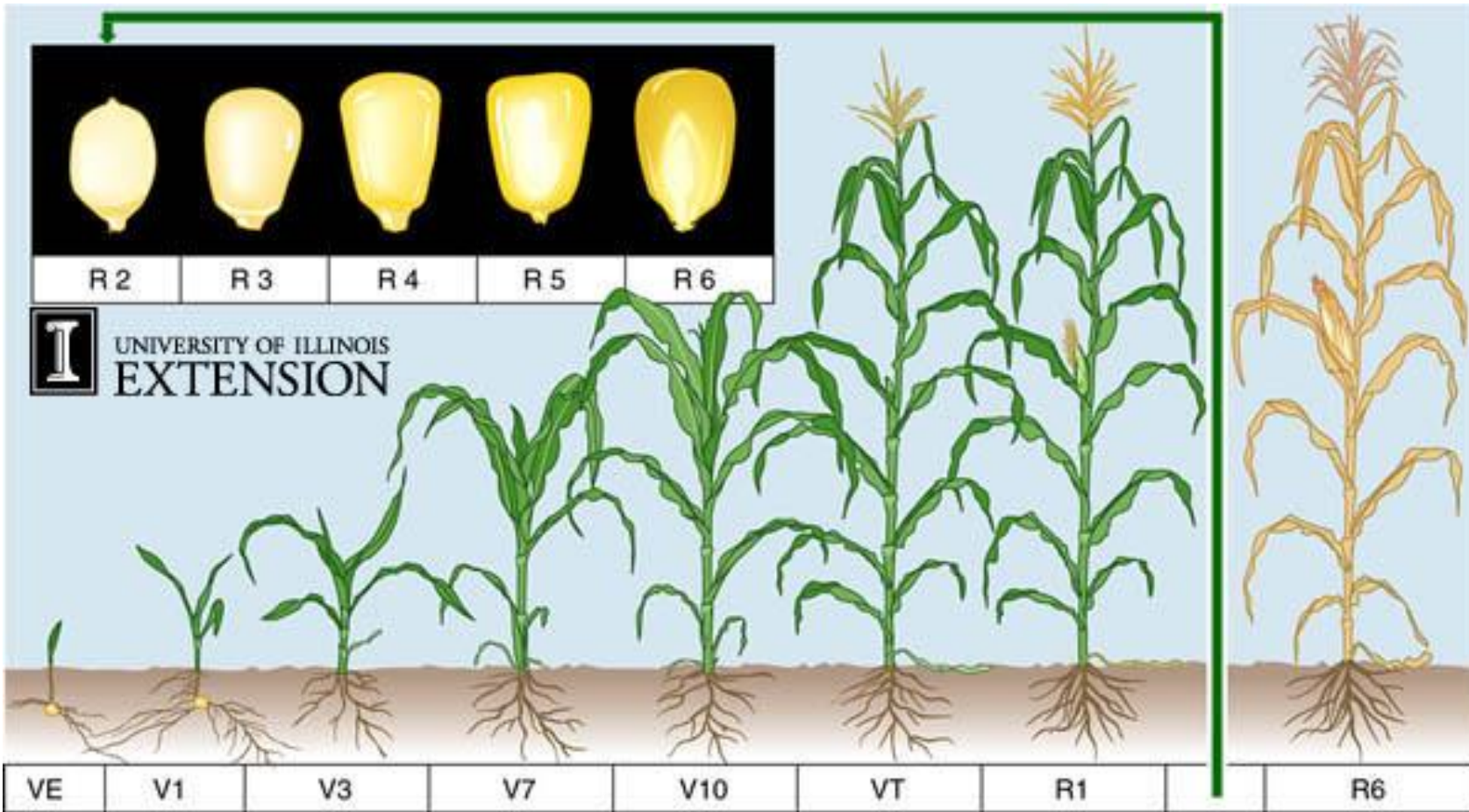
DKC26-40RIB
BRAND BLEND

RELATIVE MATURITY: 76

TRAIT: VT2PRIB

VTDoublePRO RIB COMPLETE

- Has shown improved yield and drydown vs. current products in maturity
- Very good test weight and standability
- Has displayed strong performance from the east to the west
- Strong foliar disease package allows use in most environments
- Good early season growth allows for early planting
- Has shown good potential as an early dual purpose product

What: Strong Yield Performance of Recent Deployment Classes

Corn

>7 bu/ac avg. advantage[1]

// **DeKalb** outperforms competitive products for the **13th** consecutive year

Soybeans

~2 bu/ac avg. advantage[2]

// **Asgrow** outperforms competitive products for the **9th** consecutive year

Cotton

81 lbs lint/ac avg. advantage[3]

// **Deltapine** outperforms competitive products for the **9th** consecutive year

[1] Bayer estimates – Annual yield advantage calculated each year by comparing 5 leading DEKALB products within each state having a minimum of 100 comparisons to national competitor products containing similar crop protection traits as of **November 12, 2018**. All comparisons are head-to-head using +- 2RMs and weighted average calculated using 15% moisture.

[2] Bayer estimates – Annual yield advantage calculated by comparing the top five Roundup Ready 2 Xtend competitor products by volume to the top five performing Asgrow Roundup Ready 2 Xtend products within a +/- 0.3 day maturity group as of November 13, 2018. The average across comparisons was weighted based on number of comparisons.

[3] Bayer estimates – Data as of November 15, 2018. Yield advantage calculated over three years (2016 to 2018) comparing commercially available leading Deltapine products by region to leading commercially available competitive products with similar traits. A minimum of 6 comparisons within a region were required for inclusion.

What: How we use genomic information
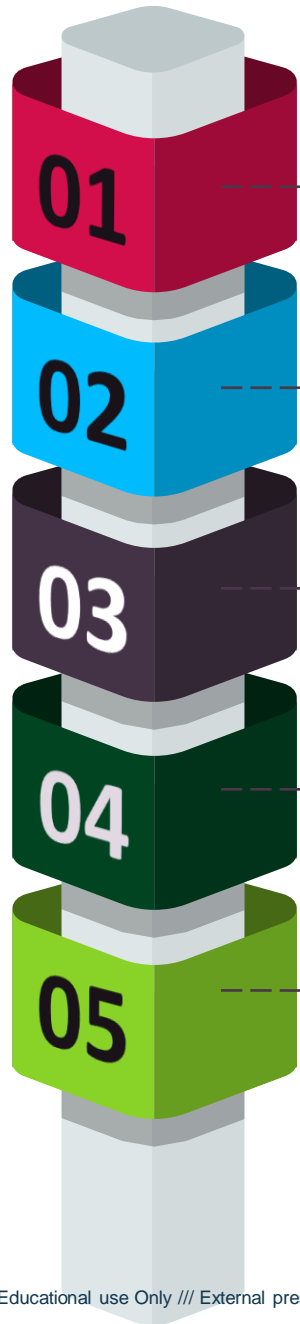
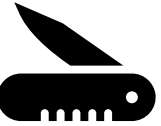## **Quality control**

Parent offspring, heterozygosity

Fingerprint

High density on parents and finished inbreds

Marker assisted selection

Forward and backcross breeding Flexible marker, few loci

Genomic selection

Historic training populations and new selections – Imputation

Discovery and validation

New trait association and validation

01
02
03
04
05

What: Genomic selection in the lab increased *speed and scale*

St. Louis is the biggest "field testing" program

ELIMINATE SC1

DNA SEQUENCE CHIPS

CHESTERFIELD RESEARCH PARK
ST. LOUIS, MISSOURI
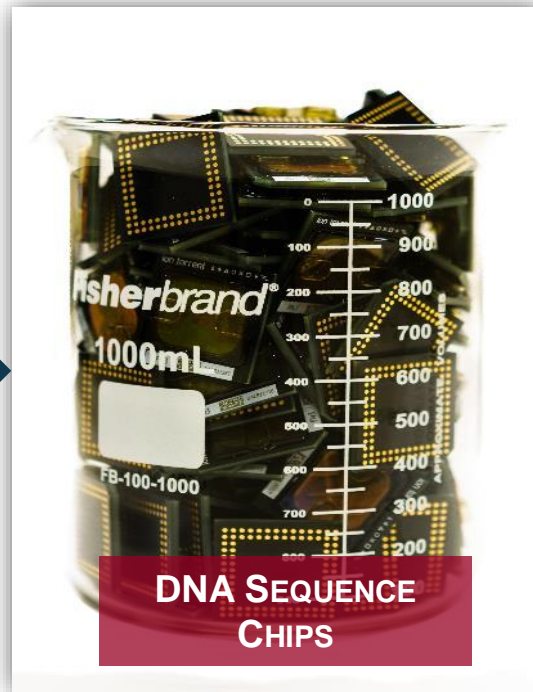
SKIP 1 YEAR OF FIELD TESTING 5X INCREASE IN PIPELINE SIZE

What: Plan for the future

Product design

Genomic prediction

Parental cycle

Product Development

Commercial Cycle

Commercial
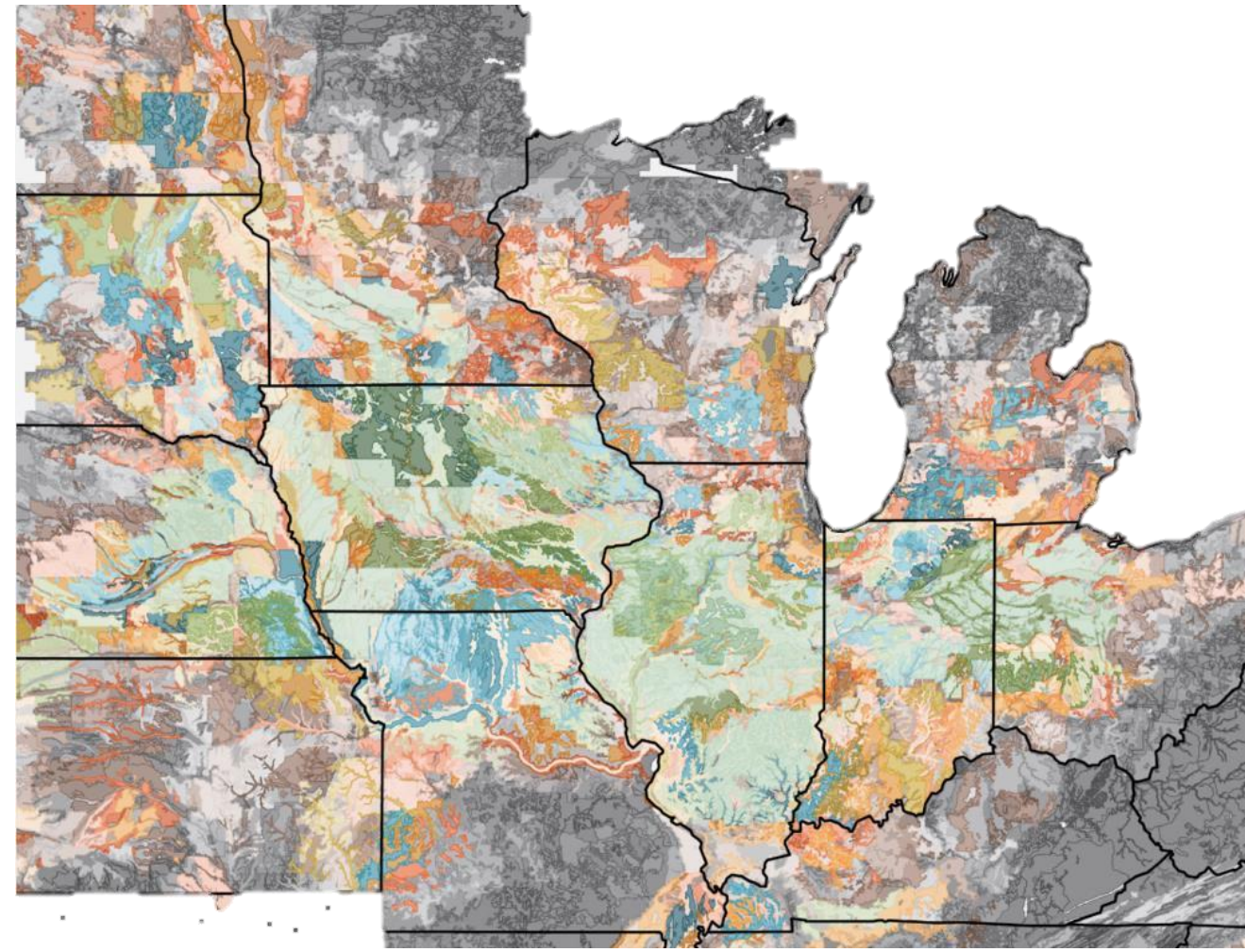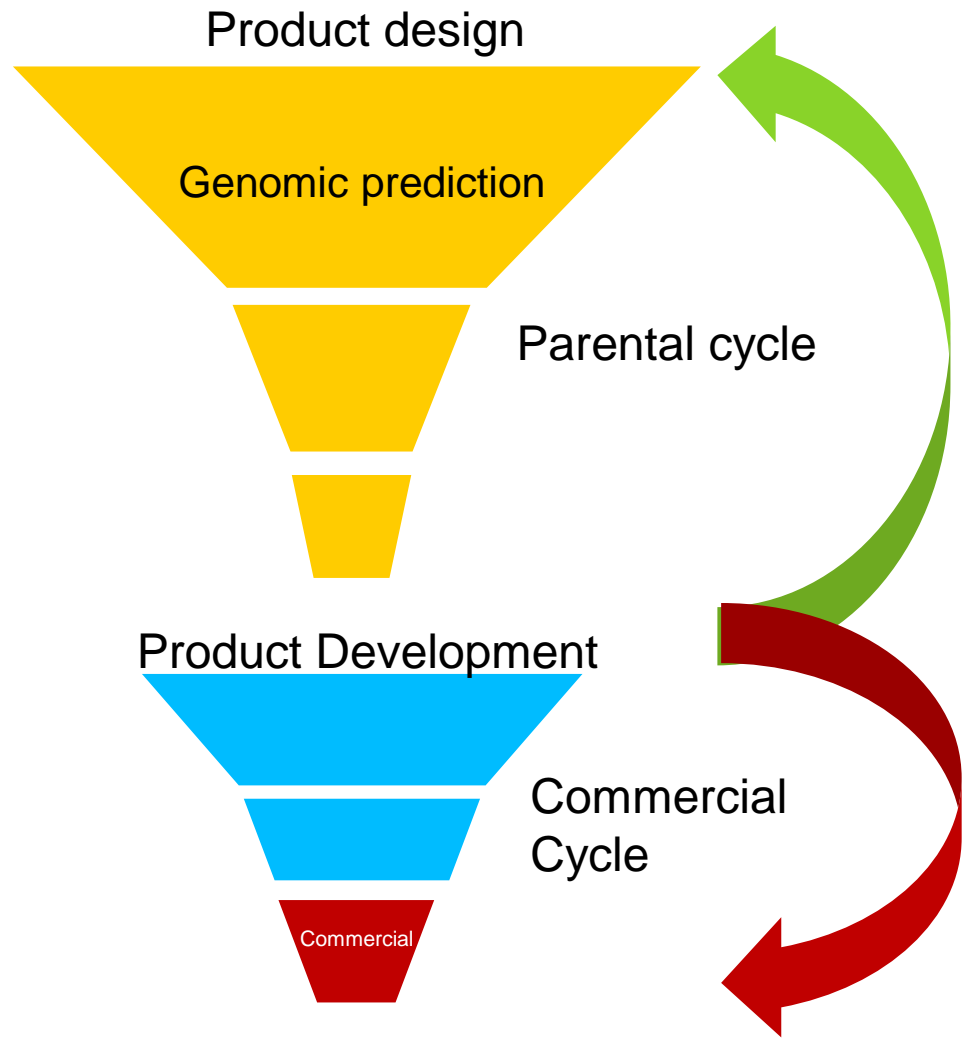
Who: Our Plant Breeding Team

Global team

65

21

13

8

18

120+ locations **in 25+** countries

SIX ROW CROPS

Corn

Wheat

Soybean

Rice

Cotton

OSR/Canola

Who: Plant Breeding Team and who is making decisions

Breeding

Product Design
- Corn
- Soy
- Cotton
- Canola/OSR
- Rice

Product Development
- North America
- Latin America
- Europe-Africa
- Asia Pacific

Enabling teams
- Planning
- Testing
- Analytics
- Multiseason nurseries
- Strategy and Operations

- Regulatory
- Commercial
- Production
- Biotech
- Chemistry
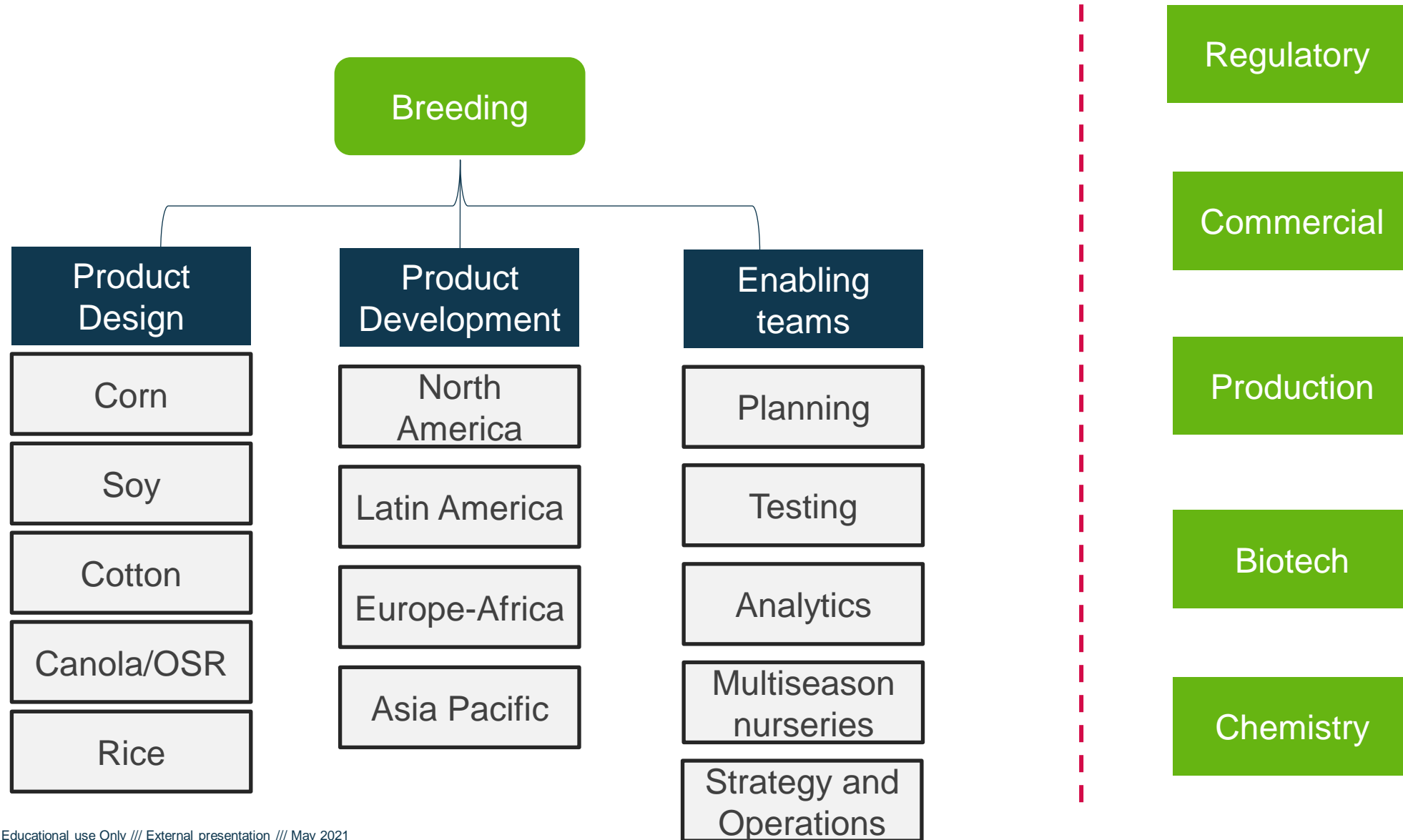
Who: Team of teams

Global and Local. Experts and Generalists.
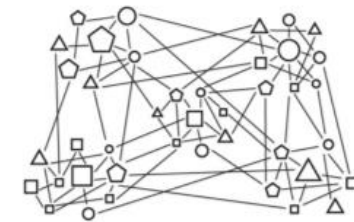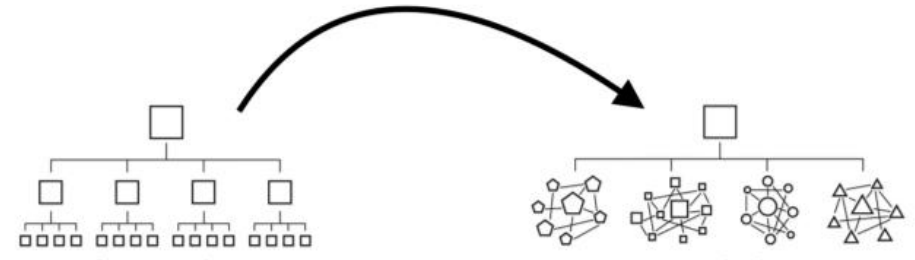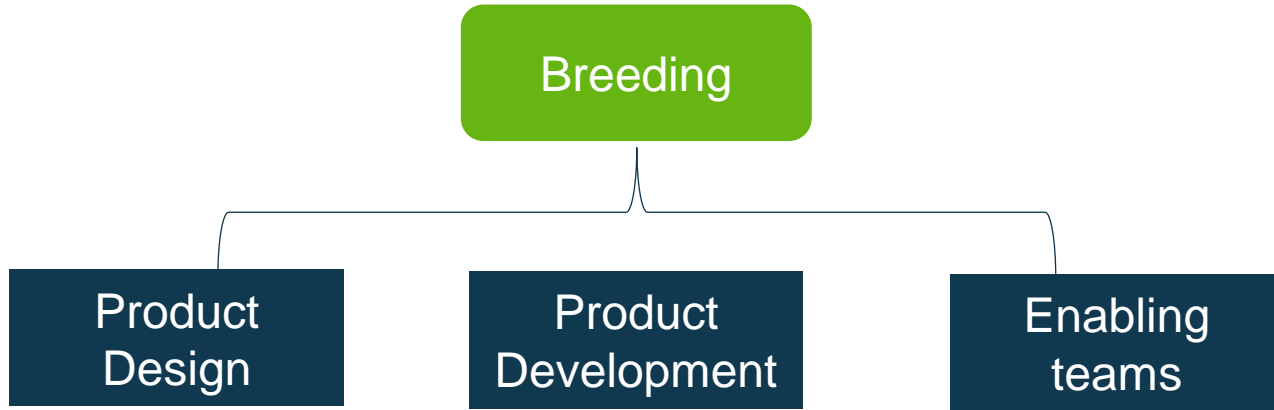
How: Change is inevitable

Our past, present and future

1. Innovation and continuous improvement

2. Software

3. Databases

4. Analytics

5. Organization

6. Strategy

Dekalb + Holdens
- Breeding software – Virgo/Maris
- Databases: Local servers – each station
- Innovations: BLUP, MAS, combined germplasm

Monsanto Molecular Breeding
- Breeding software - MIDAS
- Databases: Central Computing Cluster – LSF
- Innovations: MAB, Chipping, increased size and scope

Breeding 3.0
- Breeding software – Apollo/Velocity
- Databases and computing: AWS, Google cloud
- Innovations: GWS, DH chipping, EVA – OR + prediction

Precision Breeding
- Breeding software – Velocity, Product 360
- Databases and computing – AWS, Google Cloud
- Innovations – Advanced breeding methods, AI, GxExT

How: Breeding 3.0

GENETIC DIVERSITY
- Expand Germplasm Diversity
  Breeding Effort
- Native Traits
- Seed Movement

AUTOMATION
- Field Equipment
- Seed Handling
- Imaging Phenotyping

INCREASE GENETIC GAIN

BREEDING METHODS
- Doubled Haploid Optimization
- Haploid Chipping
- Reduce Cycle Time
- Genomic Selection

ANALYTICS
- Predictive Analytics
- Operations Research
- Prescriptive Pipeline

How: Precision Breeding

Continued Investment in Data Science and New Technologies are Driving Future Opportunity

| Advanced Breeding Methods	Data Science and Artificial Intelligence	Prescriptive Operations and Logistics	Product Performance Validation	Tailored Solutions Outcome

// Trait integration in the cloud enables better trait combinations even faster
 	
// Key parts of the pipeline are protected and accelerated in the greenhouse
	// Apply advanced analytics to every decision
	
	// Partner with Climate to enable next-gen product development
		// Better logistics enable innovation in seed testing and product characterization
		
		// Every North American field location is prescribed using analytics
		
		// Manage hundreds of thousands of SKUs
			// Prescriptive planting and environmental characterization to maximize product placement
			
			// Integrating and applying imaging to guide decisions
			
			// Globally connected harvest
				// Product recommendations that have been field proven
				
				// Input optimization by product and environment
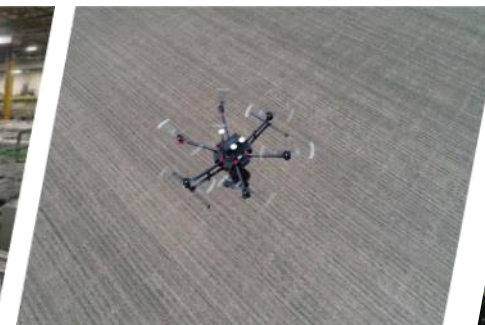
SKU = Stock Keeping Unit

How: Transforming Seed Logistics

Delivering more valuable, timely data on each product

Evolving our operations to better

Represent Customer Fields…

New, centralized seed distribution process enables seeds to be counted, sorted and then organized to be planter ready - providing **new levels of precision and data accuracy**.
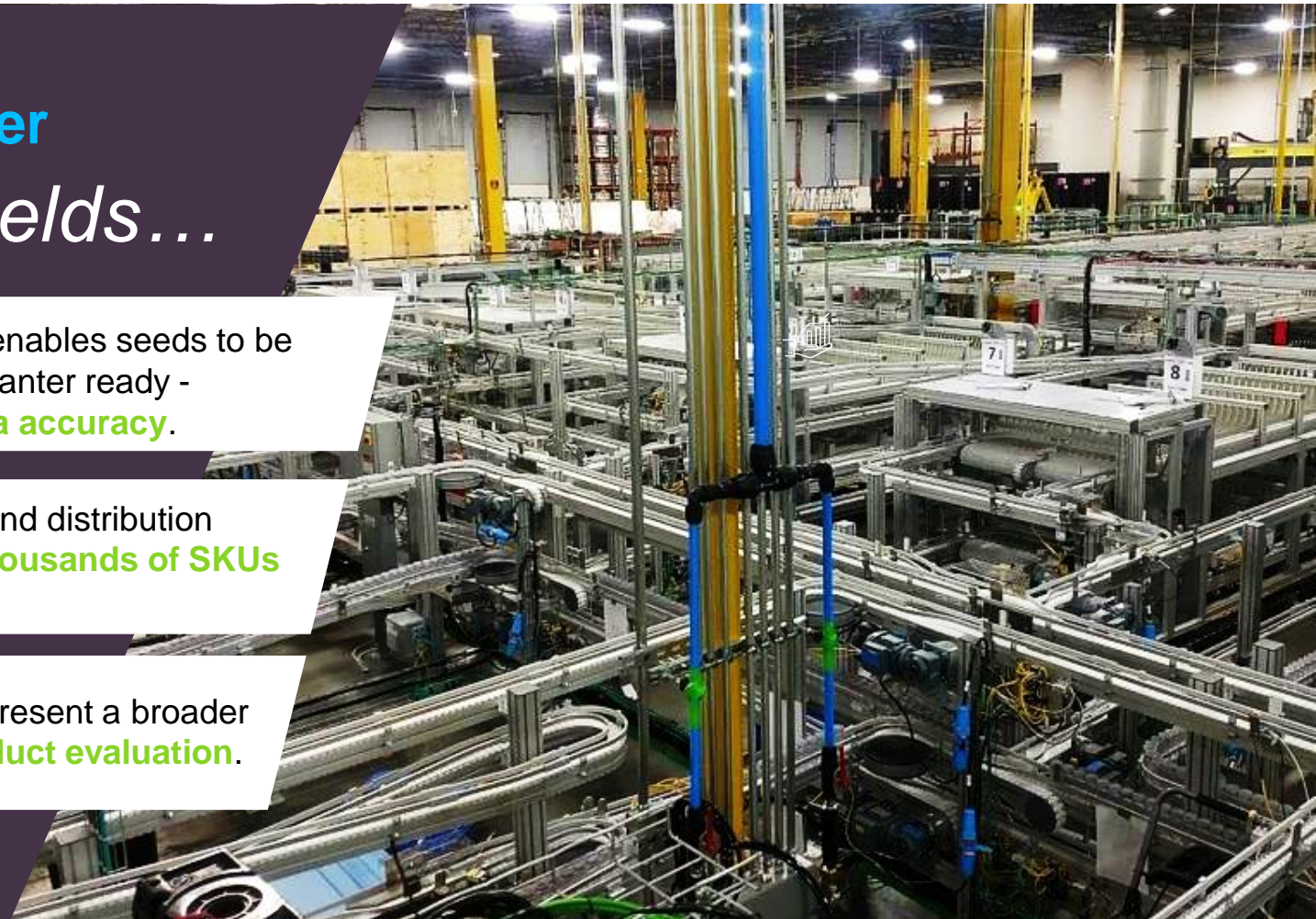
Adaptable, high throughput seed processing and distribution system capable of **managing hundreds of thousands of SKUs** for our global field testing program.

Optimally select and manage plot locations, represent a broader diversity of field conditions, and **maximize product evaluation**.

Video: Transforming Seed Logistics Brings Value to our Customers

How: Gaining product insight through innovative field testing

More Diverse Conditions

// Test and monitor products across hundreds of possible scenarios

// Understand what happens locally!

More Insightful Data

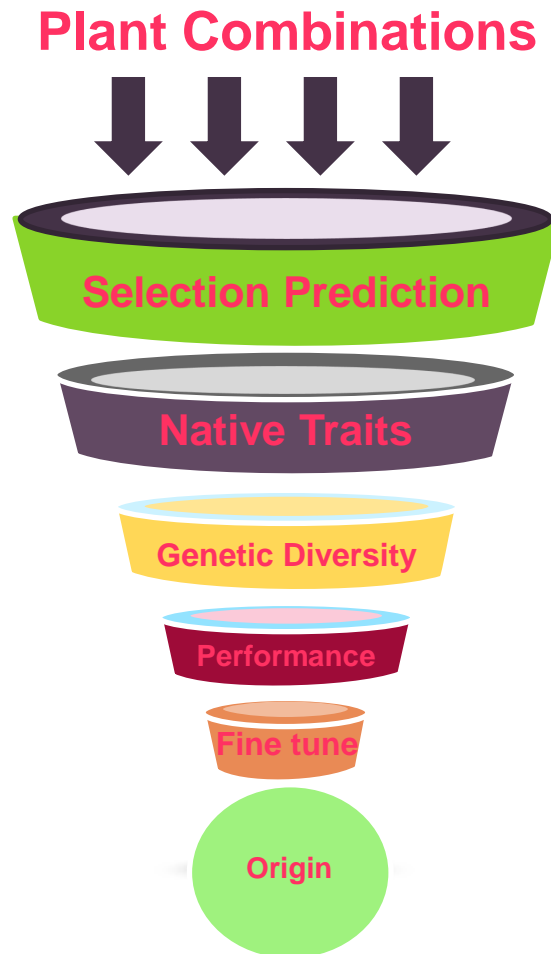// Proprietary equipment and automation enables data accuracy and optimized operations

Integrated Acre Testing

// Integrated testing and precise product placement to deliver more product knowledge and insights

How: Potential for virtual plant breeding capabilities and data types

Plant Combinations

Selection Prediction

Native Traits

Genetic Diversity

Performance

Fine tune

Origin

100's of Millions of Data Records analyzed Every Night

Virtual Breeding Capability
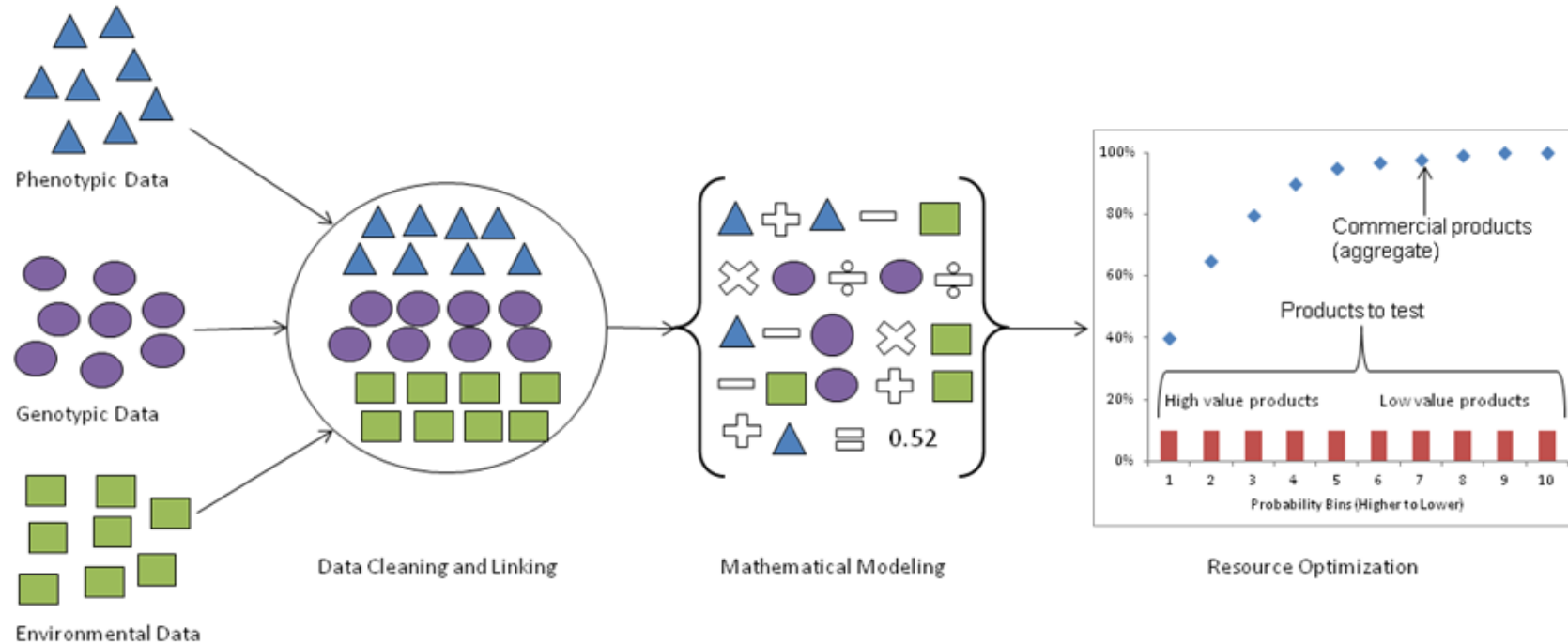
20

How: Method for model building

Fig. 9. Predictive Analytic Process for Resource Optimization.

Butruille et al. 2015. Plant Breeding Reviews. 39: 199-282.
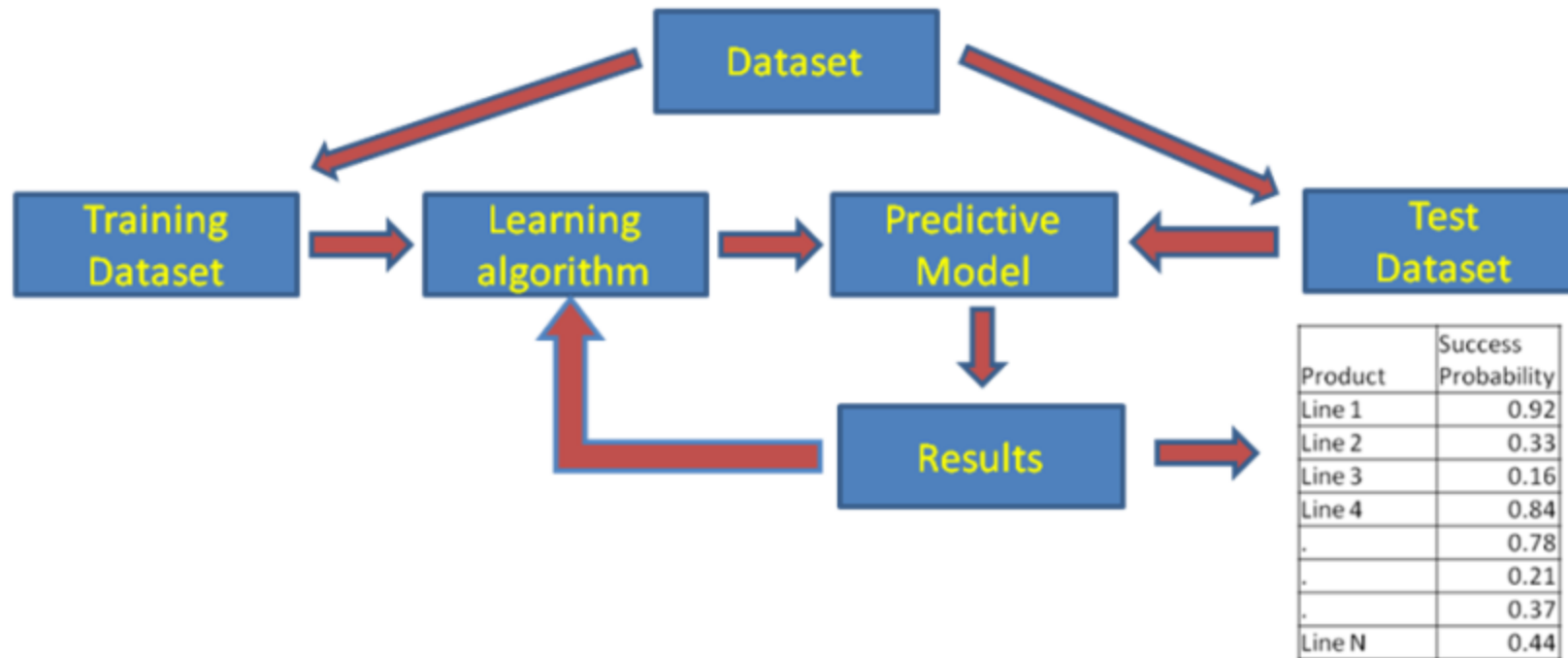
How: Iterative predictive model building

Fig. 8. Schematics for building predictive models.

Butruille et al. 2015. Plant Breeding Reviews. 39: 199-282.

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How
// Change is eternal – Innovation and continuous improvement: Software, databases, analytics, organization, strategy.

The time to innovate is now
Precision Breeding

"Everything else can wait, agriculture can't."

– Norman Borlaug –

Improving lives through better harvests

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