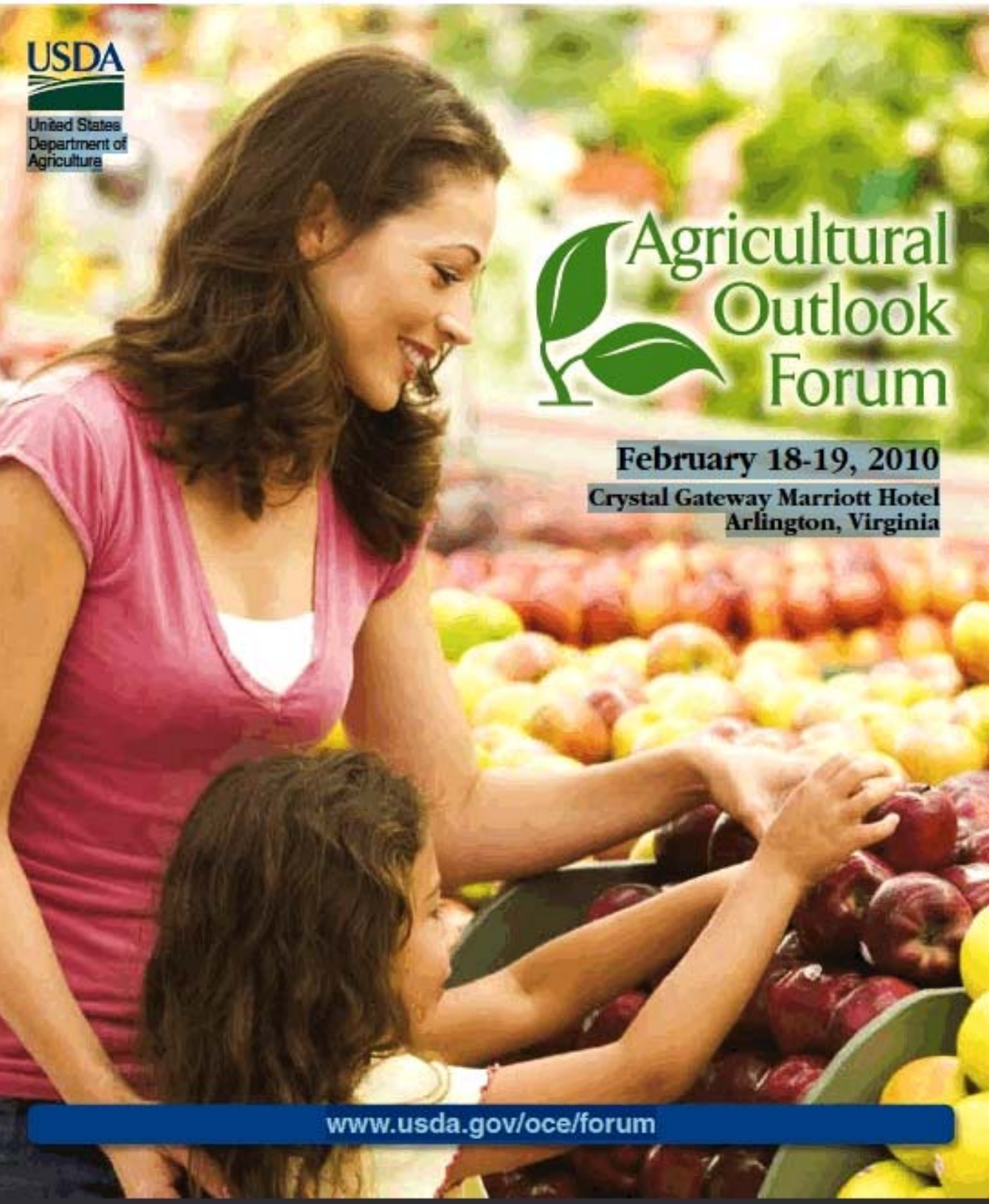
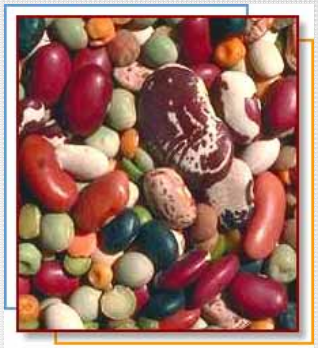


The Importance of Plant Improvement to Sustainable Specialty Crop Systems

Jim McFerson

Washington Tree Fruit Research Commission

Horticulture & Plant Breeding



UW-Madison --- BS, PhD

Texas A&M --- MS

Petoseed: Plant breeder

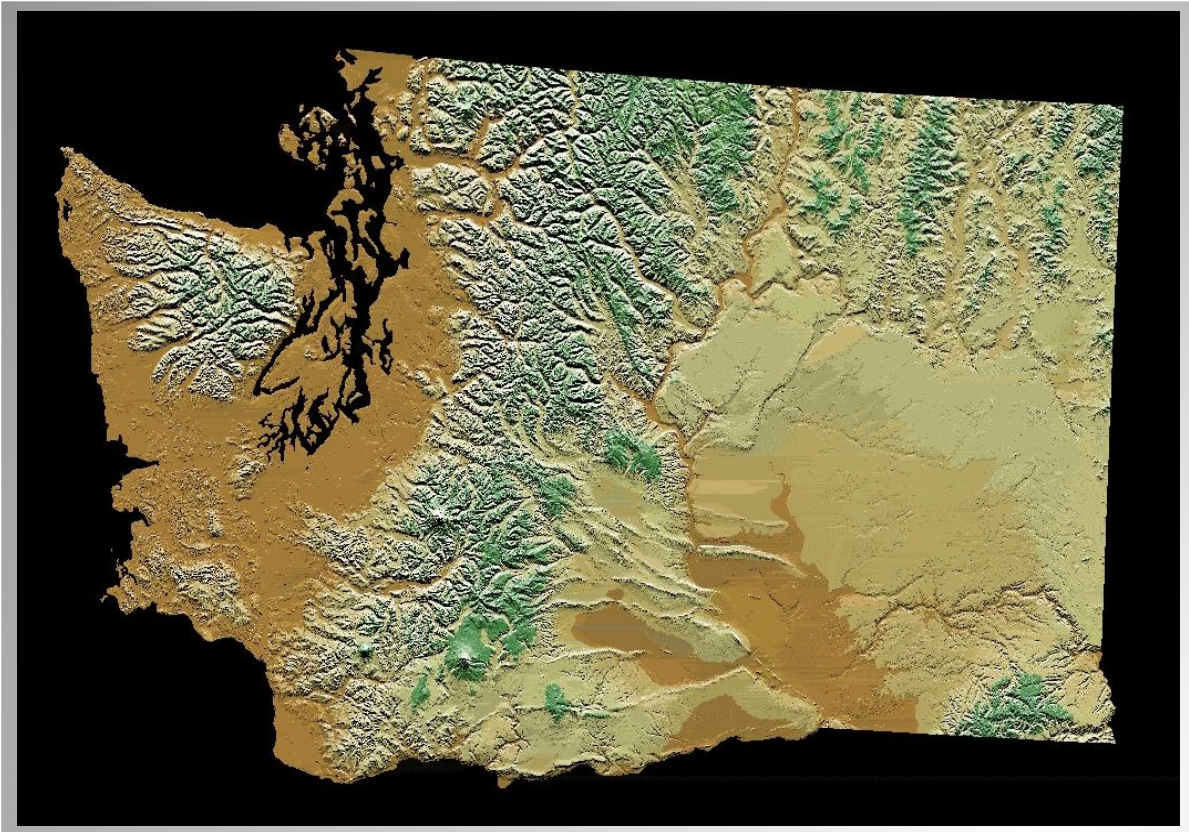
USDA-ARS Geneva: Geneticist

WTFRC: Manager, Researcher

Born
Mt.
Pleasant IA

Cascade
Garlic

small
farm
<$10k



WASHINGTON TREE FRUIT RESEARCH COMMISSION

- research focus
- established by State Legislature in 1969
- per-ton assessment on Washington producers
- annual budget $4M

Plant improvement

Sustainable

Specialty crop

Systems

Plant improvement

Sustainable

Specialty crop

Systems

Plant improvement

Classical plant breeding uses deliberate interbreeding (crossing) of closely or distantly related individuals to produce new crop cultivars with desirable properties.

Modern plant breeding uses techniques of molecular biology to select, or in the case of genetic modification, to insert, desirable traits into plants.

For many specialty crops, plant improvement includes clonal selection, compound plants, and application of exogenous plant growth regulators.

Plant improvement

Sustainable

Specialty crop

Systems

Sustainable Agriculture

An integrated system of plant and animal production practices having site-specific application that will, over the long term:

- Satisfy human food and fiber needs
- Enhance environmental quality and the natural resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- Sustain the economic viability of farm operations
- Enhance the quality of life for farmers and society as a whole

-- Public Law 101-624, Title XVI, Subtitle A, Section 1603

Courtesy Molly Jahn

College of Agricultural and Life Sciences
University of Wisconsin-Madison

Stakeholders

Sustainable Agriculture

"Living in material comfort and peacefully with each other within the means of nature."

- Wackernagel & Rees

Courtesy Molly Jahn

College of Agricultural and Life Sciences
University of Wisconsin-Madison

Stakeholders

Sustainable Agriculture

THE TRIPLE BOTTOM LINE

People

Planet

Profits

Courtesy Molly Jahn

College of Agricultural and Life Sciences
University of Wisconsin-Madison

Plant improvement

Sustainable

Specialty crop

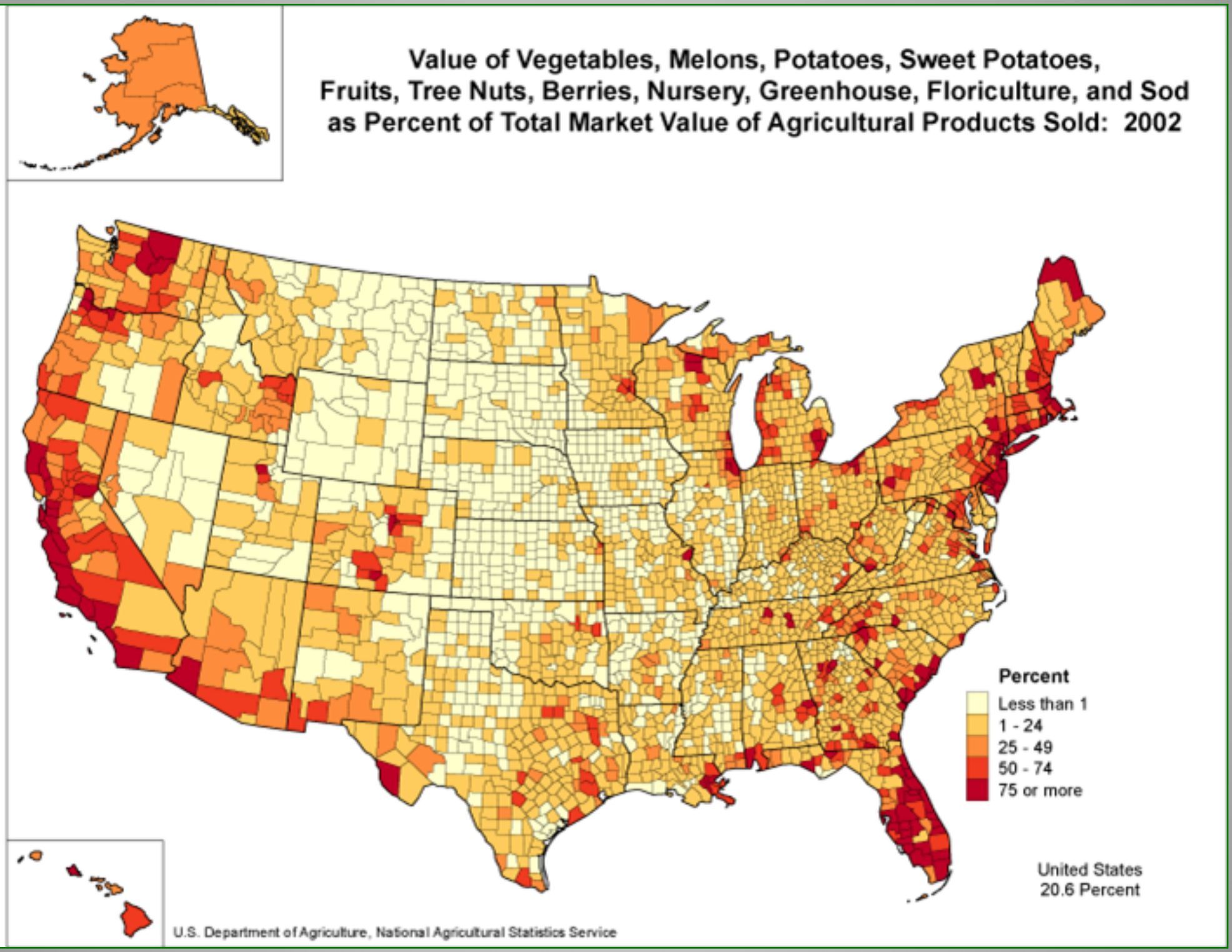
Systems

The Specialty Crop Industry

- Fruits, nuts, vegetables, nursery and landscape crops
- >$50B annual US production value
- Diverse
  - cropping systems
  - processing systems
  - location
  - everything
- High-value, labor-intensive, high-risk

Specialty Crop Industries

- Fruits, nuts, vegetables, nursery and landscape crops
- >$50B annual US production value
- Diverse
  - cropping systems
  - processing systems
  - location
  - everything
- High-value, high-risk, labor- and management-intensive


Value of Vegetables, Melons, Potatoes, Sweet Potatoes,
Fruits, Tree Nuts, Berries, Nursery, Greenhouse, Floriculture, and Sod
as Percent of Total Market Value of Agricultural Products Sold: 2002
Percent
Less than 1
1 - 24
25 - 49
50 - 74
75 or more
United States
20.6 Percent
U.S. Department of Agriculture, National Agricultural Statistics Service

Plant improvement

Sustainable

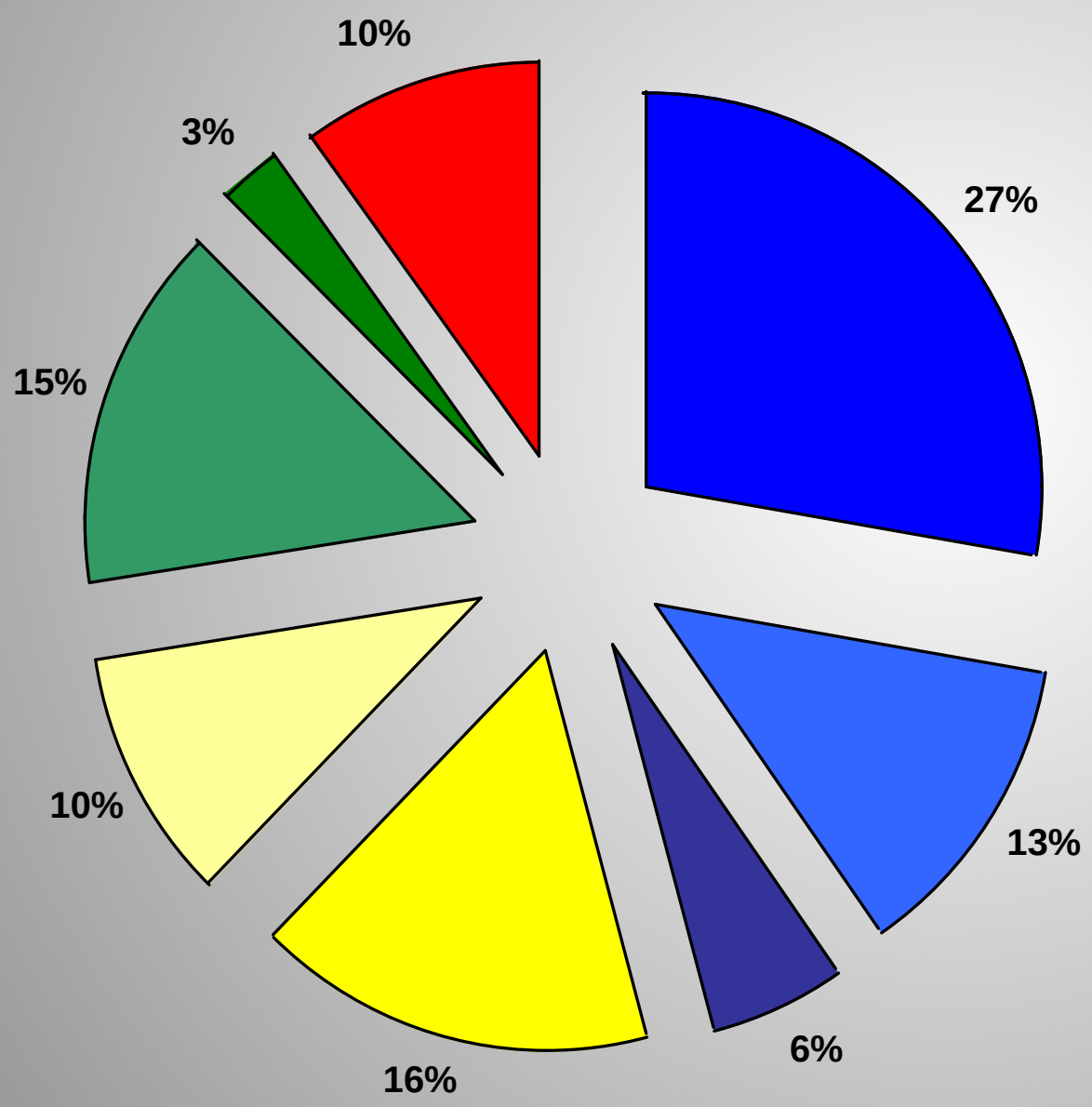
Specialty crop

Systems

3D

Typical apple production and harvest costs

Clark Seavert, OSU



- Labor: pruning & thinning
- Labor: harvest
- Labor: other
- Machine: fuel & repairs
- Machine: replacement cost
- Chemical: general
- Chemical: fertilizer
- Other costs

Skookum

Citrus mechanical harvester

GIANT EAGLE
Orange Juice
FROZEN CONCENTRATED
12 FL OZ (355 mL)
PULP FREE

Genetic technologies

Engineering technolgies

Predictable & accessible systems
Genetics and Engineering

Measure, model, and manage the best genetics

Technology Roadmap for Tree Fruit Production (2001)

To be profitable in a globally competitive marketplace, the U.S. tree fruit industry must deliver the highest quality fruit and reduce production costs 30% by 2010

Plant breeding, genetics, & genomics

Engineering: precision ag diagnostics automation

IT & economic analysis

Crop health, development & quality

Improved consumer products and food services

Plant Improvement

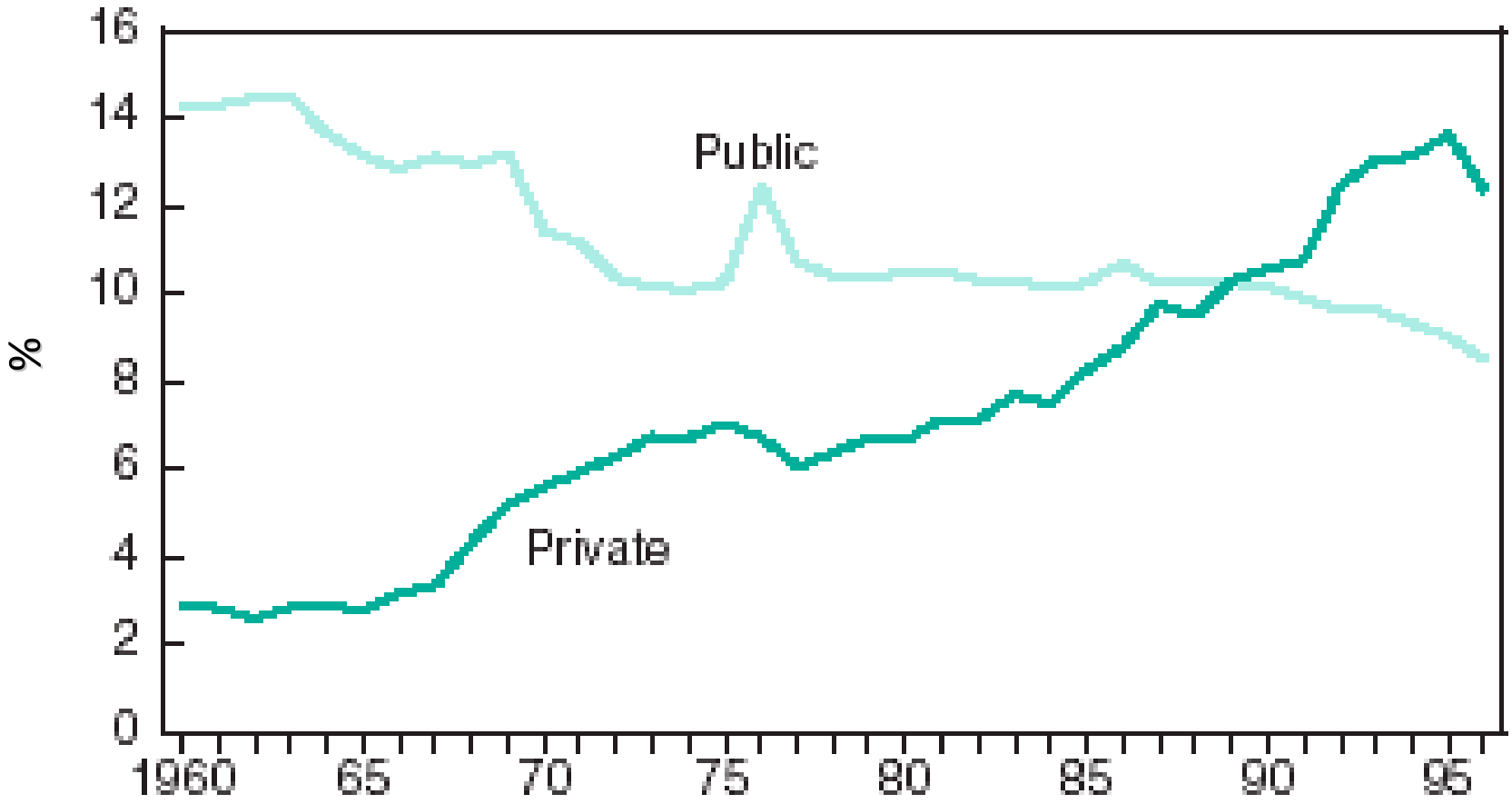
Fundamental for sustainability by any definition

- Utilize natural resources efficiently
- Optimize inputs
- Improve yield, quality, nutrition
- Maximize local adaptation
- Expedite regulatory compliance

Courtesy Molly Jahn

College of Agricultural and Life Sciences
University of Wisconsin-Madison

Plant breeding as a share of total agricultural R&D expenditures



The Seed Industry in U.S. Agriculture / AIB-786
Economic Research Service/USDA

Courtesy Molly Jahn

College of Agricultural and Life Sciences
University of Wisconsin-Madison

Plant Breeding Education Curriculum Development: Delphi Study

Allen Van Deynze, Jamie Miller, Cary Trexler, Fred Bliss

Use of a **Delphi Study** offers a proven mechanism for bringing together a group of experts (breeders) and other stakeholders to develop a comprehensive list of the most important *educational*, *competency,* and *experiential* components for graduate level training in plant breeding. All results from this study will be made publically available for use internationally.

2008 Farm Bill

- **International Market Access ($1.1 billion)**
  - ✓ Market Access Program
  - ✓ Technical Assistance for Specialty Crops
- **Nutrition Investment ($1.1 billion)**
  - ✓ Expands Fresh Fruit & Vegetable Snack Program to all 50 states
  - ✓ Provides a free fresh fruit and vegetable snack to >3M children
- **Specialty Crop Block Grant Program ($466 million)**
  - ✓ State targeted programs addressing infrastructure needs
  - ✓ Prioritizes marketing, food safety, quality, handling, labor
- **Pest and Disease Programs ($377 million)**
  - ✓ Prioritize pest and disease threats to production of specialty crops
  - ✓ Develop action plans and targets federal resources to emergencies
- **Specialty Crop Research Initiative ($230 million)**
  - ✓ Specialty Crop Research Initiative: Plant breeding, production efficiency, precision ag, product quality

Specialty Crop Research Initiative

- $230 million over 5 yrs
- competitive basis
- matching funding
- significant extension component
- transdisciplinary
- Stakeholder priorities
  - plant genomics genetics, and breeding
  - precision agriculture
  - production efficiency
  - product quality

Carrot breeding stocks with superior resistance to root knot nematodes

Courtesy Phil Simon

USDA ars Agricultural Research Service
www.ars.usda.gov

Improving Carotene Content of Carrot in the U.S. Crop

- Result of classical plant breeding

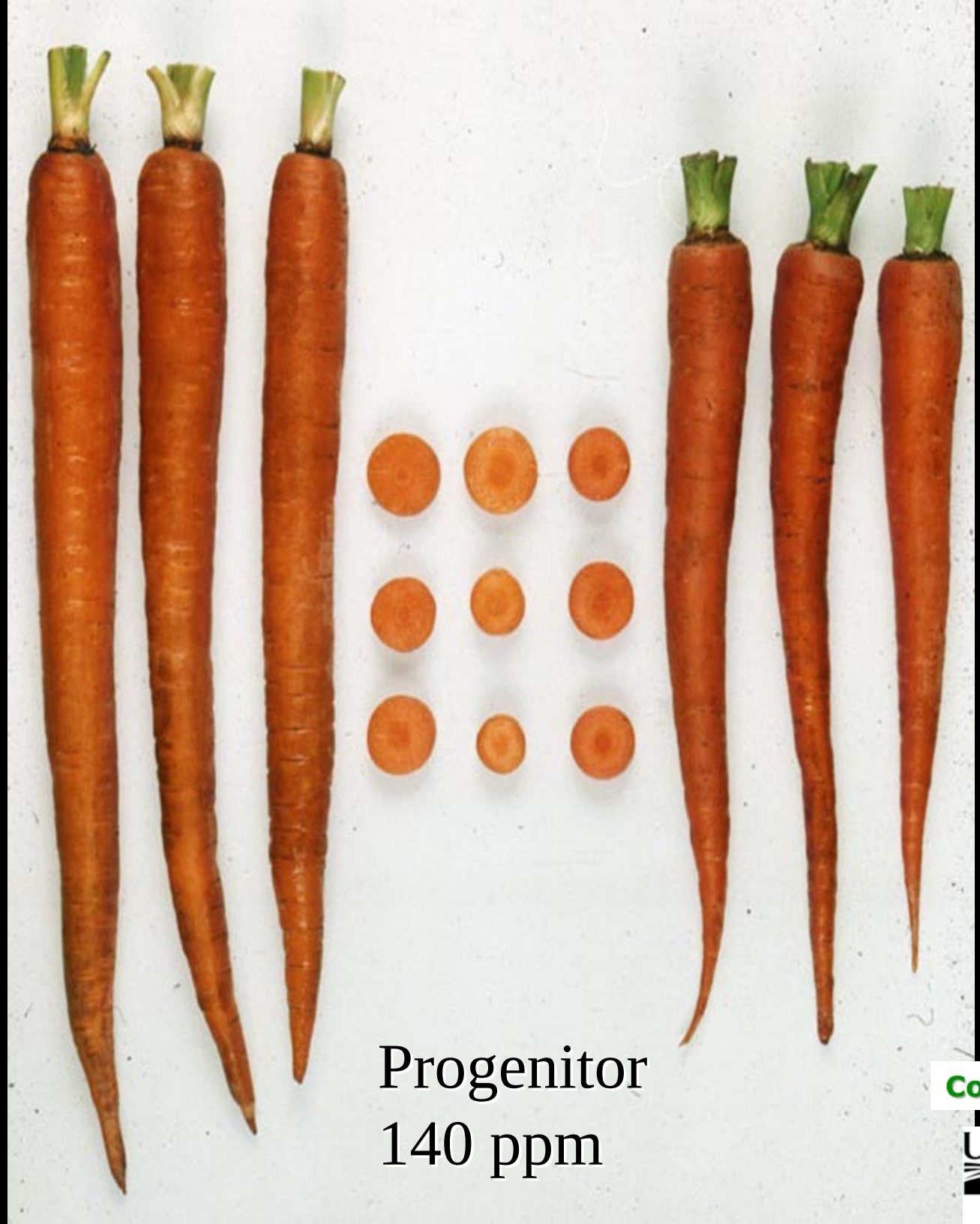
- 1950's – 60 ppm
- 1970's – 90 ppm
- 1990's – 130 ppm

- 2010 - 2/3 of typical carrot contains enough provitamin A to fully satisfy daily adult vit A requirements

Courtesy Phil Simon

USDA ars Agricultural Research Service
www.ars.usda.gov

Beta III
270 ppm



HCM
450 ppm

Courtesy Phil Simon

USDA ars Agricultural Research Service
www.ars.usda.gov

Increasing the Farm and Consumer Value of Carrots

- Uniform appearance and size
  - Impetus for developing hybrid varieties
- Freedom of defects and disease
  - Leaf blight
  - Nematodes
- Culinary Quality
  - Sweet
  - Not harsh (turpentiney, bitter)
  - Succulent
- Orange Color
- Convenience

  "cut and peel"
- Nutritional Quality

Courtesy Phil Simon

USDA ars Agricultural Research Service
www.ars.usda.gov

RosBREED Mission Statement

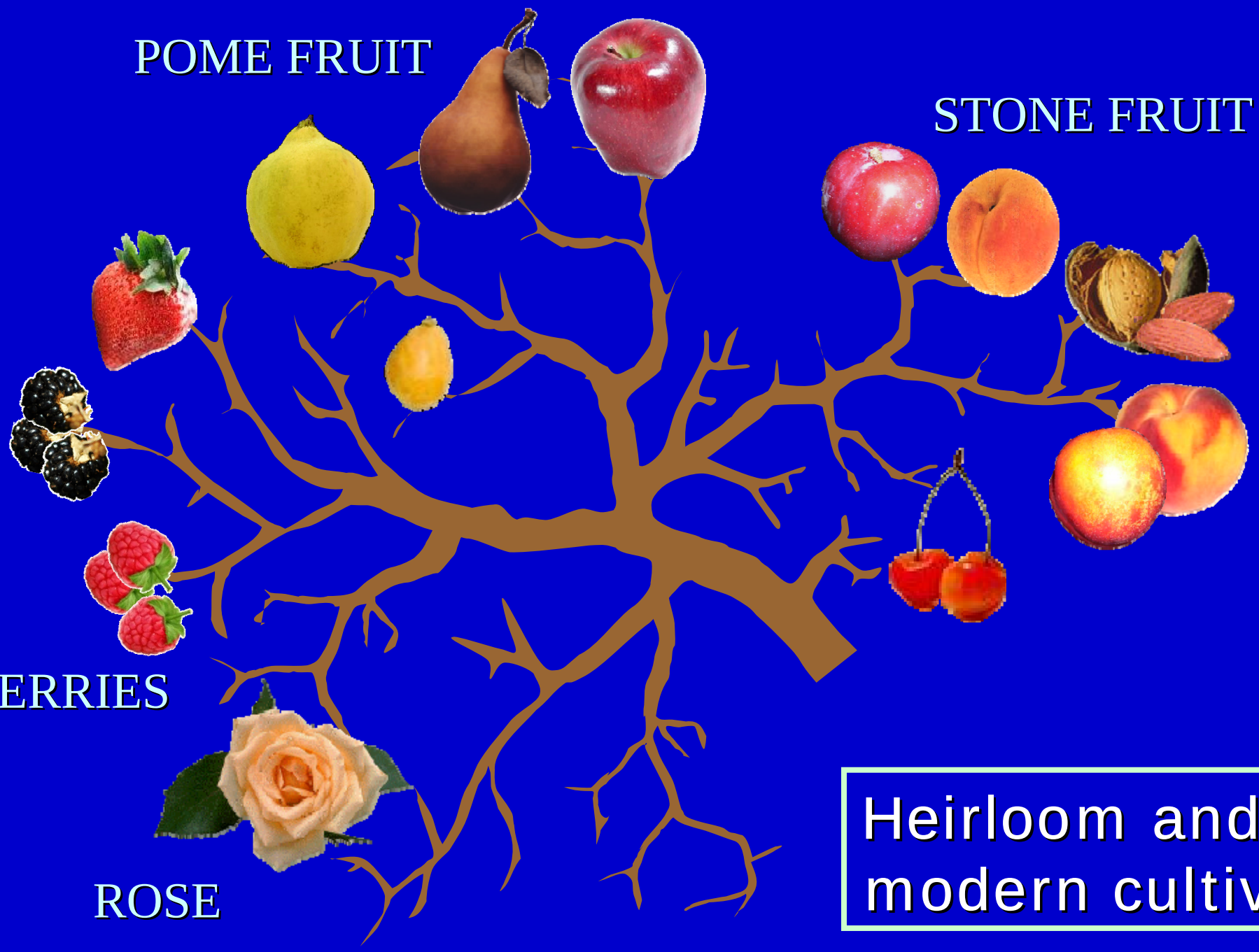
We will develop and apply marker-assisted breeding, based on improved knowledge of industry value and consumer preferences, to accelerate and increase the efficiency of rosaceous cultivar release and successful cultivar adoption.

4 yrs
$7M federal
$7M matching

Amy Iezzoni, Michigan State Univ
Cameron Peace, WA State Univ

Specialty Crop Research Initiative
USDA United States Department of Agriculture
National Institute of Food and Agriculture

The Rosaceae family of horticultural crops



Heirloom and modern cultivars

Honeycrisp: a breakthrough cultivar

- Honeycrisp apple - introduced 1991 by the Univ of Minn.
- Dramatic attention and U.S. market share this decade.
- An ultra-crisp juicy texture and pleasing flavor
- 30 years from crossing to commercialization.

Focus on fruit quality

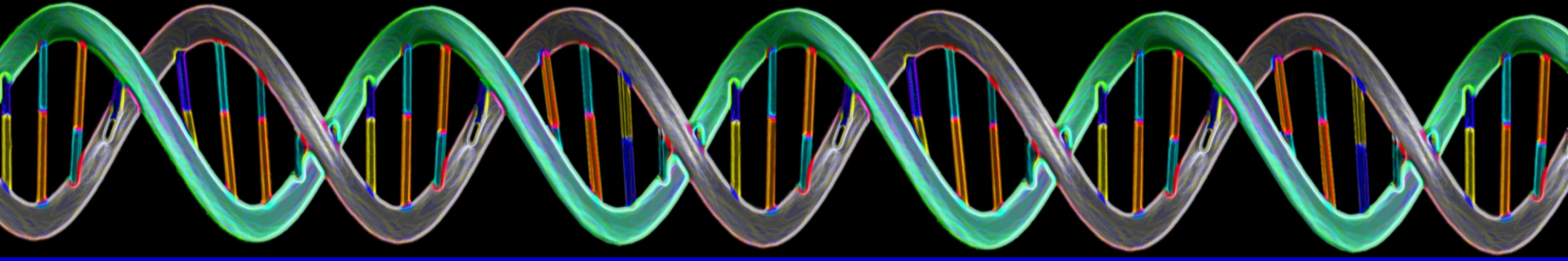


Image courtesy of NSF

Apple, peach & diploid strawberry genome sequences will be available in 2010

(Arabidopsis = 157 Mb/C)

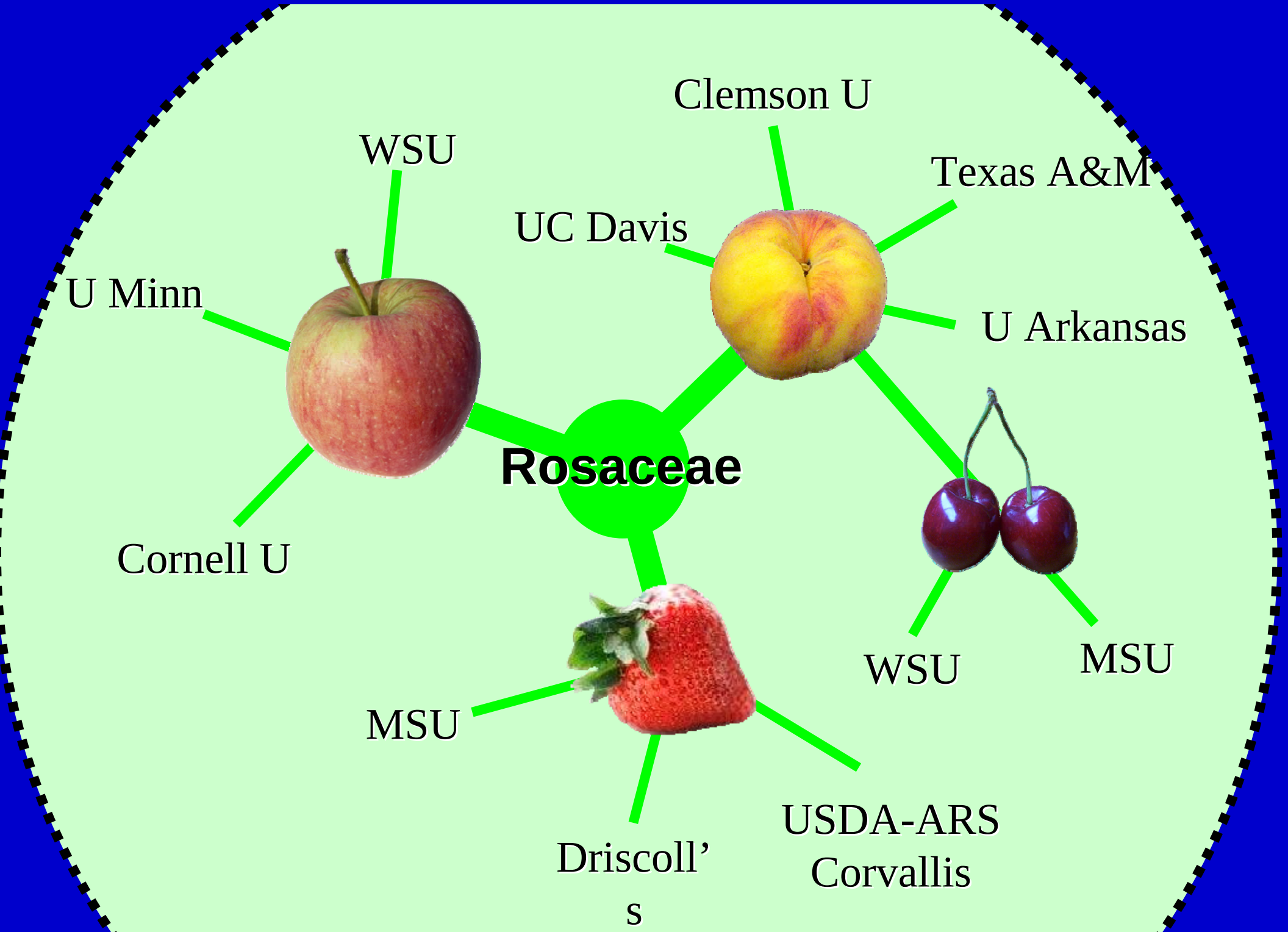
750 Mb/C

280 Mb/C

206 Mb/C

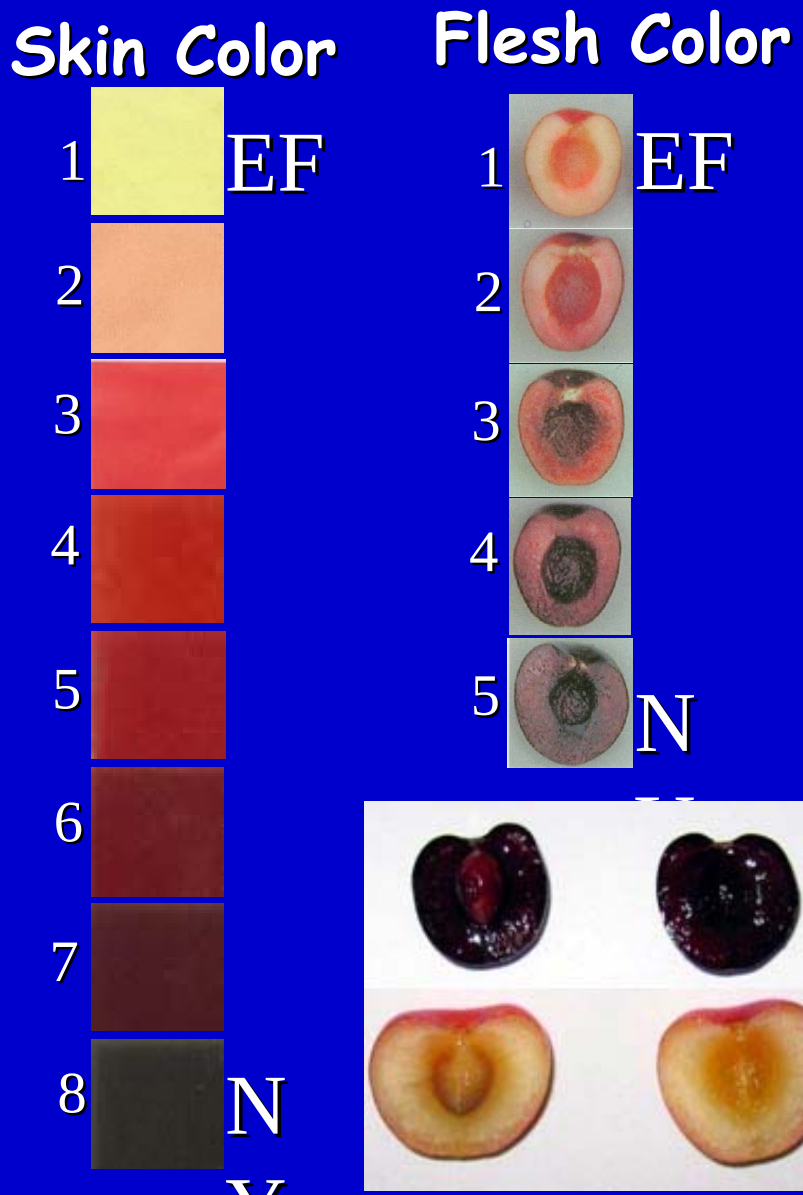
Images courtesy of www.beakandskiff.com, www.ehow.com, entomology.lsu.edu

RosBREED DEMONSTRATION BREEDING PROGRAMS



The same major gene is believed to be responsible for red core & foliage in apple, and skin & flesh color in cherry.

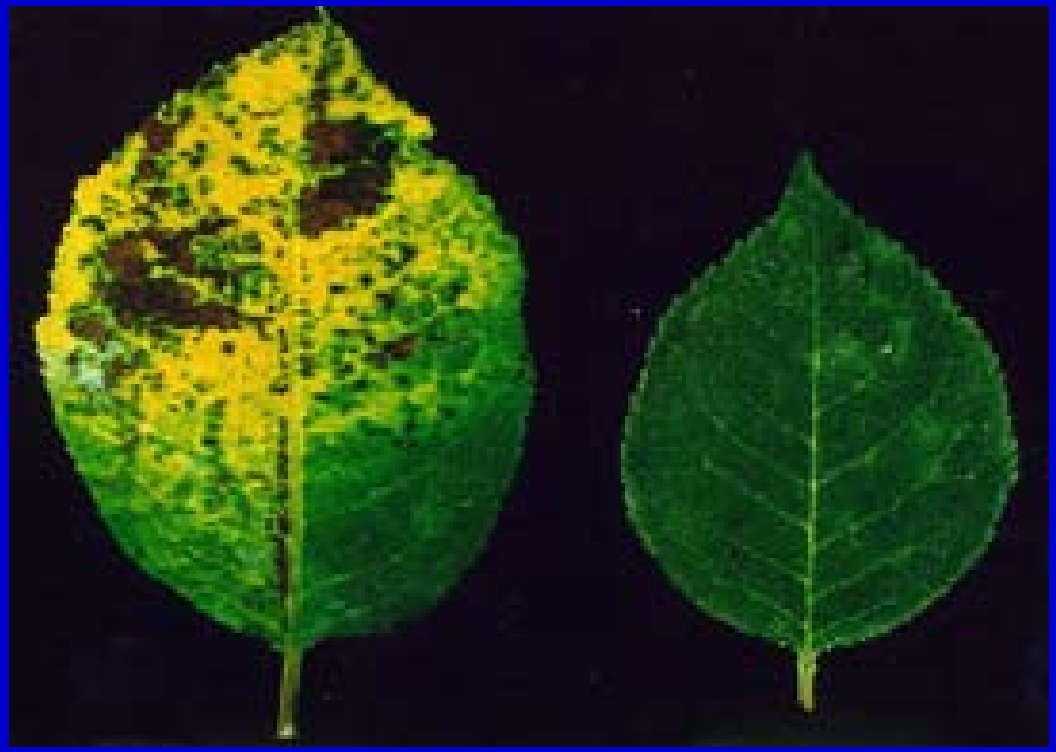
Chagne et al. 2007. BMC Genomics 8**:212**



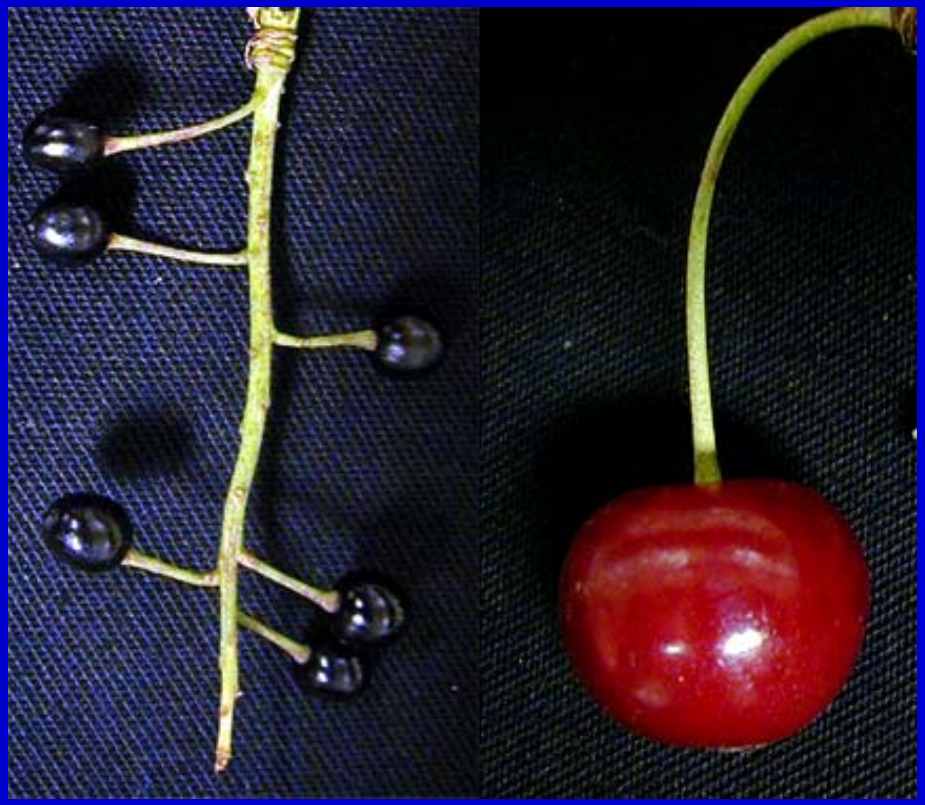
Sooriyapathirana et al. (in review)

How will RosBREED help breed cherry leaf spot resistant tart cherry cultivars?

Susceptible Resistant



Resistant Susceptible



RosBREED will generate knowledge of the genetic control of fruit size & enable the use of this information to more efficiently achieve the desired fruit size while retaining the CLS resistance.

Sweet cherry cultivar

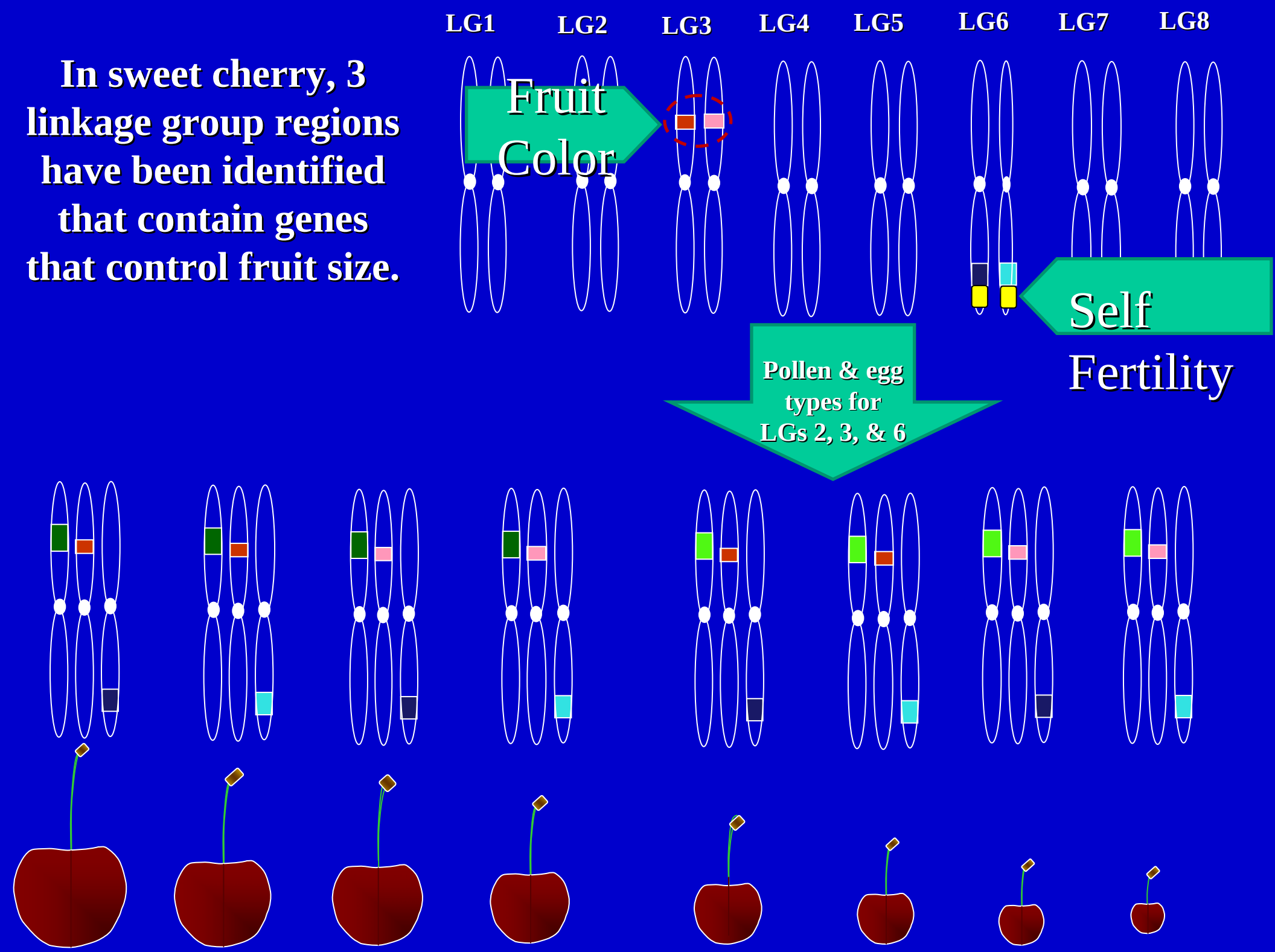
12 grams

We are identifying the genetic changes that are responsible for this increase in fruit size.

2 grams

Wild forest cherry

In sweet cherry, 3 linkage group regions have been identified that contain genes that control fruit size.



RosBREED Stakeholder Advisory Panel

Josefina Alcala
Jim Allen
Phil Baugher
Henry Bierlink
Chalmers Carr III
Robert Curtis
Bill Dodd
Chrislyn Particka
Bruce Grim
Rick Harrison
Philip Korson
Kevin Moffitt
Tom Stokes
Gary van Sickle

Genetic technologies

Engineering technolgies

Comprehensive Automation for Specialty Crops (CASC)

http://www.fieldrobotics.org/casc/Welcome.html

Comprehensive Auto...

Comprehensive Automation for Specialty Crops (CASC)

Welcome | Motivation | Partners | Publications | Events | Trip Reports | Commercialization | Advisory Board | Press | Contact

CASC is a multi-institutional initiative led by Carnegie Mellon Robotics Institute to comprehensively address the needs of specialty agriculture focusing on apples and horticultural stock. CASC will develop methods to improve production efficiency, identify threats from pests and diseases, and, detect, monitor and respond to food safety hazards. We expect advances from the integration of robotics technology and plant science.

CASC is funded by the USDA Cooperative State Research, Education & Extension Service with matching support from industry and the Pennsylvania Infrastructure Technology Alliance.

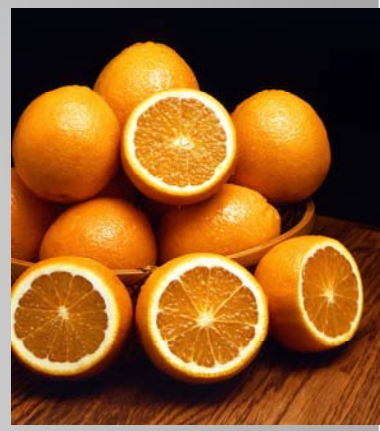
4 yrs
$6M federal
$6M matching

Sanjiv Singh, Carnegie Mellon Univ

Specialty Crop Research Initiative

USDA United States Department of Agriculture
National Institute of Food and Agriculture

Thanks



Stakeholders

Soil, Water, & Nutrition Management

Production Systems

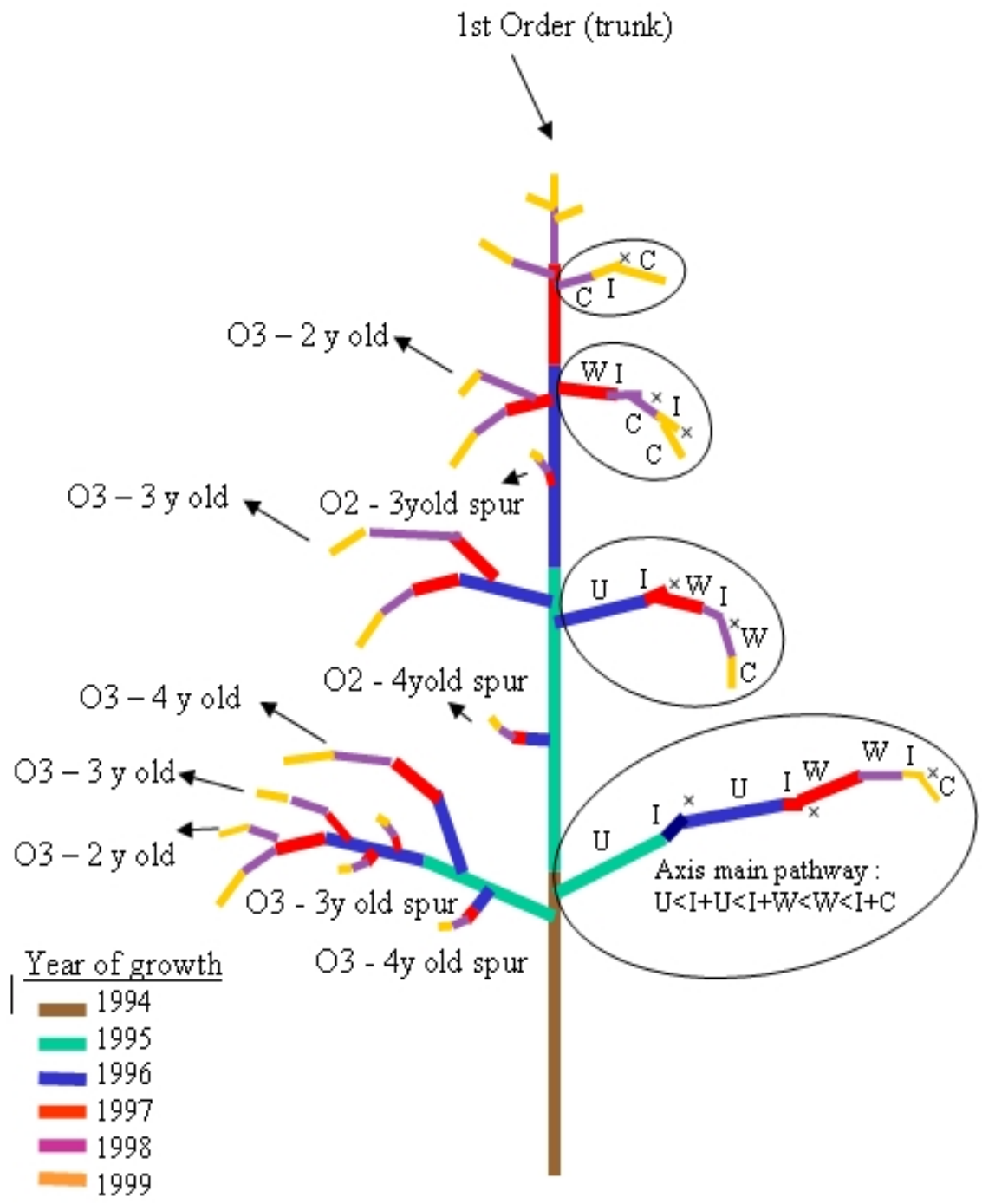
Crop health

Crop Quality Management

Vision Robotics orchard scout prototype

Quincy 2008

Picture Courtesy of Geraldine Warner, Good Fruit Grower


1st Order (trunk)
O3 – 2 y old
O3 – 3 y old
O2 - 3yold spur
O2 - 4yold spur
O3 – 4 y old
O3 – 3 y old
O3 – 2 y old
O3 - 3y old spur
O3 - 4y old spur
Axis main pathway :
U<I+U<I+W<W<I+C
Year of growth
1994
1995
1996
1997
1998
1999

Oxbo / Picker Technologies mechanical assist prototype

August 2009

Pasco WA

Future Technology