ERA CoBioTech (ERA-Net Cofund on Biotechnologies)

ACHEMA2018

Kick-off session: "Biotechnology for a sustainable bioeconomy"

Model-guided evolution for balanced attenuation of wine ethanol content by developing non-GMO yeast strains and communities

CoolWine

Ramon Gonzalez

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant 722361

Frankfurt am Main, 15.06.2018

Project partners

- Spanish Council for Scientific Research, Spain
- Rovira i Virgili University, Spain
- Norwegian University of Science and Technology, Norway
- European Molecular Biology Laboratory, Germany
- University of Gothenburg, Sweden
- Bodegas Roda S.A., (not funded)

- Total project budget: 1.504.000 €

- Project started: May 20018

Why doing research on wine improvement?

Some figures on the European wine sector

- Contribute with >€ +6 billion to the EU trade balance
- About 10% of value of agricultural production for some countries
- 20% of total employment in EU agriculture: >5 million jobs
- European Landscape Convention: relevance of vineyards

Why doing research on wine improvement?

Spain

- 69 Designations of Origin
- 46 Protected Geographic Indic.
- 13 % World vineyard surface (1st)
- 14 % Word wine production (3rd)
- 1st wine exporter in volume
- 1% Spanish GDP
- 20% Spanish Agro-food GDP
- Landscape
- Culture
- Tourism

Why doing research on wine improvement?

La Rioja

- 41% of Agro-food production
- 27,4% of farmland
- 9% del GDP
- 15.000 farmers
- >500 wineries

Global warming and alcohol degree

- Total increase of around 3% ABV since the eighties
- Related to climate change
- Impact on consumer acceptance and international trade
- Lower alcohol wine market estimated +30% per year
- Other producing countries (NZ) have started large research programs to address this issue
- Market not ready for GMO-based solutions

Suitable carbon sink?

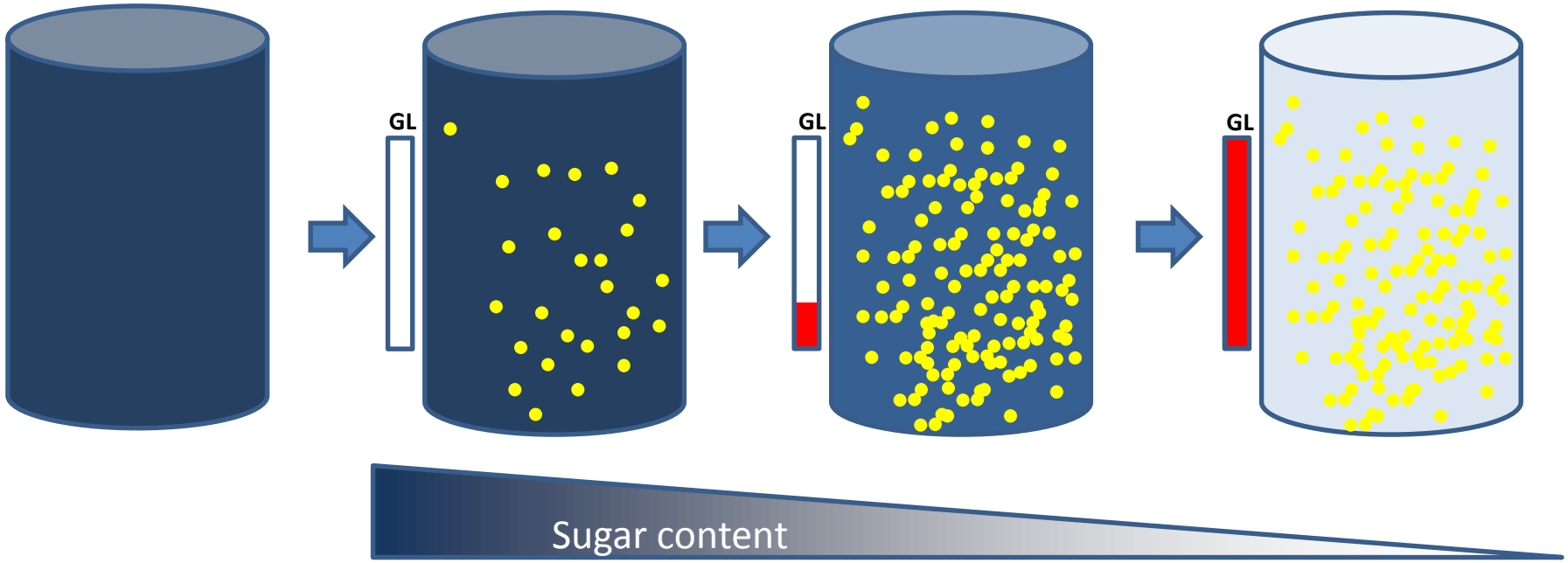
We need going from above 16% to around 12% ethanol

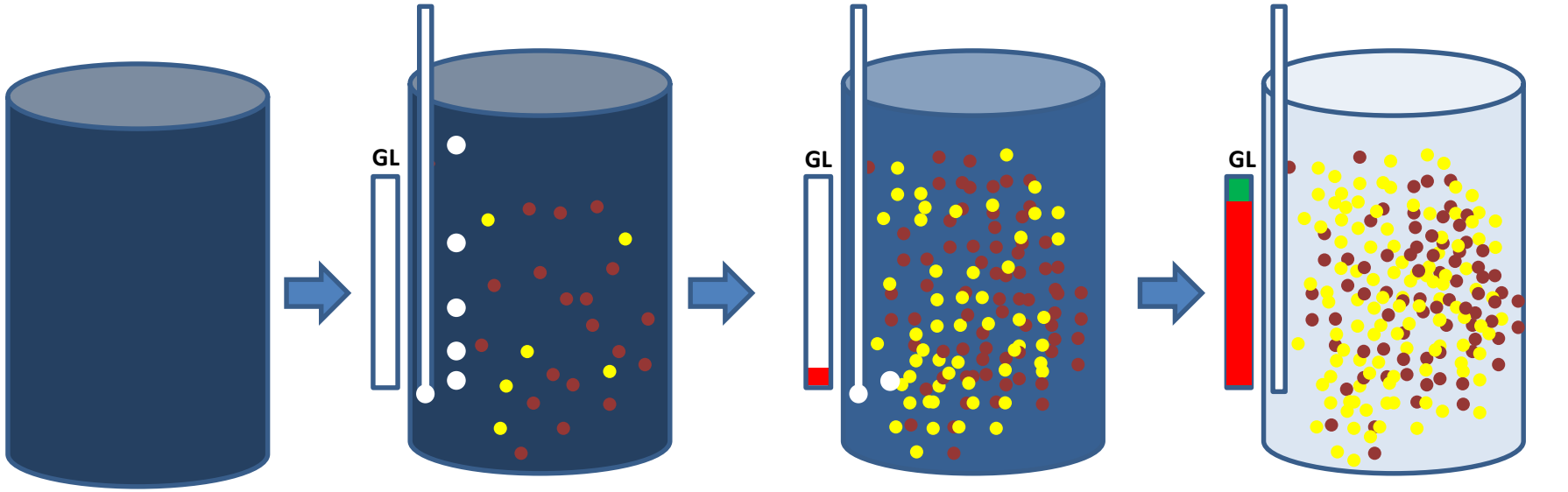
-1% ethanol ➡ +15,8 g/L glycerol

Glucose ⟶ 2 Ethanol + 2 CO_2

Glucose + 6 O_2 ⟶ 6 CO_2 + 6 H_2O

Alcohol level reduction by co-inoculation and aeration





Experimental evolution to improve wine yeast strains

Problems to tackle

- Competitive fitness of Crabtree-negative yeasts
- Yeast strain/species compatibility
- Acetate production by *S. cerevisiae* (which is always present)

Adaptive laboratory evolution tools (in part they are outcomes of WineSys/ERASysApp)

Computational biology tools

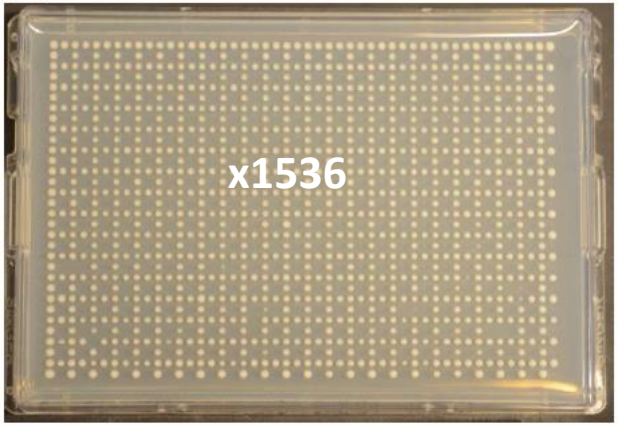
- dircFBA (FBA that incorporates resource allocation constraints)
- Evolvex (prediction of non-obvious optimal evolution conditions)
- SMETANA (metabolic modeling of microbial communities)

High throughput

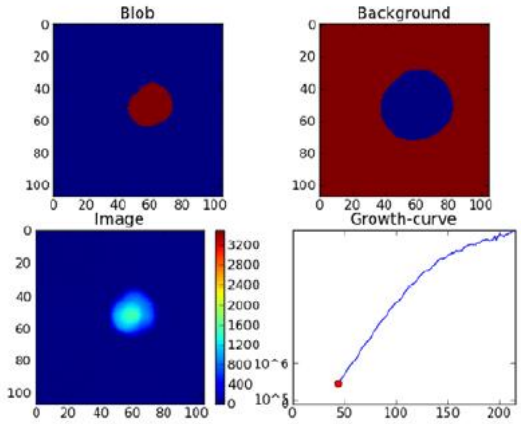
- Massively parallel adaptive evolution
  - ✓ 25 scanners operate in parallel
  - ✓ Each scanner takes 6144 individually evolving populations.

ERA CoBioTech

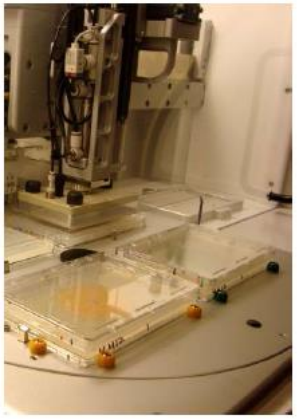
A



D

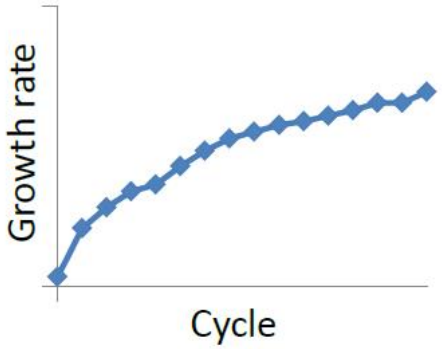


B



C

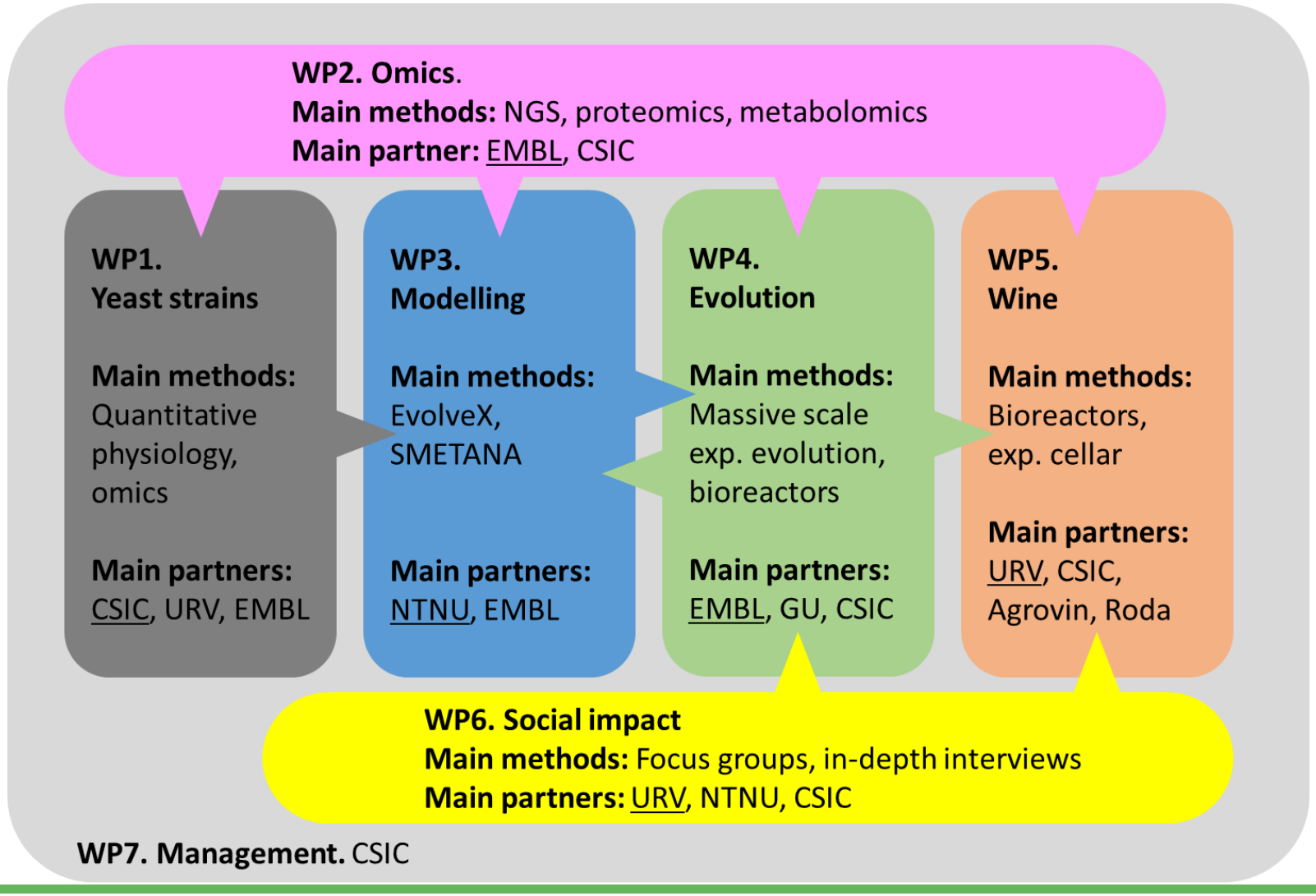
E



Modeling targets

- Accurate modeling of Crabtree and (aerobic) acetic acid production
- Diversification of carbon sinks if not respiration
- Accurate modeling of metabolic complementarity
- A high number of yeast species

	TRACK 1	TRACK 2
WP1	*S. cerevisiae* mutant strain characterization. Plus data from WineSys	Non-Saccharomyces (NS) strain characterization in mono- and co-cultures
WP3	Improvement of *S. cerevisiae* metabolic models for aerobic fermentation	Metabolic modelling of NS and communities. Identification of target pathways
WP4	EvolveX guided high throughput ALE of *S. cerevisiae* industrial strains	EvolveX guided high and medium throughput ALE of NS wine yeast strains
WP5	Wine production assays with *S. cerevisiae* improved strains	Wine production assays with mixed starter cultures


WP2. Omics.
Main methods: NGS, proteomics, metabolomics
Main partner: EMBL, CSIC
WP1.
Yeast strains
Main methods:
Quantitative physiology, omics
Main partners:
CSIC, URV, EMBL
WP3.
Modelling
Main methods:
EvolveX, SMETANA
Main partners:
NTNU, EMBL
WP4.
Evolution
Main methods:
Massive scale exp. evolution, bioreactors
Main partners:
EMBL, GU, CSIC
WP5.
Wine
Main methods:
Bioreactors, exp. cellar
Main partners:
URV, CSIC, Agrovin, Roda
WP6. Social impact
Main methods: Focus groups, in-depth interviews
Main partners: URV, NTNU, CSIC
WP7. Management. CSIC

Societal impact

WP6 (NTNU, URV, CSIC)

- Socio-ethical analysis
- Focus groups (scientist, producers, consumers, health authorities)
- Questionnaires (associated to wine tasting)
- In-depth interviews

Central analytical axes

- natural/artificial
- environmental/non-environmental
- healthy/unhealthy
- improved/impoverished
- safe/unsafe
- traditional/futuristic
- GMO-free/lab construct.

More details on project plan

Communication and dissemination plan

- Will be shaped by results of WP6
- Stakeholders as above
- Avoid promoting wine consumption

Data management

- FAIRDOM
- EMBL and NTNU will coordinate this activity for CoolWine (as done in a previous ERA-SysAPP project)

Expected outcomes

- Improved metabolic models for relevant yeast species
- Refined computational tools for yeast metabolism modeling
- Improved wine yeast strains, and methods to do so from other genetic backgrounds
- Improved wine fermentation protocols
- Wine with <12% ethanol from juices with >15% PAD

- Wines will be produced at pilot scale (TRL6)

Contact details

http://www.icvv.es/english/microwine_en

rgonzalez@icvv.es