

Yonghua Li-Beisson

Equipe «Environnement, Bioénergies, Microalgues et Plantes»

Institute de Bioscience et Biotechnologies d'Aix-Marseille

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Research areas:

- Photosynthesis and CO_2 concentrating mechanism
 - **Lipid metabolism**
- Hydrocarbon synthesis and secretion

Applications:

- Climate
- Food security
- Green chemistry
- Renewable fuels

Microalgae are food, feed and fuels

CO₂



Researchers genetically engineer fish oil in plants

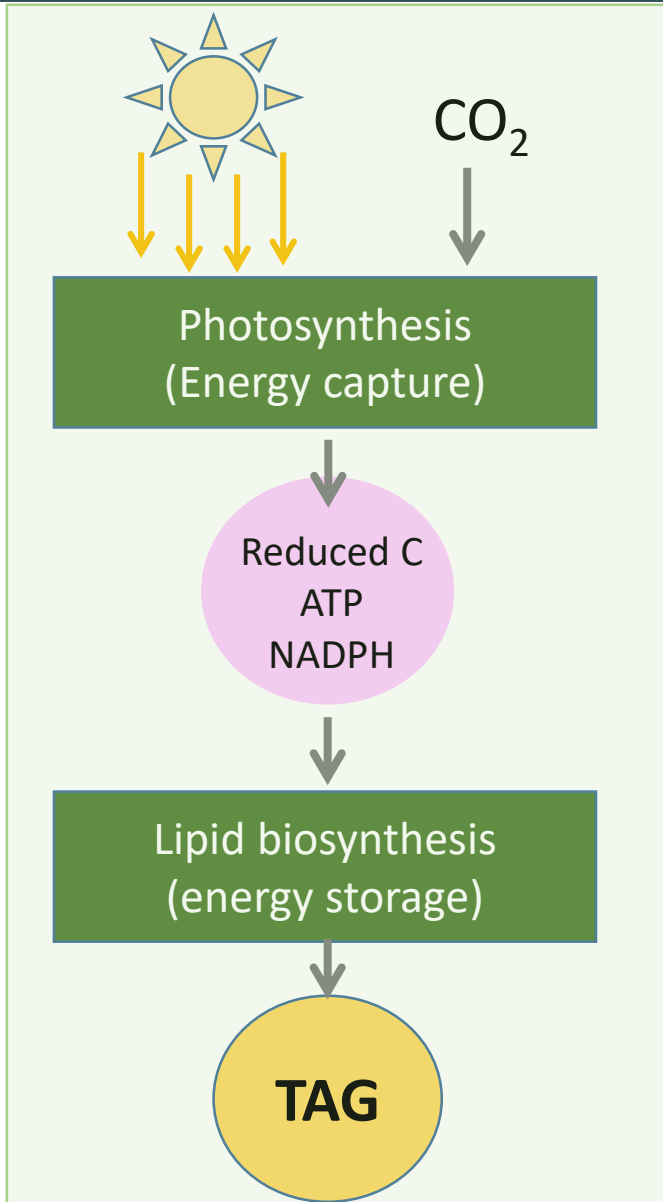
Robert Ferris | @RobertoFerris
Friday, 10 Jul 2015 | 11:33 AM ET



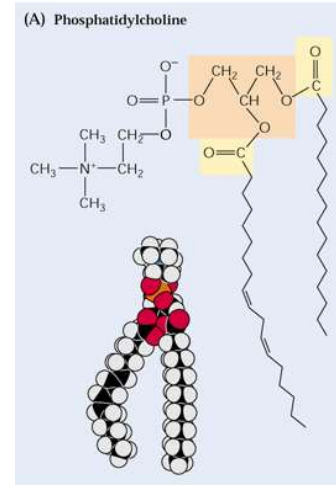
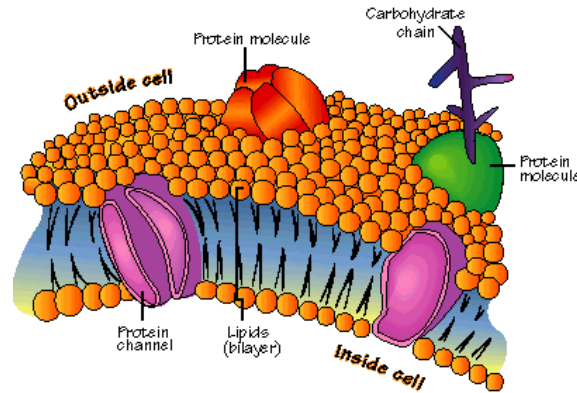
Researchers have raised a genetically engineered crop on land that contains certain nutrients found only in fish oil and algae, and it's hoped that the breakthrough could help the fish-farming industry keep growing.



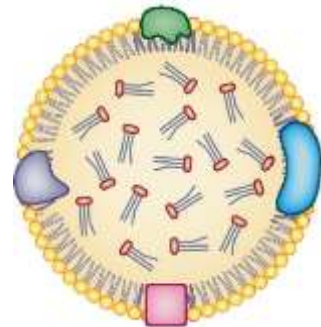
Oil is the most efficient form of carbon and energy storage and can accommodate the widest range of fatty acid structures



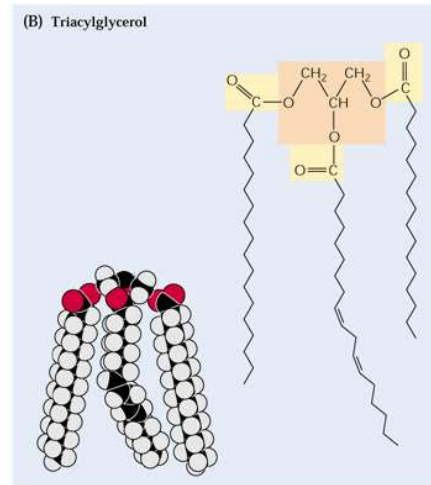
Membrane lipids



Storage lipids (TAGs)



Lipid droplet (LD)



Common fatty acids	
Unusual fatty acids	
Non-glycerolipids	
	alkane/ hydrocarbon
	wax ester

The production of microalgae remains marginal, and limited to niche market

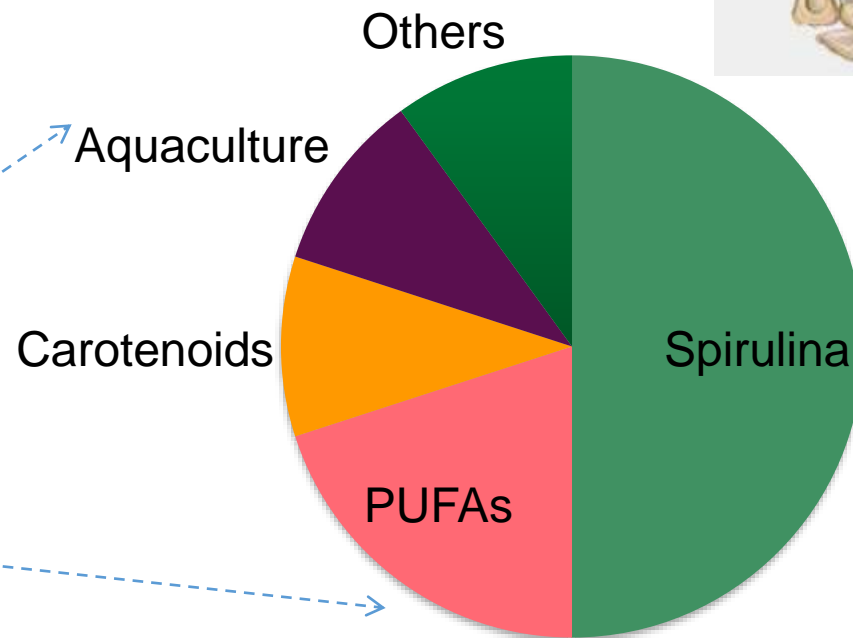
Soybean
345 Mt/year

Rapeseeds
33 Mt/year

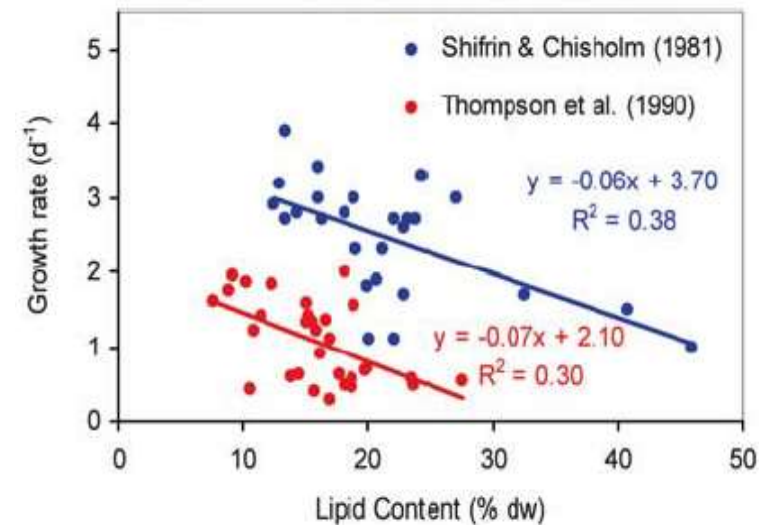
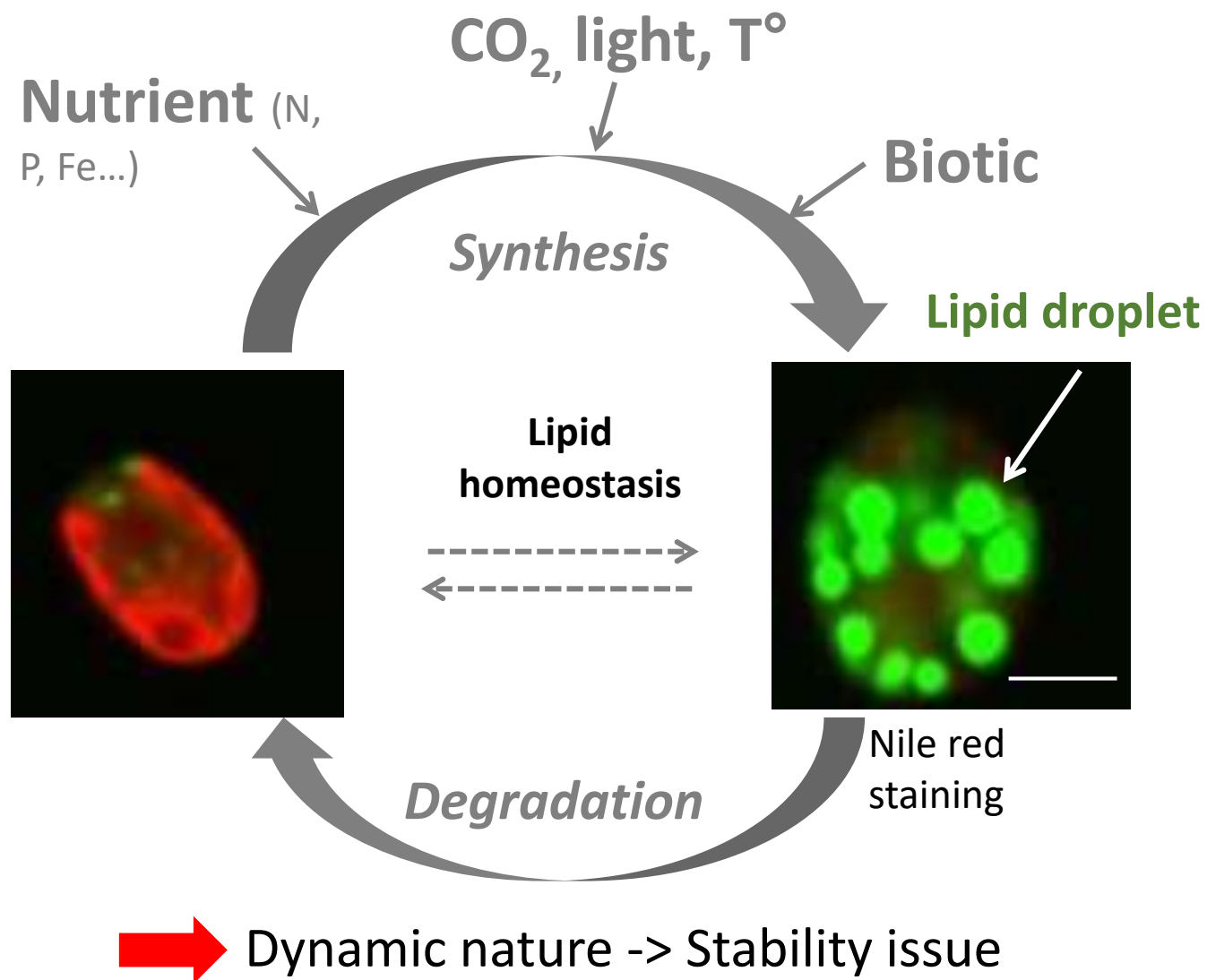
Microalgae
0.015 Mt/year



Traditional oilseed crops



Major challenges in algal domestication



Williams and Laurens (2010) *Energy Environ. Sci.*

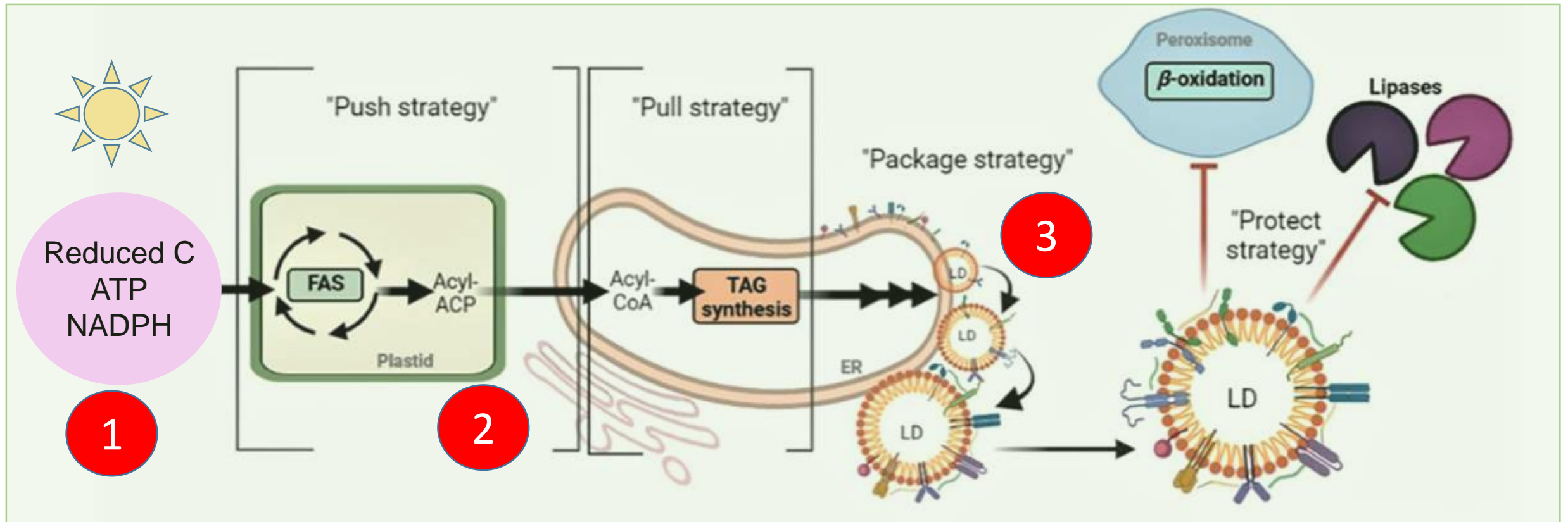
➔ Inverse relationship between oil content and cell growth

Goals:

- 1) Improve oil content,
- 2) Tailor its fatty acid composition
- 3) Engineer lipid excretion

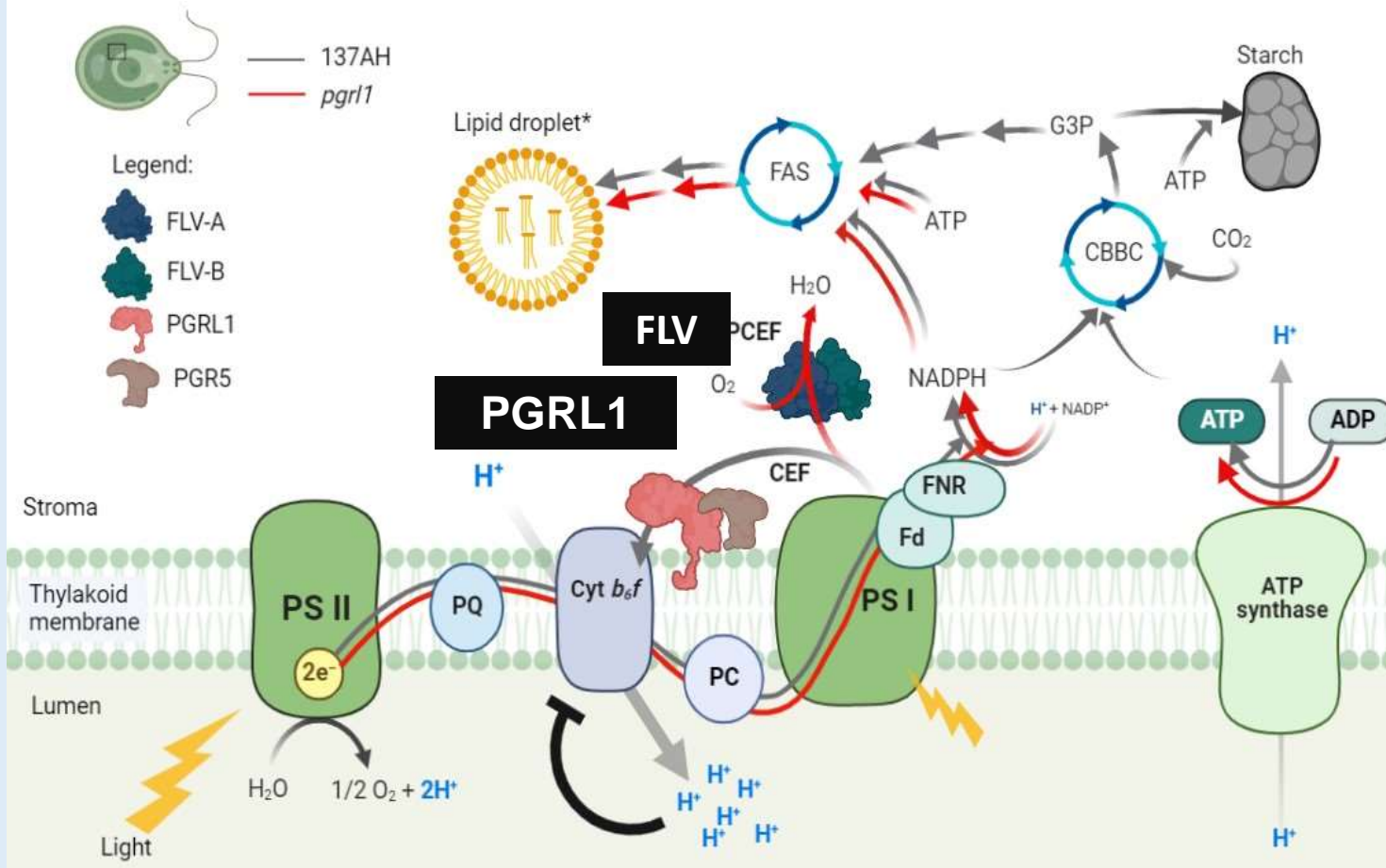
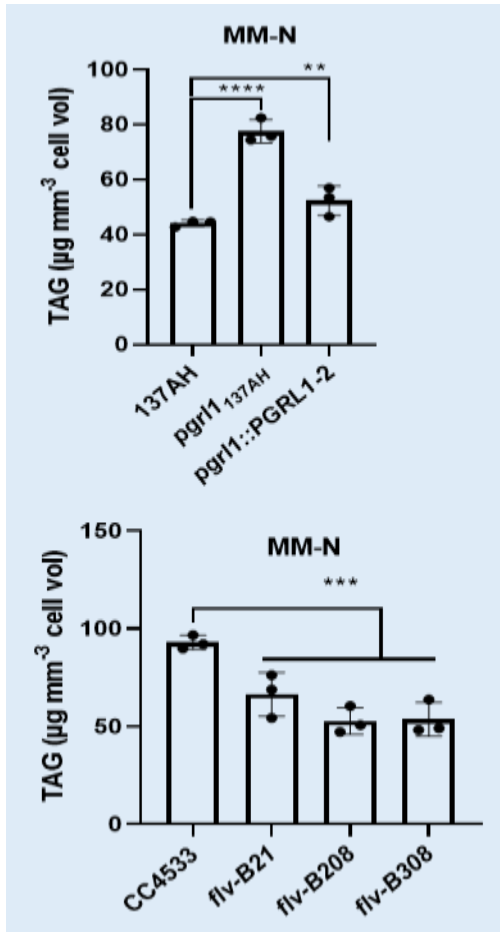
« Push, Pull, and Protect » strategy

> Several hundred reactions are involved, accross multiple subcellular compartments



[modified from Sagun et al 2023 *Frontiers in Plant Science*]

1: Manipulating electron management pathways affects oil content

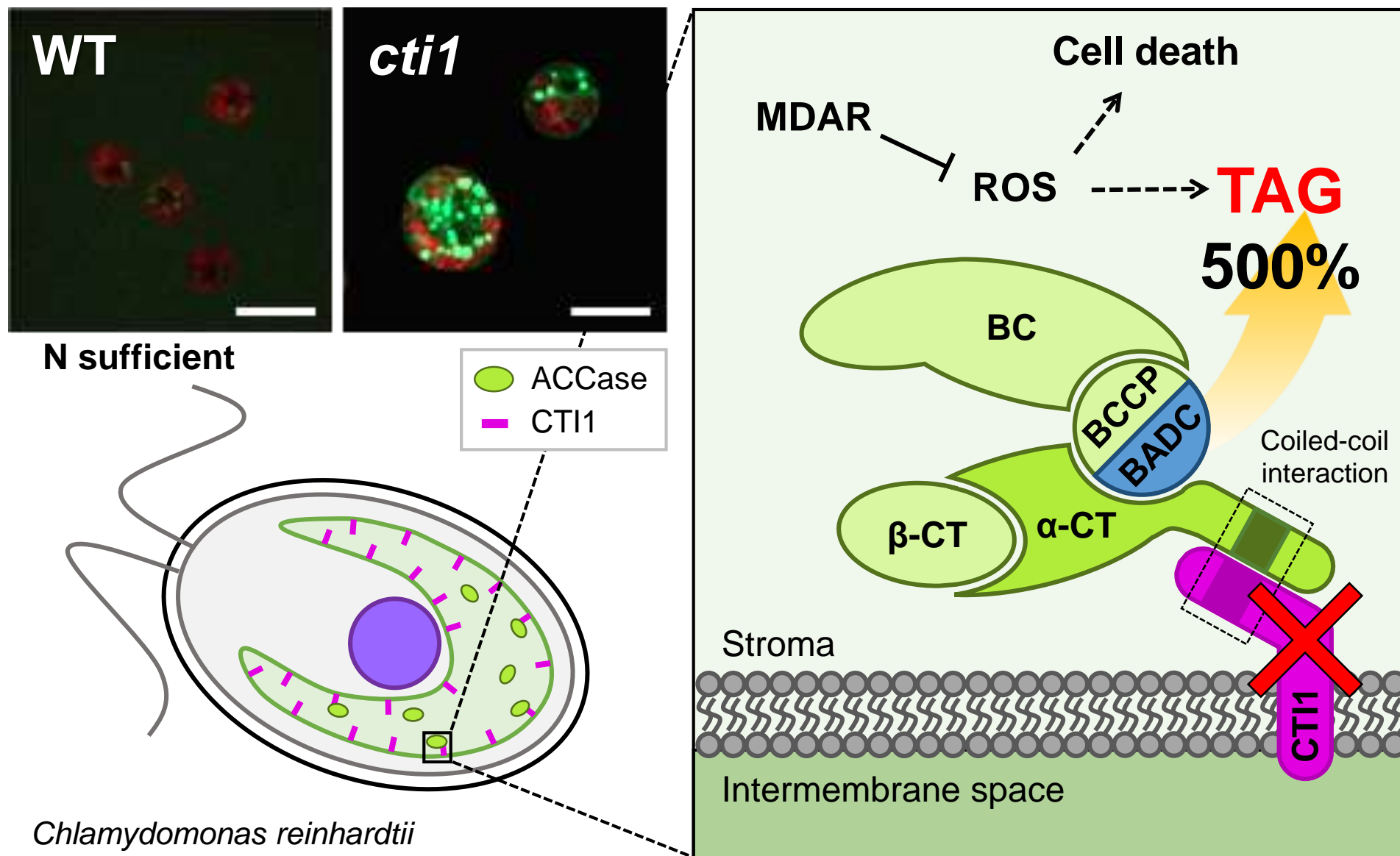


Ousmane Dao
(thèse: 2019-2024)

➔ ! Cyclic and pseudo-cyclic electron pathways play antagonistic roles during nitrogen deficiency in *Chlamydomonas reinhardtii*

[Dao et al 2024 *Plant Physiology*]

2, Knocking out the carboxyltransferase interactor 1 (CTI1) boosted oil content by fivefold without affecting cell growth

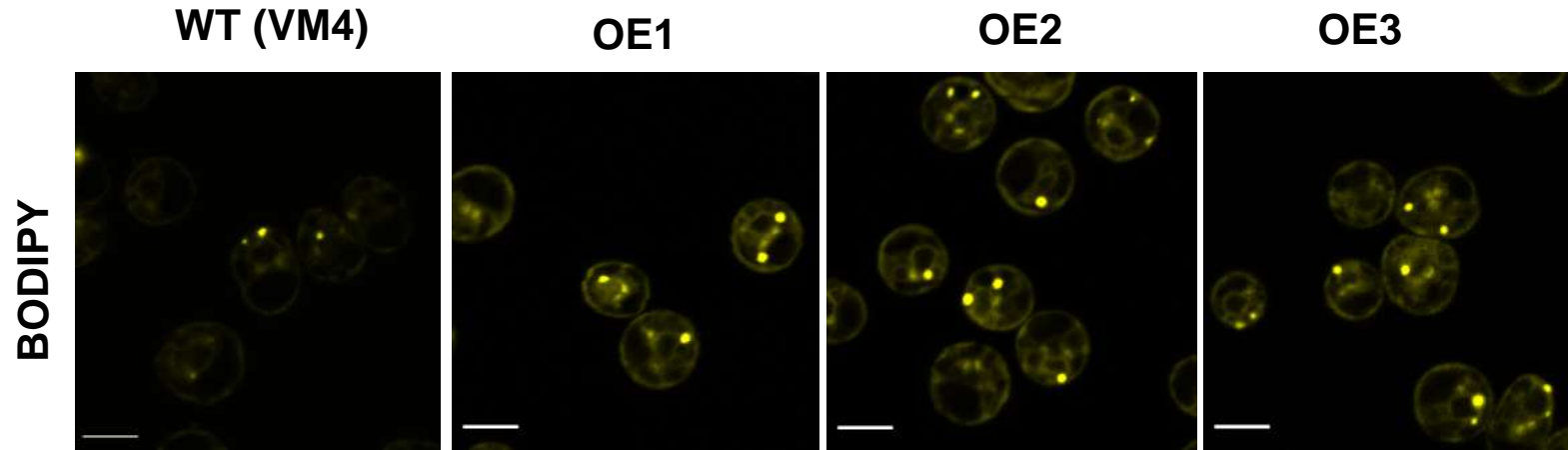
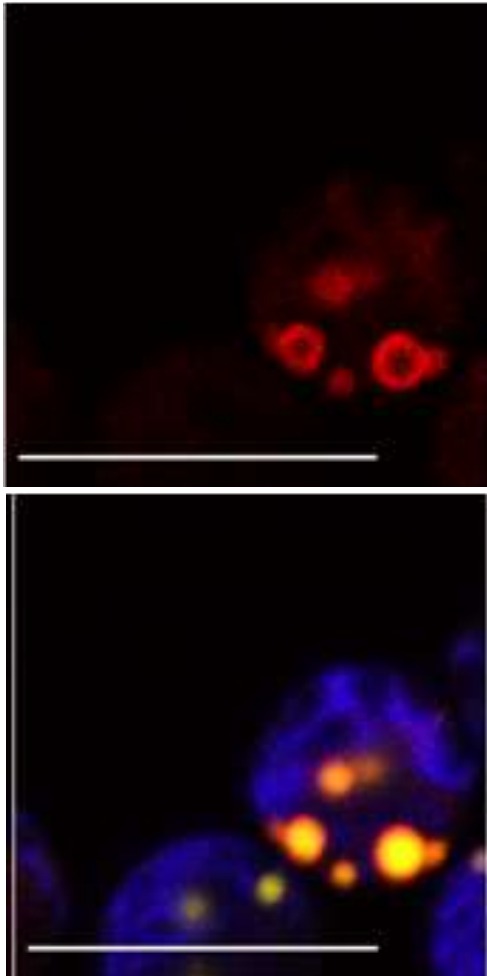


Zhongze Li
(post-doc:
2021-2023)

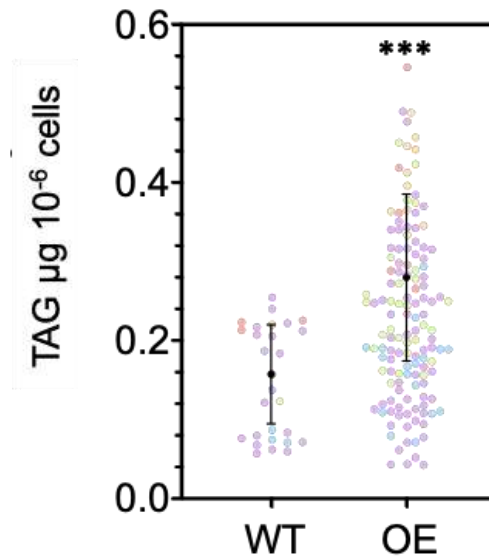
[Li et al 2024
Plant Biotech J
revised]

3, Over-expression of a LD-located α/β -hydrolase (ABHD1) increases LD number and TAG content

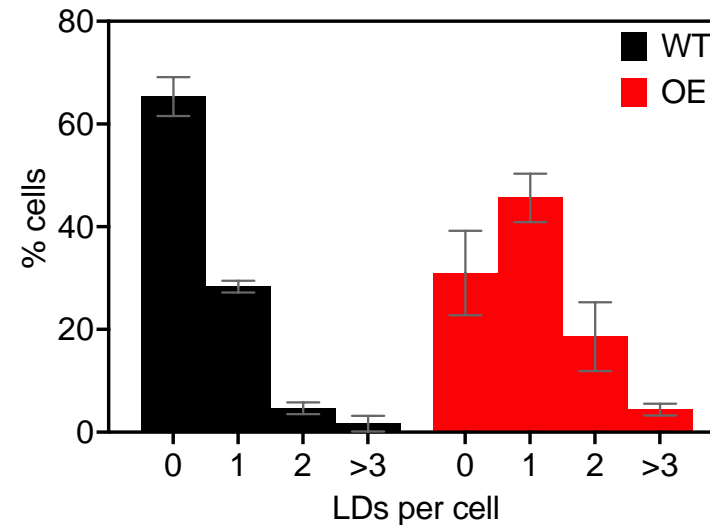
ABHD1-mCherry



Ismael Torres-Romero
(thèse: 2016-2019)

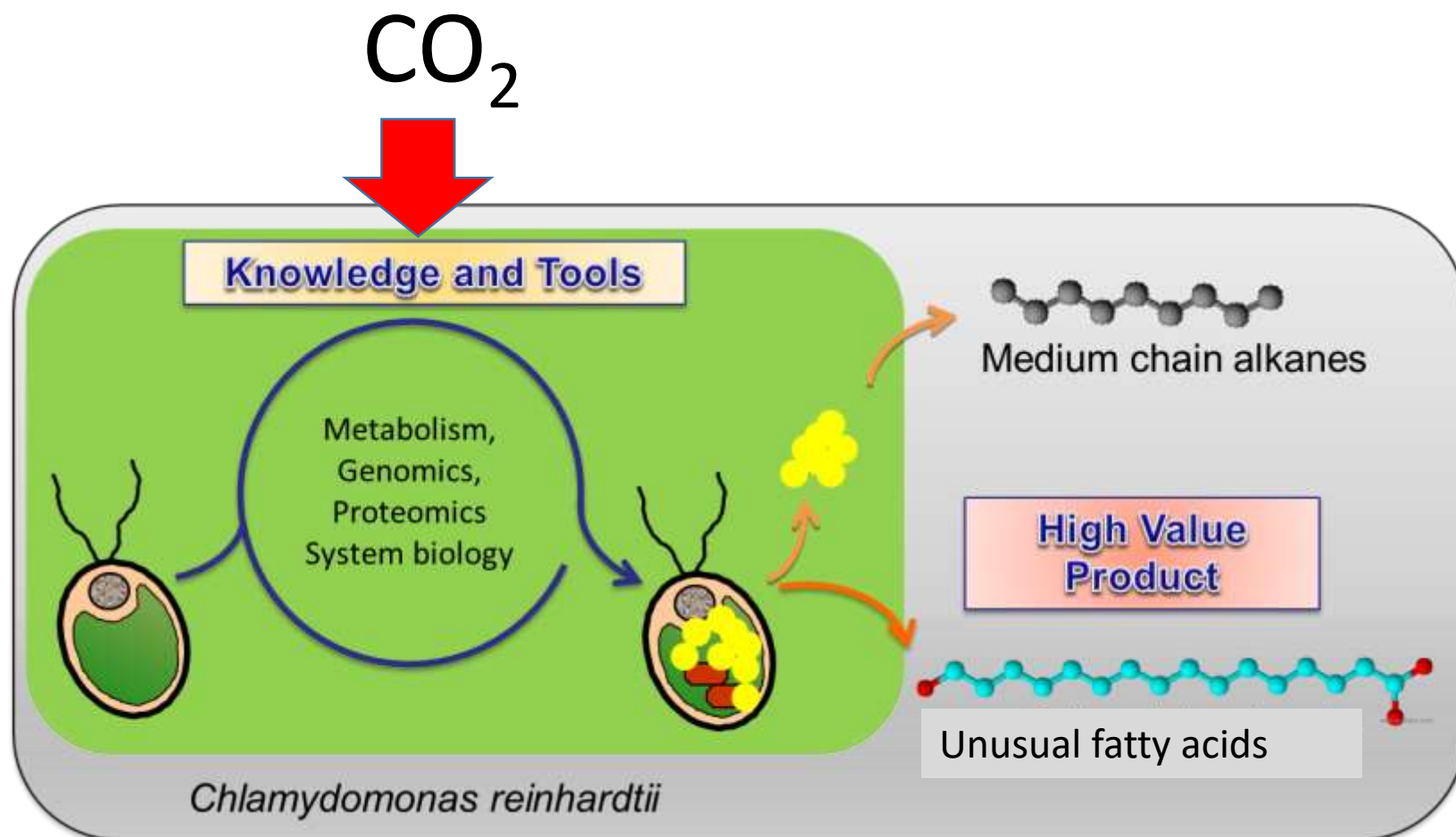


LD number distribution:

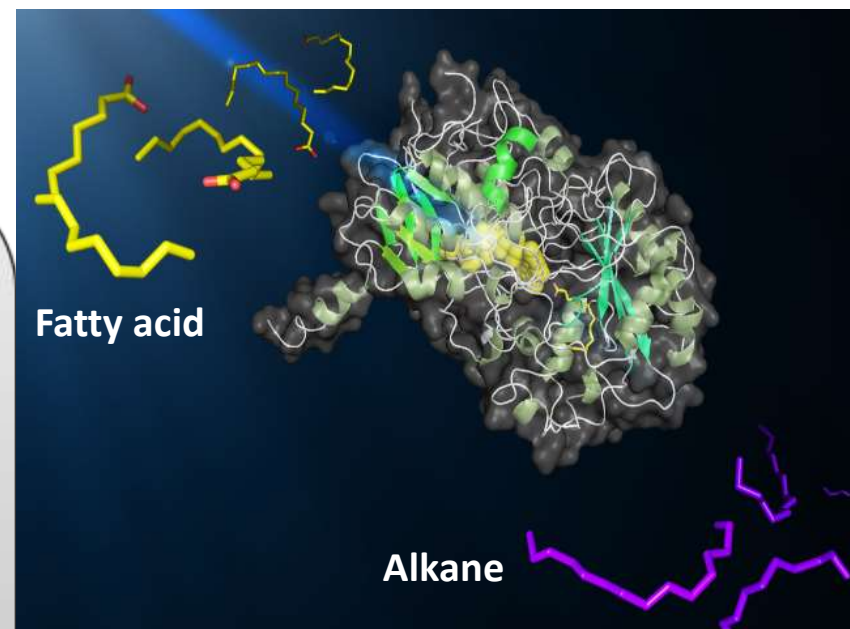


[Torres-Romero
et al 2024
*National Science
Review*]

Résumé: from CO₂ to useful products



Blue light



Beisson et al. 2016 *Patent CEA-CNRS*
Sorigué et al. 2017 *Science*
Sorigué et al. 2021 *Science*

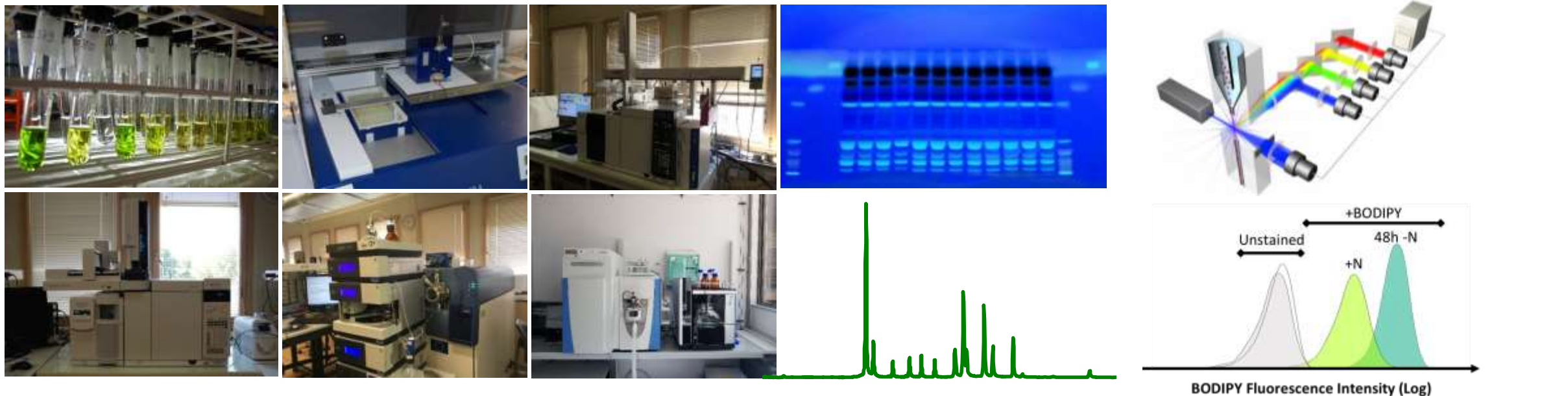
Oil: for chemistry

Starch: for degradable plastics

Value added products

Antioxidants, carotenoids, PUFAs,
specialty fatty acids, Biomedicals...

From lipid extraction, lipid classes and fatty acid analysis to lipid molecule species:



Type of apparatus:

Flow cytometer

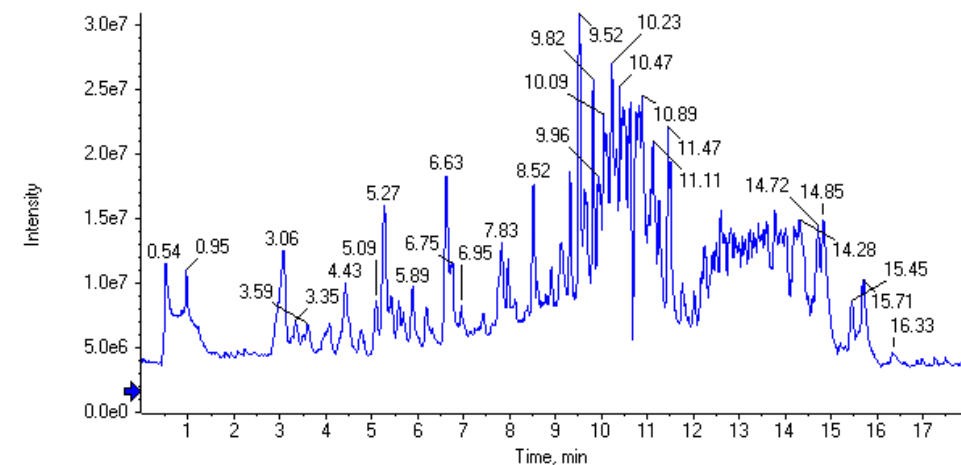
HP-TLC

2 GC-MS

GC-FID/MS

thermo-desorber GC-MS

EC-MS, and LC-MS/MS (Orbi-trap)



Algal domestication: a revolution of the 21st century

Plants



Teosinte

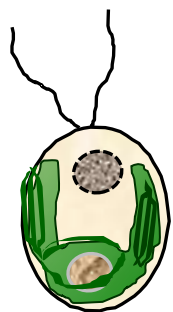


7 000 - 10 000 years

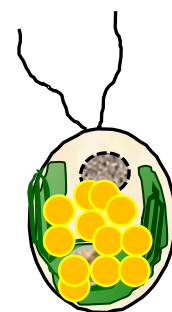


Maize

Algae



Genetics
Genomics
Physiology
Synthetic biology



● oil



FIT FOR 55



*“The European climate law makes reaching the EU’s climate goal of reducing **EU emissions by at least 55% by 2030** a legal obligation.”*

*“The proposal is to increase the current EU-level target of at least 32% of renewable energy sources in the overall energy mix to **at least 40% by 2030...**”*

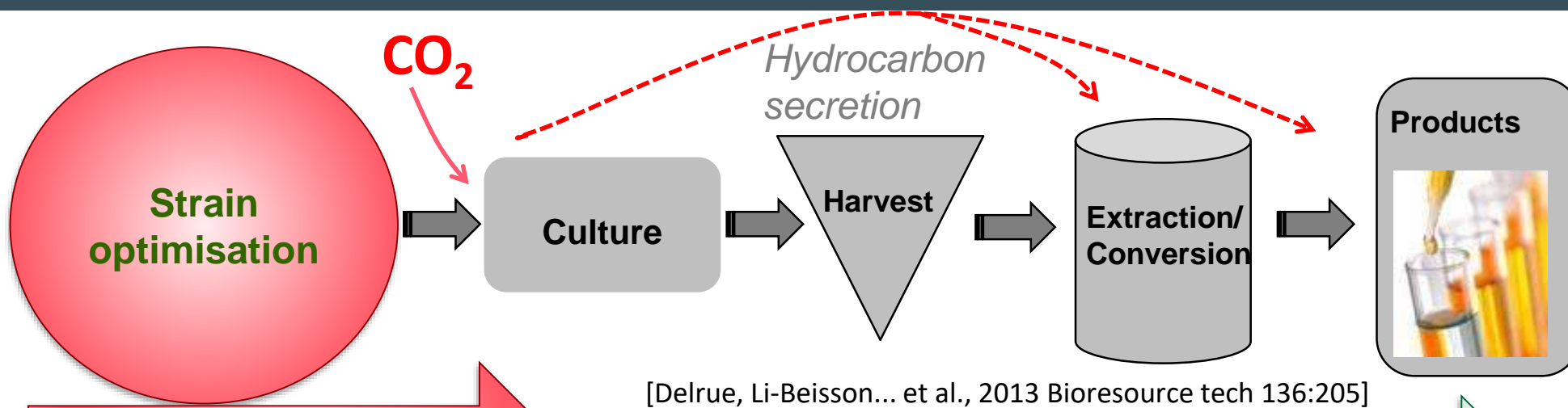
Equipe: ~25 personnes (8 chercheurs, 6 ITA, et 10-15 CDDs)



Collaborators:

- Alistair Fernie (Germany)
- Andreas Weber (Germany)
- Anja Krieger-Liszkay (France)
- Eric Marechal (France)
- Fantao Kong (China)
- Inna Khozin-Goldberg (Israel)
- Jay Thelen (USA)
- Jian Xu (China)
- Jin Liu (China)
- Katrin Philippar (Germany)
- Matteo Ballatori (Italy)
- Phil Bates (USA)
- Rachid Thiam (France)
- Yasuyo Yamaoka (Korea)
- Youngsook Lee (South Korea)

Cité des Energies: from microalgae to bioproducts



[Delrue, Li-Beisson... et al., 2013 Bioresource tech 136:205]

