

Translational Research in Crops

Case example on wheat



Translational Research

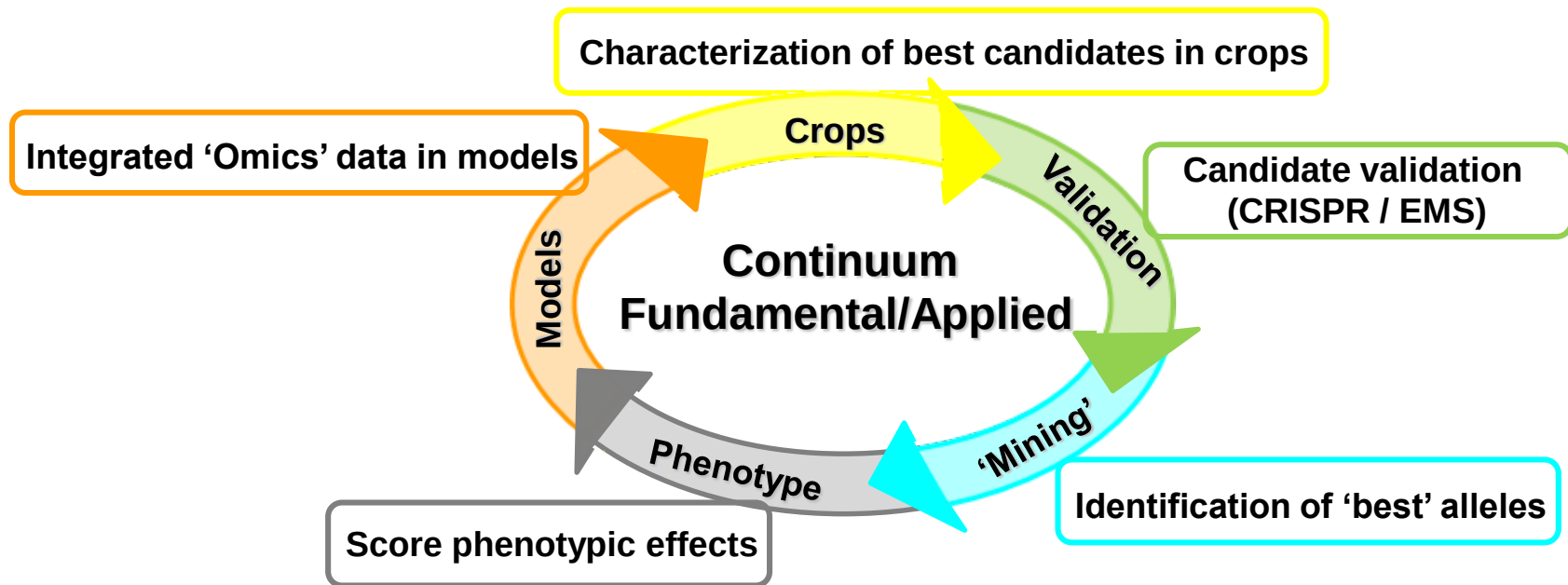
Translational research defined in Medicine (80's):

➔ From 'Bench to Bed'

and transferred to Agriculture (after 2010)

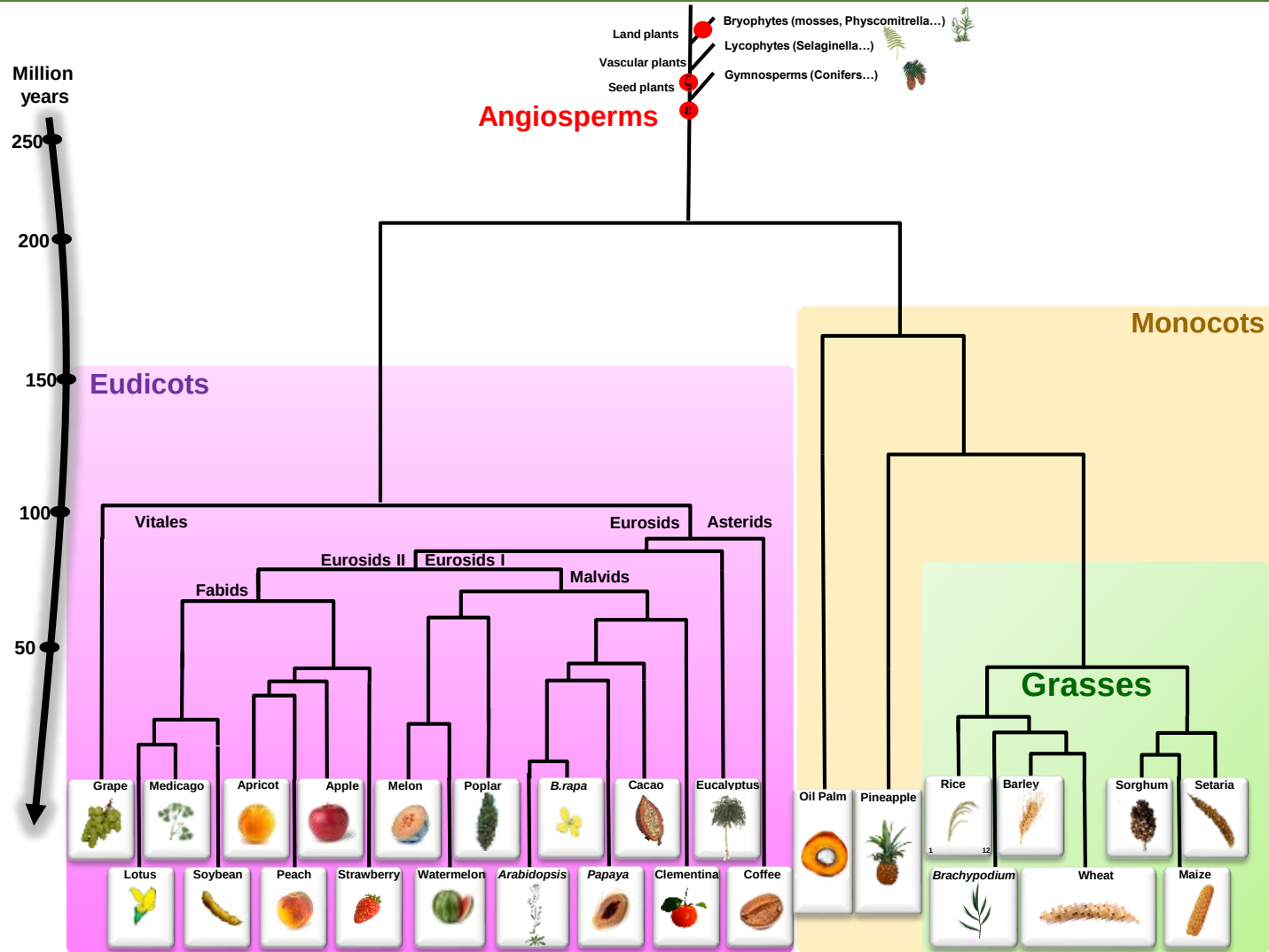
How to exploit knowledge gained from model species into breeding of crops:

➔ From models/pivots in pots to crops in plots



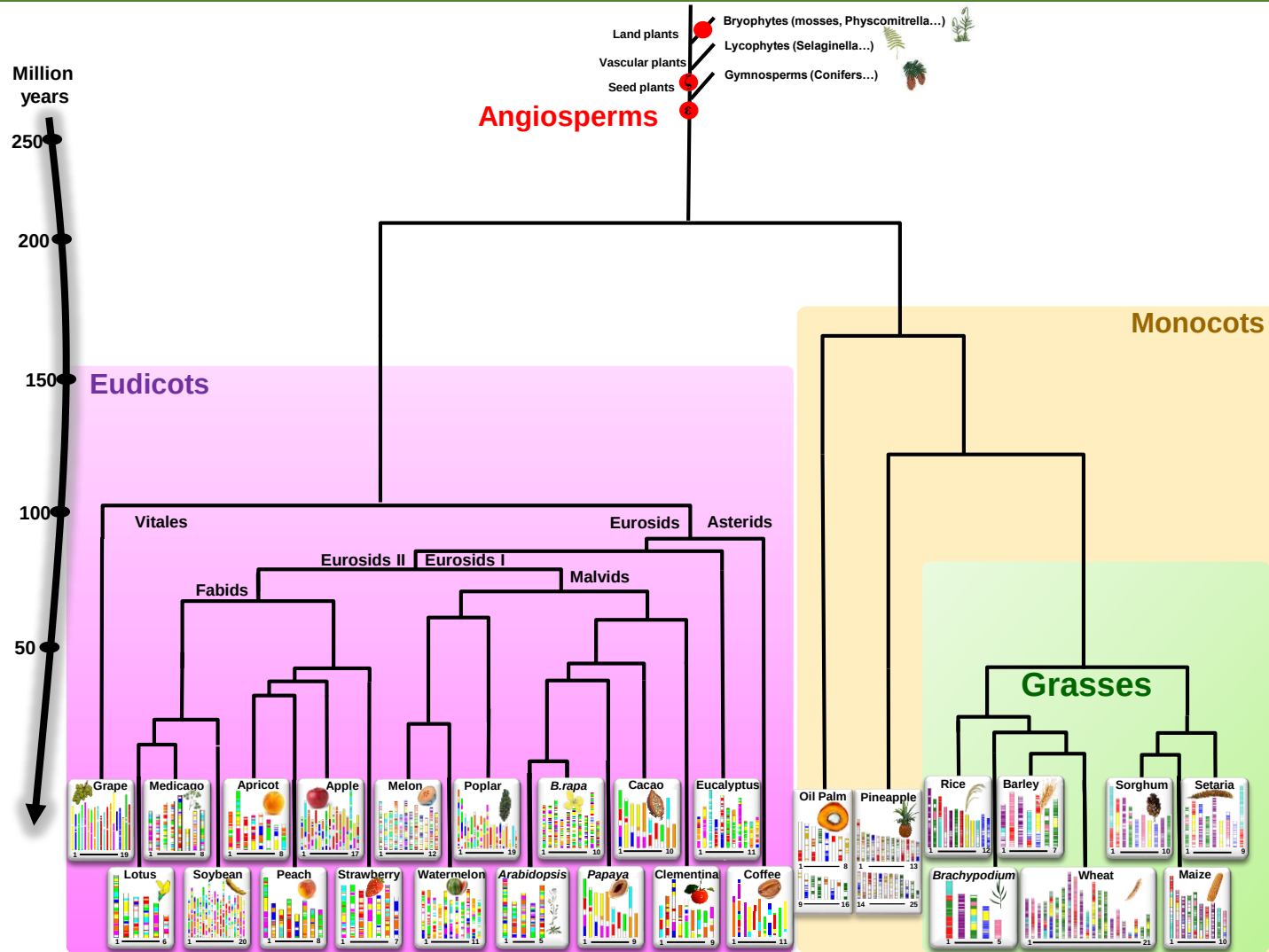
Translational research requires the best identification of conserved genes/functions between angiosperms.

Angiosperm Origin & Evolution



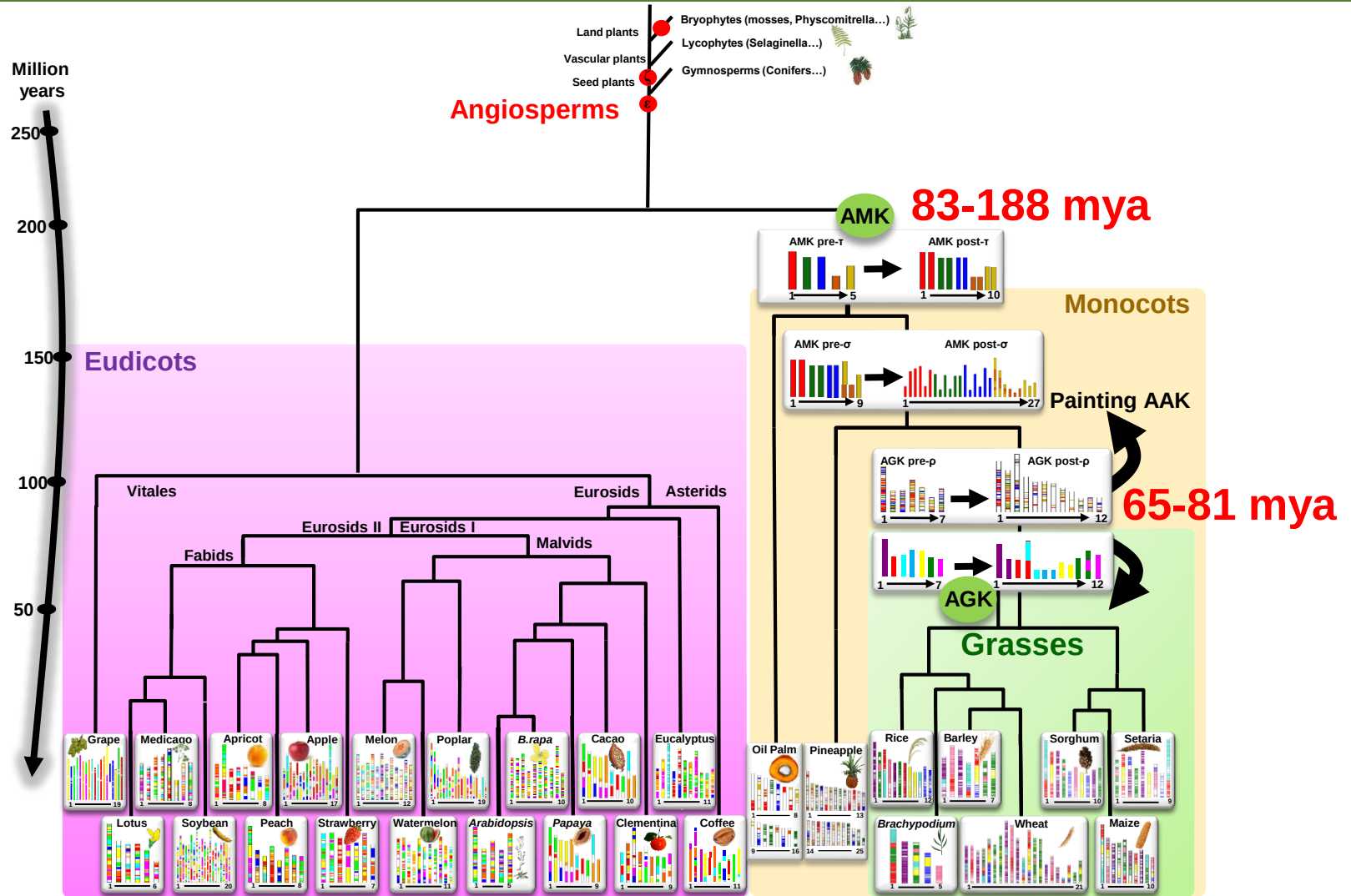
NAT GENET (2017) 49(4):490-496

Angiosperm Origin & Evolution



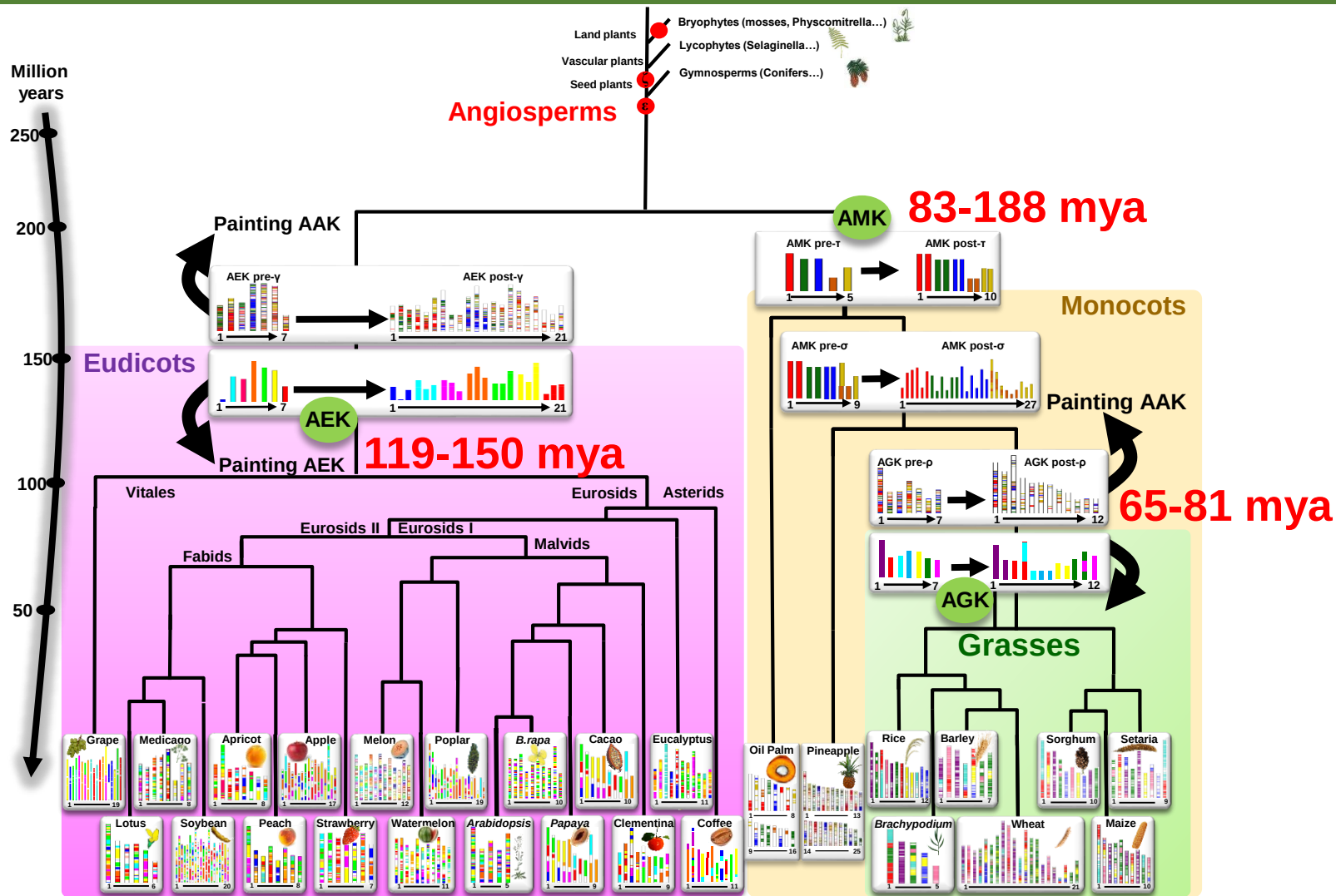
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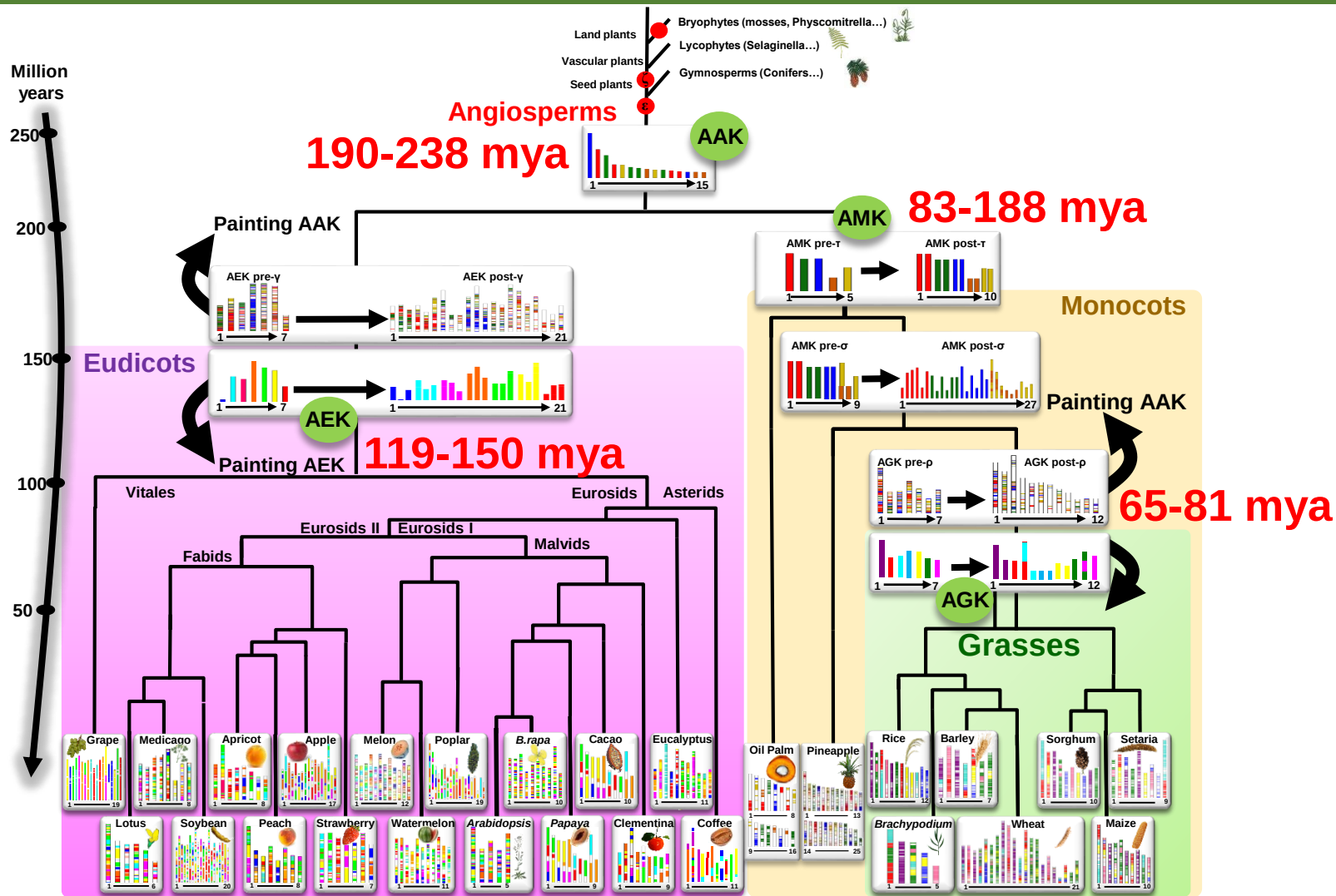
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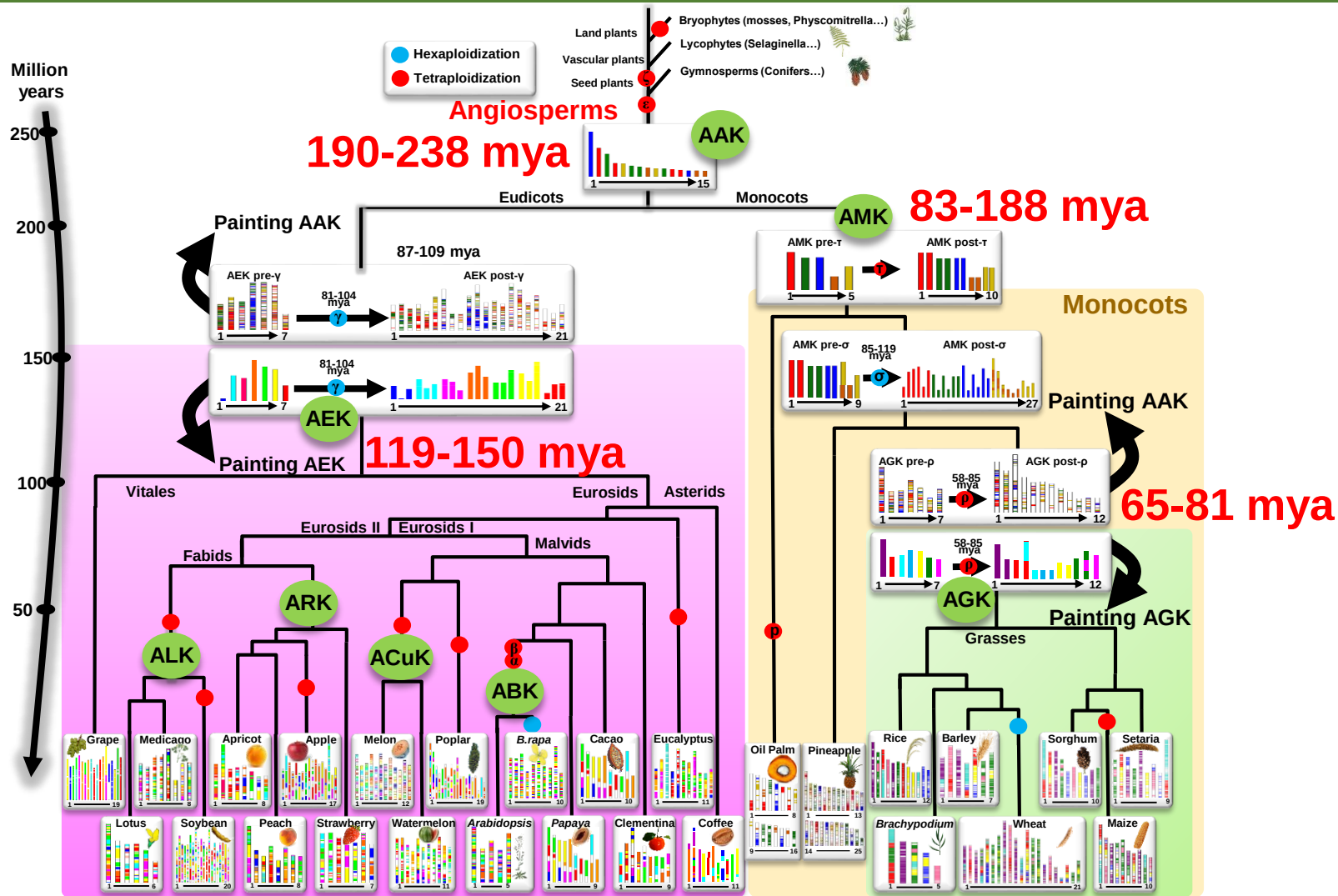
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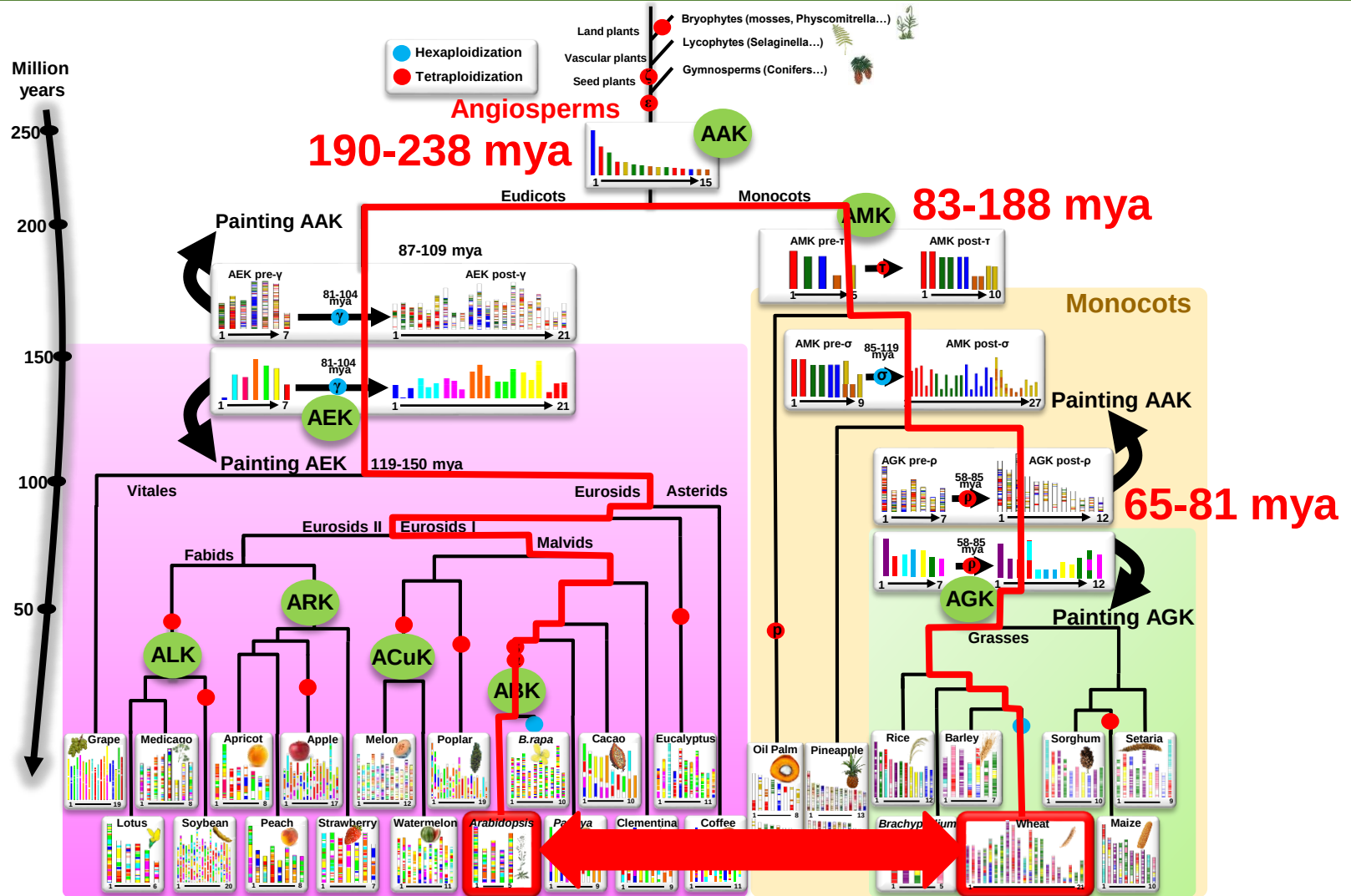
Angiosperm Origin & Evolution



Conclusion 1: angiosperm evolution since 214 mya from reconstructed AAK-AEK-AMK (and AGK-ALK-ARK-AcuK-ABK) involving series of polyploidization events

NAT GENET (2017) 49(4):490-496

Angiosperm Origin & Evolution



Conclusion 2: Ancestors as 'bridges' between species to identify conserved genes-functions-traits

NAT GENET (2017) 49(4):490-496

Translational Research Approaches

Approach 1:

Can we identify, from a known gene driving a key trait in one species (pivot), if the gene is conserved in other species from which the trait is also of interest.

Example of grain-related traits-genes in cereals, legumes, brassicaceae...

Example of fruit-related traits-genes in solanaceae, cucurbitaceae, prunoideae

Approach 2:

Which gene or gene family differentiate a group of species harbouring a key trait from species that do not have the considered trait

Example of woody vs herbaceous

Example of C3 vs C4 species

GENOME BIOL. (2019) 20(1):29.

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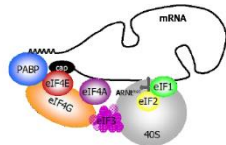
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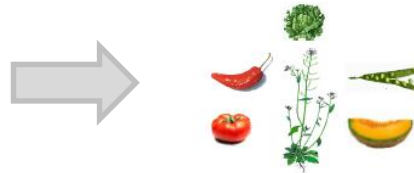
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Example of Success

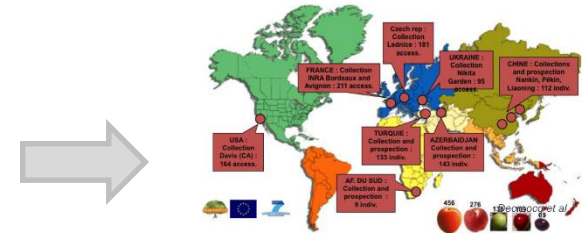
☒ C. Caranta – V Decroocq INRAE [PPV/Sharka resistance in *Prunus/Rosaceae*]



A thaliana Infection by PPV requires EIFs



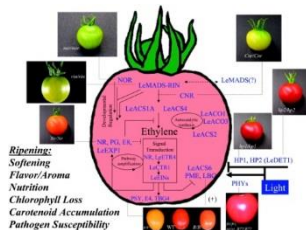
RNA virus resistance conserved in plants



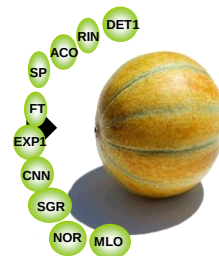
Screening for mutations in *Prunus* natural variation
Screening a mutant collection for peach (TILLING)

TPJ (2014) 79: 705-716
MOL PLANT PAT (2013) 14: 844-854
BMC PLANT BIOL (2015) 25: 15:159
FEBS LETT. (2007) 581(5): 1041-6
TRENDS PLANT SCI (2006) 11(1): 40-5

☒ A. Bendhamane INRAE [Quality in *Cucurbitaceae/Solanaceae*]



Genes involved in Ripening



Conserved genes in Melon

Nor TILLING Mutant in Melon



Control line in Melon



Screening a mutant collection for Melon (TILLING)

Plant J (2017) doi: 10.1111/tpj.
Science (2015) 350(6261):688-91
PLoS One (2010) 5(12):e15776.
Science (2008) 321(5890):836-8

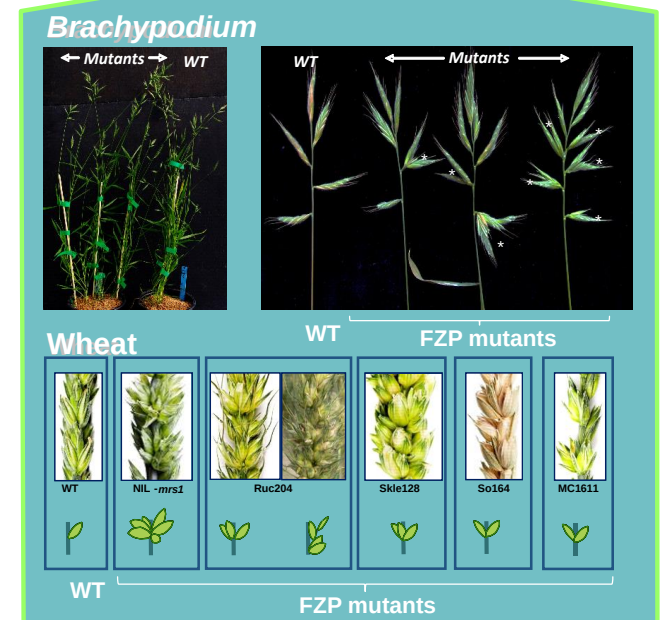
Example of Success

APETALA2/Ethylene Response Factor transcription factor

FZP gene



SyntenyViewer tool @ URG I



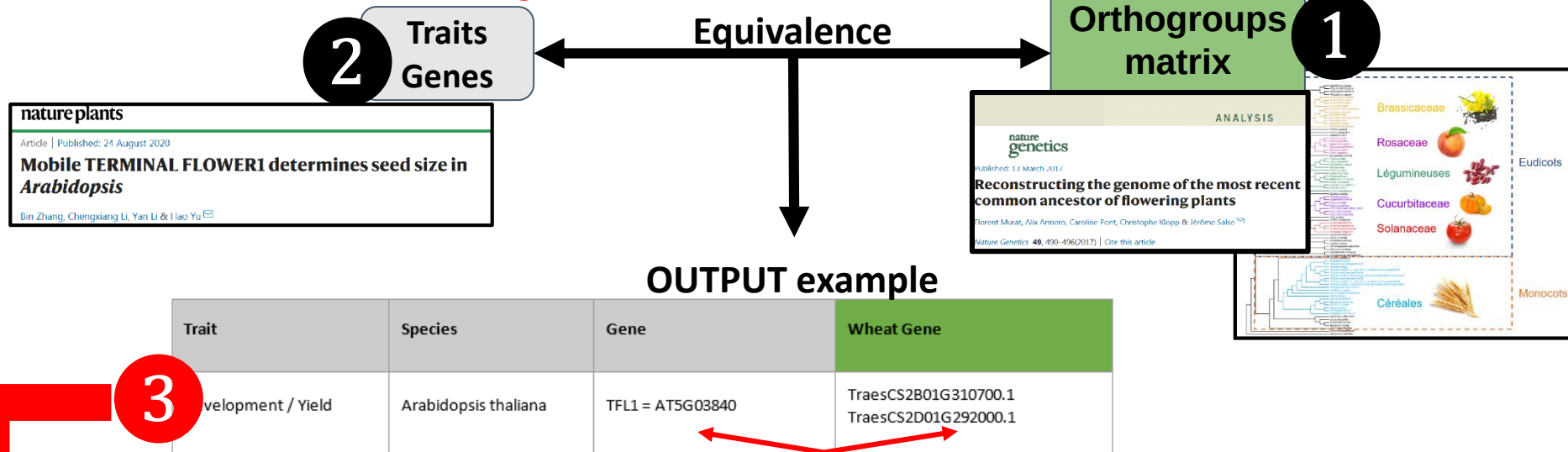
FZP (FRIZZY PANICLE) gene-function conserved in driving supernumerary spikelets

PLANT PHYSIOL. (2015) 167(1):189-99.

Example of Success

1213 validated genes

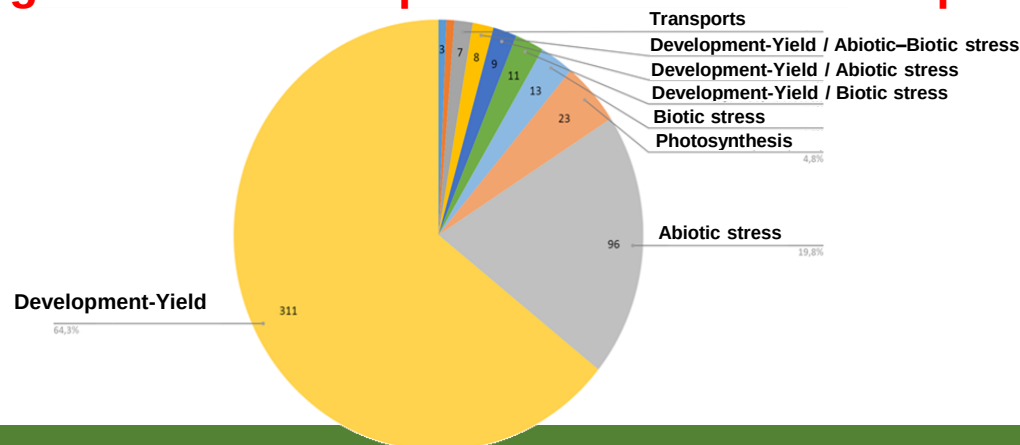
81 species



Arabidopsis → *Wheat*

1 154 (77%) validated genes in models/pivots conserved in crops

Which traits ?



Example of Success

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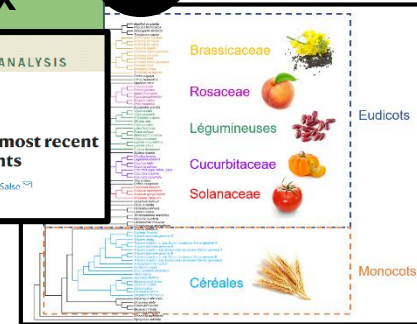
2 Traits Genes

Equivalence

81 species

Orthogroups matrix

1



OUTPUT example

Trait	Species	Gene	Wheat Gene
Development / Yield	Arabidopsis thaliana	TFL1 = AT5G03840	TraesCS2B01G310700.1 TraesCS2D01G292000.1

Arabidopsis → Wheat

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Which traits ?

Beyond gene, which gene allele to introduce in breeding programs ?



Gilles Charmet

535K SNP on 487 accessions

Example of Success

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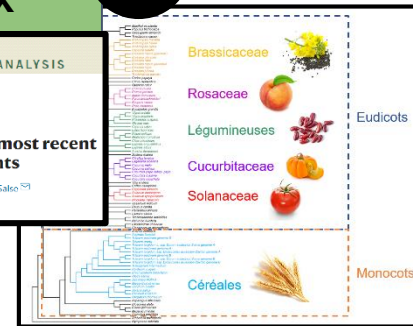
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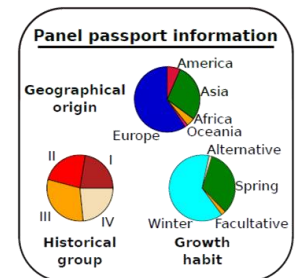
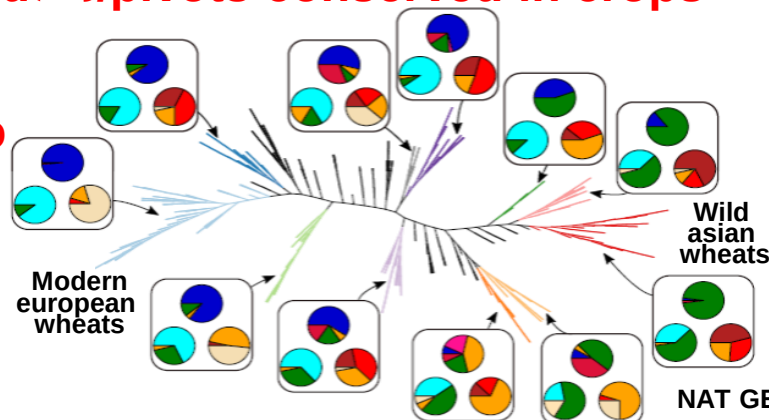
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NAT GENET. (2019) 51(5):905-911

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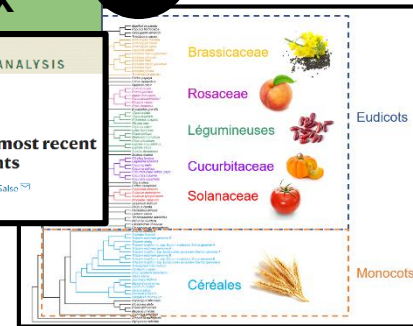
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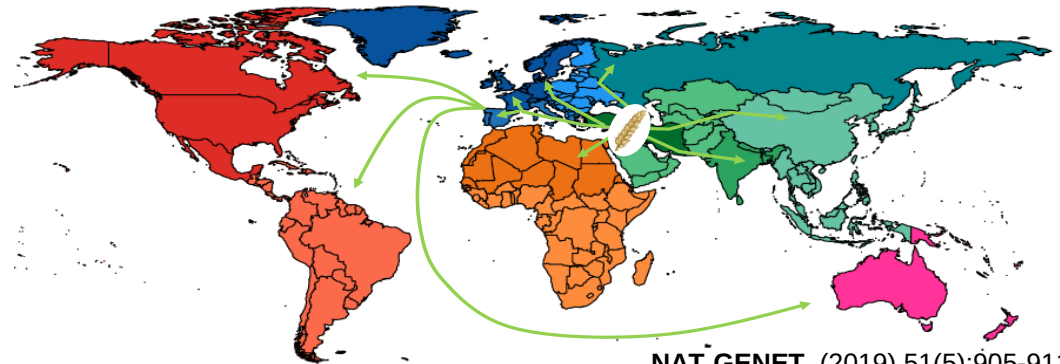
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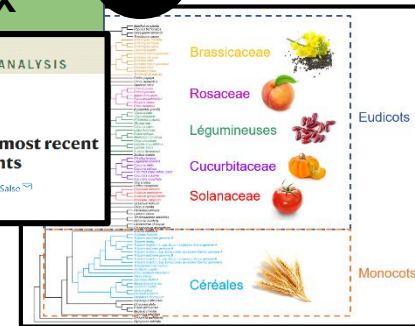
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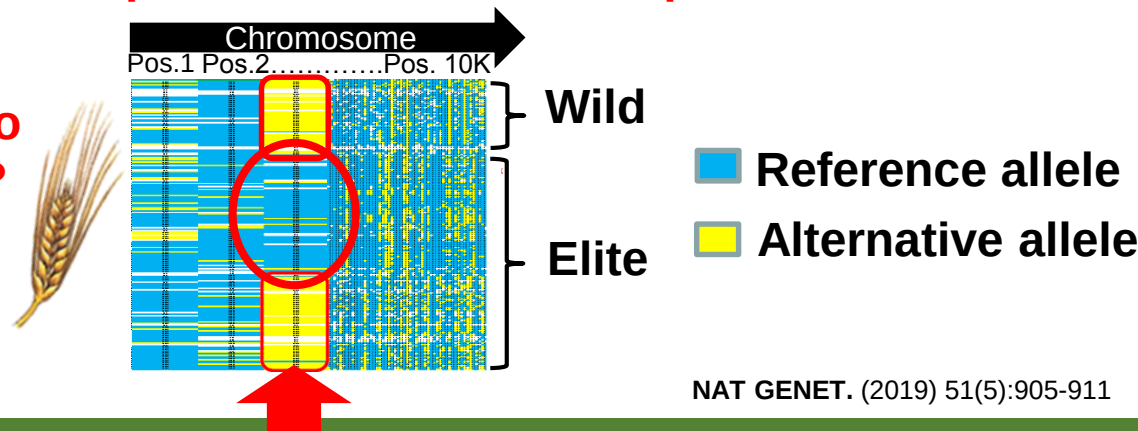
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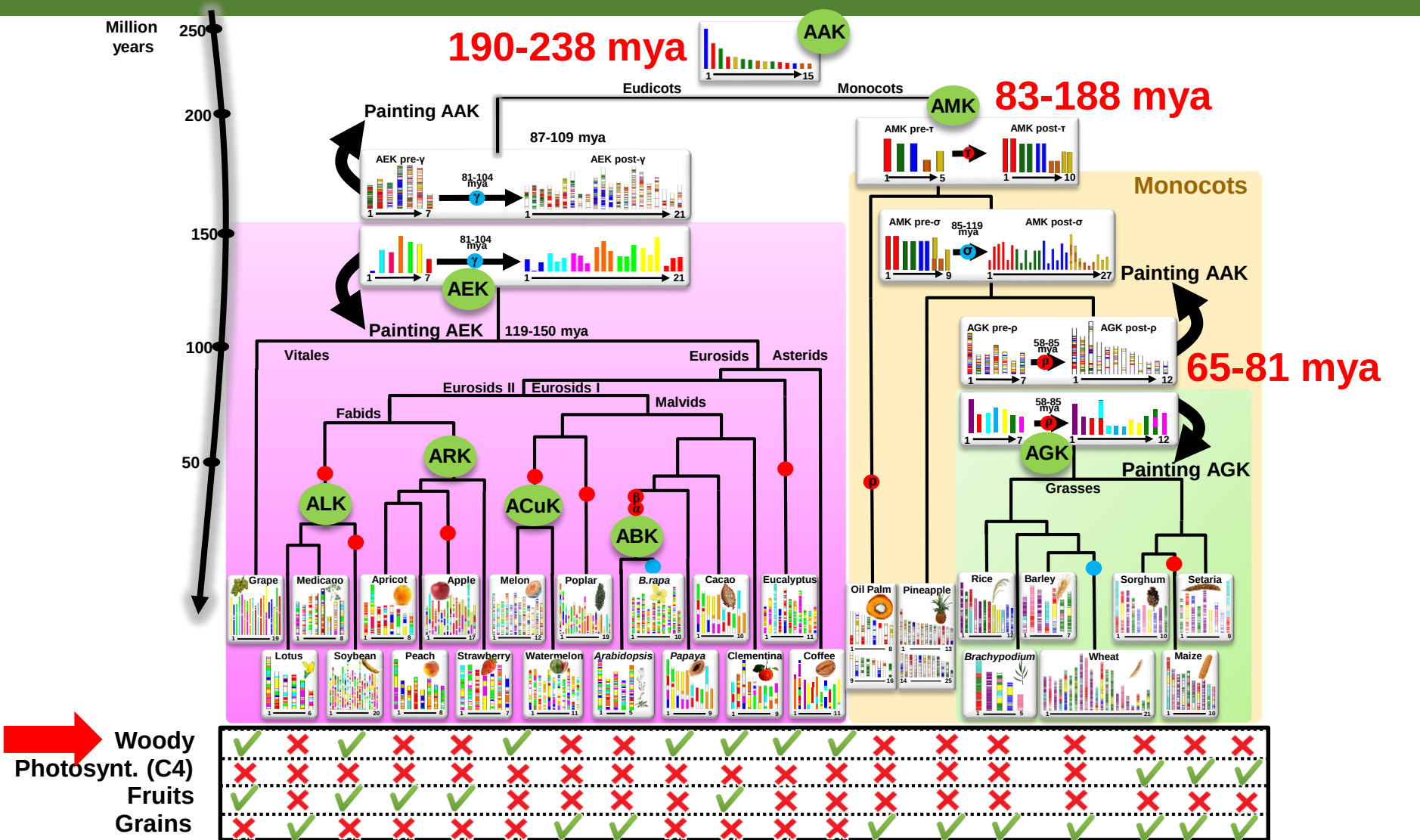
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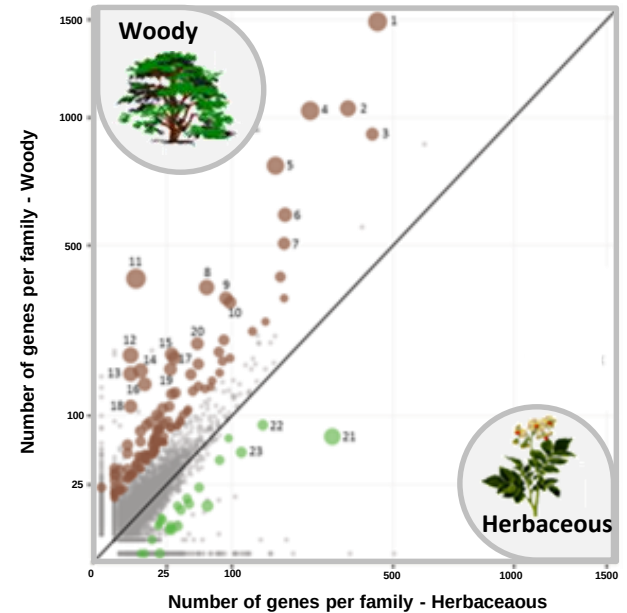
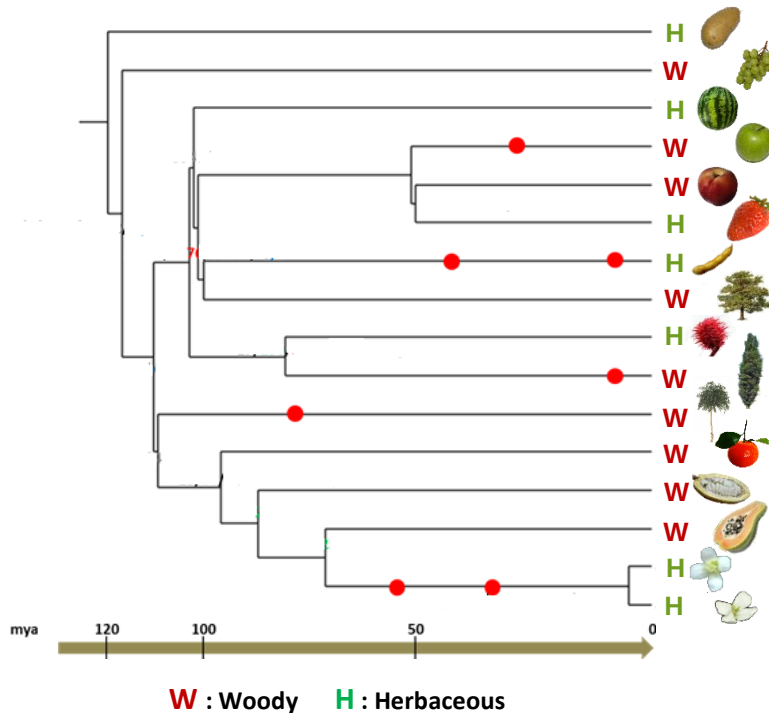
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Angiosperm Origin & Evolution



Translational research of processus (**EVO-DEVO** Evolutionary Developmental Biology approach)

Example of success



Categories

- Woody
- Herbaceous
- No significant change

-log(FDR)

- [50[
- [100
- [150[

Functions

- 1.4.8.12.14. : NB-LRR
- 2.10.17.20 : RLK
- 3.5.9. : LRR-RLK
- 6.15. : LRR-RPL
- 7. : LRR
- 13. : F-Box

EVO-DEVO approach to identify 'omics' drivers of key processus-functions.

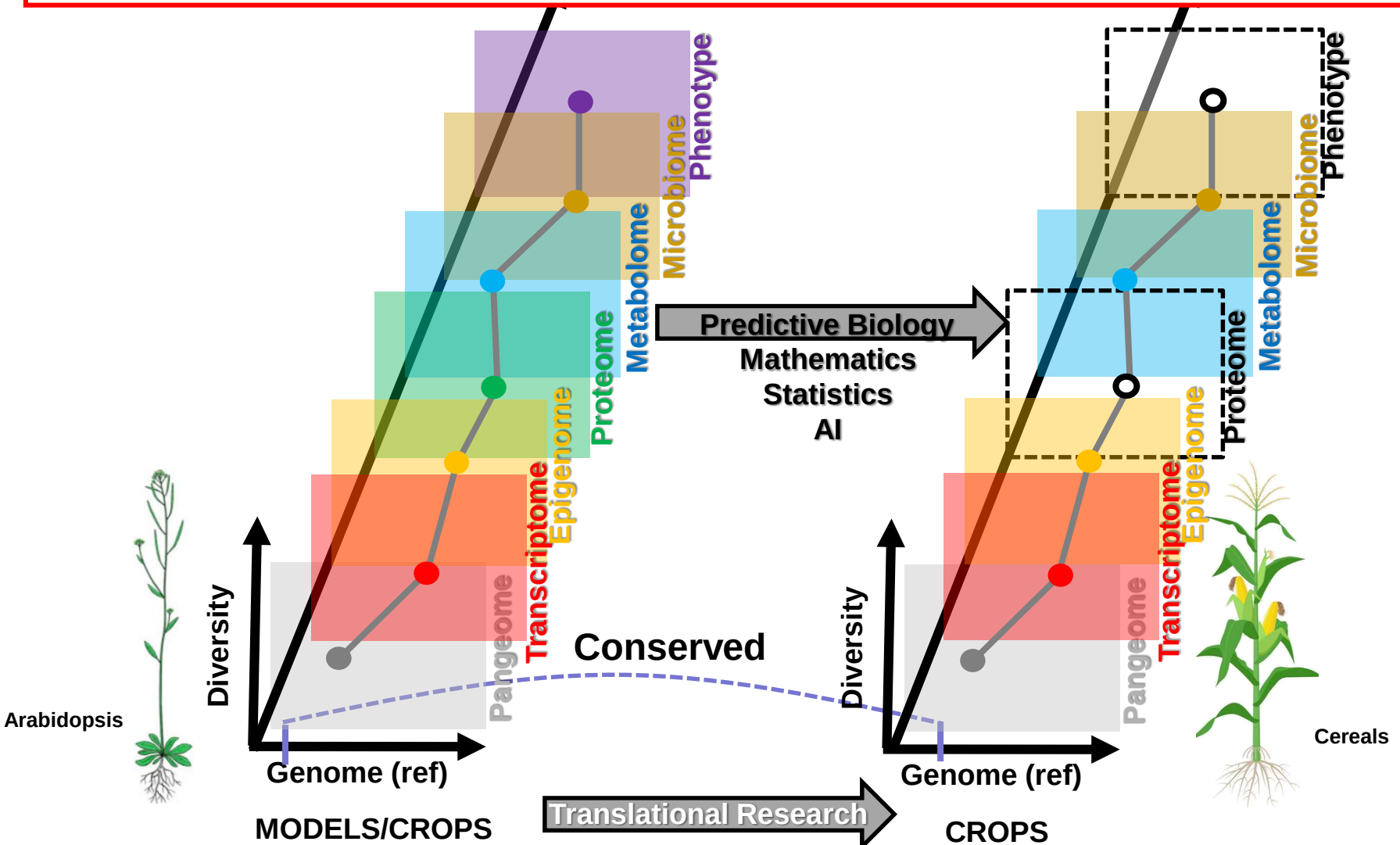
NAT PLANTS (2018) 4(7):440-452

Messages

- ◆ **Translational research** from models/pivots to crops;
- ◆ Ancestral genomes deliver **conserved genes/functions** in 'bridging' angiosperms species;
- ◆ Available *via* **SyntenViewer** for Translational Research of key Traits;
- ◆ Introduce (beyond transfer) **novel functionalities** (traits or services) in species;
- ◆ Provide best candidates (alleles) for traits in crops for **functional validation** prior introduction in breeding.

Perspectives

From comparative (structural) genomics to integrated **comparative poly-omics**





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Mamadou DIA SOW



Emile MARDOC

Former staff



Wandrille DUCHEMIN



Moaine El BAIDOURI



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Raphael-Gauthier Flores
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Marion Dalmais
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Raphael Flores
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Hadi Quesneville



<https://www.whealbi.eu/project/wheat-consortium/>



Paleogenomics & Evolution (PaleoEVO).
UMR1095 INRA – UCA “Genetics, Diversity & Ecophysiology of Cereals”



