Università degli Studi di Padova

DAFNAE
Department of Agronomy Food Natural resources Animals Environment

When Plant Science meets Plant Breeding

Prof. Serena Varotto

"How can fundamental research serve agricultural productivity"

Basic Research/Applied Research

BASIC Research: ***research that is meant to increase our scientific knowledge base***

Model species: Arabidopsis thaliana

Crop species

APPLIED Research: ***increase the amount of knowledge to actually come up with a practical solution to a problem***

A matter of Time

- Many practical solutions to real world problems have emerged directly from basic research. For this reason, the distinction between basic research and applied research is often simply a matter of time

Basic research identified the genetic cause of dwarfism

Applied research use the basic information to produce dwarf crops

From Basic Research to Innovation

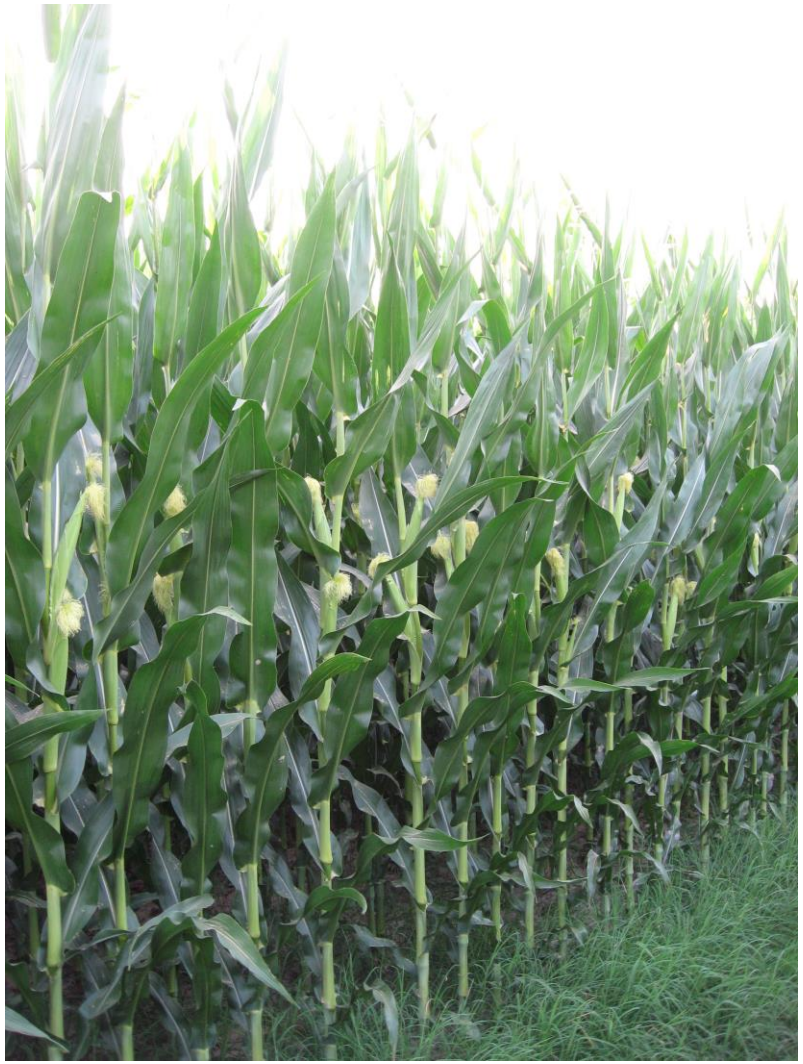
- Basic Research is constantly expanding our understanding of the natural world.
- Research, Development and Innovation are keys to creating a strong, stable and competitive Agriculture.
- In order to achieve this, the transfer of knowledge between Science and Agriculture must be facilitated.
- The science, skills, methods, protocols and expertise from Research Institution and University can be transferred to producers and Governmental Institution generating economic value and agriculture development.

From Plant Science to Agriculture Research

- **History has shown that science can solve the agriculture and food production problems, but to do so, the agricultural research must be substantially reinvigorated.**

- **Research can tackle how to grow more food with fewer resources under increasingly difficult growing conditions. But this can be accomplished only if basic research in plant science are fruitful translates to crop breeding and agricolture research with enough funding to pursue transformative ideas.**

The Green Revolution



- Improved varieties (dwarf/hybrids)
- Irrigation, fertilizers, plant protection products
- High Technology

Towards a more Sustainable Agriculture

The intensification of agriculture has focused on plant varieties for improving production:

- under optimized conditions,
- with significant agronomic inputs.

- the intensive cultivation of a limited number of crops
- narrowed the number of plant species humans rely on.

From Basic Research to Innovation

A new agricultural paradigm is required

- **reducing dependence on high inputs**
- **increasing crop diversity,**
- **yield stability and environmental resilience.**

If agriculture is to have any chance of answering these challenges, we must have new and improved techniques and technologies.

Advances in Genome Sequencing

After the release of the Arabidopsis genome in 2000 and the advent of Next Generation Sequencing (NGS) technology in 2005, the number of sequenced plant genomes has rapidly increased to more than 100.

Nearly two-thirds (**63%**) of the sequenced plant genomes are from **crops**, while model, non-model and crop wild relatives make up the remainder;

The high throughput and low cost of NGS technologies made it possible to sequence crops with lower economic value or large genomes and have paved the way for establishing new model specie

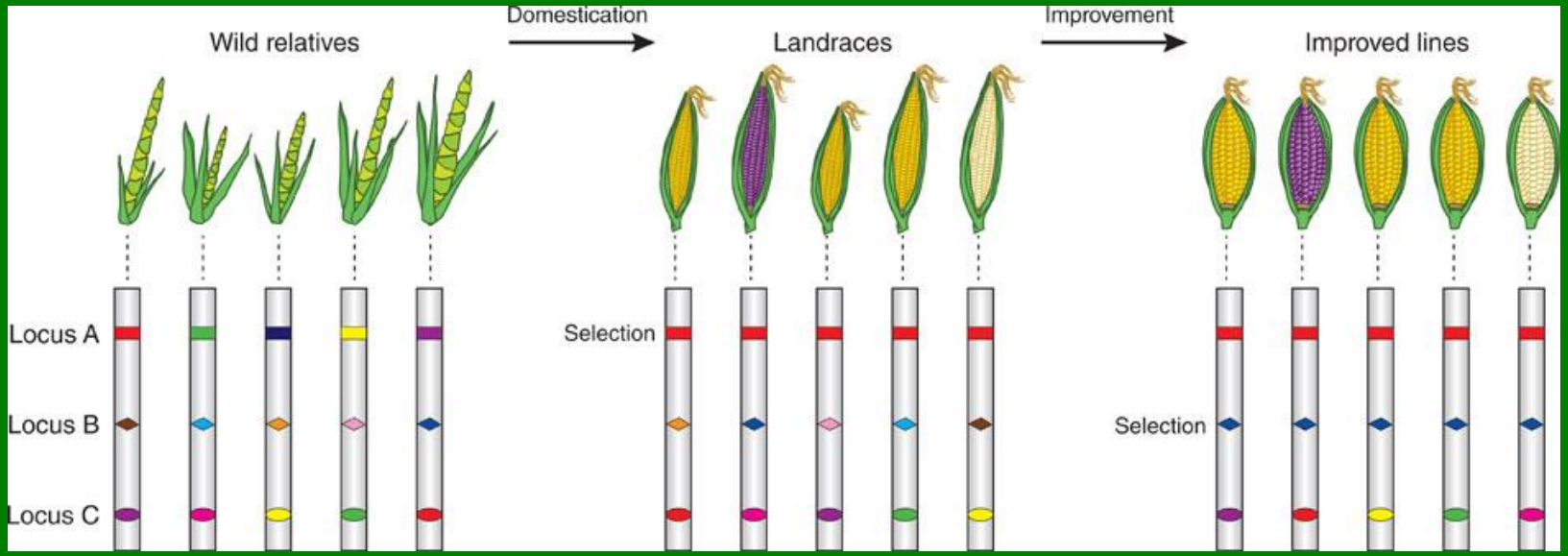
Lost of Genetic variability in Crops

What is the impact of reduced sequencing costs and increased number of model species for basic and applied research?

It is possible to study the effect of human selection and look for new interesting genes controlling agronomic traits.

- **Many crop genomes have gone through a very tight breeding bottleneck to arrive at our table.**
- **The impact is that a great deal of diversity is lost in current breeding germplasm. .**

The genetic bases of phenotypic variations



www.nature.com

Genome sequence → **Genetic diversity** → **Phenotipic variations**

Epigenetic diversity → **Phenotipic variations**

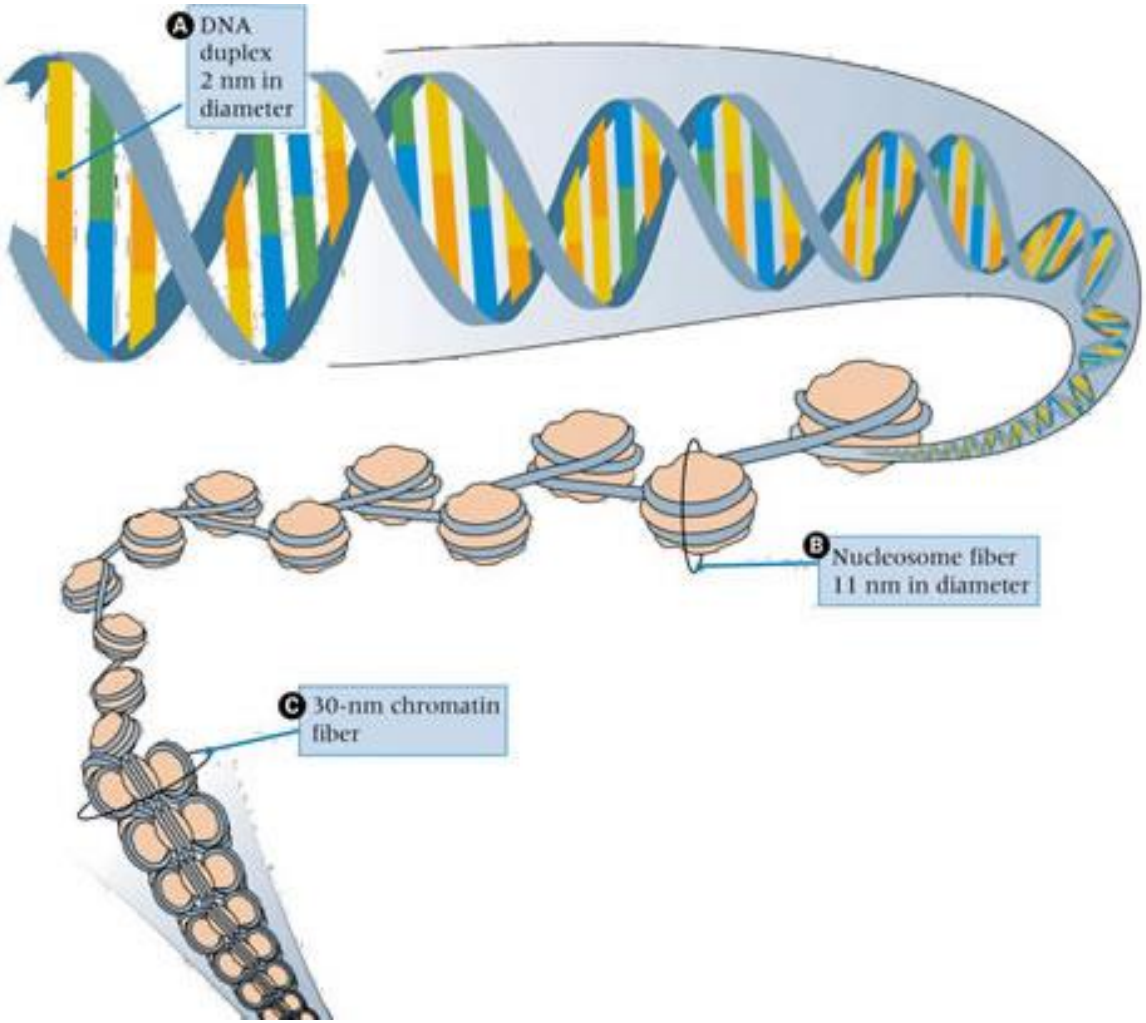
Epigenetics

Organism Genetic Diversity

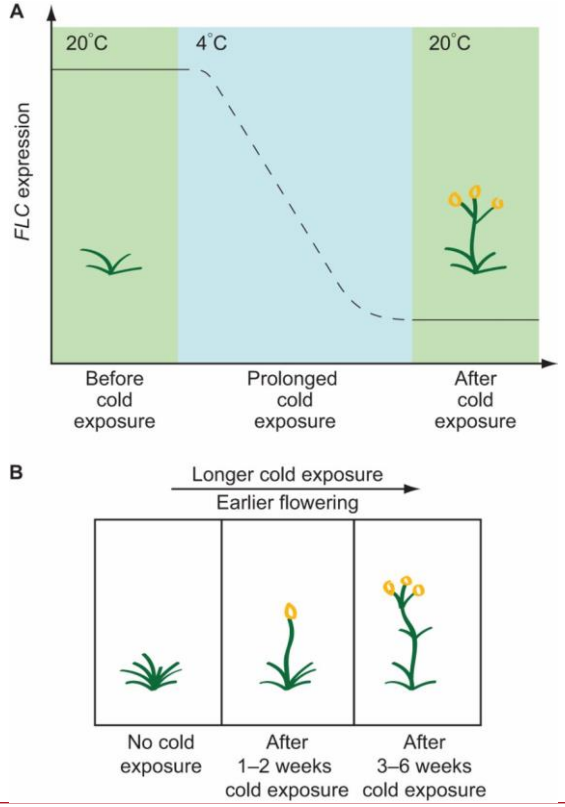
DNA sequence

Chromatin states

Epigenetic mechanisms



In Plants memory of events can be stored at chromatin level: vernalization.



Acquired Environmental Epigenetics Advances: from Arabidopsis to maize

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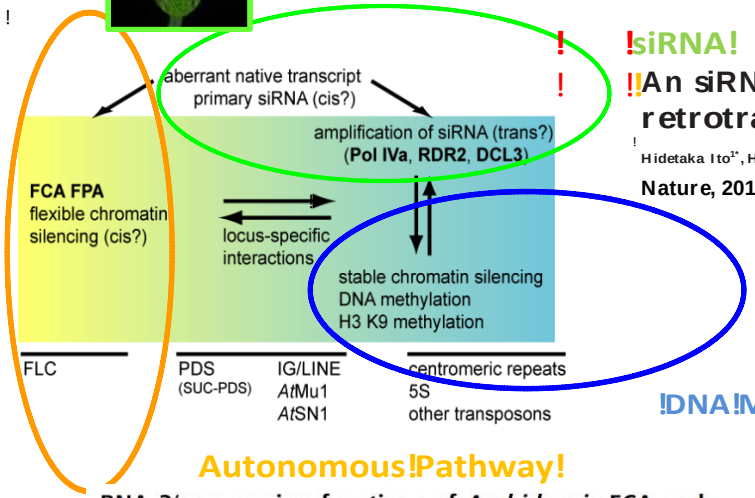
AENEAS Project

The Epigenome and the Environment

- Does the environment induce epigenetic changes?
- If yes, how long do they persist?
- What are the mechanisms for durable epigenetic changes?



!siRNA!

!!An siRNA pathway prevents transgenerational retrotransposition in plants subjected to stress

Hidetaka Ito[1*], Hervè Gaubert[1*], Etienne Bucher[1*], Marie Mirouze[1], Isabelle Vaillant[1] & Jerzy Paszkowski[1]

Nature, 2011 Apr 7;472(7341):115-9

Onsen:
specific combination between epi-regulators mutants and environmental shocks induces mobilizaton of selected TEs

!DNA!METHYLATION!

Autonomous!Pathway!

RNA 3′ processing functions of *Arabidopsis* FCA and FPA limit intergenic transcription

Cagla Sonmez[a,1], Isabel Bäurle[a,2], Andreas Magusin[a], Rene Dreos[a], Sascha Laubinger[b,3], Detlef Weigel[b], and Caroline Dean[a,1]

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Breeding for future Agriculture

- A second Green Revolution, driven largely by eliminating production constraints, may integrate activities towards advancing the productivity frontier and transforming production systems.

- Genomic tools provide an infrastructure to lay bare the secrets of the genetic potential of plants to respond to a range of environments.

- Much foundational work remains to be done – and translating this information into climate resilient crops will require additional large investments.

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Thank you for attention