

➤ Phenotype variations of *Fusarium* spp. under stress:
a learning process?

A. Etier, N. Calais-Yager, G. Le Trionnaire, F. Dumetz, **N. Ponts***

➤ Cereal production in France

Annual production > 50 Mt of cereals (EU rank #1)

3 major cereals produced

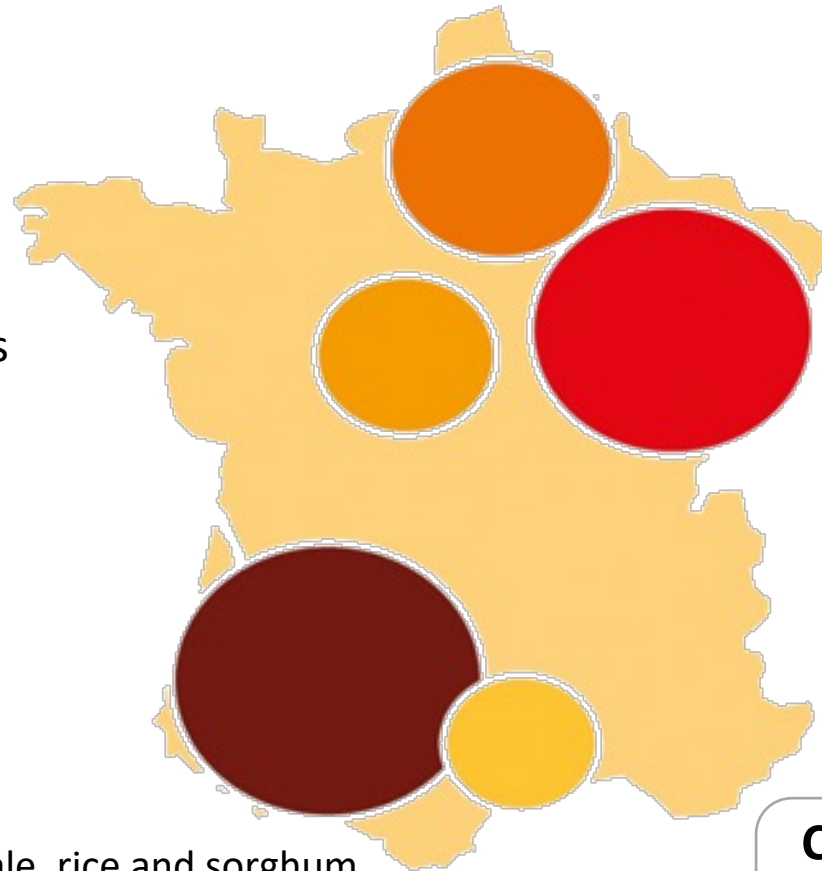
52% bread wheat

22% corn

20% barley

3% durum wheat

3% oat, rye, triticale, rice and sorghum



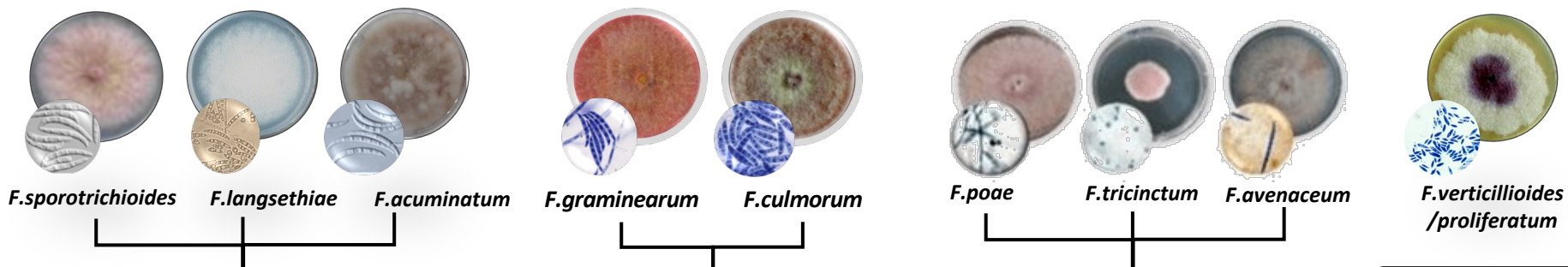
	Production
Nouvelle-Aquitaine	8,4 Mt
Grand Est	7,6 Mt
Hauts-de-France	6,3 Mt
Centre-Val de Loire	5,8 Mt
Occitanie	4,6 Mt

Contaminations with phytopathogenic fungi are frequent
Yield loss ⇔ Economic problems

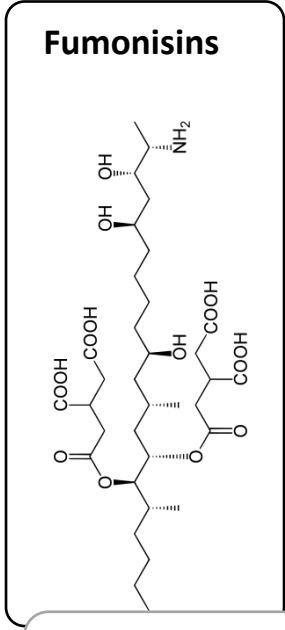
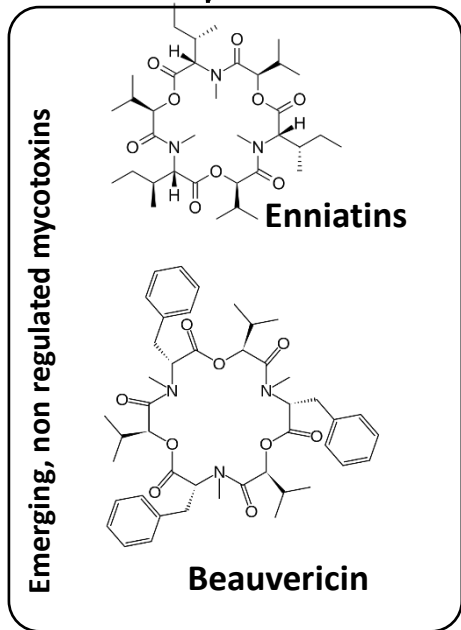
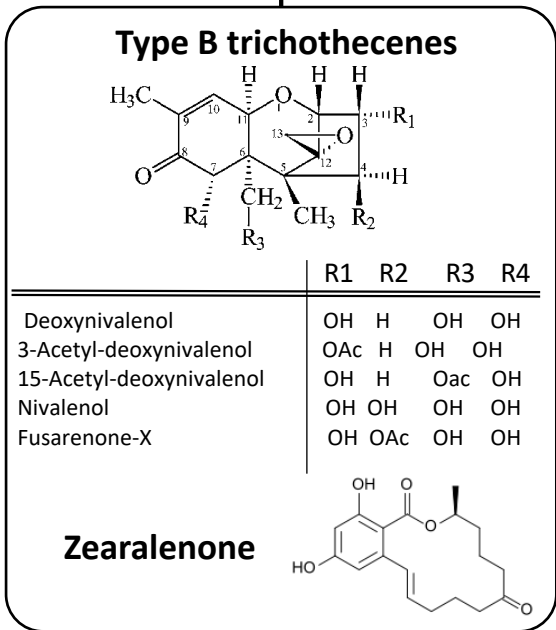
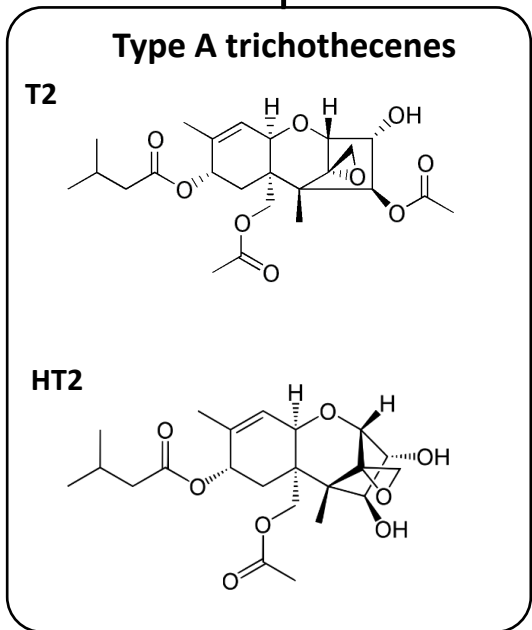
➤ Mycotoxins/fungi encountered in France

Fusarium species are the most worrisome in the fields, before harvest

Fungi



Mycotoxins



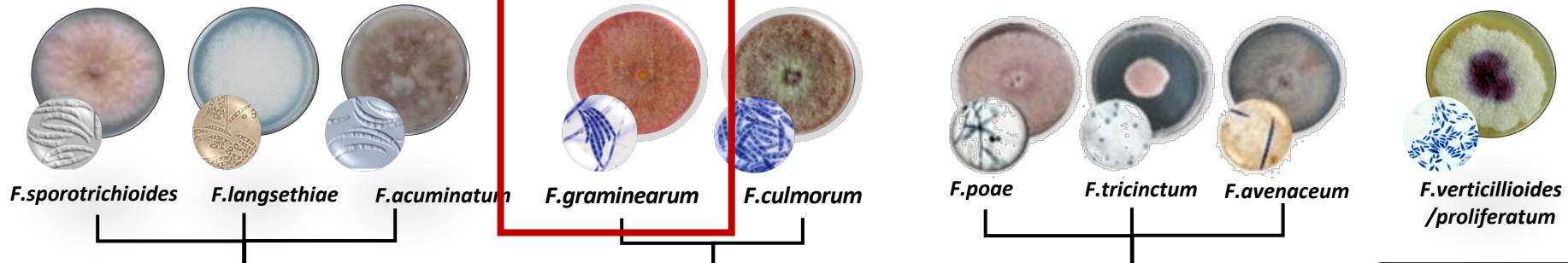
↔
Public health concern

➤ Mycotoxins/fungi encountered in France

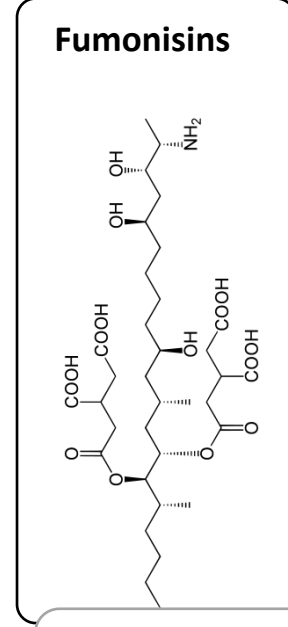
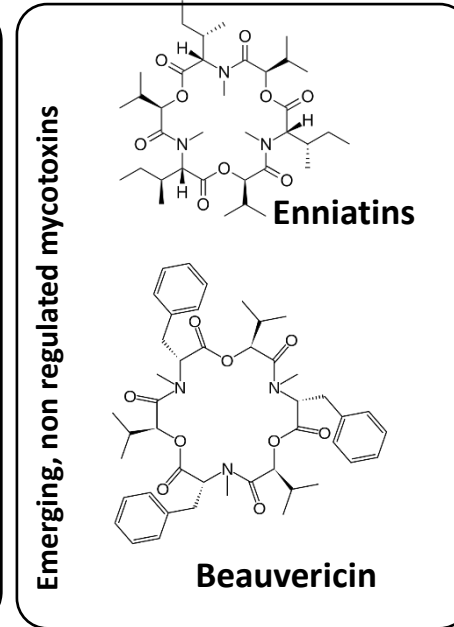
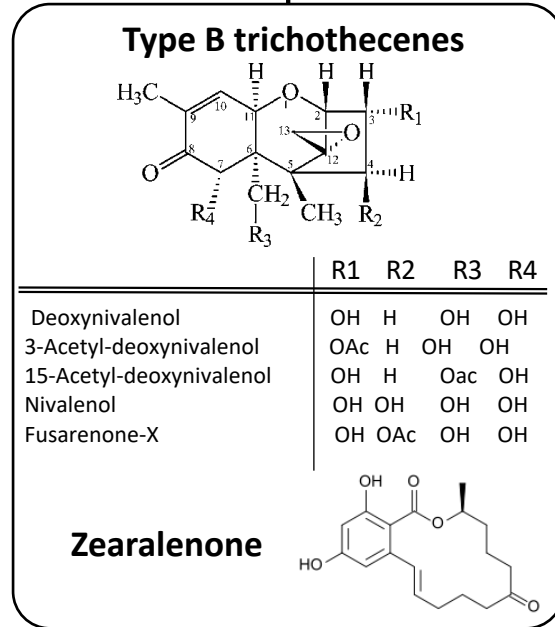
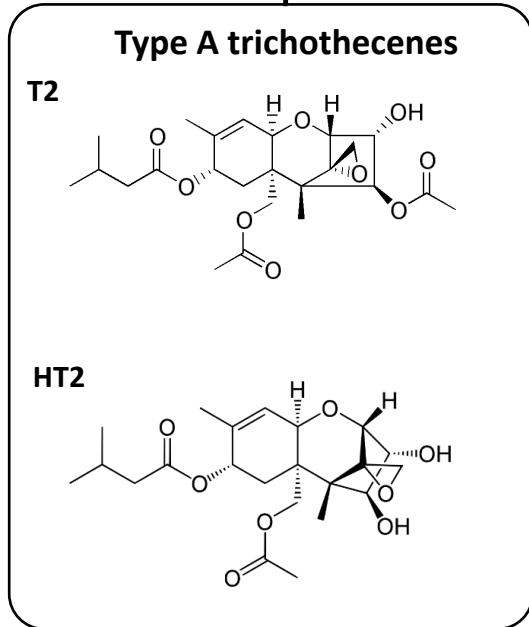
Fusarium species are the most worrisome in the fields, before harvest



Fungi

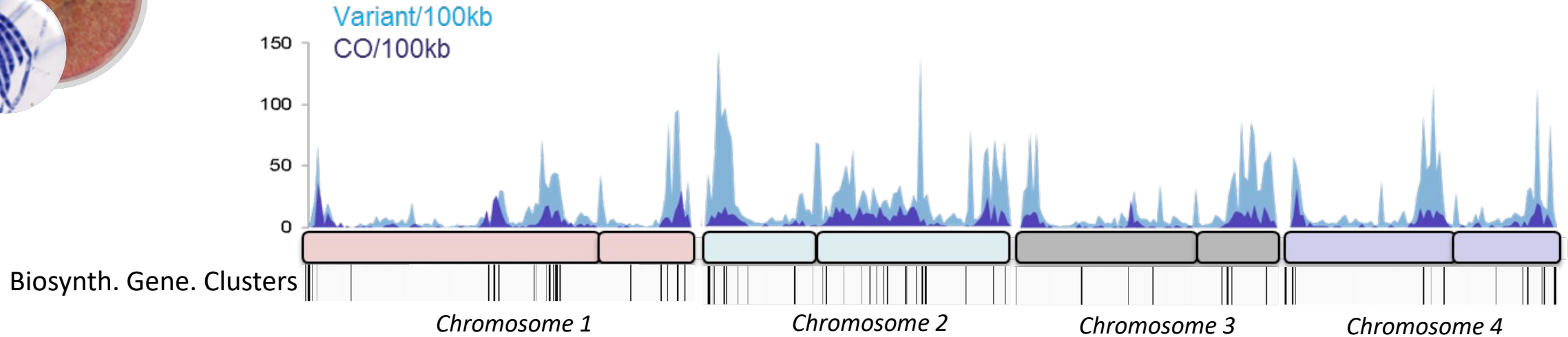
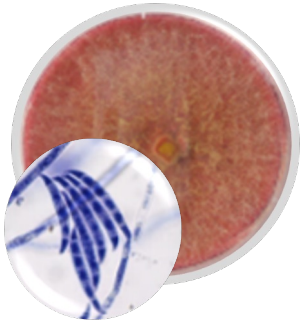


Mycotoxins



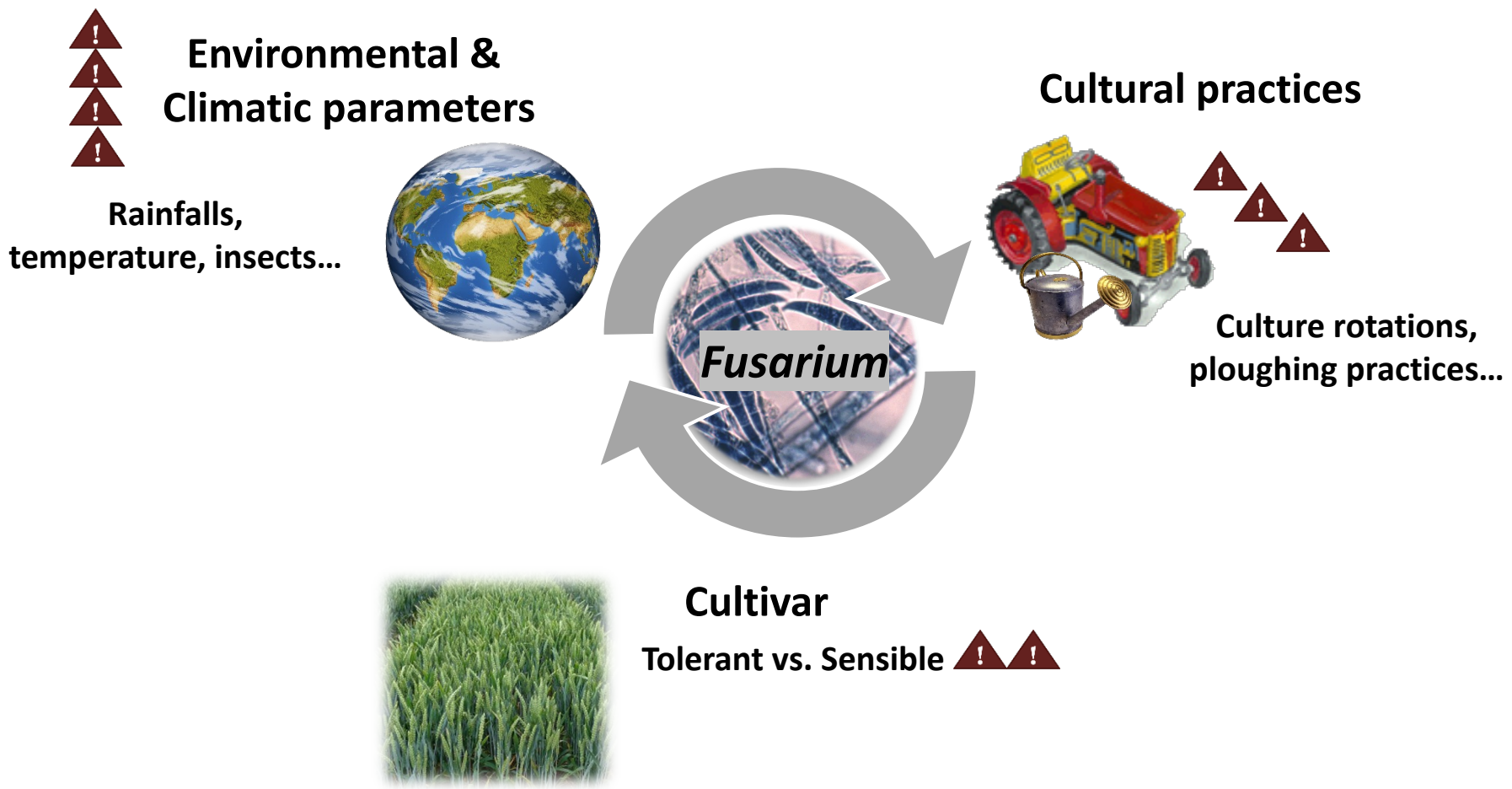
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Public health concern

➤ The *Fusarium graminearum* genome

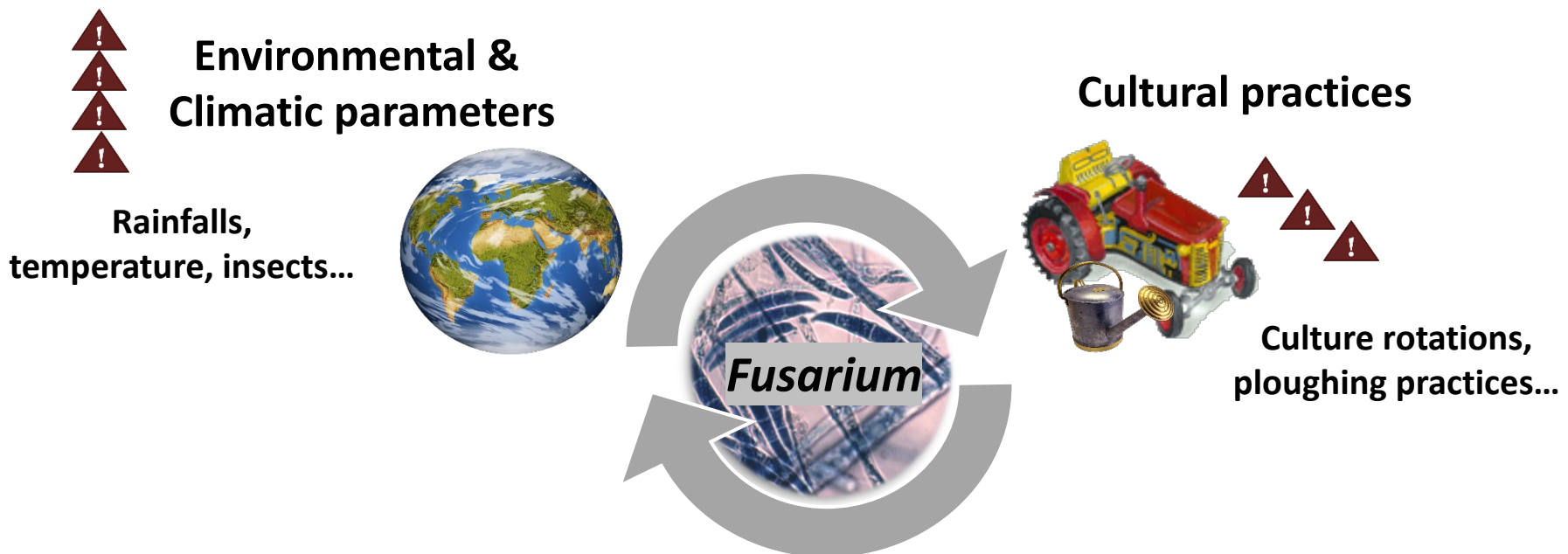


- ~37 Mb
- 4 chromosomes
- >14k genes
- 67 Secondary Metabolites Biosynthetic Gene Clusters

> Factors that influence fungi/toxins occurrences



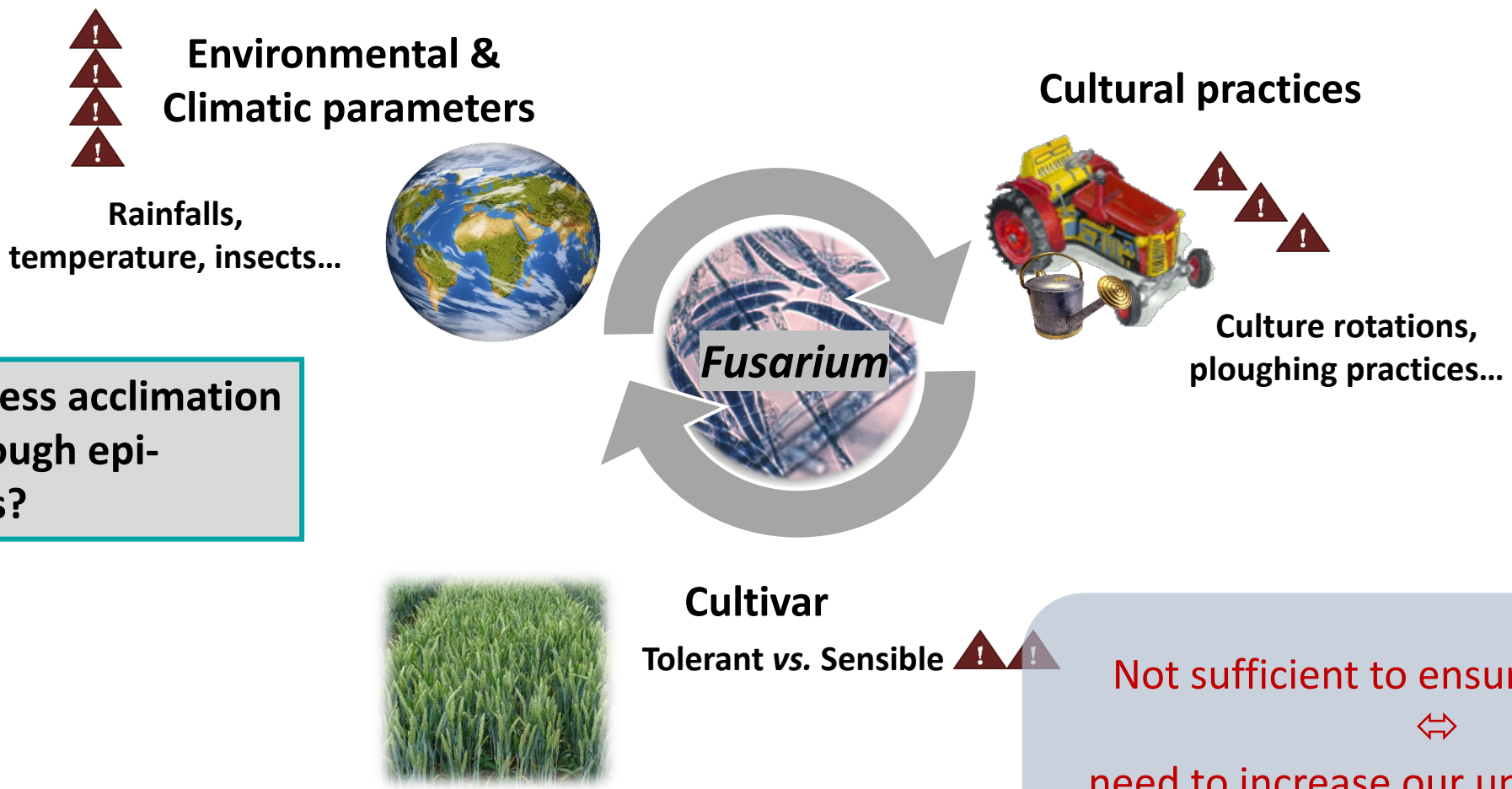
> Factors that influence fungi/toxins occurrences



Not sufficient to ensure food safety
⇔
need to increase our understanding of *Fusarium* & the mechanisms leading to contaminations with mycotoxins



> Factors that influence fungi/toxins occurrences

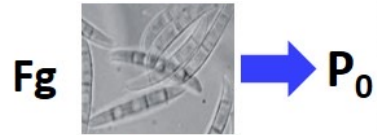


Q: Can stress acclimation occur through epimutations?

Not sufficient to ensure **food safety**
⇔
need to increase our understanding of **Fusarium** & the mechanisms leading to **contaminations with mycotoxins**



> Acclimation to stress

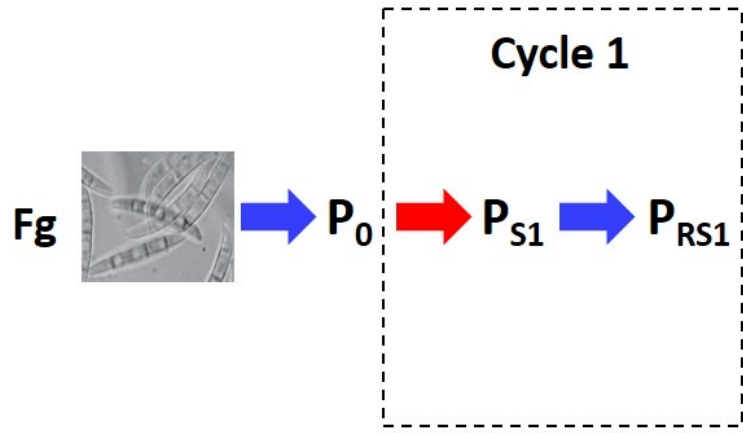


➔ Optimal temperature

P_0 : Initial phenotypic value

Steps	Description	Observation
P_0	Basal state	Basal state

> Acclimation to stress

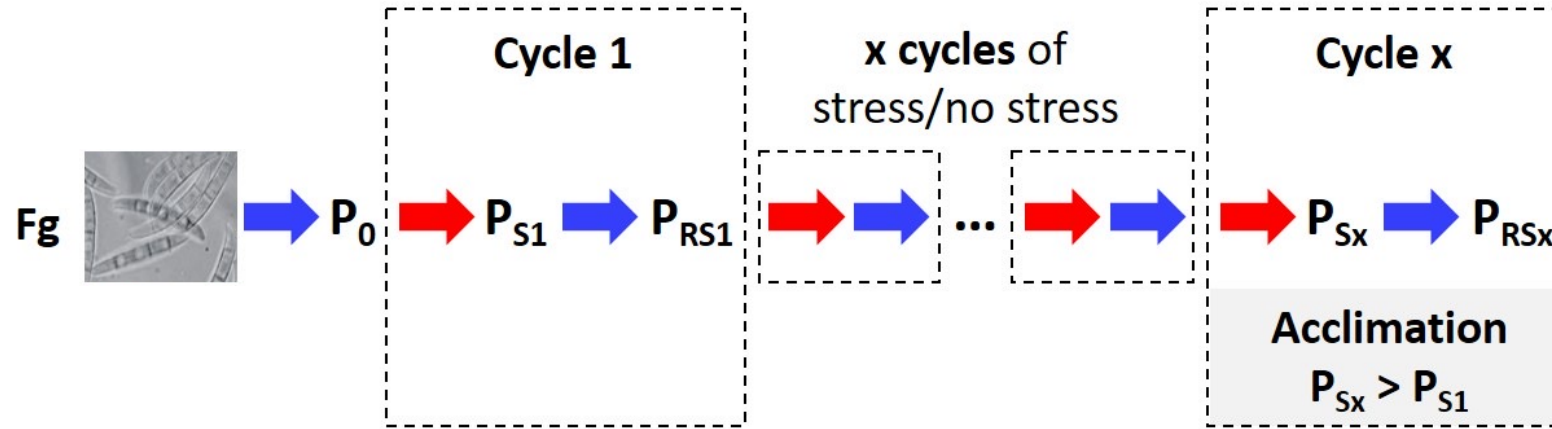




➔ Optimal temperature
➔ stress

P_0 : Initial phenotypic value | P_{S_n} : phenotypic value after stress n

Steps	Description	Observation	Comparison
P_0	Basal state	Basal state	
P_{S1}	Unacclimated stressed state	Effect of the first stress	With P_0

> Acclimation to stress

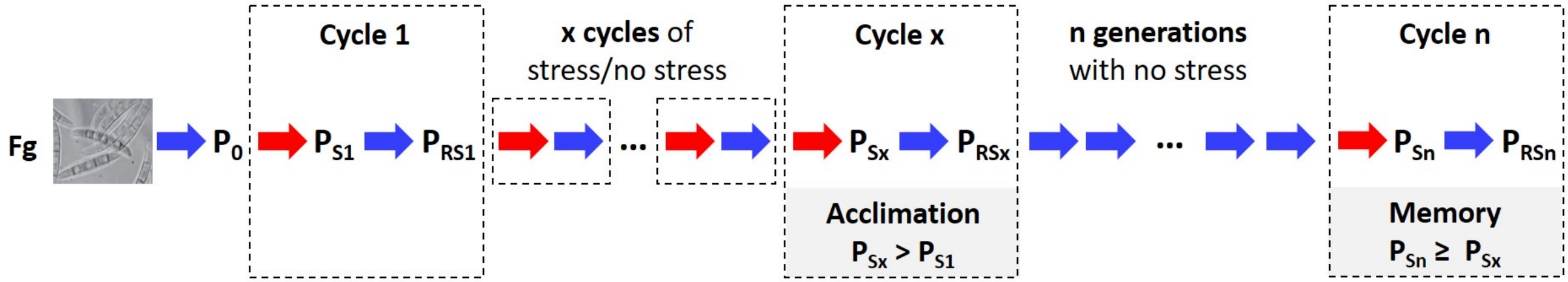


 Optimal temperature
 stress

P_0 : Initial phenotypic value | P_{Sn} : phenotypic value after stress n

Steps	Description	Observation	Comparison
P_0	Basal state	Basal state	
P_{S1}	Unacclimated stressed state	Effect of the first stress	With P_0
P_{RS1}	Recovery after 1 st stress	Persistent effects of a single stress	With P_{S1} and P_0
P_{Sx}	Acclimated state	First cycle where acclimation is observed	With P_{S1}
P_{RSx}	Acclimated rest state	Quick variation after stress release; allows differentiating effects of immediate stress release from true epigenomic memory.	With P_{Sx} and P_{Sn-1}

> Acclimation to stress



➔ Optimal temperature
➔ stress

P_0 : Initial phenotypic value | P_{S_n} : phenotypic value after stress n | P_{RS_n} : phenotypic value after recovery post-stress n

Steps	Description	Observation	Comparison
P_0	Basal state	Basal state	
P_{S1}	Unacclimated stressed state	Effect of the first stress	With P_0
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P_{RSx}	Acclimated rest state	Quick variation after stress release; allows differentiating effects of immediate stress release from true epigenomic memory.	With P_{Sx} and $P_{S_{n-1}}$
$P_{S_{n-1}}$	Memorization state	Epigenomic memory	With P_0 and P_{Sx}
P_{Sn}	Revived memory	Stress response mechanism after memorization	With P_{S1} and P_{Sx}

➤ Acclimation to stress

Heat stress

Q:

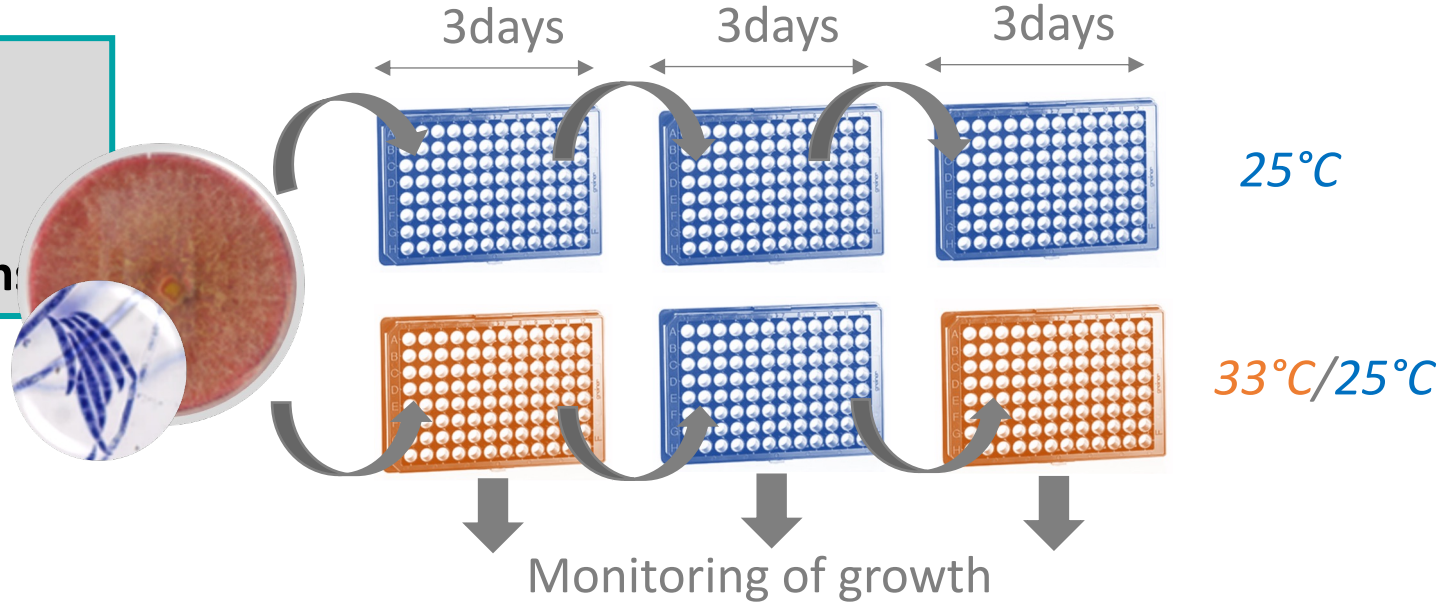
**Can stress (heat)
acclimation occur
through epi-mutations?**



> Acclimation to stress

Heat stress

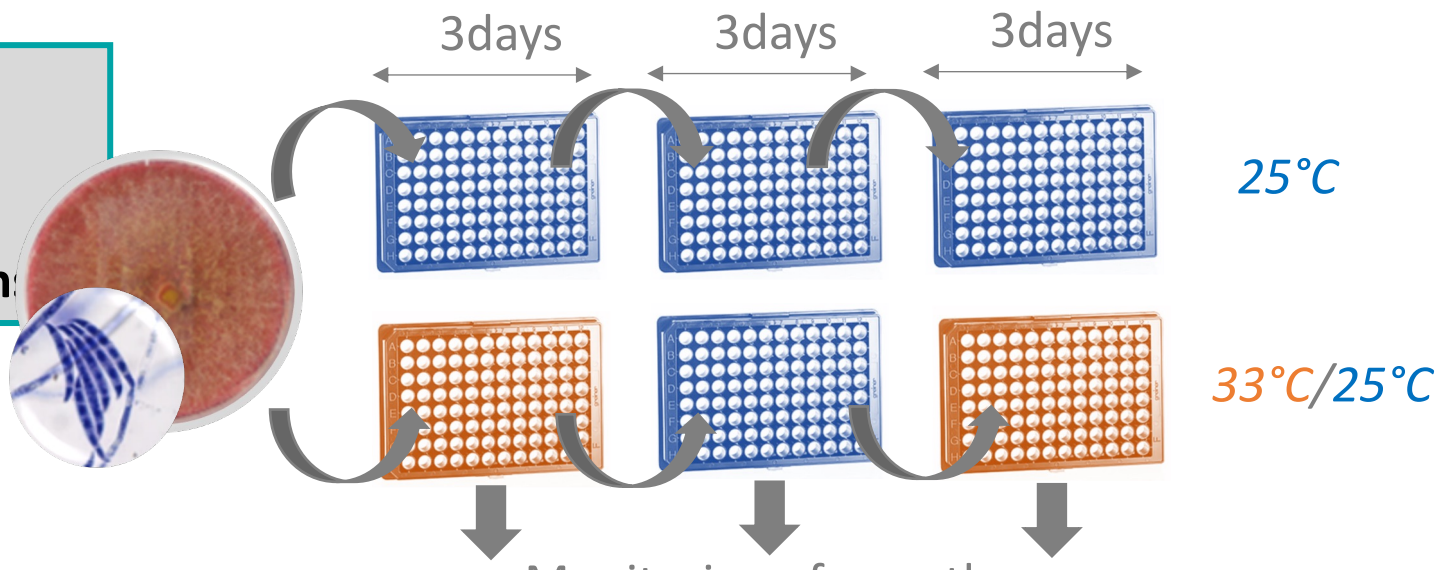
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Can stress (heat)
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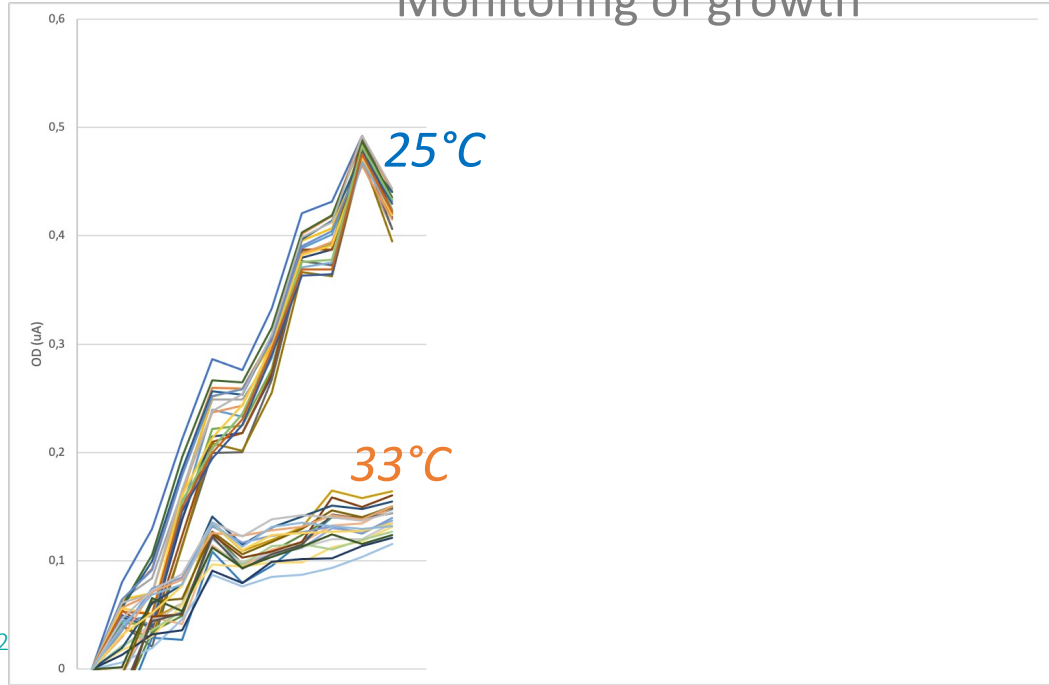
➤ Acclimation to stress

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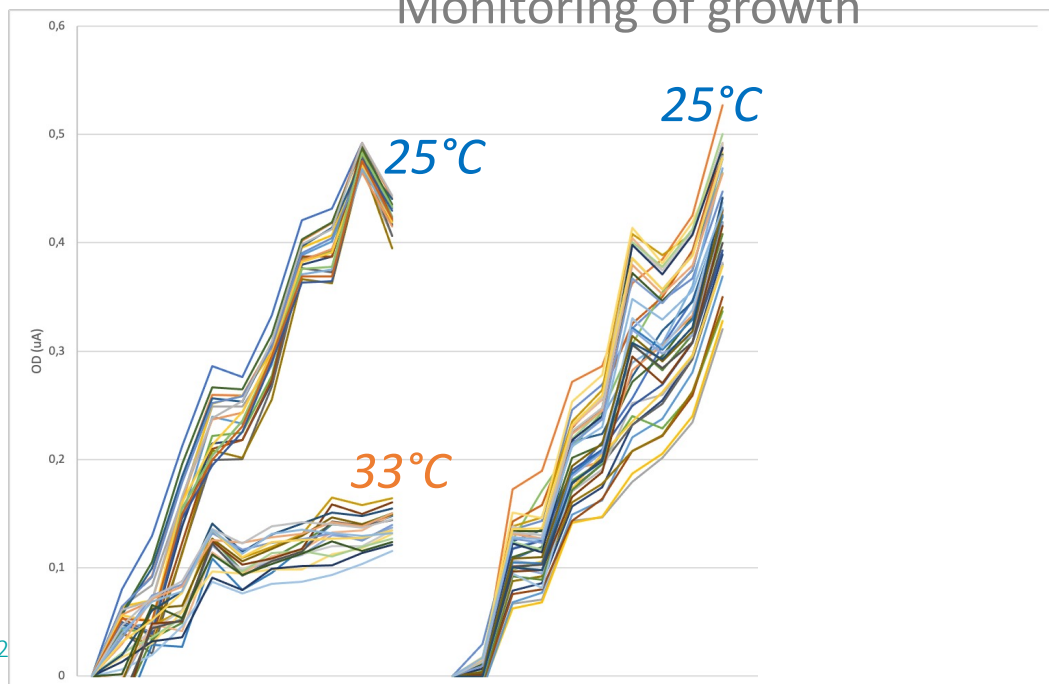
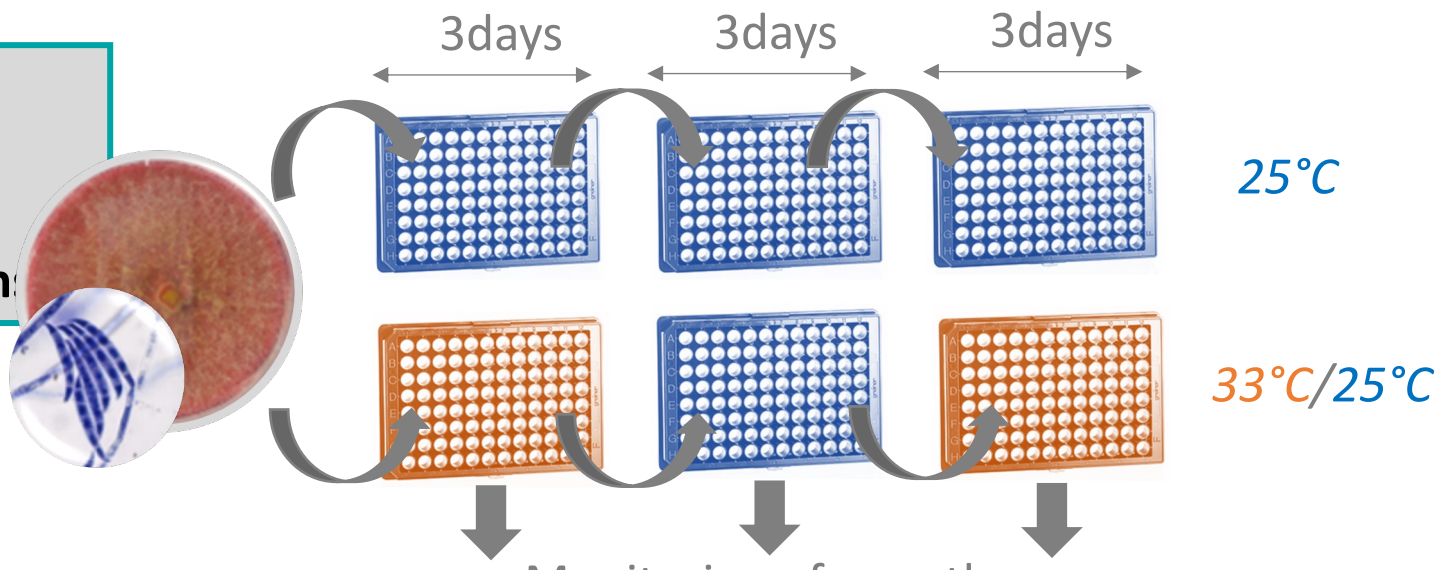
Monitoring of growth



> Acclimation to stress

Heat stress

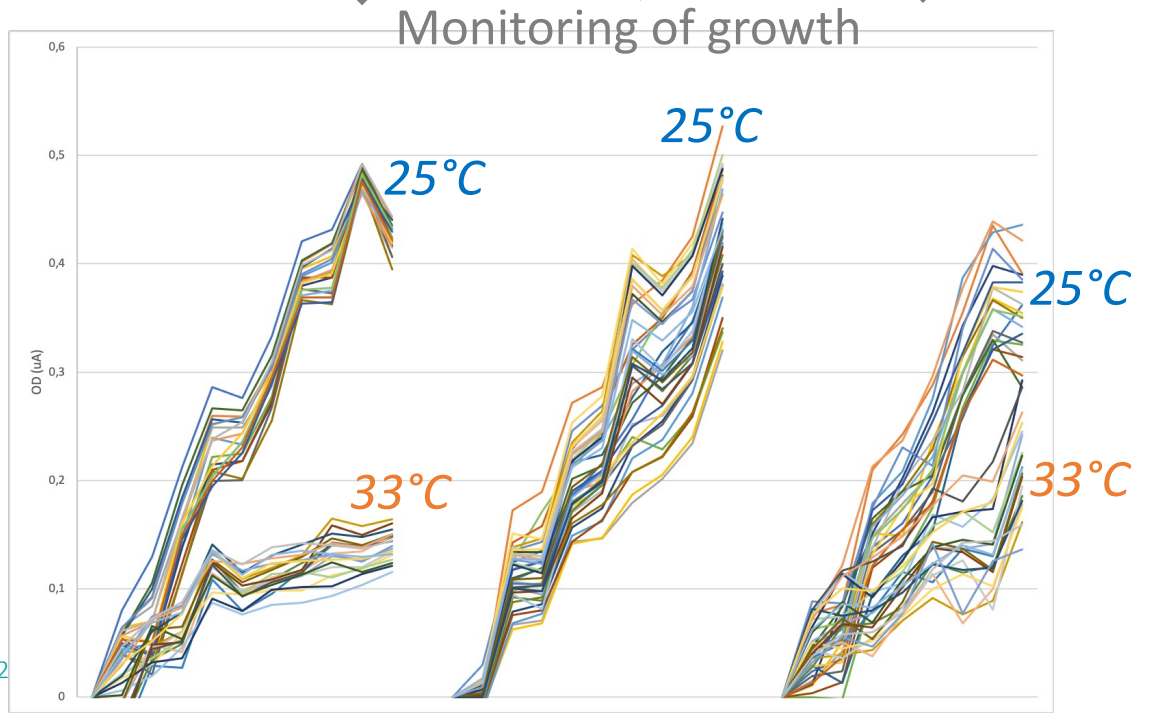
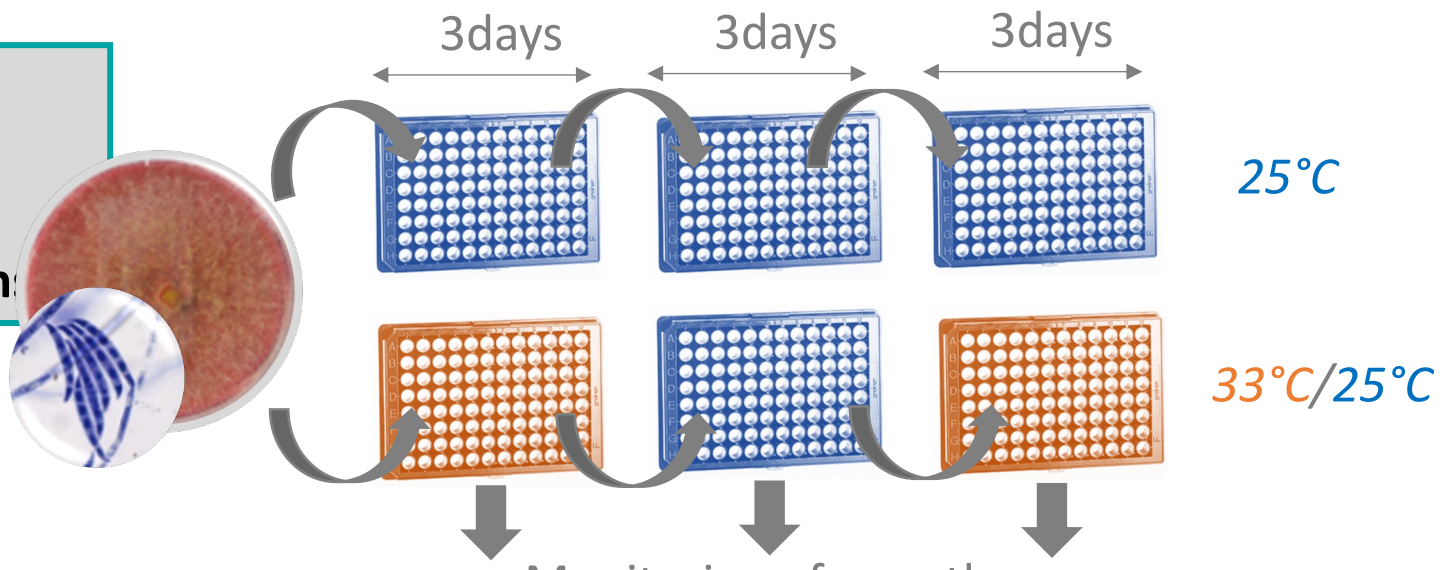
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➤ Acclimation to stress

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H₀
Rapid emergence of heat-tolerant phenotypes suggests epi-variations



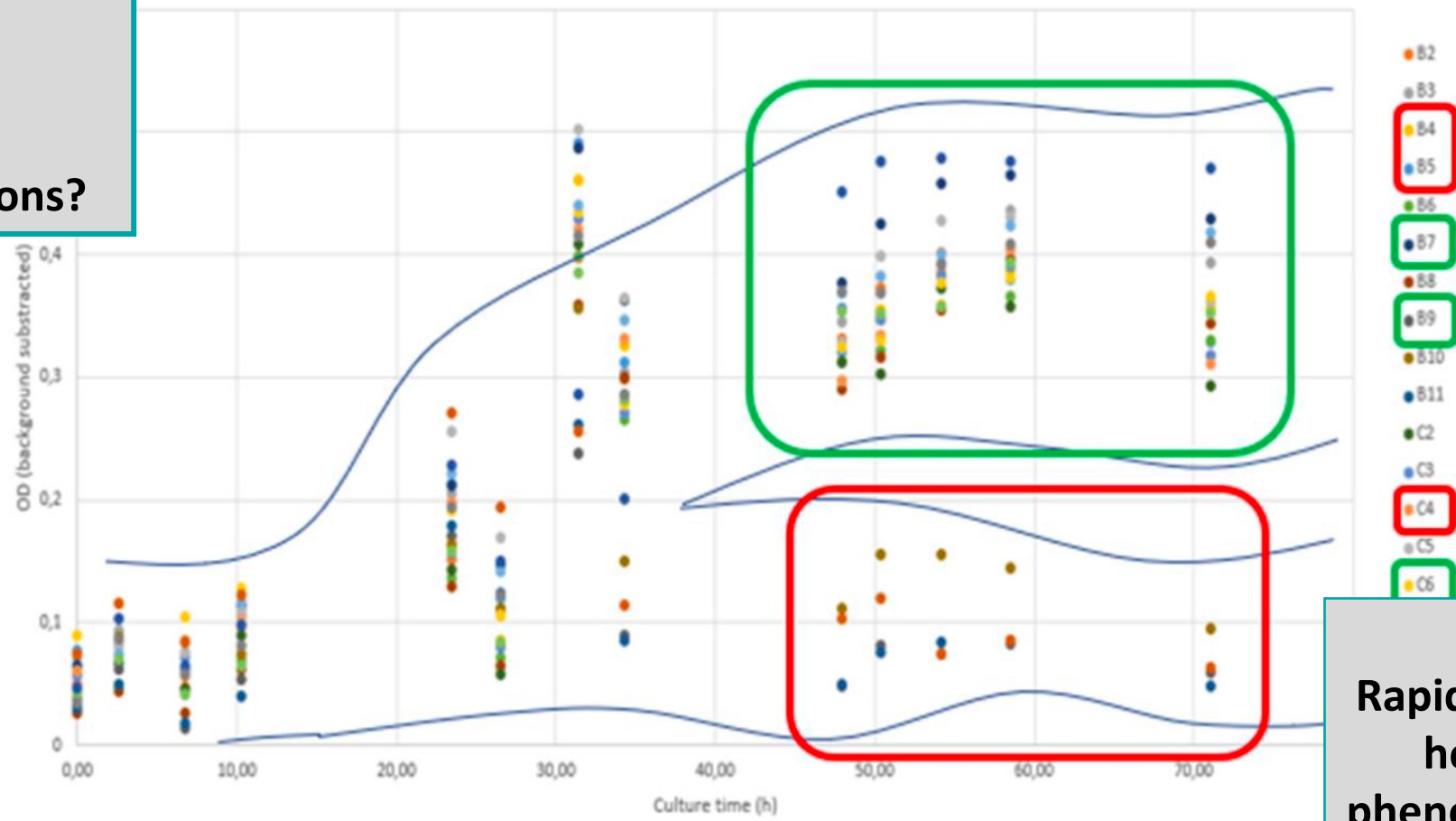
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➤ Acclimation to stress

Heat stress

Q:
Can stress (heat)
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33°C/25°C/ 33°C /25°C/ 33°C



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Rapid emergence of
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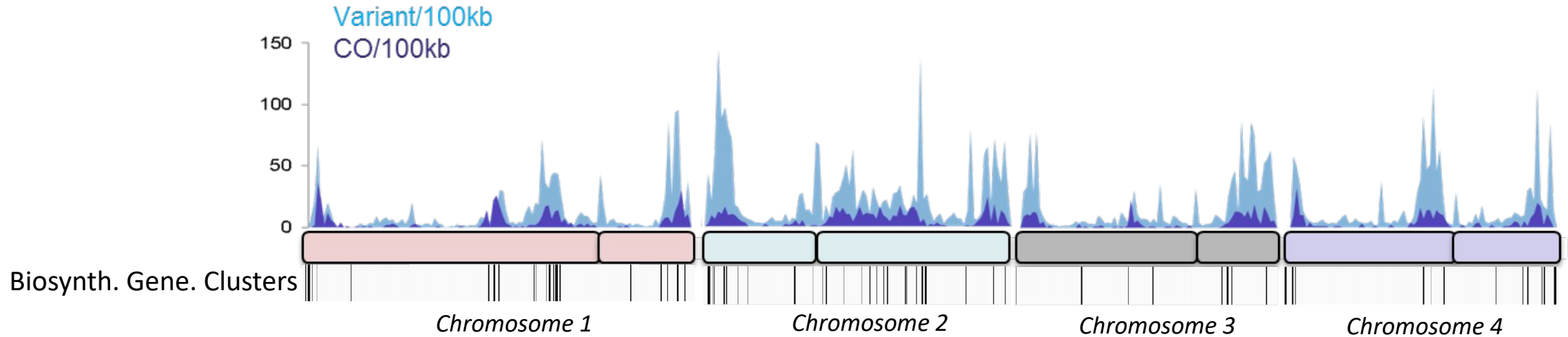
➤ How?



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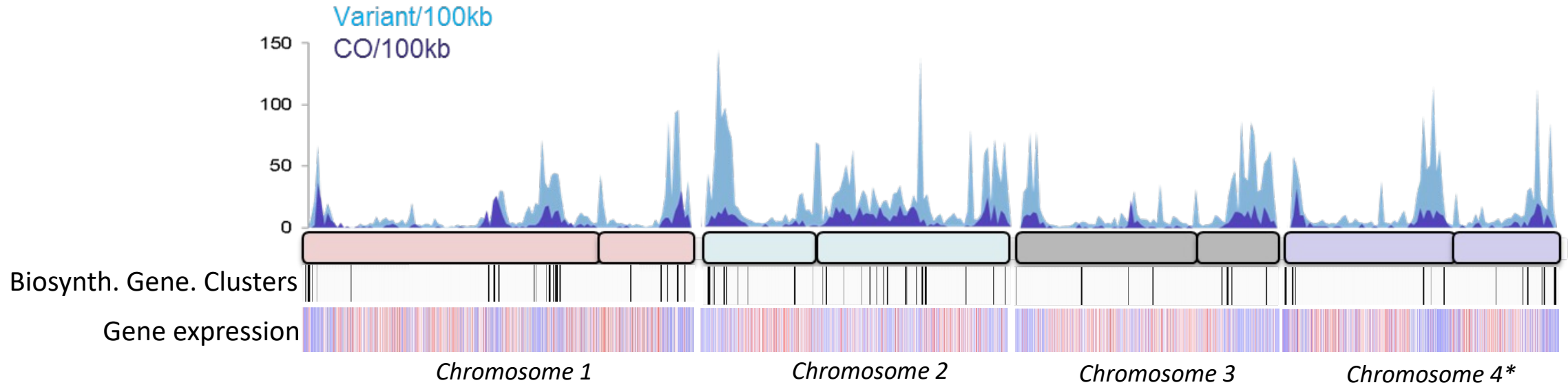
➤ The *Fusarium graminearum* genome

- ~37 Mb; >14k genes; 4 chromosomes; 67 Secondary Metabolites Biosynthetic Gene Clusters



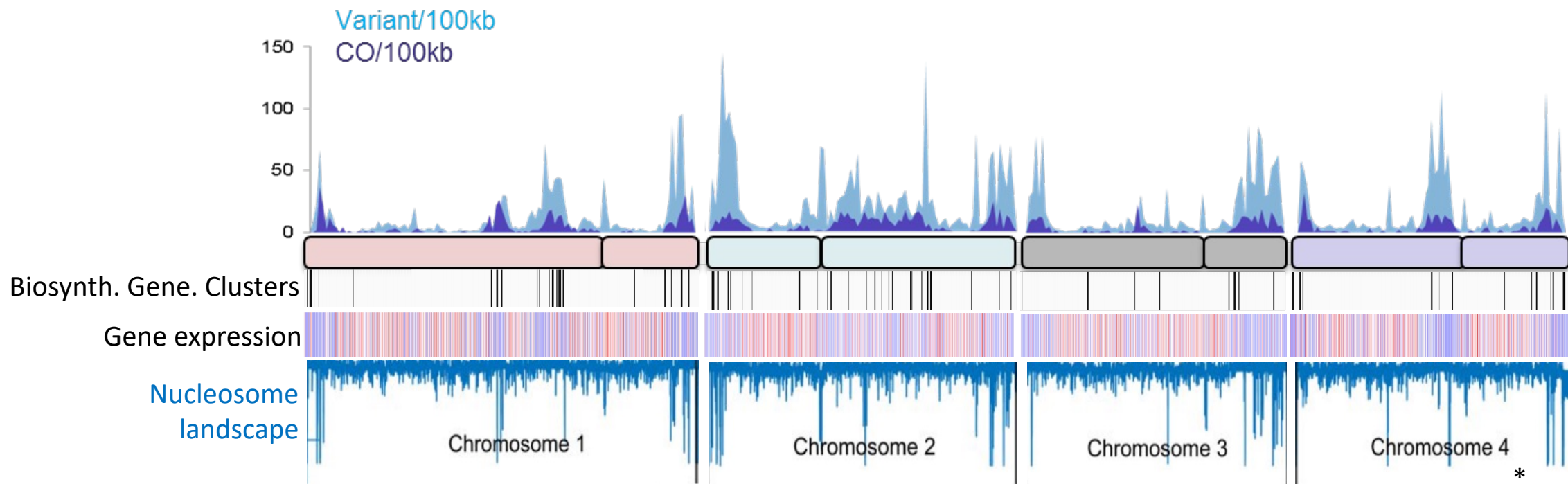
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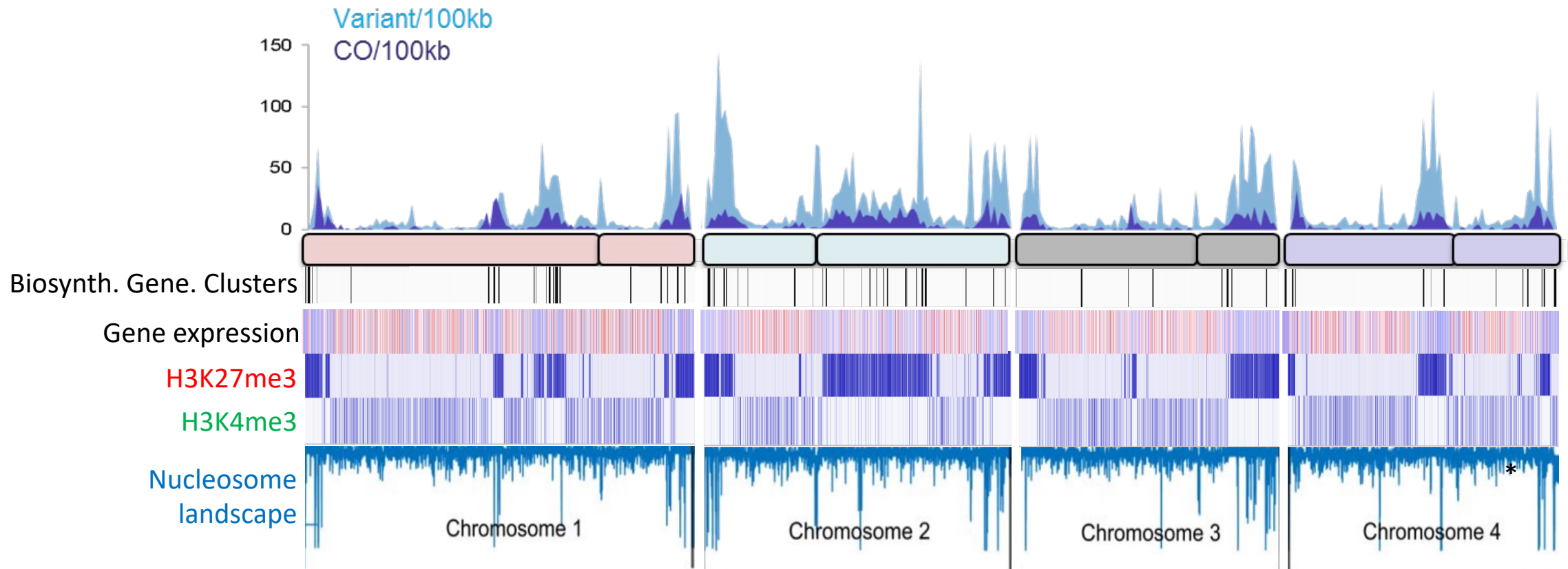
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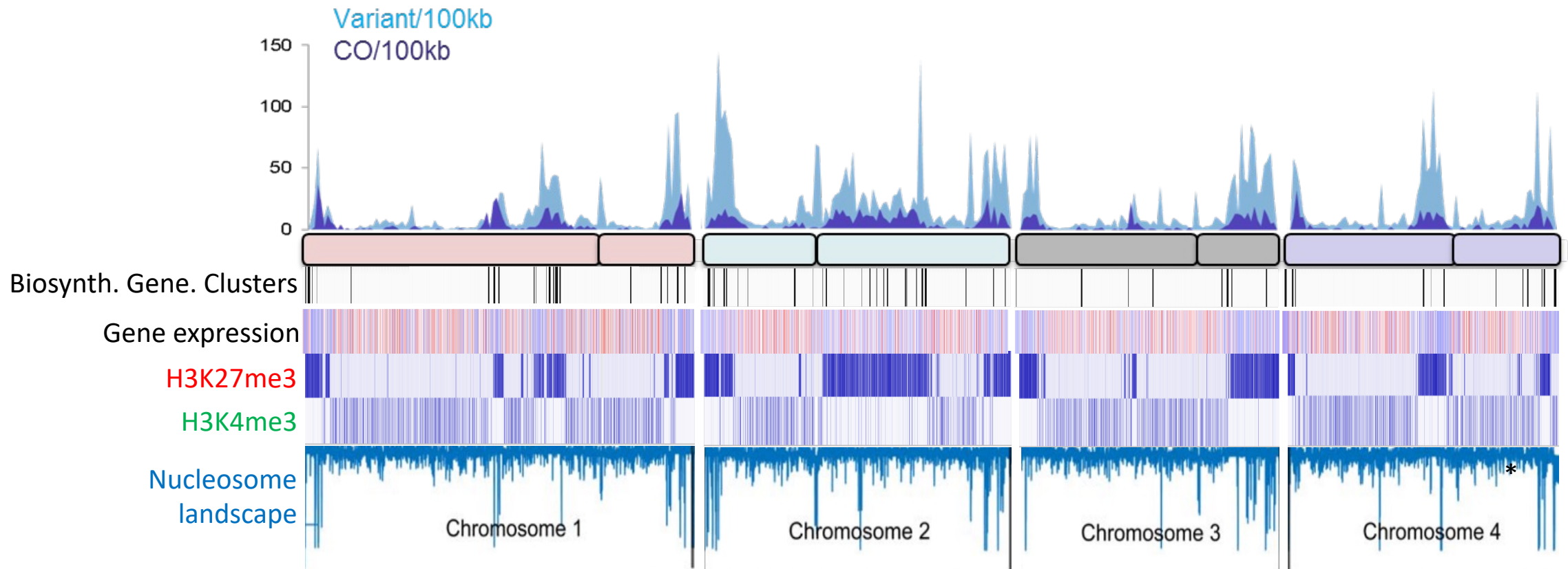


Bi-modal 2-speed genome?



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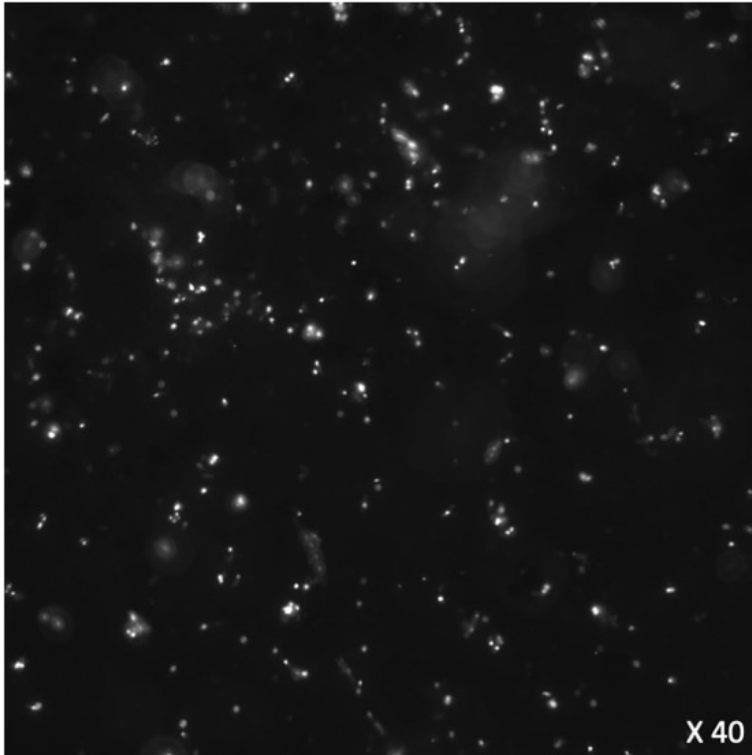


Bi-modal 2-speed genome?

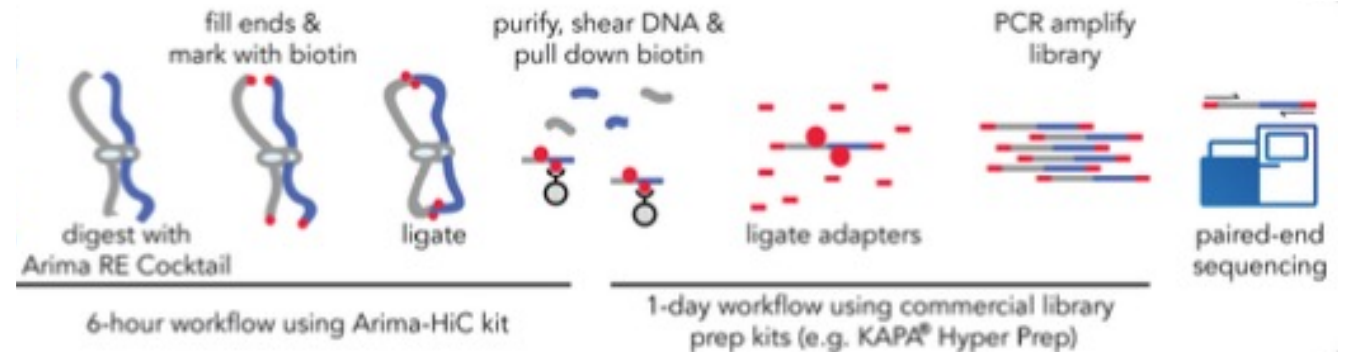
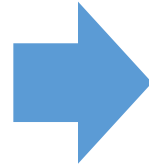
What about in 3D?



➤ The *Fusarium graminearum* genome INSIDE THE NUCLEUS: *in situ* Hi-C



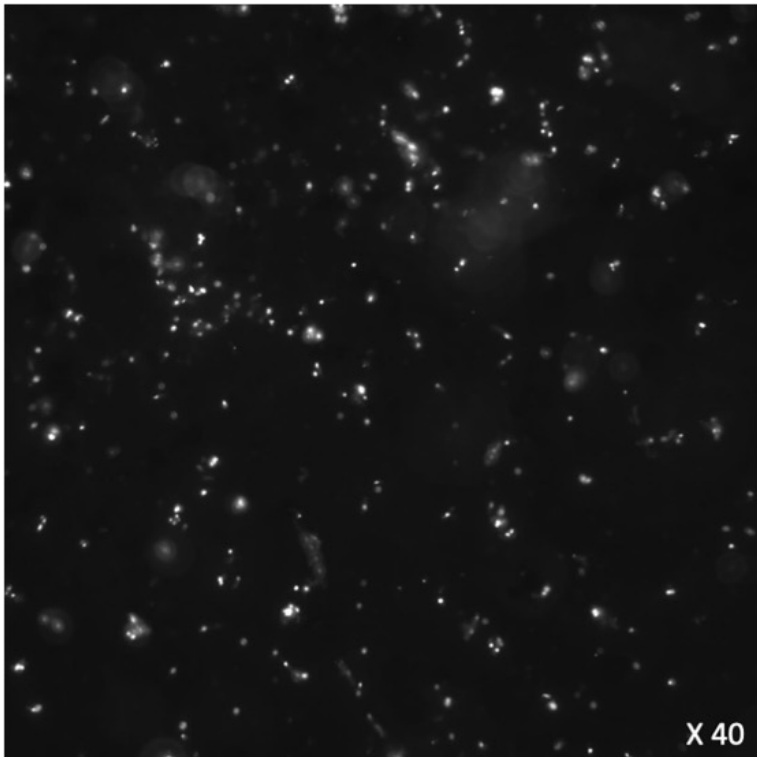
1 – Isolating intact nuclei



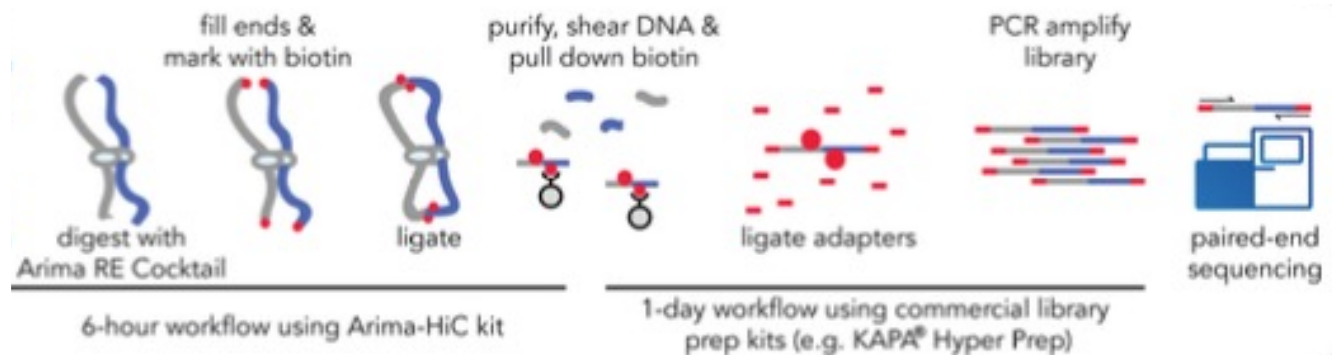
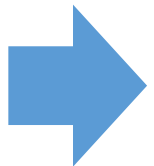
2 – Preparation of sequencing-ready chimeric fragments

3 – Illumina® paired-end sequencing

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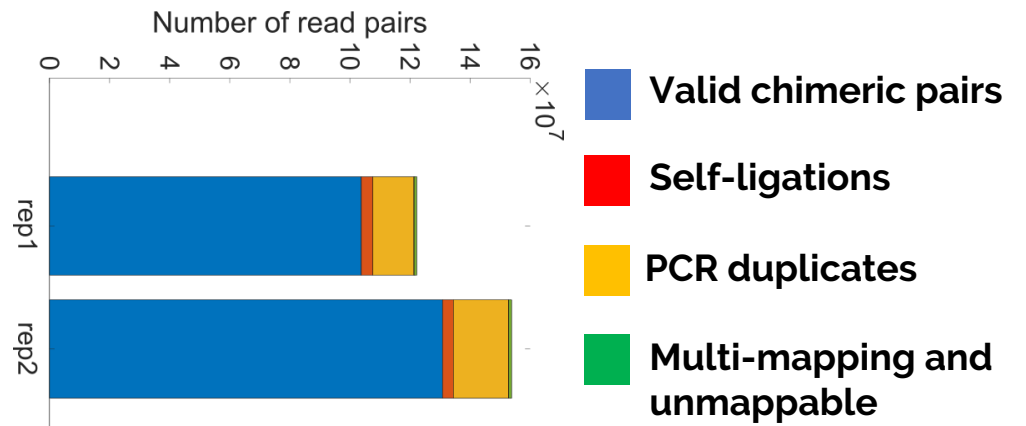
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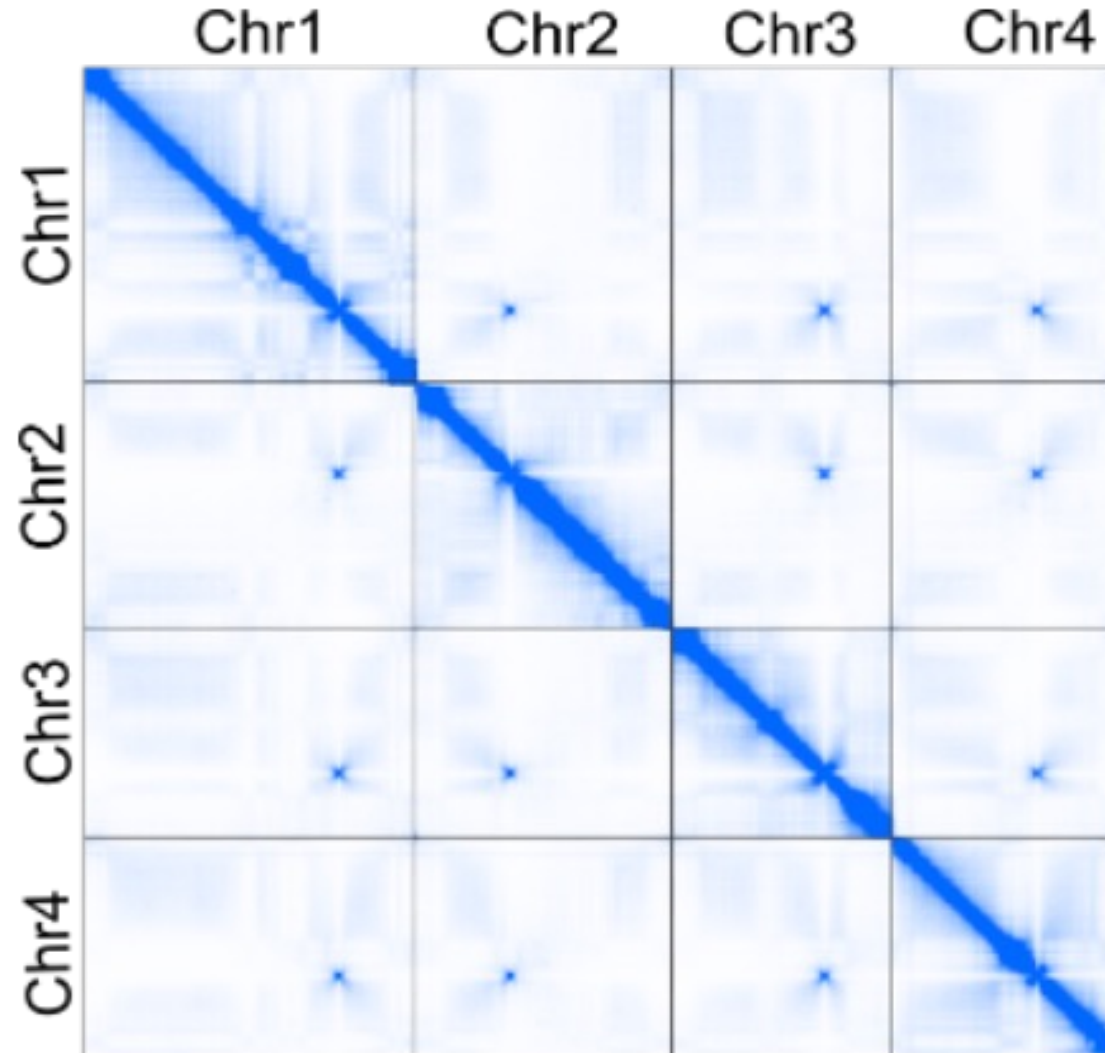
3 – Illumina® paired-end sequencing

4 – Read processing and data analysis.



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➤ The *Fusarium graminearum* genome INSIDE THE NUCLEUS: *in situ* Hi-C



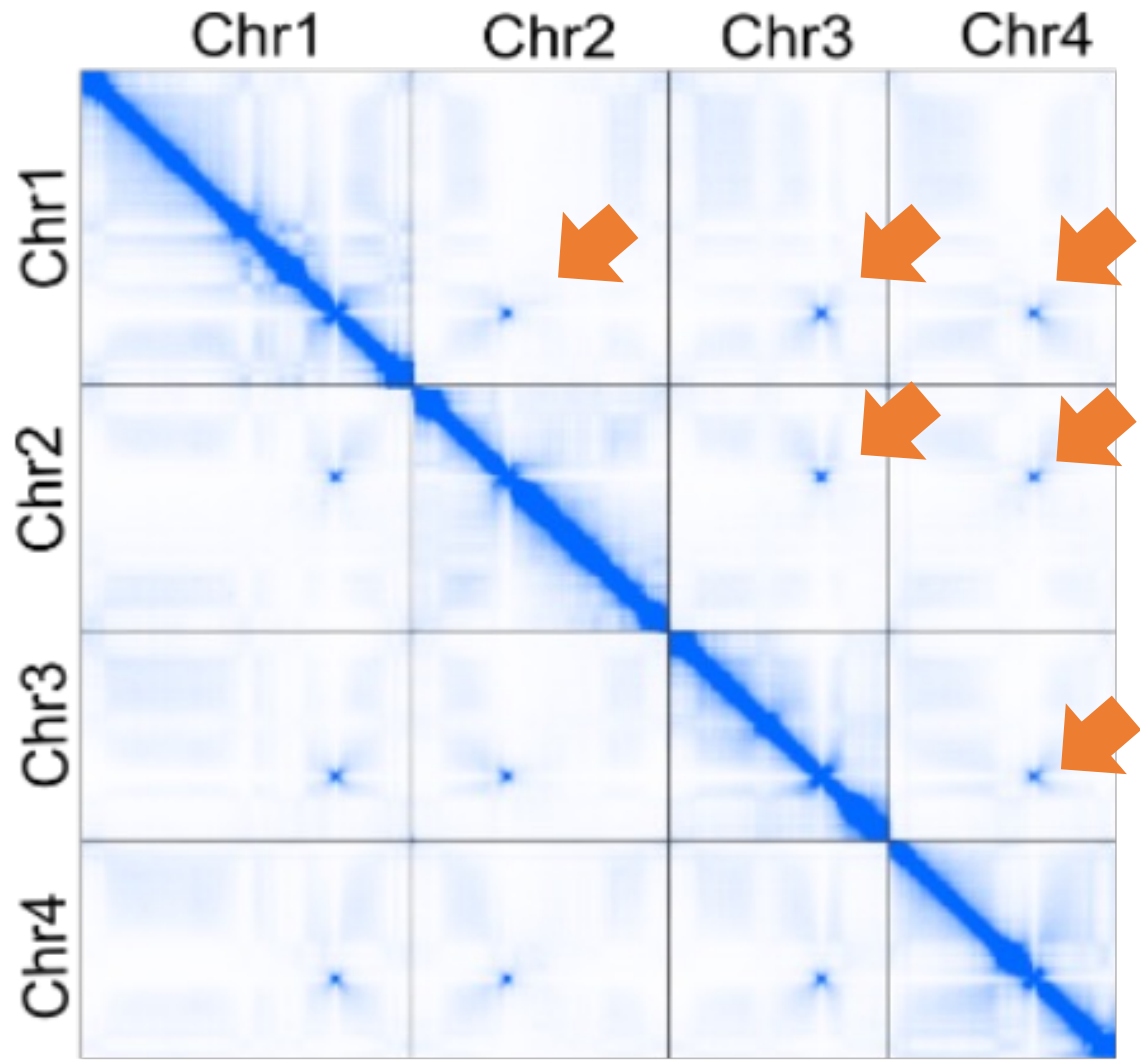
1 pixel = 1 contact

Intensity \Leftrightarrow contact frequency

What we expect *vs.* what we observe

➤ The *Fusarium graminearum* genome INSIDE THE NUCLEUS: *in situ* Hi-C

Trans-interactions at centromere *loci*



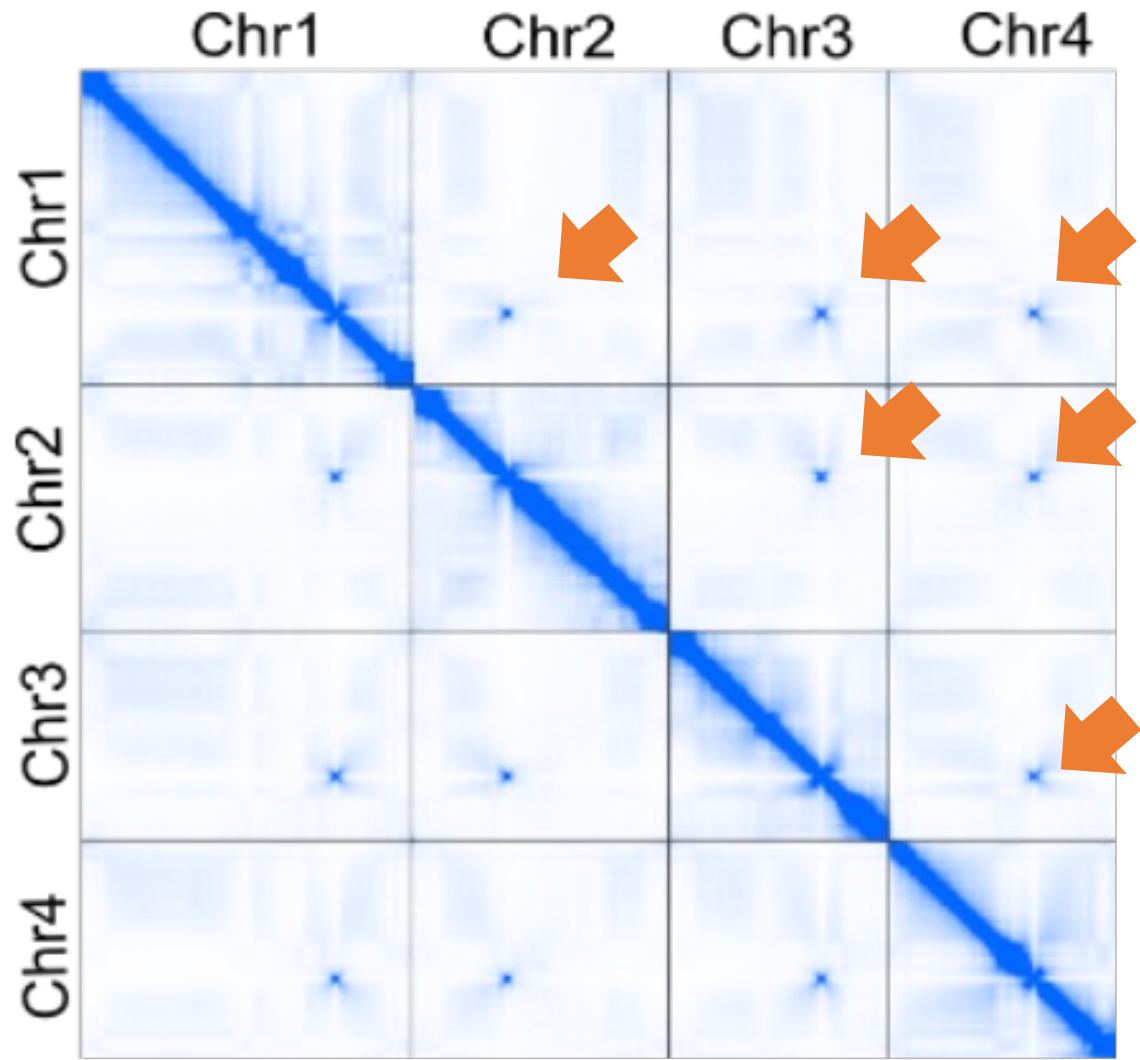
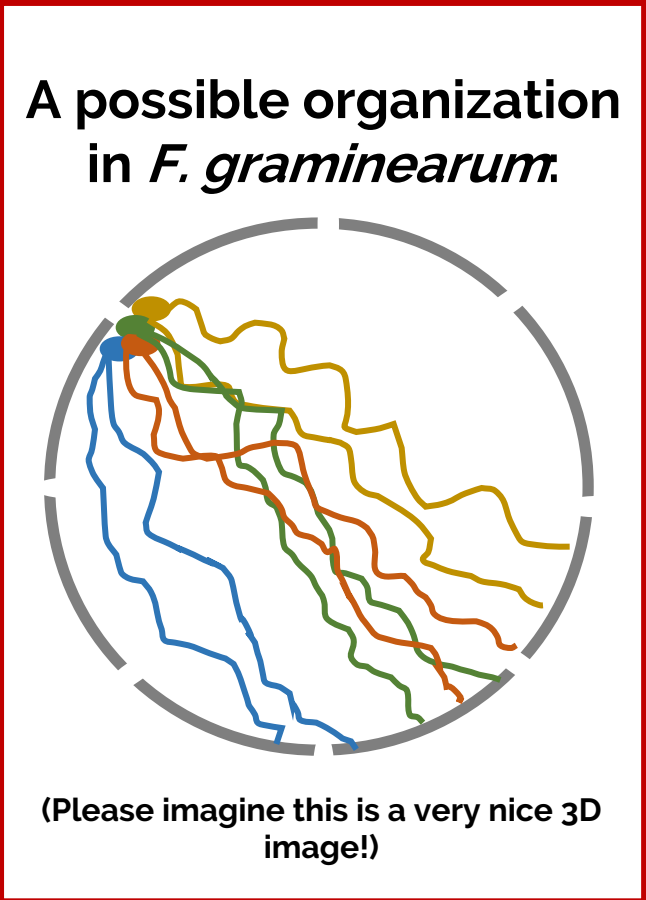
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What we expect vs. what we observe



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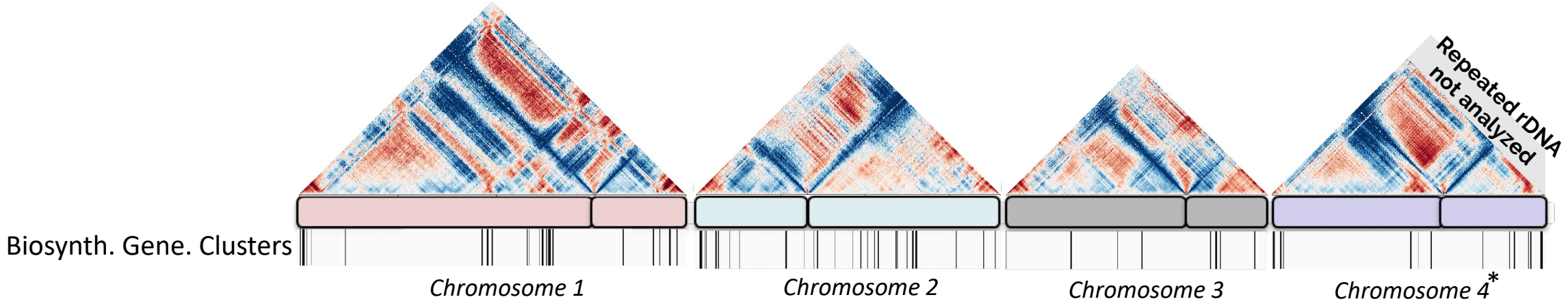
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Observed vs. expected



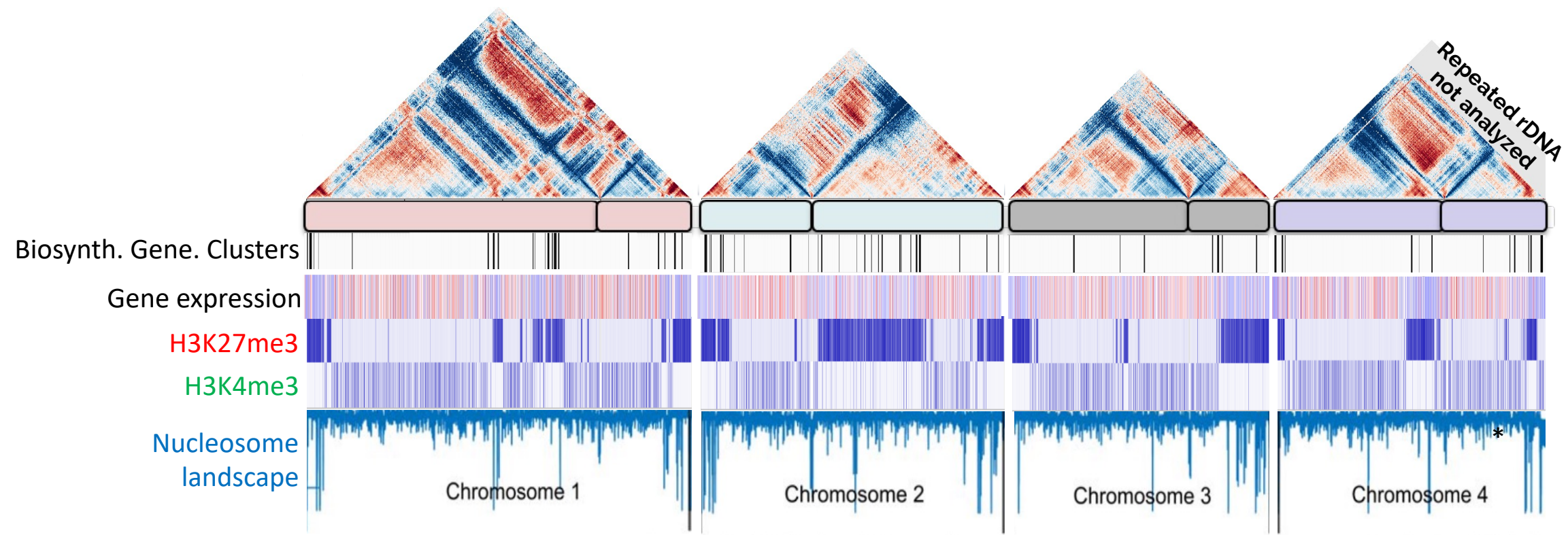
Pearson correlation between distances



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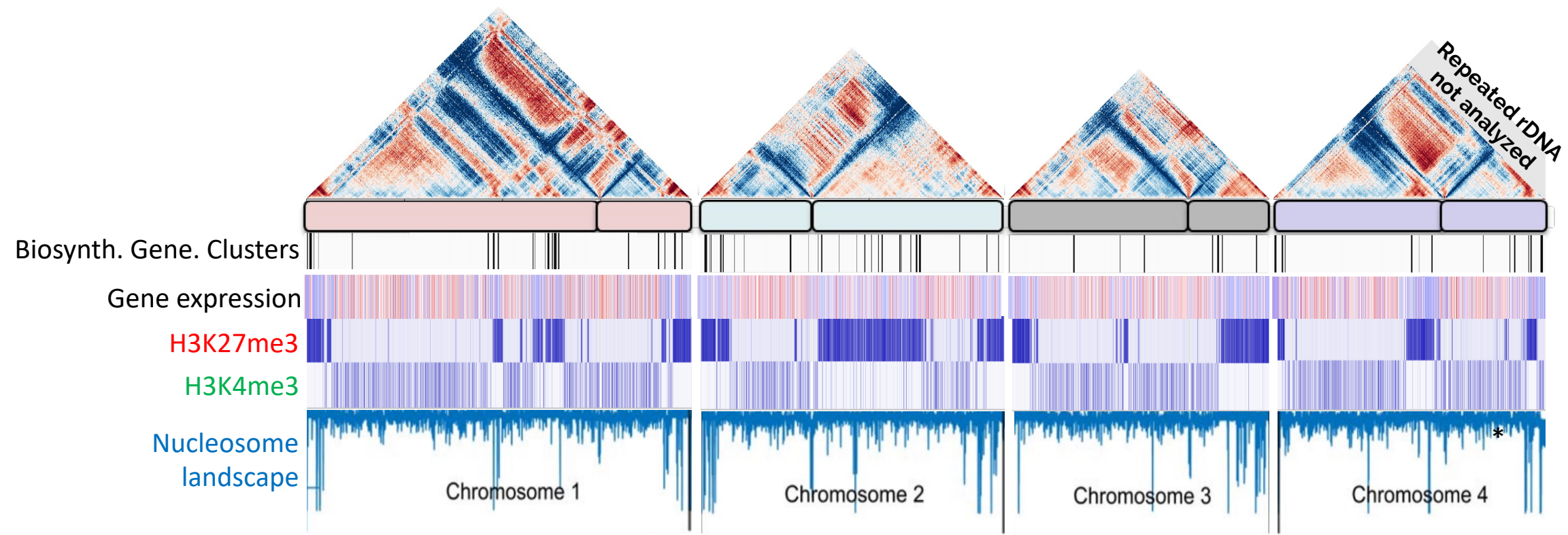
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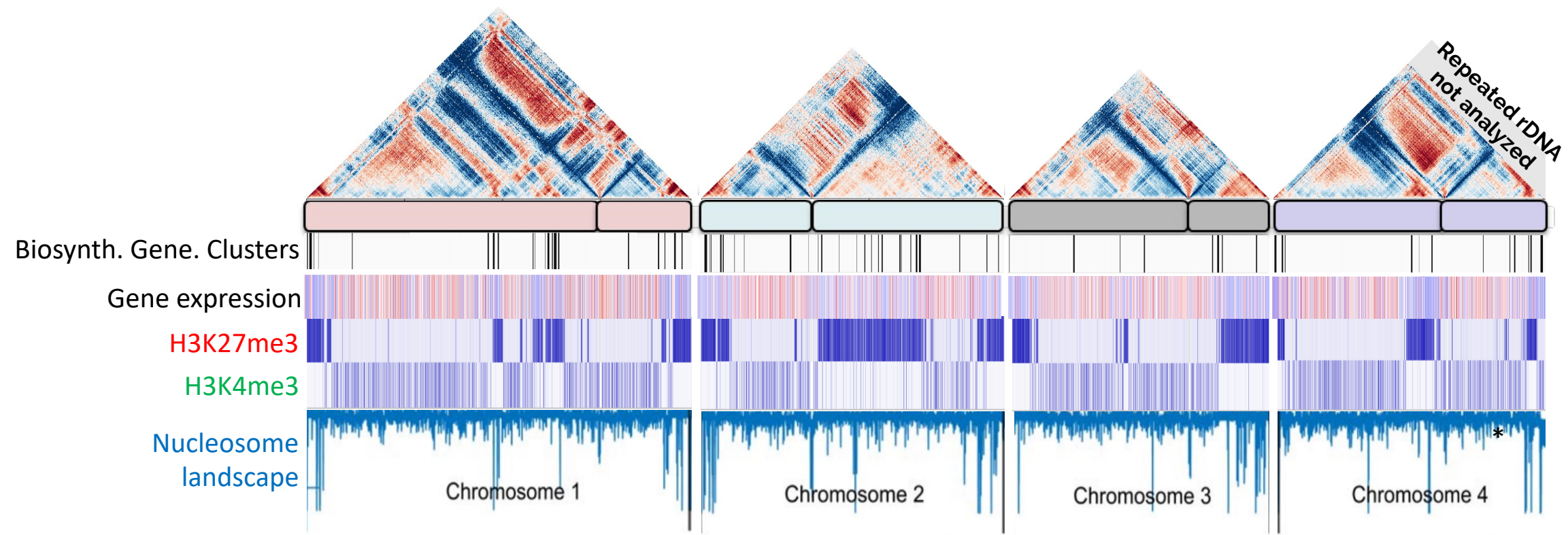
Chromatin-driven bi-modal 2-speed genome...



INRAE

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Chromatin-driven bi-modal 2-speed genome...

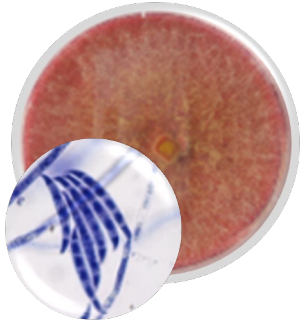
Hard-wired – local rearrangements under stress (soooo preliminary...)



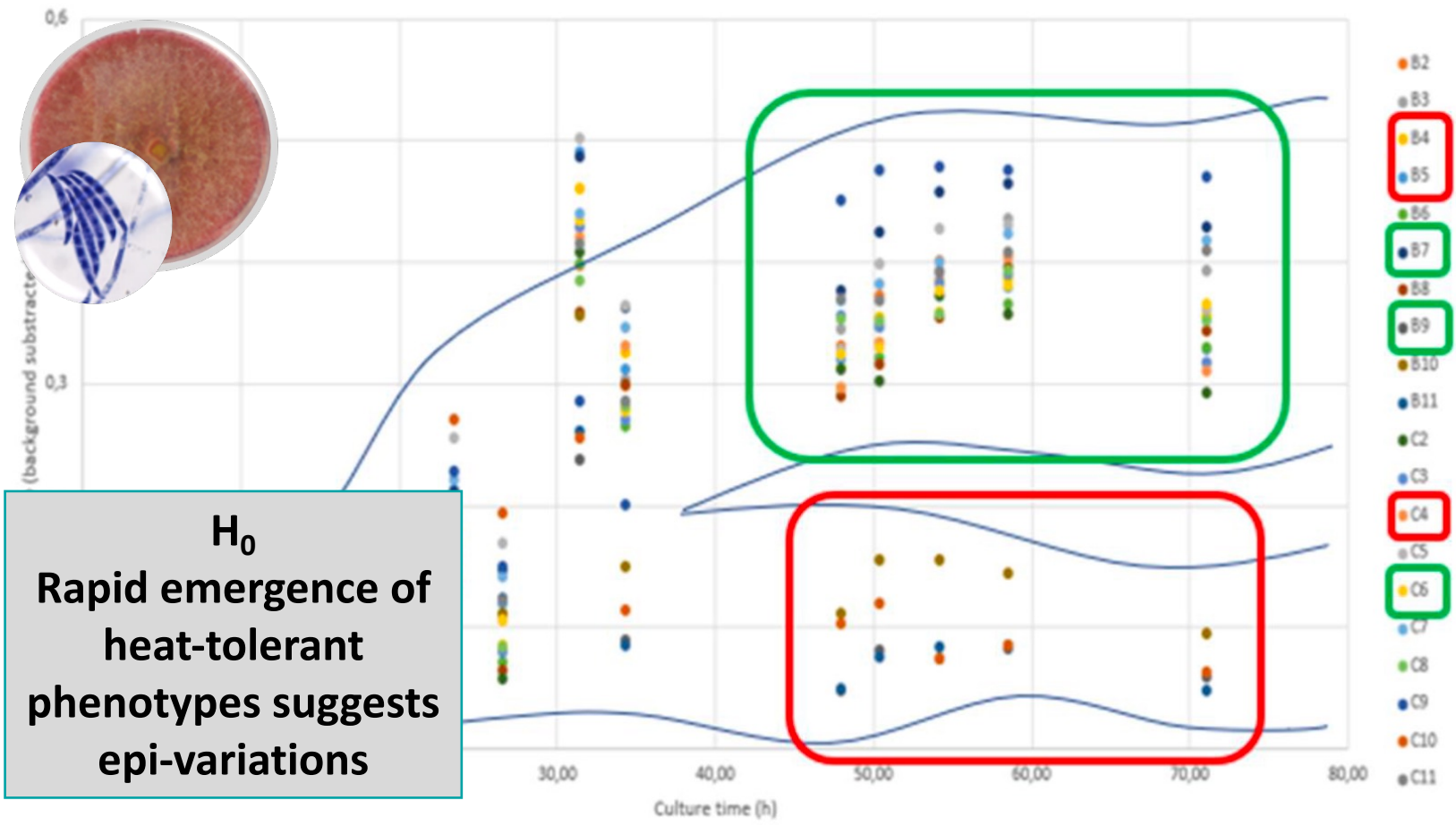
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➤ Phenotype variations of *Fusarium* spp. under stress: a learning process?

To remember...



➤ Phenotype variations of *Fusarium* spp. under stress: a learning process?

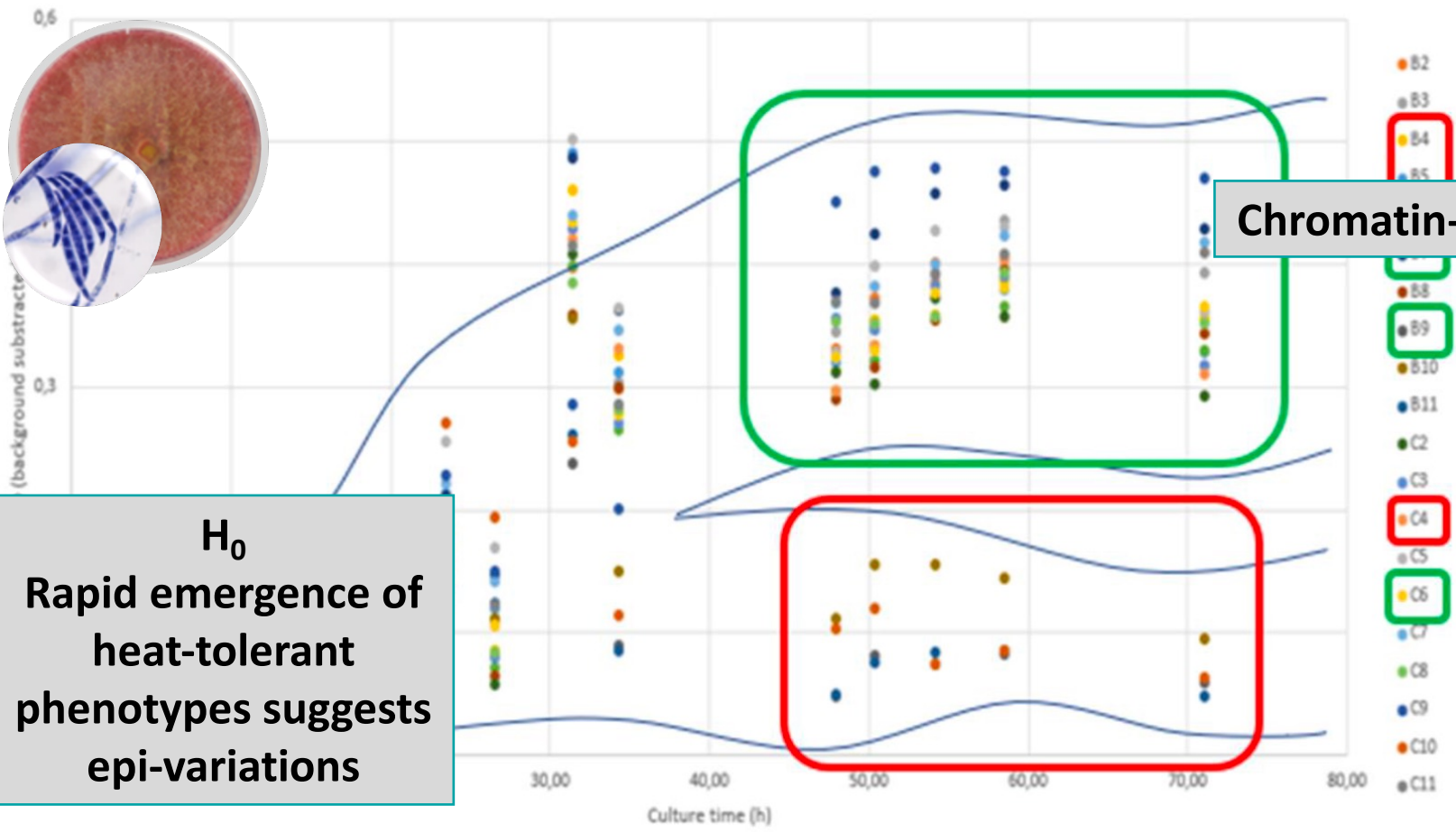


H₀
 Rapid emergence of heat-tolerant phenotypes suggests epi-variations



To remember...

➤ Phenotype variations of *Fusarium* spp. under stress: a learning process?



Chromatin-driven bi-modal 2-speed genome...

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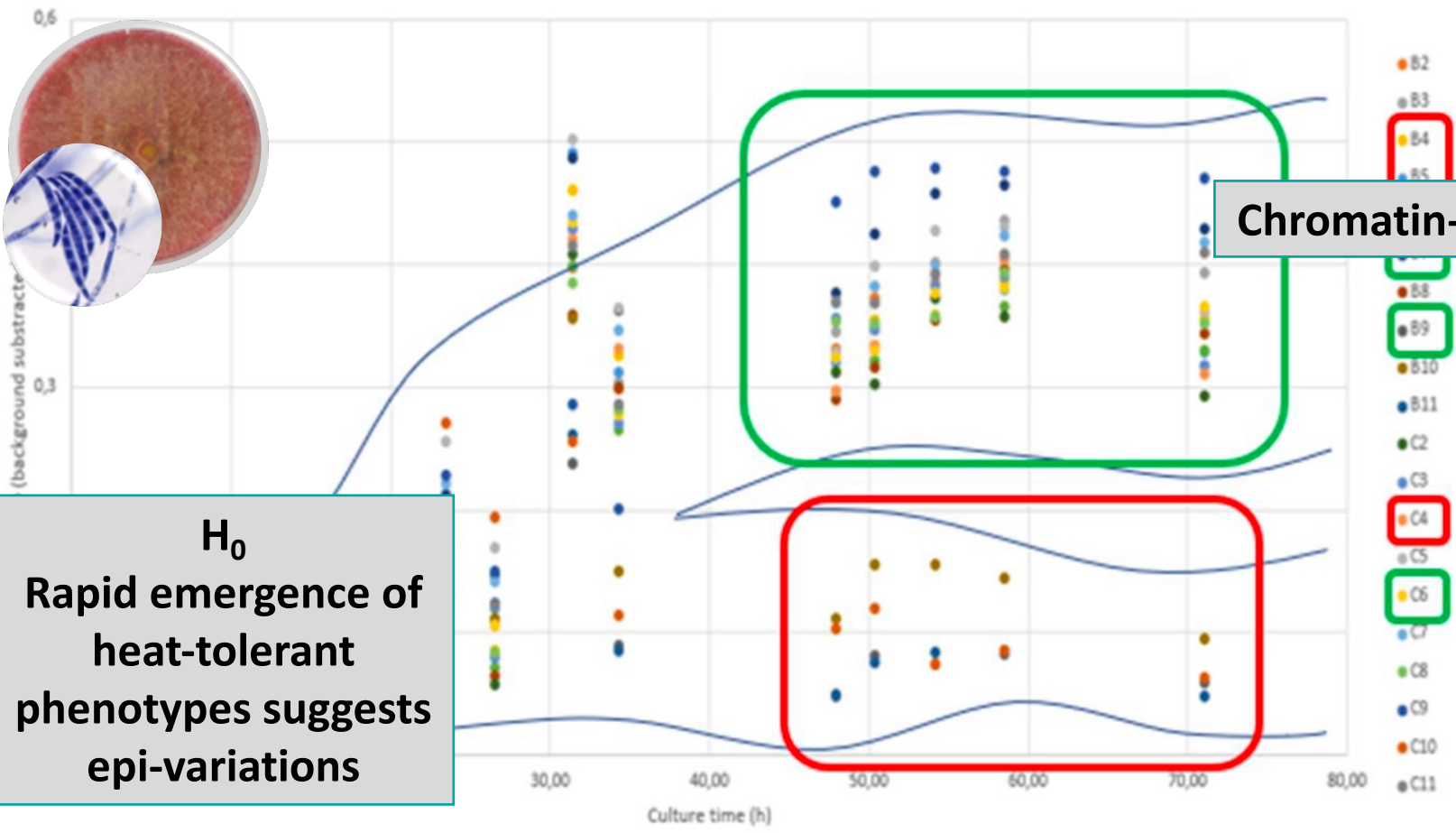
A possible organization in *F. graminearum*:

(Please imagine this is a very nice 3D image!)



To remember...

➤ Phenotype variations of *Fusarium* spp. under stress: a learning process?



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 Rapid emergence of heat-tolerant phenotypes suggests epi-variations

Chromatin-driven bi-modal 2-speed genome...

A possible organization in *F. graminearum*:

(Please imagine this is a very nice 3D image!)

Rearrangements under stress to be confirmed



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➤ Thank you all!



Special thanks to:

**Aurelie Etier
Fabien Dumetz**



**Gael Le Trionnaire & Nathalie
Prunier-Leterme (INRAE Rennes)**



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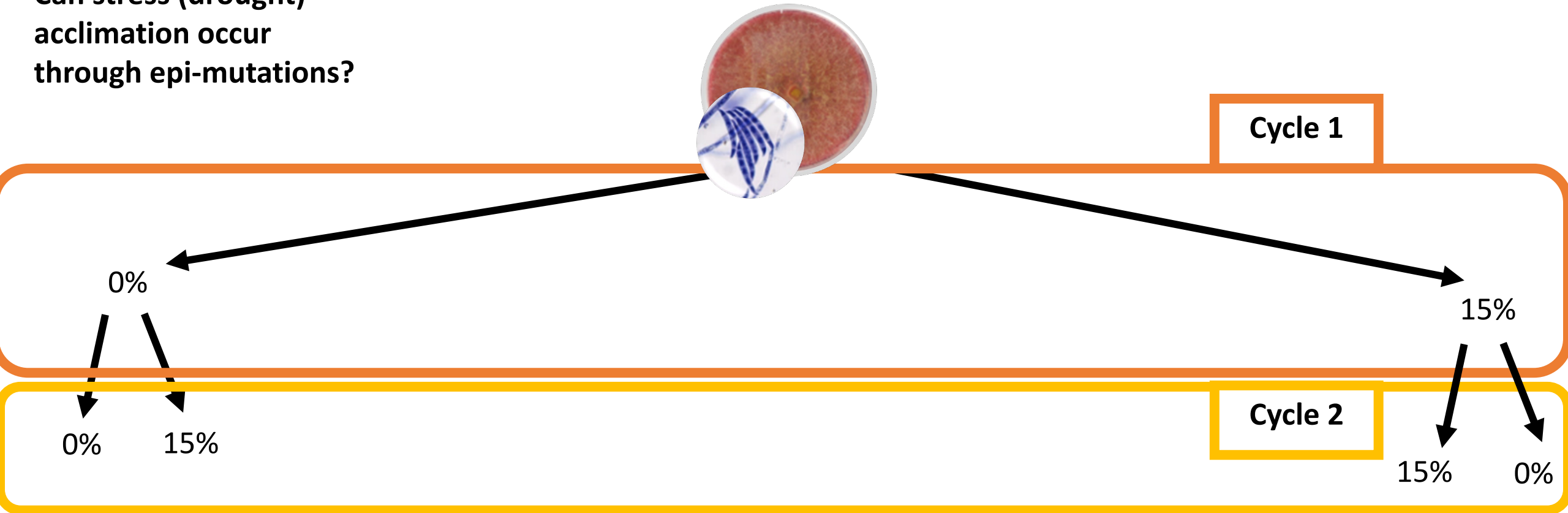
WEPSD - EPICATCH Works

> Acclimation to stress

Drought-like stress

+ PEG-6000

Q:
Can stress (drought)
acclimation occur
through epi-mutations?



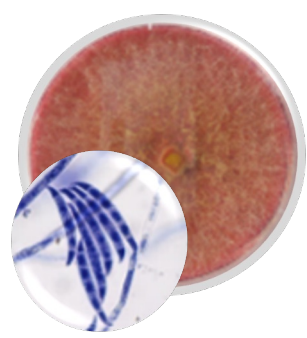
Etc.



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> Acclimation to stress

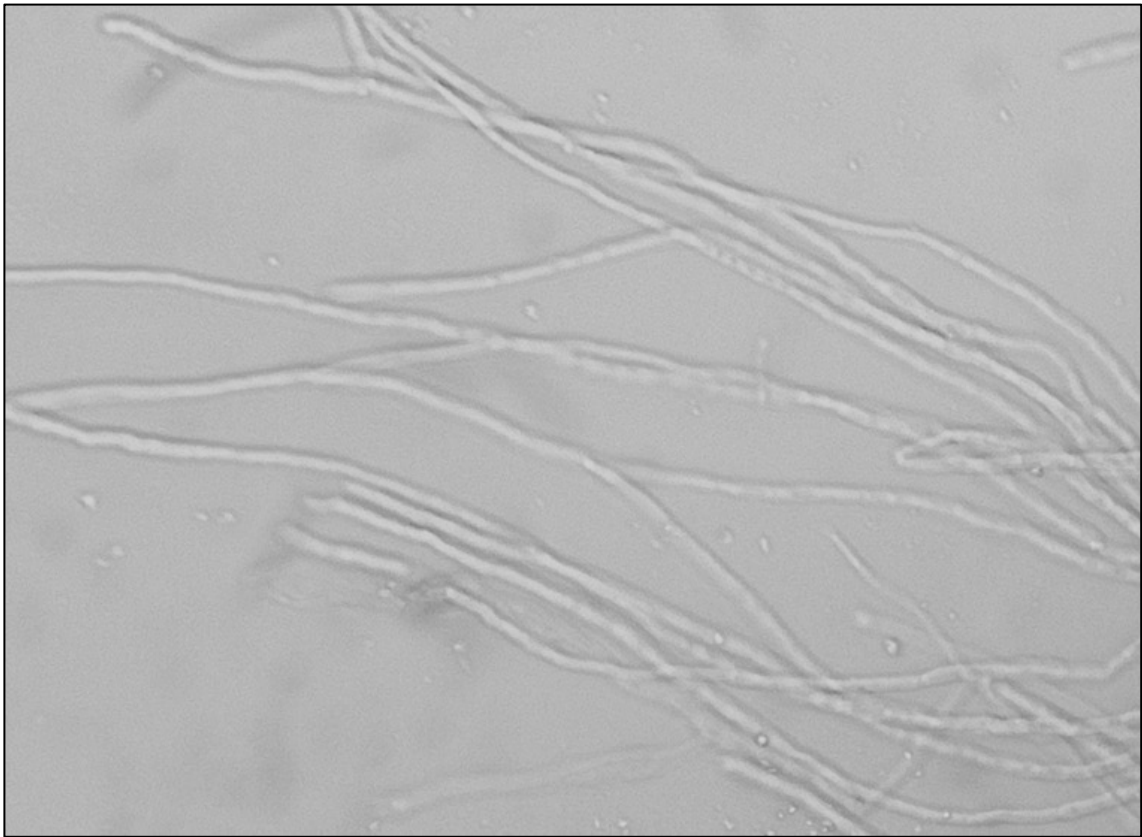
Drought-like stress + PEG-6000



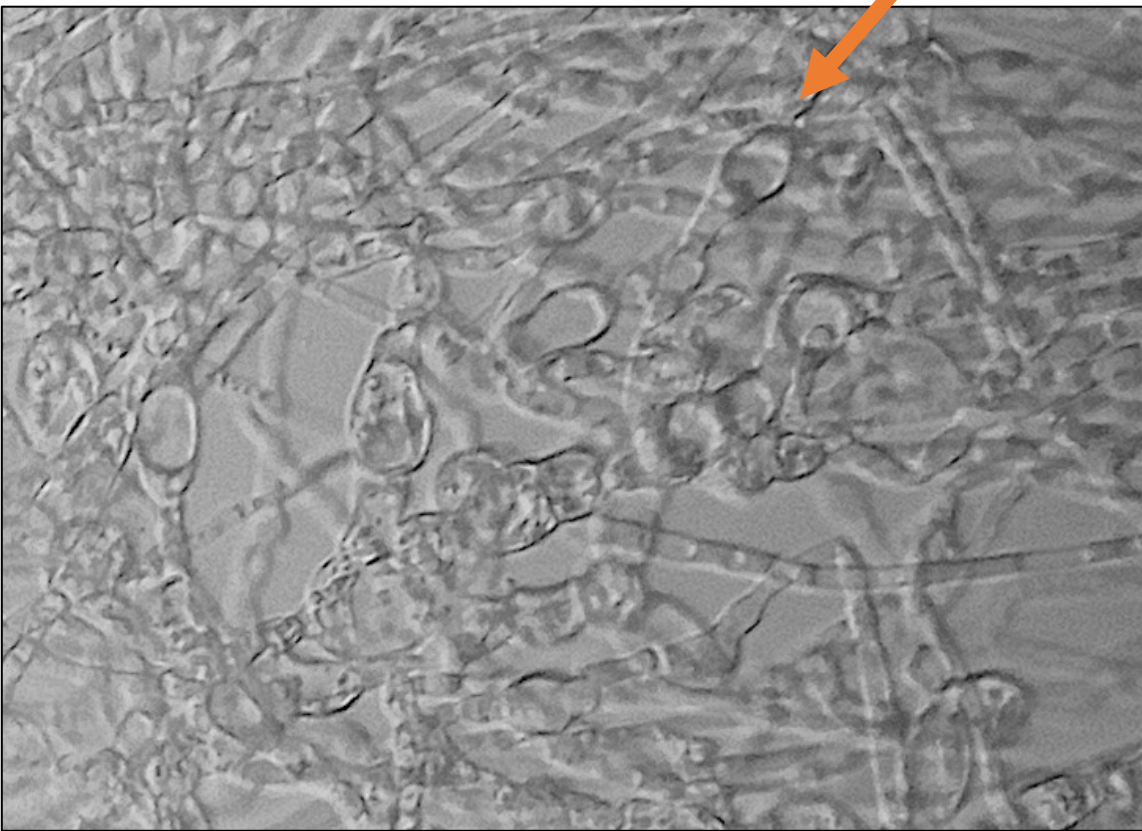
Cycle 1

Chlamydozoospores with PEG-6000

0%



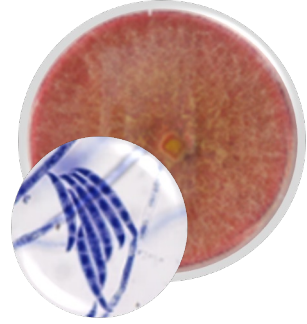
15%



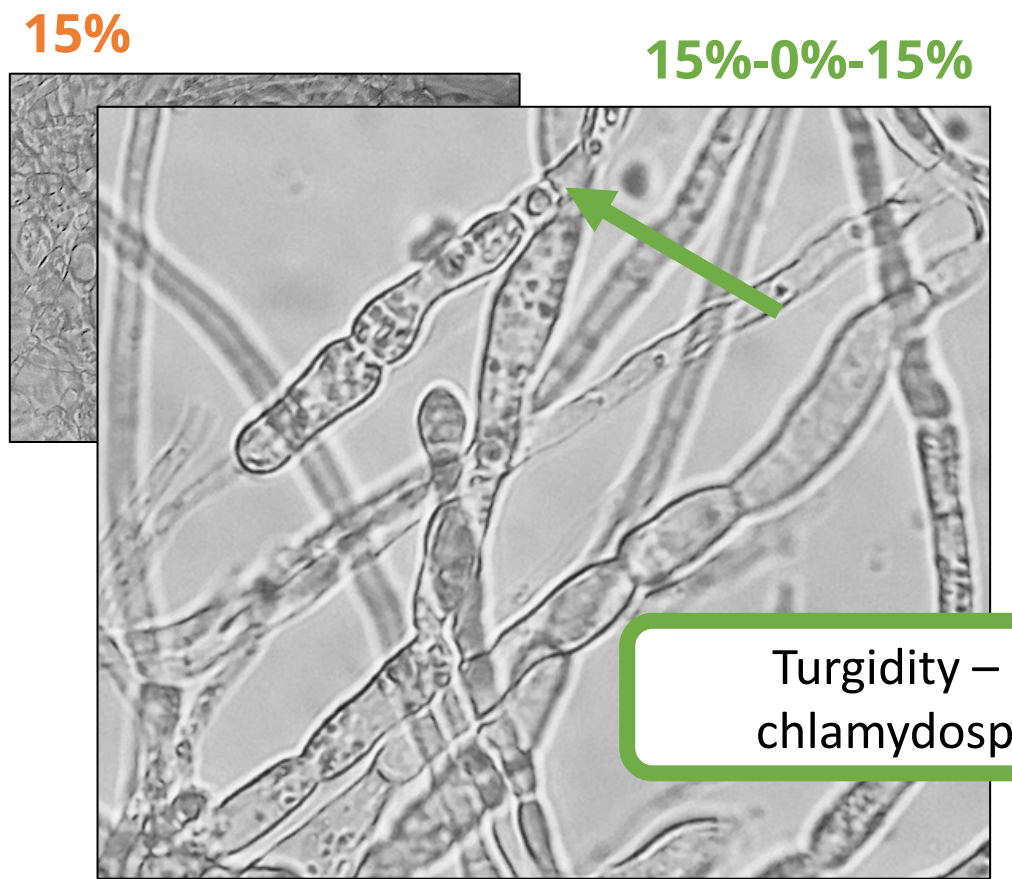
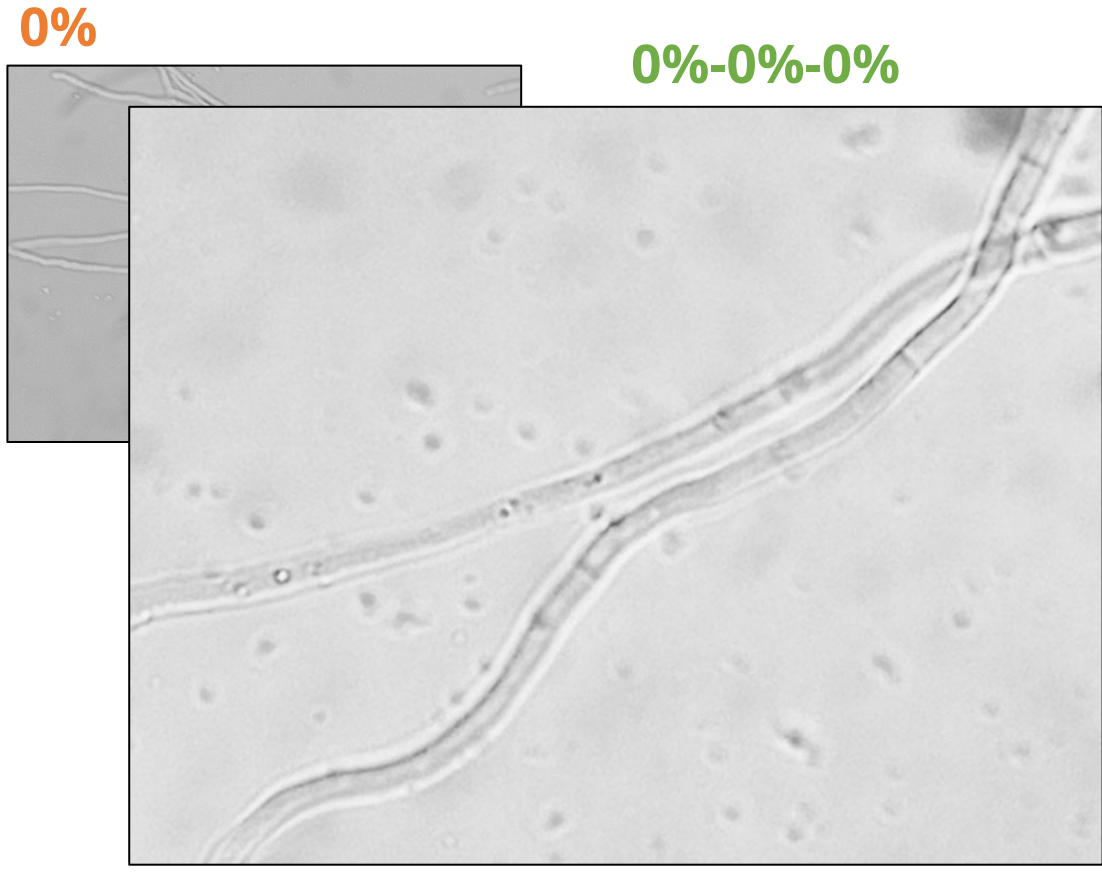
INRAE

> Acclimation to stress

Drought-like stress + PEG-6000



Cycle 1
Cycle 3



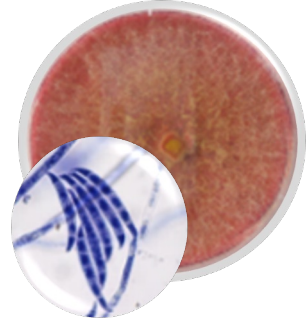
Turgidity – less chlamydospores



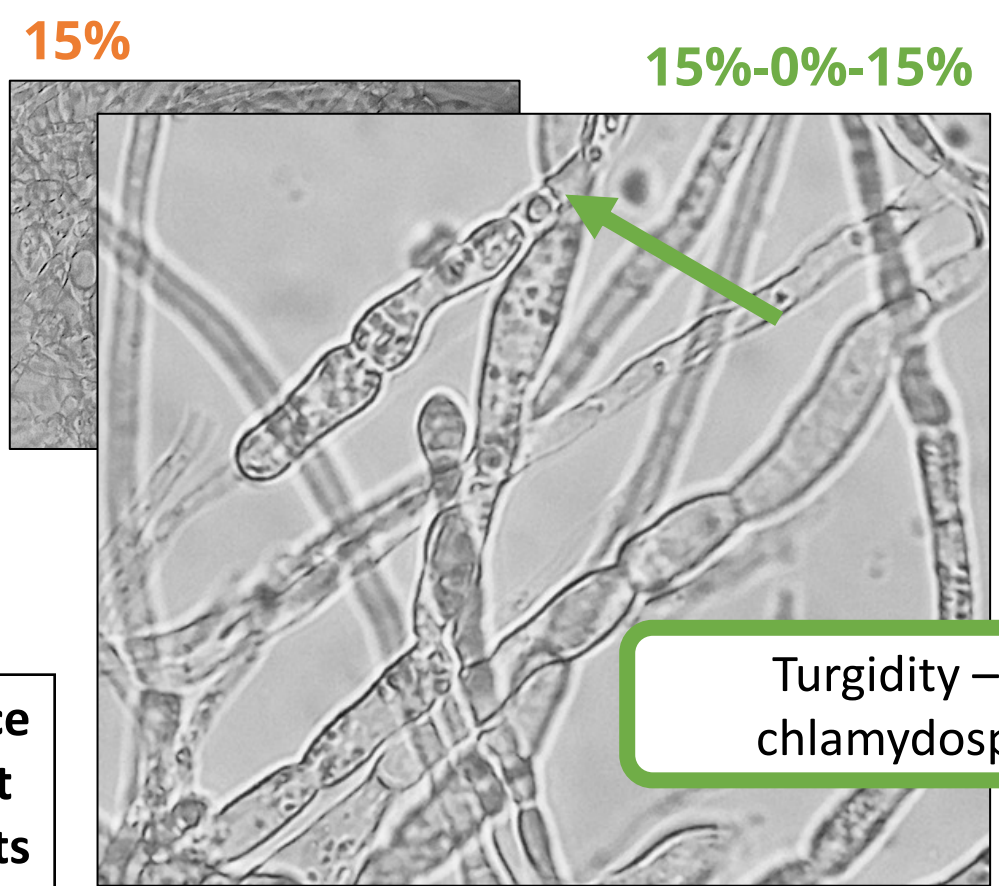
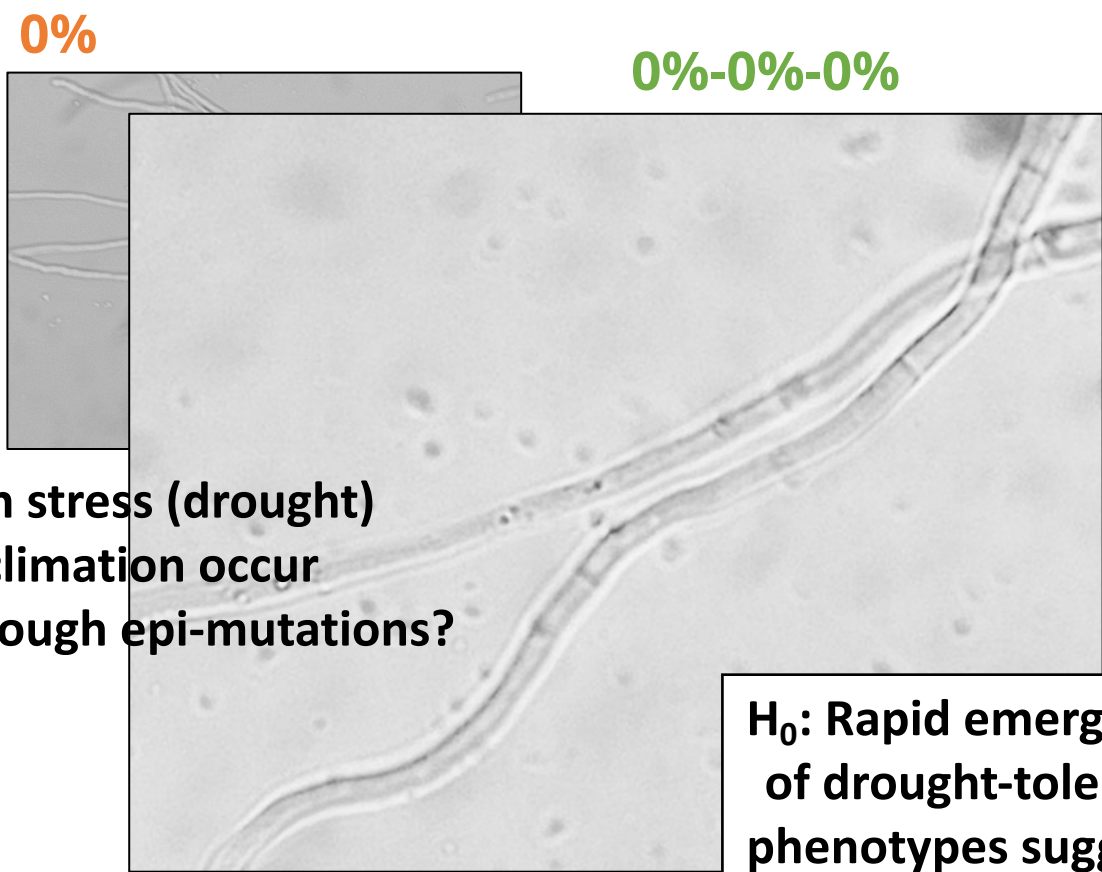
INRAE

> Acclimation to stress

Drought-like stress + PEG-6000



Cycle 1
Cycle 3



Q: Can stress (drought) acclimation occur through epi-mutations?

H₀: Rapid emergence of drought-tolerant phenotypes suggests epi-variations

Turgidity – less chlamydospores



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