



**Amazing  
Germplasm**



**Traditional  
Genetics**



**International  
Collaboration**

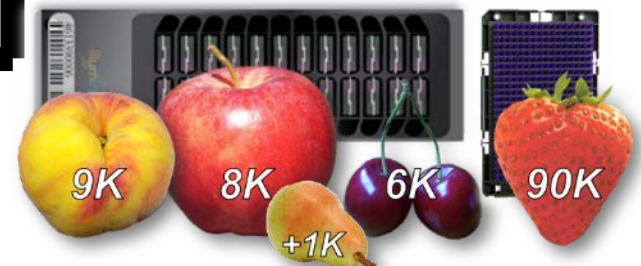


**DNA-Based  
Technologies**

**Cultivar Development  
Pipeline**

**Genomics Research  
Advances**

**RosBREED**



**Cameron Peace, Nahla Bassil, Michael Coe, Chad Finn, Ksenija Gasic, Stan Hokanson, Jim Luby, Dorrie Main, Jim McFerson, Jay Norelli, Mercy Olmstead, Vance Whitaker, Chengyan Yue, and Amy Iezzoni**

# Outline of Presentation



United States  
Department of  
Agriculture

National Institute  
of Food and  
Agriculture

- 1 Amazing Germplasm × Traditional Genetics
- 2 International Collaboration × DNA-Based Technologies
- 3 Cultivar Development Pipeline × Genomics Research Advances

## RosBREED

DISEASE  
RESISTANCE × HORTICULTURAL  
QUALITY → SUPERIOR  
CULTIVARS



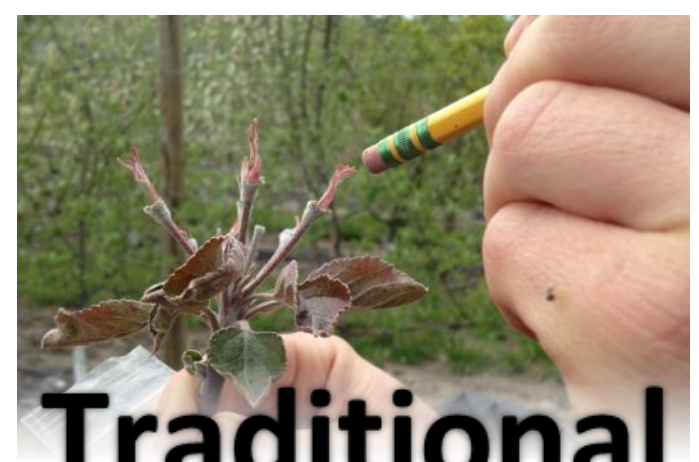
[WWW.ROSBREED.ORG](http://WWW.ROSBREED.ORG)



# 1



**Amazing  
Germplasm**



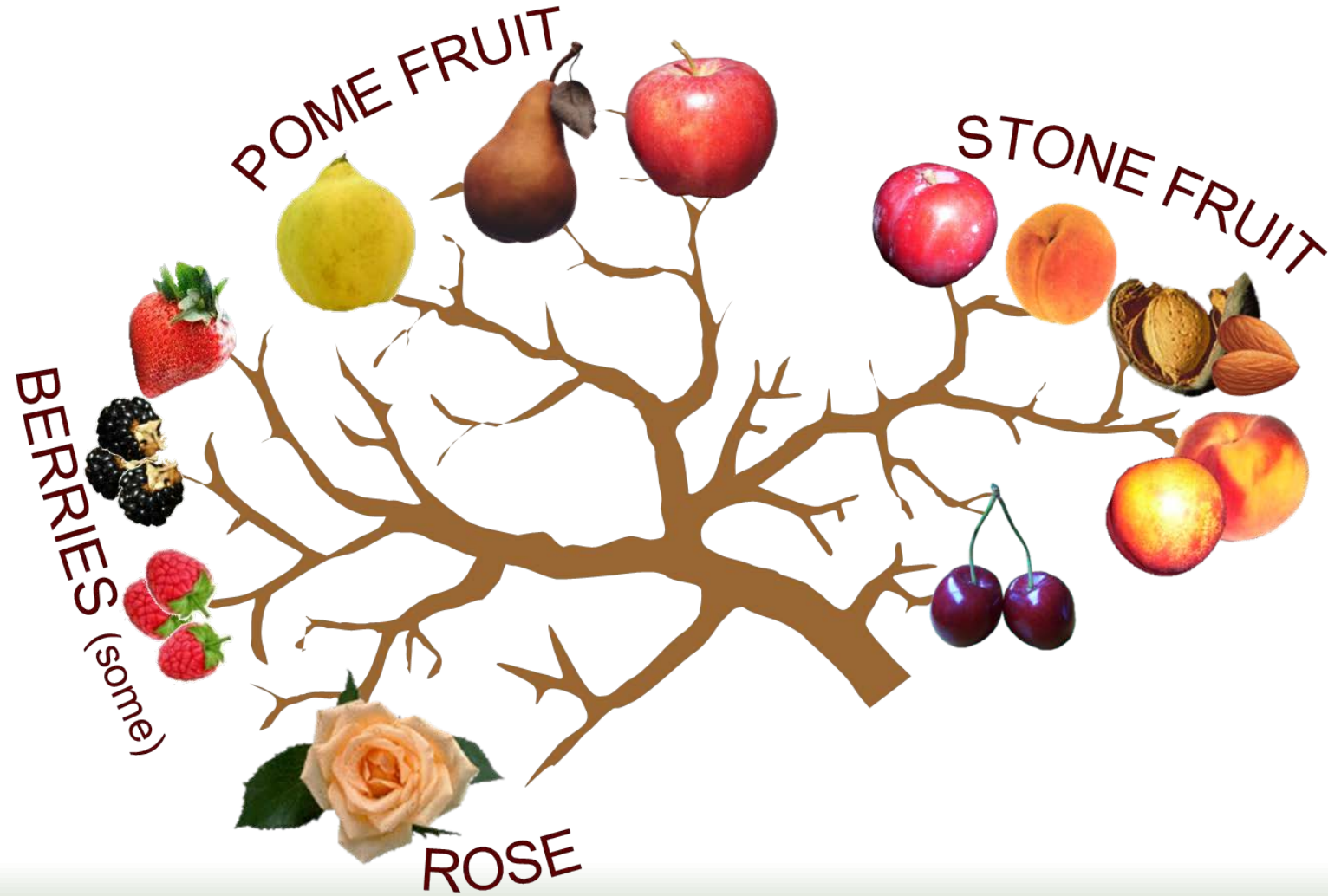
**Traditional  
Genetics**



**Cultivar Development  
Pipeline**



# The Rosaceae Family



**RosBREED**

DISEASE RESISTANCE + HORTICULTURAL QUALITY



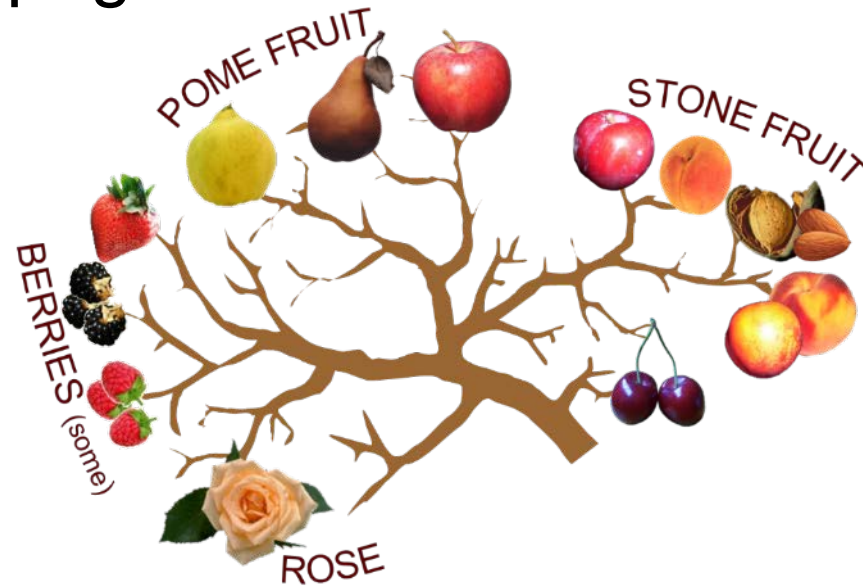
# Amazing Germplasm!





# Features of Rosaceous Crops

- Product quality is paramount
- Clonally propagated
- Perennial



- Often long juvenility
- Often obligate outcrossers
- Often high heterozygosity
- Sometimes polyploid

- Few generations in cultivation, much diversity in primary gene pools  
→ huge genetic gains possible



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# Traditional Genetics

- Crossing & selecting mostly by phenotype
- Quantitative genetics rarely used
- Breeders often rely on serendipity



Challenges: large plant sizes, long juvenility,  
disease resistances combined with superior quality

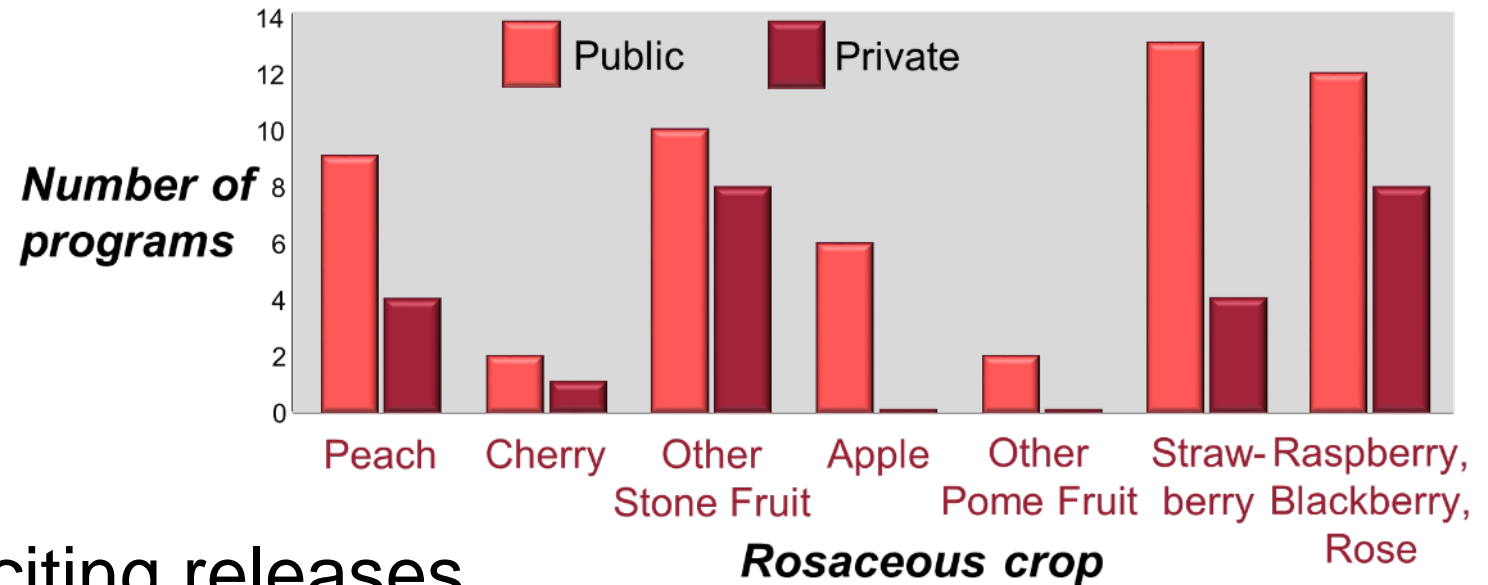


Cosmic Crisp™ brand WA 38, an eye-catching, large, dark red apple



# → Cultivar Development Pipelines

- Need for much public breeding (some crops/regions not commercially viable?)



- Many exciting releases

- Cultivar development pipelines are functional but inefficient



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# 2



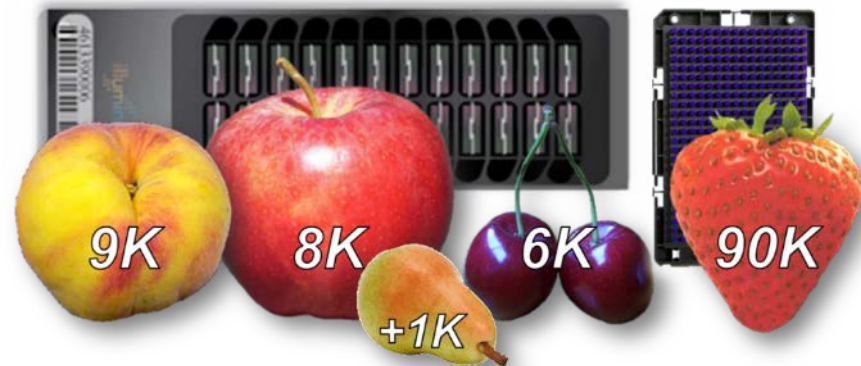
**International  
Collaboration**



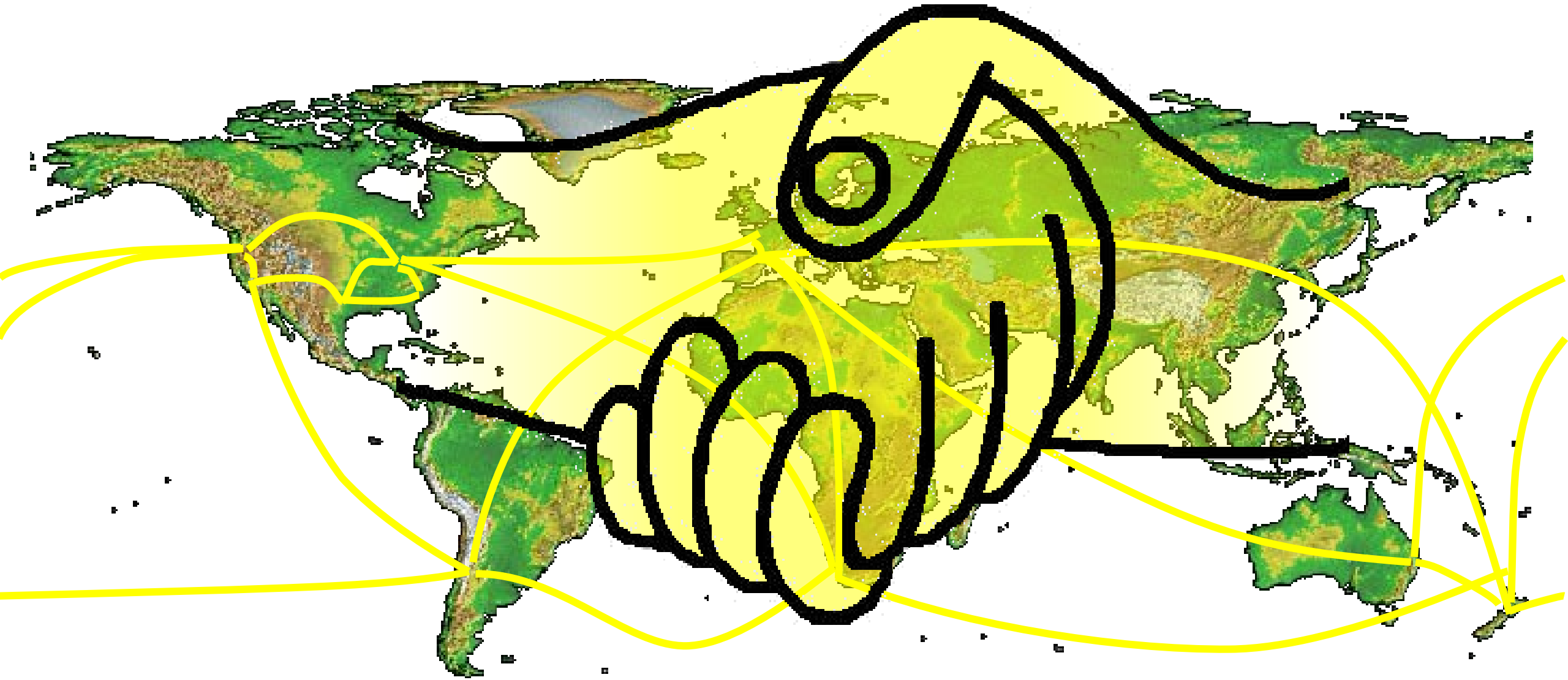
**DNA-Based  
Technologies**



**Genomics Research  
Advances**




# Strong Spirit of Collaboration





# International Research Community Hub

**GDR** | **Genome Database  
for Rosaceae**

Search

Login

Home | Contact

General

Help

Species


Data

Search


Tools

Breeders Toolbox

Community



**Genomic, Genetic, and Breeding Resources  
for Rosaceae Crop Improvement**



**Welcome to the Genome Database for Rosaceae**

Initiated in 2003, the Genome Database for Rosaceae (GDR) is a curated and integrated web-based relational database providing centralized access to Rosaceae genomics, genetics and breeding data and analysis tools to facilitate basic, translational and applied Rosaceae research. GDR is supported by grants from the [NSF Plant Genome Program](#) (2003-2008), [USDA NIFA Specialty Crop Research Program](#) (2009-2019), [USDA NIFA National Research Support Project 10](#) (2014-2019), and the [Washington Tree Fruit Research Commission](#) (2008-2016), [Clemson University](#), [University of Florida](#) and [Washington State University](#).

**What's new in GDR?**

- [Gene Naming Guideline is available](#) (4/23/15)
- [F. vesca genome V1.1.a2 and V2.0.a1 and Malus x domestica genome V3.0.a1 available](#) (4/6/15)
- [Peach genome V2.0.a1 available](#) (3/18/15)
- [New QTL, markers and genetic map data from apple and rose are available](#) (3/15/15)
- [New search interfaces for haplotype data](#) available (2/9/15)
- [GDR related presentations are available for download](#) (1/15/15)

**General Information**

[Report a problem](#) | [Ask us a question](#) | [Post a job](#) | [Post a meeting or event](#) | [Used GDR data or tools in your research - how to reference us.](#)

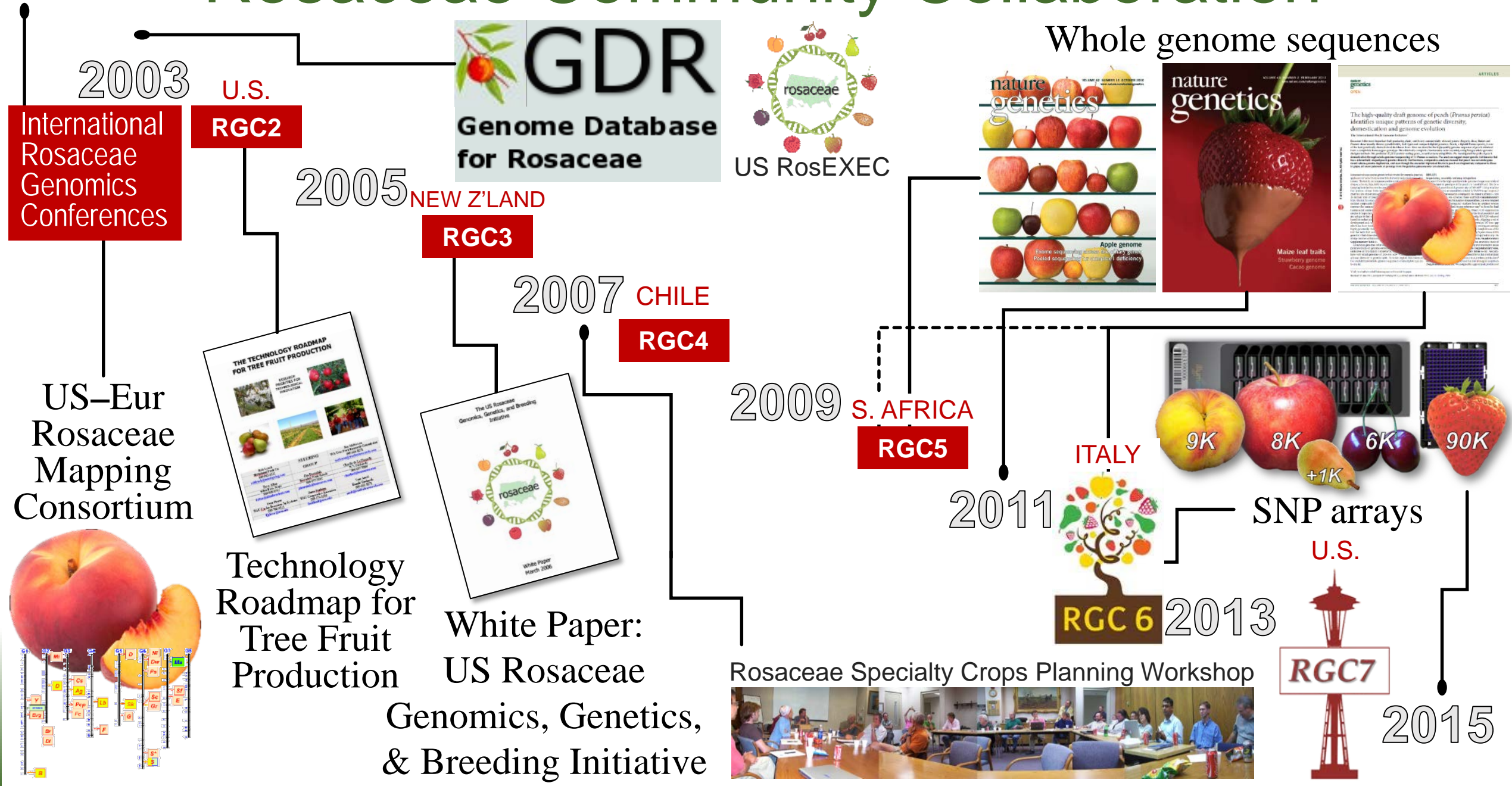
**News**

- [Gene Naming Guideline available](#) (4/23/15)
- [Rose transcriptome data and 68K Axiom SNP array data](#) (Koning-Boucoiran et al. 2015) are available for download (4/23/15)
- [GDR Newsletter April 2015 available](#) (4/6/15)
- [F. vesca genome V1.1.a2 and V2.0.a1 and Malus x domestica genome V3.0.a1 available](#) (4/6/15)
- [Prunus persica genome V2.0.a1 available](#) (3/18/15)
- [New QTL, markers and genetic map data for apple and rose](#) (3/15/15)
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- [Announcements archive](#)

Supported by grants from the [NSF Plant Genome Program](#) (2003-2008), [USDA NIFA Specialty Crop Research Program](#) (2009-2019), [USDA NIFA National Research Support Project 10](#) (2014-2019), and the [Washington Tree Fruit Research Commission](#) (2008-2016).

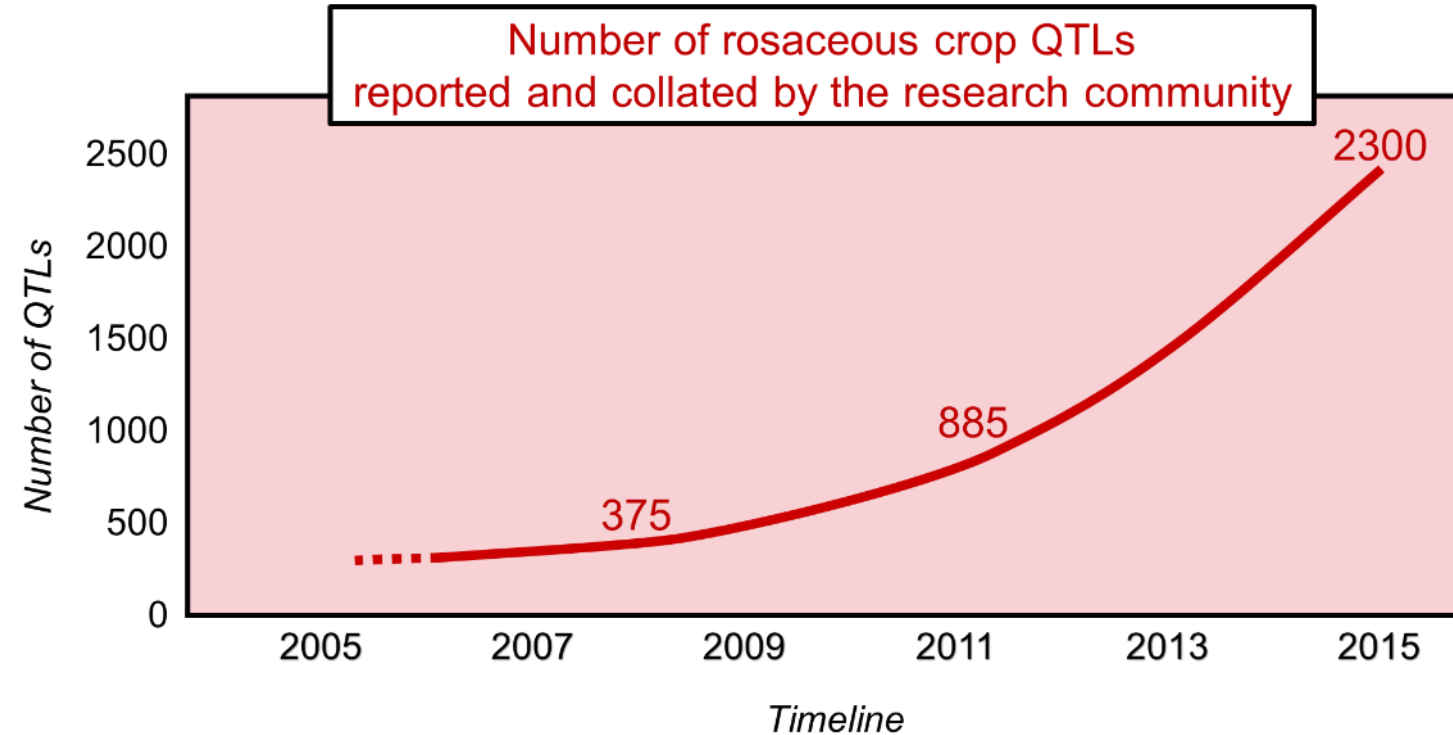
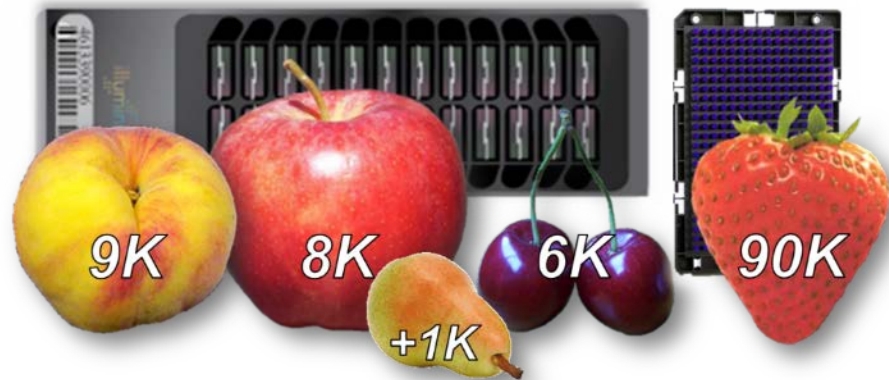
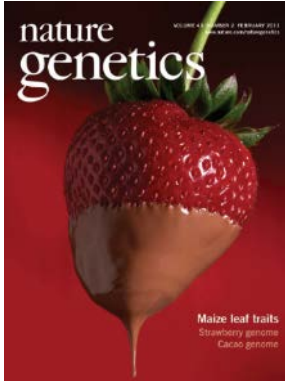
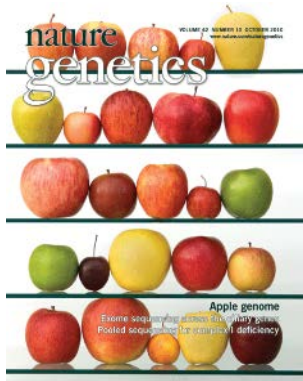
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# Rosaceae Community Collaboration





# → Genomics Research Advances



- Powerful genomics resources and many discoveries
- Little translation to breeding application

## RosBREED

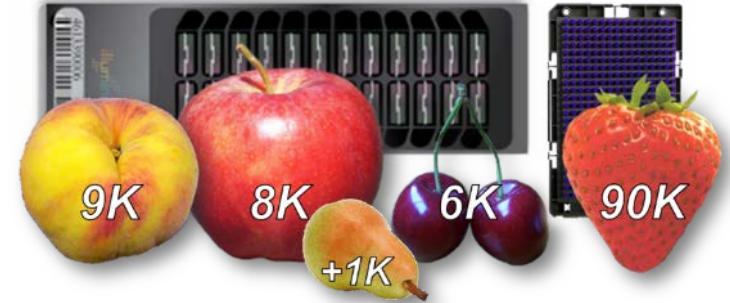
DISEASE RESISTANCE + HORTICULTURAL QUALITY



# 3



**Cultivar Development  
Pipeline**



**Genomics Research  
Advances**

**RosBREED**





# Genomics-Assisted Breeding

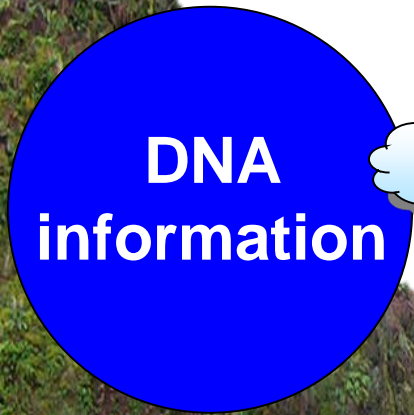
Genomics resources  
(e.g., whole genome sequences)



More efficient development of new cultivars



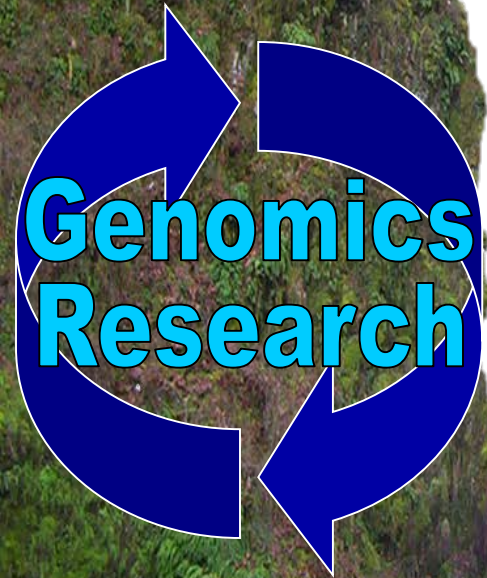
# The Chasm!



*good intentions*

*skeptical dismissal*

**Decision  
support**





# Some Reasons for the Chasm

**DNA  
information**

Reported QTLs themselves:

- Trait low priority / low value
- Weak linkage
- Different germplasm
- Unknown functional alleles
- Unknown genetic action
- Unknown linkage relationships
- Unknown environment effects
- Unknown management effects

No suitable DNA testing services

Not believed to be cost efficient

No training in routine DNA testing

**Decision  
support**

**Breeding  
Programs**

**Genomics  
Research**

# Bridging the Chasm

A stone arch bridge with multiple smaller arches supporting its main span, crossing a deep, mossy chasm. The bridge has a decorative railing with vertical balusters. The scene is set against a white background.

**DNA  
information**

**Decision  
support**

**Genomics  
Research**

**Breeding  
Programs**



# RosBREED

Enabling marker-assisted breeding in Rosaceae



## MSU

Amy Iezzoni (PD)  
Jim Hancock  
Dechun Wang  
Cholani Weebadde

## Univ. of Arkansas

John Clark

## WSU

Cameron Peace (co-PD)

Dorrie Main

Kate Evans

Karina Gallardo

Raymond Jussaume

Vicki McCracken

Nnadozie Oraguzie

Mykel Taylor

## Univ. of Minnesota

Jim Luby

Chengyan Yue

## Oregon State Univ.

Alexandra Stone

## USDA-ARS

Nahla Bassil

Gennaro Fazio

Chad Finn

## Plant Research Intl.

## Netherlands

Eric van de Weg

Marco Bink

## Cornell

Susan Brown

Kenong Xu

## Clemson

Ksenija Gasic

Gregory Reighard

## Texas A&M

Dave Byrne

## Univ. of CA-Davis

Tom Gradziel

Carlos Crisosto

## Univ. of New Hamp.

Tom Davis

## “RosBREED 1”

- Funded by USDA Specialty Crop Research Initiative
- \$7.2 M federal
- Sep 2009 – Aug 2014
- Project Directors:  
*Amy Iezzoni*  
*Cameron Peace*

# RosBREED 1 Outcomes

- Socio-economic values for levels of breeding traits
- Genomics resources and DNA information:  
SNP array genome scans, QTLs



**RosBREED**  
DISEASE RESISTANCE + HORTICULTURAL QUALITY



# RosBREED 1 Outcomes

- Practical tools for breeding use:  
DNA tests for many breeding-relevant traits
- DNA information about breeding germplasm:  
genetic potential of parents, seedlings, selections, cultivars



**RosBREED**  
DISEASE RESISTANCE + HORTICULTURAL QUALITY

# DNA Tests in 2009



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# DNA Tests Now

The collage features numerous images of fruits and plants, each labeled with a specific trait being tested or improved through DNA analysis. The traits include:

- White vs. yellow flesh:** Comparison of two apple slices.
- Red stele resistance:** Close-up of plant roots.
- Acidity:** Two green apples.
- Nectarine vs. peach:** Comparison of a nectarine and a peach.
- Fruit size:** A branch with small dark fruits and a single large red cherry.
- Maturity date:** A timeline from APR to SEP with horizontal bars indicating different maturity periods.
- Fruit color:** A row of five peach slices showing different flesh colors.
- Firmness:** Two red apples.
- Freestone vs. clingstone:** Comparison of two peach halves.
- Melting vs. non-melting flesh:** Comparison of two peach halves.
- Fruit color:** A dark red cherry.
- Leaf spot resistance:** Comparison of a leaf with yellow spots and a healthy green leaf.
- Self-fertility:** A cluster of white cherry blossoms.
- Fruit storability:** A blue crate filled with green apples.
- Sweetness & acidity:** A person wearing sunglasses and an orange cap eating a fruit.
- Fruit skin coloration:** A collection of apples with various skin colors (green, red, yellow).
- Maturity date:** A timeline from JUN to JUL with horizontal bars indicating different maturity periods.
- Fruit size:** A hand holding a large red apple and a small yellow fruit.
- "Fresh sensation" (crispness, tartness, juiciness):** A hand holding a red apple.
- Bitter pit susceptibility:** Comparison of two apples, one with a dark spot.
- Fruit skin color:** Two apples with different skin colors.

## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY

# DNA Tests Now

The collage features numerous images of fruits and plants, each labeled with a specific trait being tested. The traits include:

- White vs. yellow flesh:** Two slices of fruit showing different flesh colors.
- Red stele resistance:** A cross-section of a root showing internal tissue.
- Acidity:** Two green apples.
- Nectarine vs. peach:** Two fruits, one a nectarine and one a peach.
- Fruit size:** A branch with small dark fruits and a single large red cherry.
- Maturity date:** A timeline from APR to SEP with horizontal bars indicating maturity periods for different varieties.
- Fruit color:** A row of five cross-sections of fruit showing different flesh colors.
- Firmness:** Two red apples.
- Freestone vs. clingstone:** Three cross-sections of peaches showing different stone attachments.
- Melting vs. non-melting flesh:** Three cross-sections of fruit showing different flesh textures.
- Fruit color:** A row of three different colored fruits.
- Fruit storability:** A blue crate filled with green apples.
- Leaf spot resistance:** Two leaves, one showing significant yellowing and spotting.
- Self-fertility:** A cluster of white flowers.
- Sweetness & acidity:** A person wearing sunglasses and an orange cap, eating a fruit.
- "Fresh sensation" (crispness, tartness, juiciness):** A hand holding a red apple.
- Bitter pit susceptibility:** Two apples, one showing dark spots on the skin.
- Fruit skin color:** A row of five apples with different skin colors.
- Maturity date:** A timeline from JUN to JUL with horizontal bars indicating maturity periods for different varieties.
- Fruit size:** Two different sized fruits.
- Fruit skin color:** Two different colored fruits.

## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY

# DNA Tests Now

The collage features numerous images of fruits and plants, each labeled with a specific trait being tested. The traits include:

- White vs. yellow flesh:** Two slices of fruit showing different flesh colors.
- Red stele resistance:** A close-up of a plant's root system.
- Acidity:** Two green apples.
- Nectarine vs. peach:** Two fruits, one a nectarine and one a peach.
- Fruit size:** A branch with small dark fruits and a single large red cherry.
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- Fruit skin color:** A row of five apples showing different skin colors.
- Maturity date:** A timeline from JUN to JUL with horizontal bars indicating maturity periods for different varieties.
- Fruit size:** Two fruits, one small and one large.
- Fruit skin color:** Two fruits, one yellow and one red.

## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# RosBREED 1 Outcomes

- Trained the next generation of breeders!



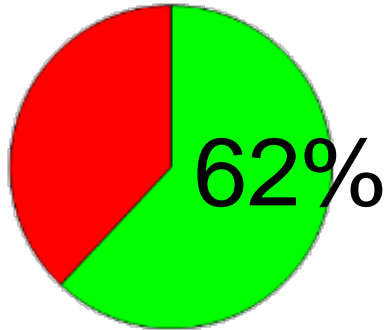
... and many of the current generation



# RosBREED 1 Outcomes

- DNA-informed breeding is now conventional!

U.S.-wide survey of Rosaceae breeders (early 2014):



Agree that "Genetic marker information will be included in 2014 in how my organization addresses plant breeding & selection"



**RosBREED**  
DISEASE RESISTANCE + HORTICULTURAL QUALITY

# ROS BREED

COMBINING  
**DISEASE  
RESISTANCE** WITH **HORTICULTURAL  
QUALITY**  
IN NEW ROSACEOUS CULTIVARS

MSU

**Amy Iezzoni (PD)**

Jim Hancock  
Bill Shane

Cornell Univ

Susan Brown

Univ New Hampshire

Tom Davis

WSU

**Cameron Peace (coPD)**

Lisa DeVetter  
Kate Evans  
Karina Gallardo  
Des Layne

**Dorrie Main**

Vicki McCracken

Pat Moore

Nnadozie Oraguzie

Univ Minnesota

Rex Bernardo  
Stan Hokanson

**Jim Luby**

**Chengyan Yue**

Cal Poly State

Kelly Ivors

Univ Queensland

Craig Hardner

Univ Arkansas

John Clark

Univ Florida

**Mercy Olmstead**  
**Vance Whitaker**

Clemson Univ

**Ksenija Gasic**

Steve Kresovich  
Amy Lawton-Rauh  
Gregory Reighard  
Chris Saski  
Guido Schnabel

USDA-ARS

**Nahla Bassil**

Richard Bell

**Chad Finn**

**Jay Norelli**

Texas A&M

Dave Byrne

Univ CA-Davis

Tom Gradziel

Carlos Crisosto



## “RosBREED 2”

- Funded by USDA Specialty Crop Research Initiative
- \$10.0 M federal
- Sep 2014 – Aug 2019
- Project Directors:  
*Amy Iezzoni*  
*Cameron Peace*



# RosBREED 2 Vision

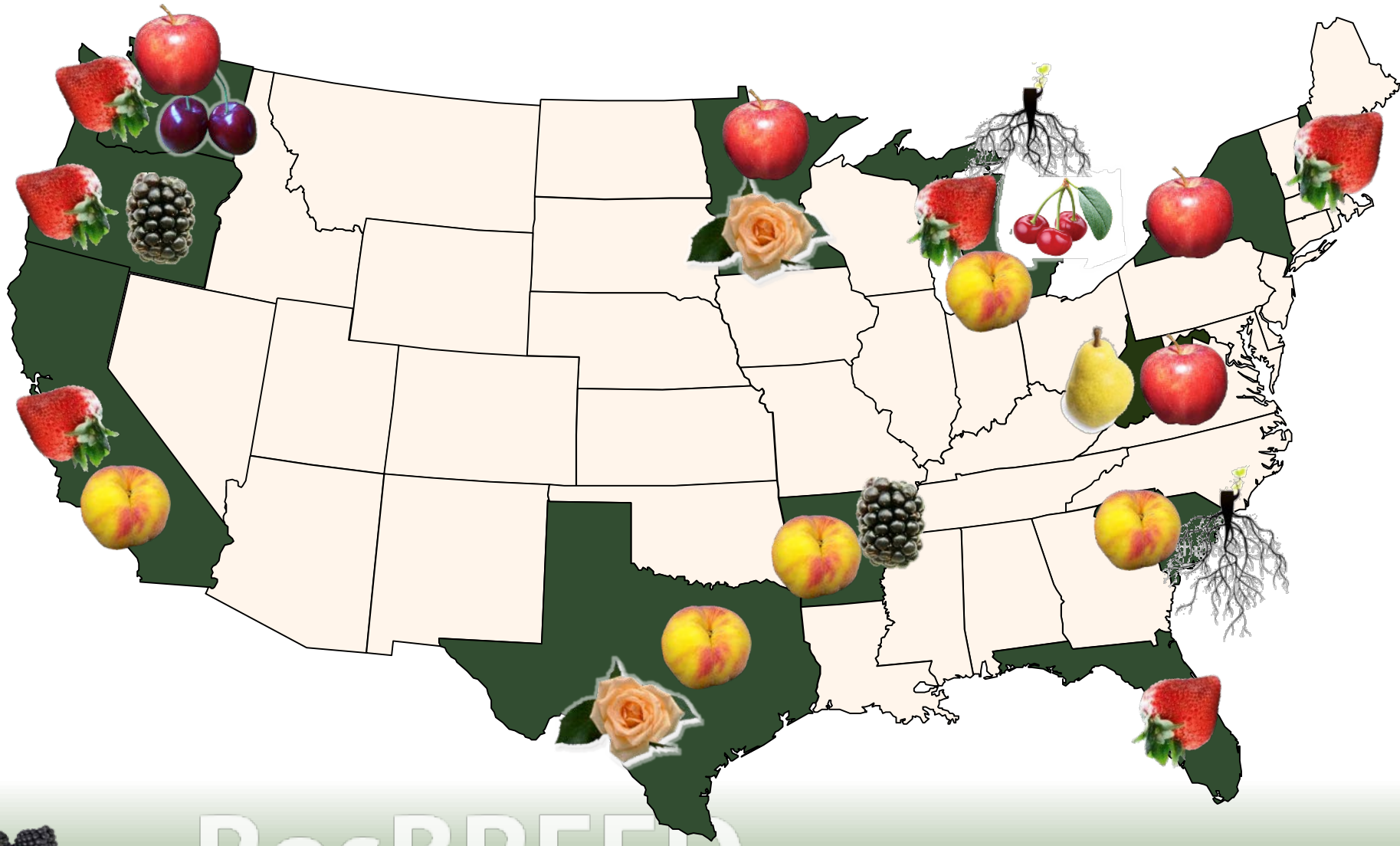
*U.S. rosaceous crop breeding programs  
will exploit genetic resources,  
applying modern genomics tools  
to efficiently, accurately, creatively, and rapidly deliver  
new cultivars with market-essential horticultural quality  
and producer-required disease resistances  
to enhance consumer demand  
and mitigate stakeholder risk  
for rosaceous fruit, nut, and floral products.*



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY

# RosBREED 2 Breeding Programs



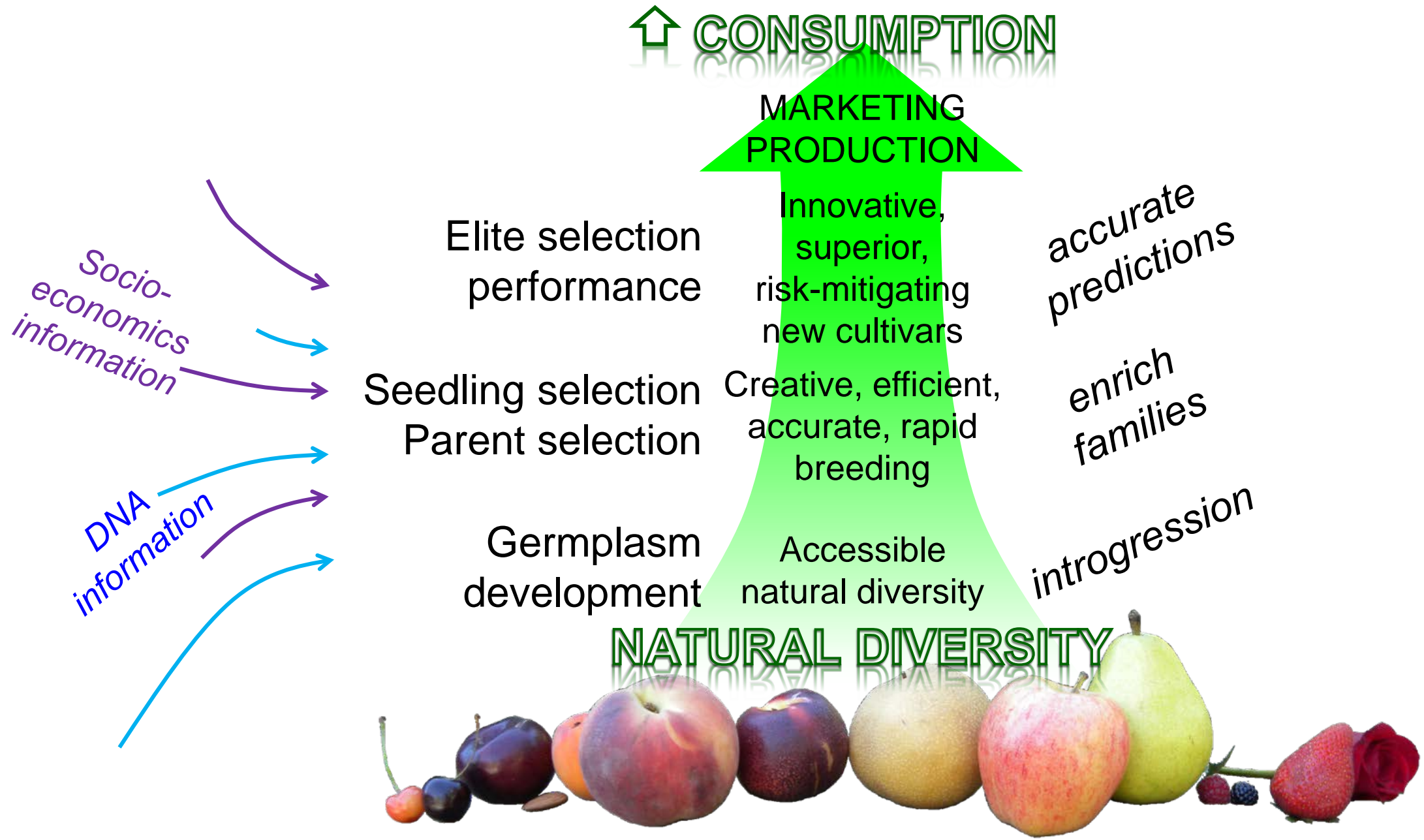
**RosBREED**

DISEASE RESISTANCE + HORTICULTURAL QUALITY

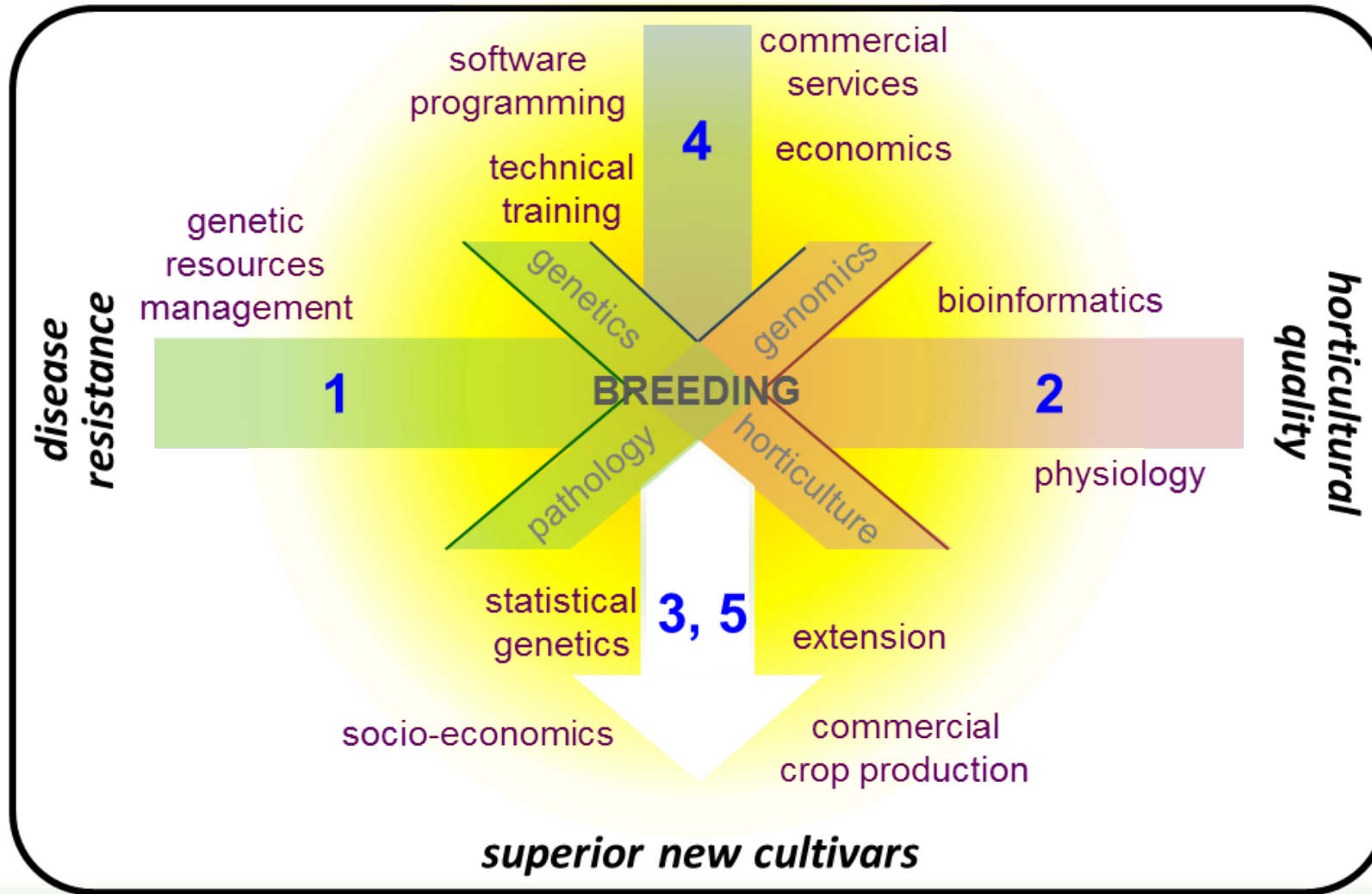




# RosBREED 2 Breeding Germplasm Levels



# RosBREED 2 Transdisciplinary Approach



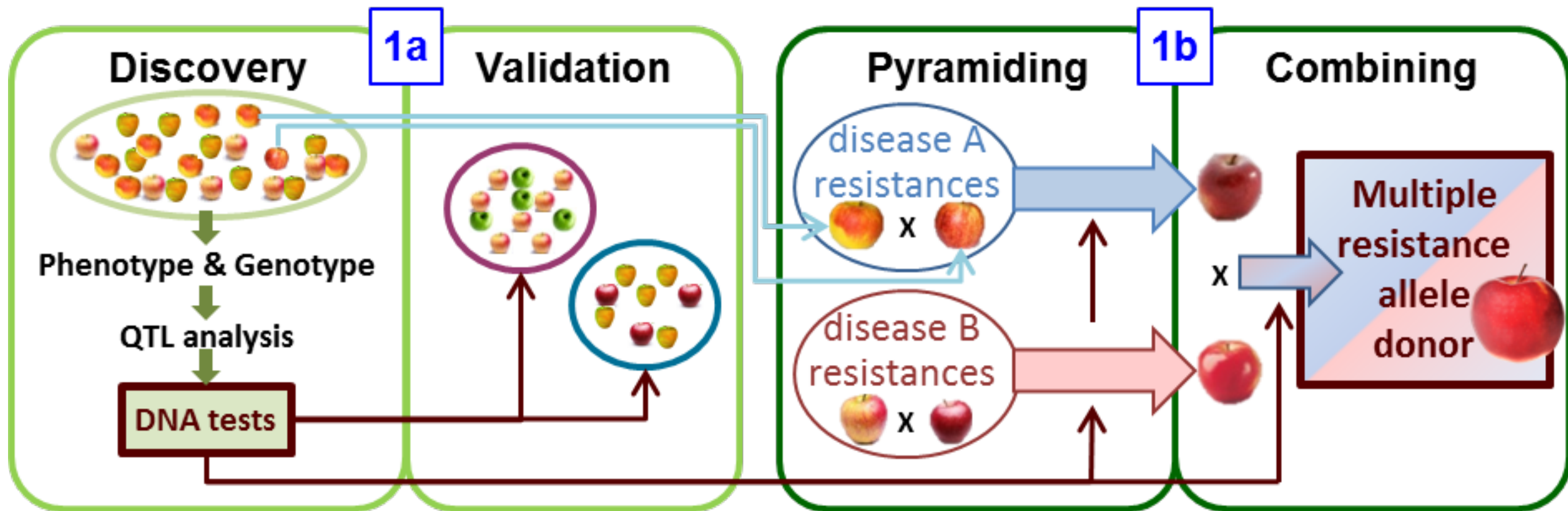
## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# Objective 1

**Obj. 1: Develop donor parents with multiple alleles for disease resistance**

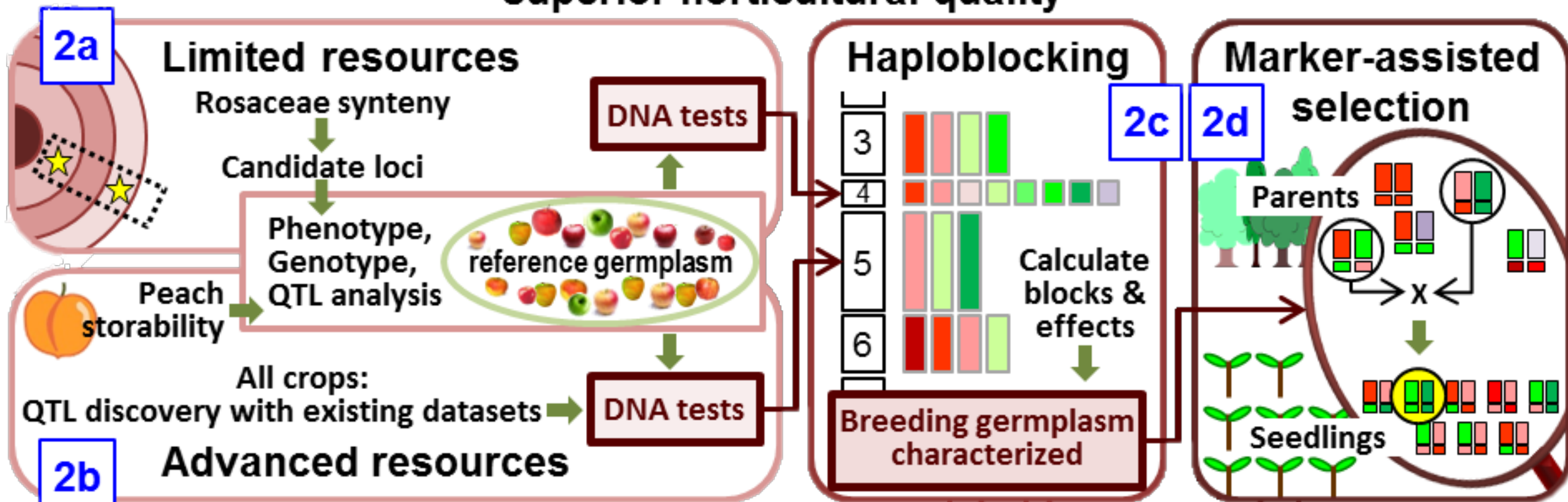


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DISEASE RESISTANCE + HORTICULTURAL QUALITY

# Objective 2

**Obj. 2: Enrich breeding families with alleles for disease resistance and superior horticultural quality**



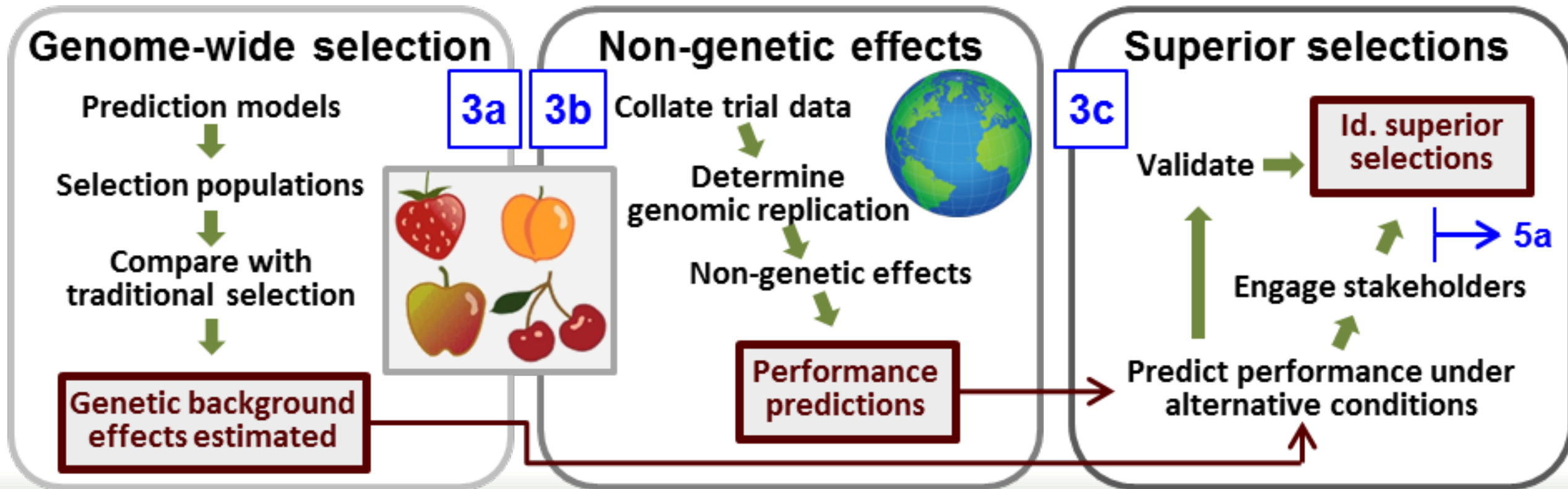
## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# Objective 3

**Obj. 3: Advance selections with alleles for superior horticultural quality and disease resistance with improved confidence**

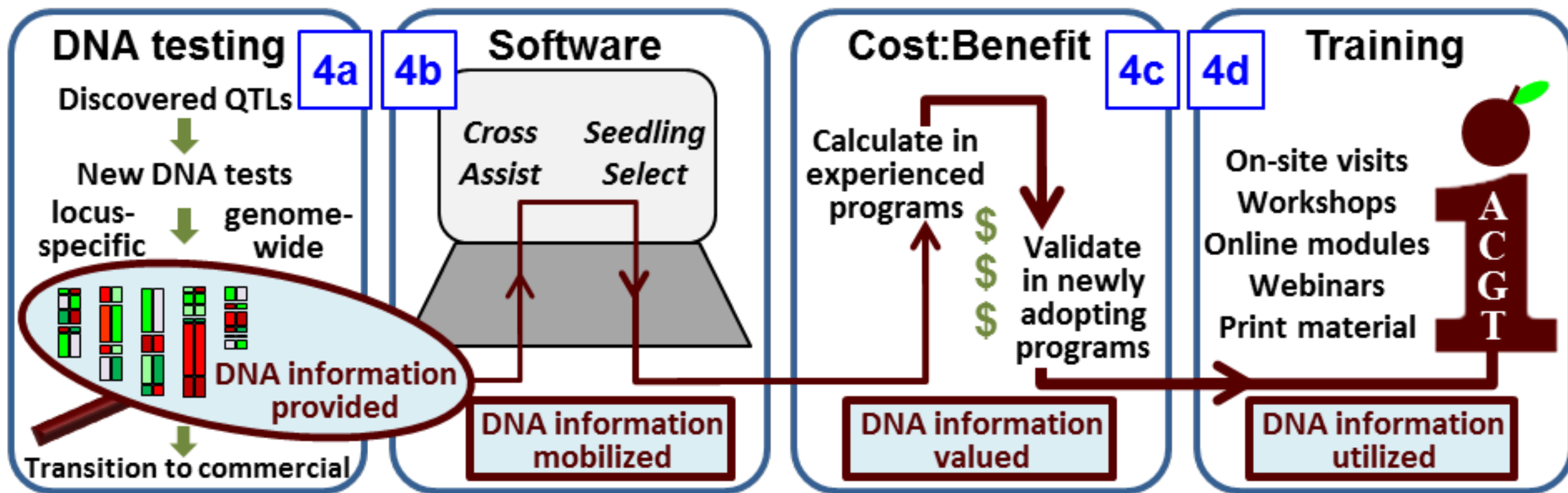


## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY

# Objective 4

**Obj. 4: Increase routine use of DNA information in rosaceous crop breeding**



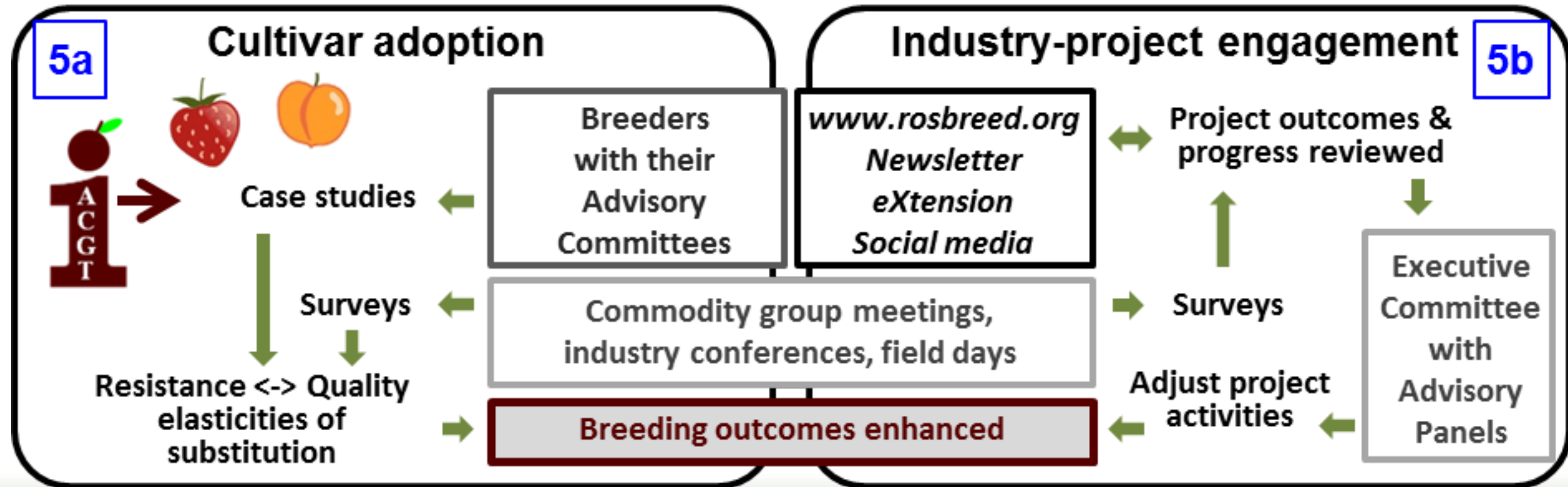
## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# Objective 5

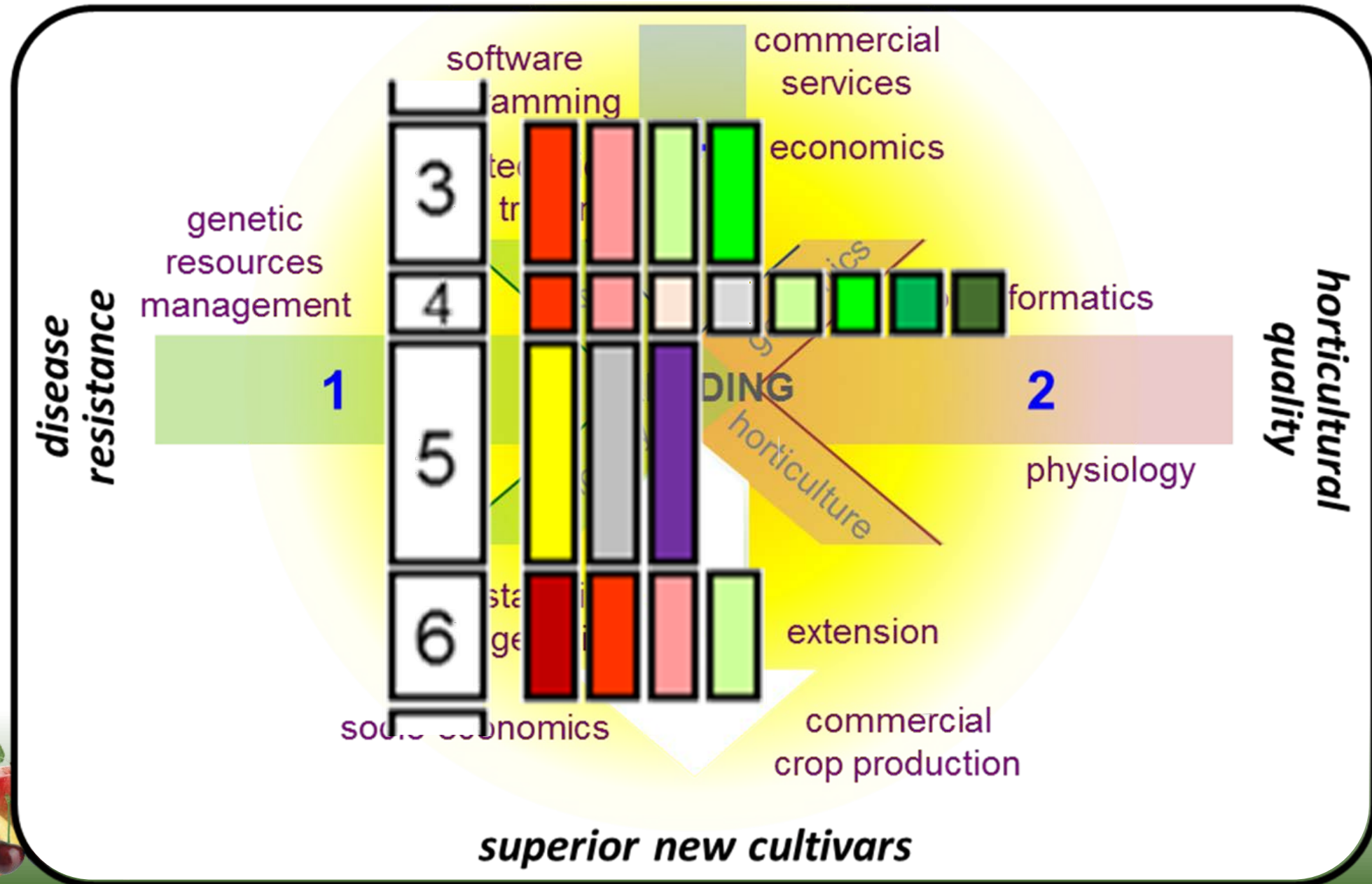
**Obj. 5: Engage industry stakeholders in project outcomes, evaluation, and adjustment**



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY

# Haploblocking





# Haploblocking

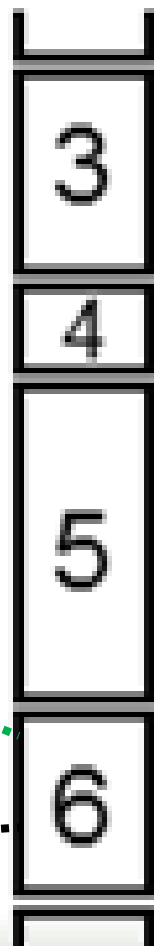
Divide each chromosome into segments that are non-recombining in historical, selected germplasm – *haploblocks*

Target tight linkages to break, if desired

LEAF SPOT RESISTANCE QTL

SWEETNESS QTL

Characterize effects and ancestry of each variant – *haplotypes*



BLIGHT RESISTANCE

SIZE

POST-ZYGOTIC SEGR. DISTORTION

SWEETNESS

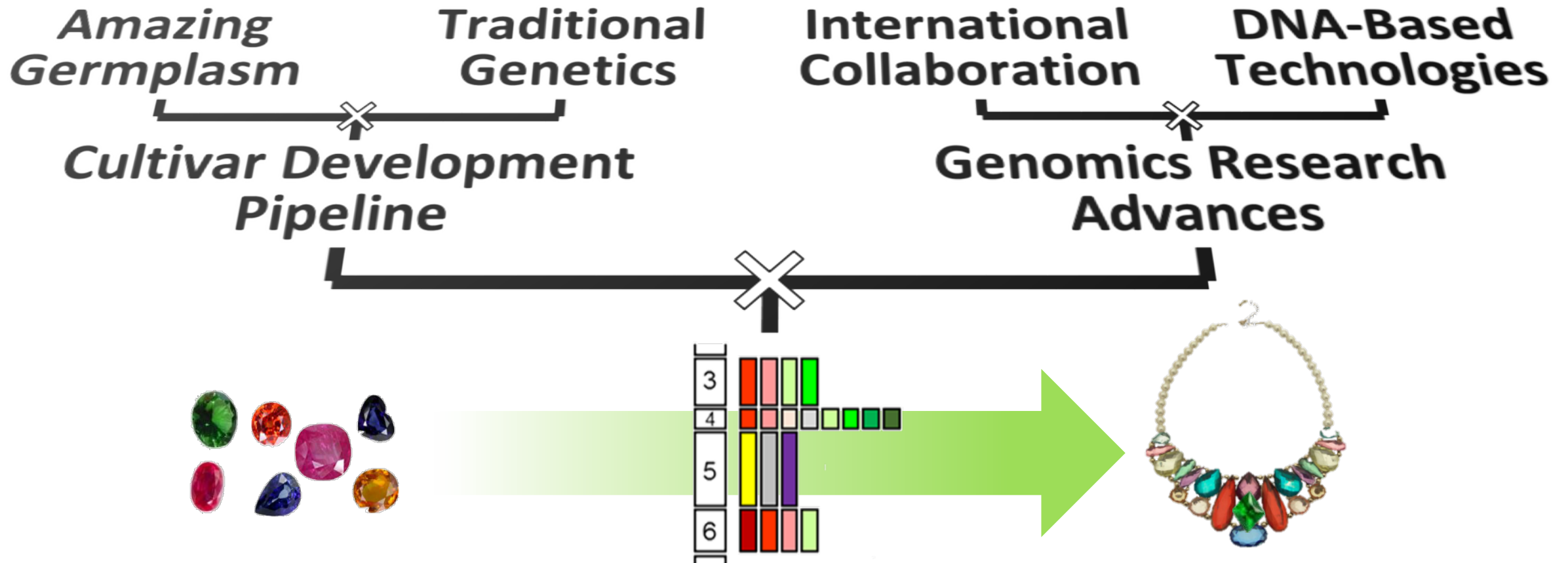


## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



# The Pedigree of RosBREED



## RosBREED

→ Enhanced breeding *efficiency, accuracy, speed, & creativity*



# The Children of RosBREED

**Amazing  
Germplasm**

**Traditional  
Genetics**

**International  
Collaboration**

**DNA-Based  
Technologies**

**Cultivar Development  
Pipeline**

**Genomics Research  
Advances**

**RosBREED**



# Acknowledgements



United States  
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National Institute  
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Agriculture

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combination of federal  
and matching funds  
(grant number 2014-  
51181-22378).





# Questions?



[www.rosbreed.org](http://www.rosbreed.org)



## RosBREED

DISEASE RESISTANCE + HORTICULTURAL QUALITY



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Agriculture