RÉPUBLIQUE FRANÇAISE
Liberté Égalité Fraternité

FRANCE 2030
PROGRAMME DE RECHERCHE
CARBONE ET ÉCOSYSTÈMES CONTINENTAUX

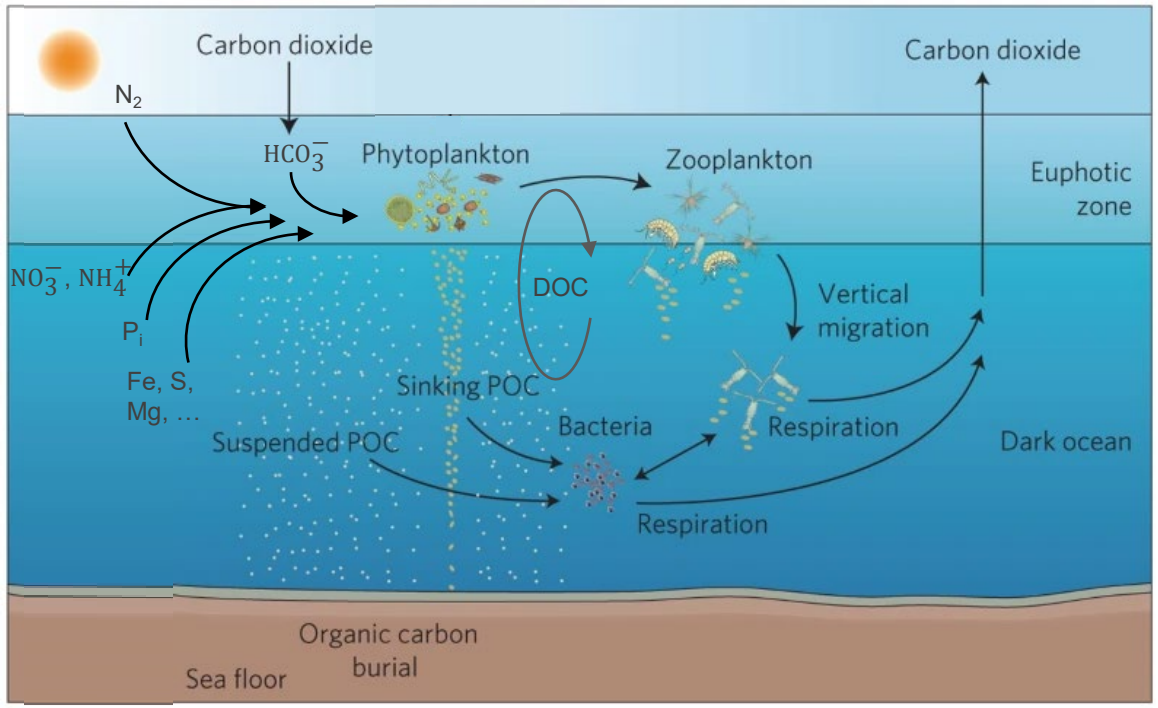
CO_2 concentration mechanisms in photosynthetic micro-organisms

How aquatic photoautotrophic micro-organisms adapt to varying dissolved inorganic carbon (DIC) concentrations and CO_2/O_2 ratio, whilst maintaining such an efficiency in CO_2 fixation?

cnrs INRAE

CO_2 fixation by photosynthetic microorganisms – ecological scale

Oceanic carbon pump

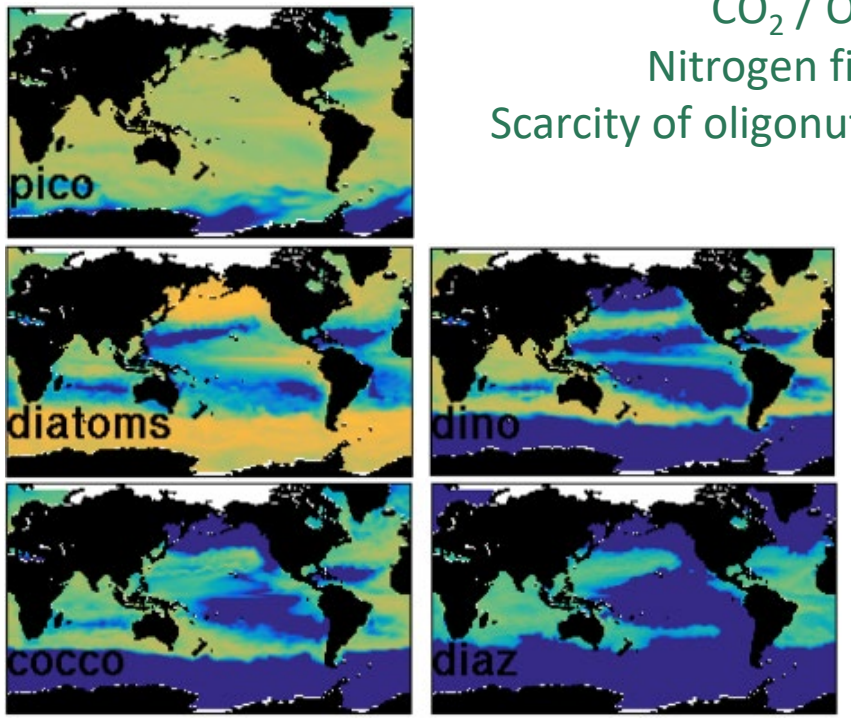


Herndl, Reinthaler, Nat. Geo., 2013
Burd, Ann. Rev. Marine Sc., 2024

POC: Particulate organic carbon
DOC: Dissolved organic carbon

Biodiversity of phytoplakton with varying adaptation to:

CO_2 / O_2 ratio
Nitrogen fixation
Scarcity of oligonutrients

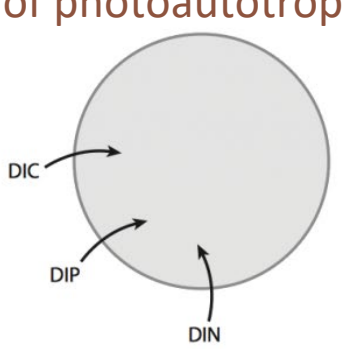


Dutkiewicz et al, Biogeosc. 2020

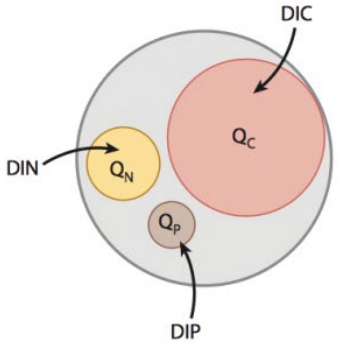
CO_2 fixation by photosynthetic microorganisms – cellular scale

In CO_2_CMϕ:
Metabolisms of CO_2 uptakes in model organisms

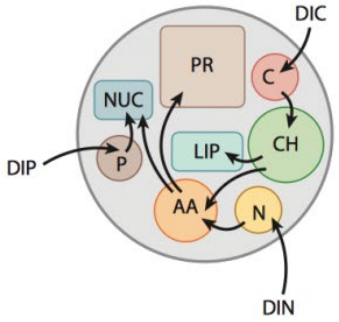
Oceanic carbon pump modelled using various parameterization of photoautotrophy



Monod type

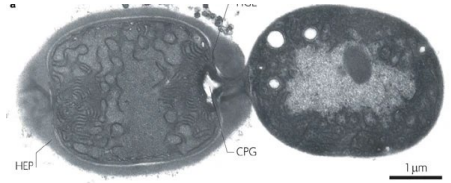


Droop/Caperon-type

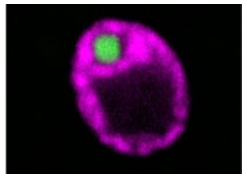


Physiology

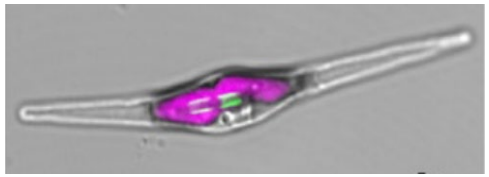
Anabaena PCC 7120



Chlamydomonas reinhardtii

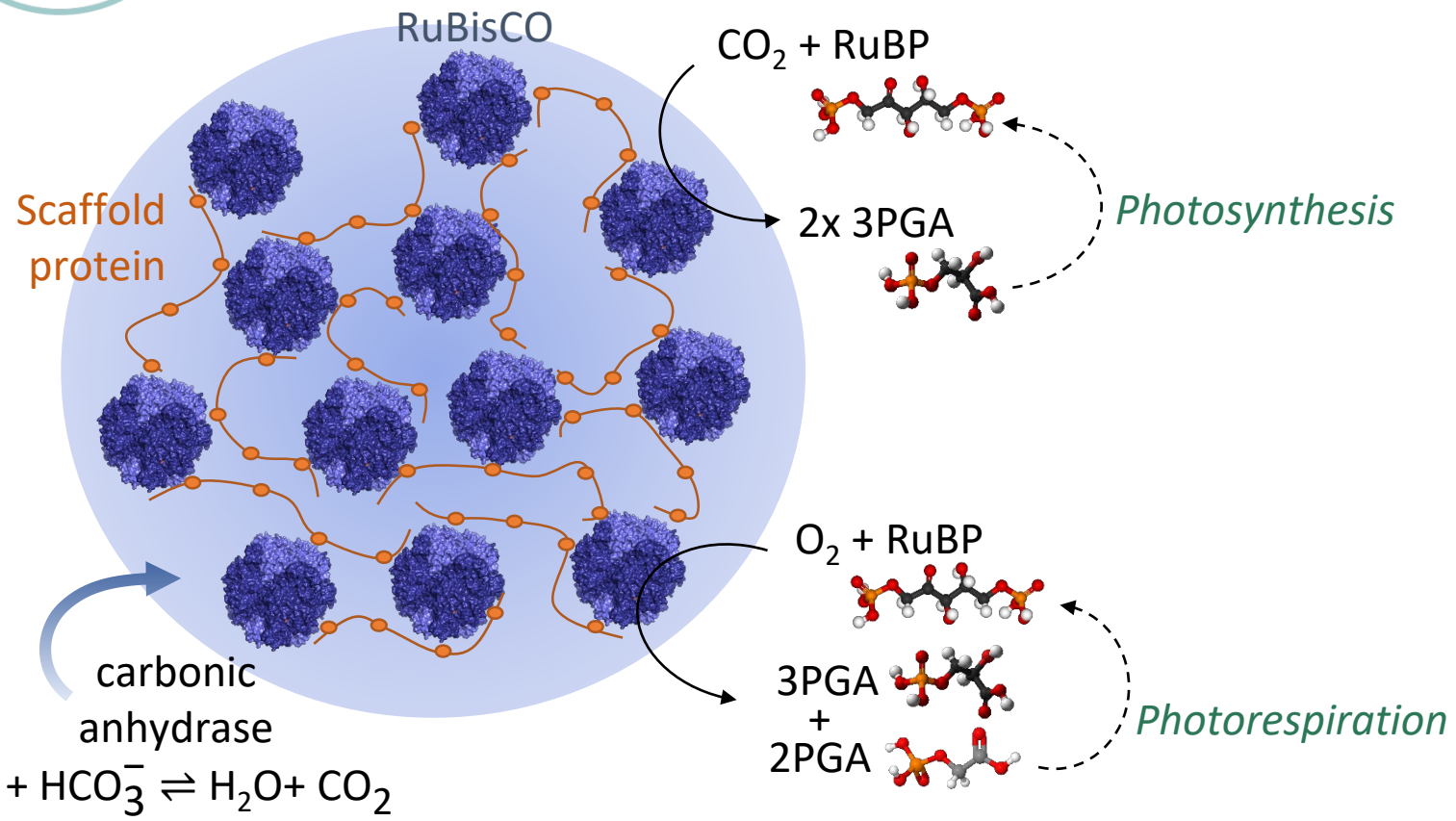


Phaeodactylum tricornutum

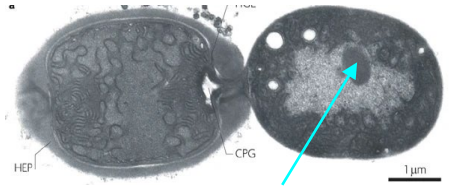


Follows and Dutkiewicz, 2011

CO_2 fixation by photosynthetic microorganisms – molecular scale

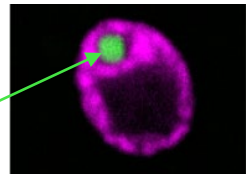


Anabaena PCC 7120



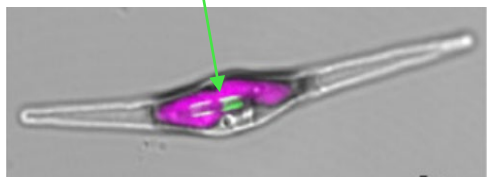
Carboxysome

Chlamydomonas reinhardtii



Pyrenoid

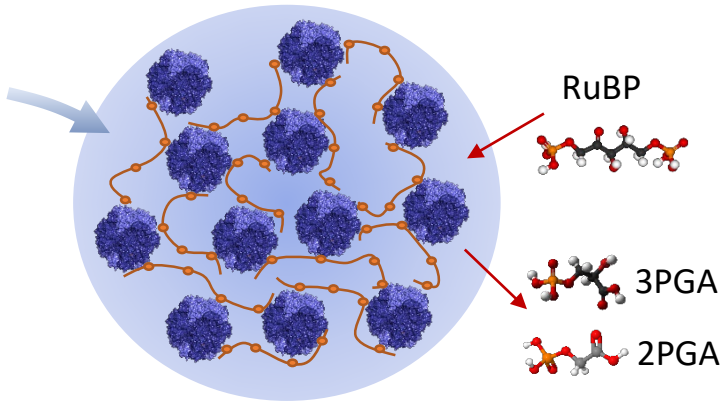
Phaeodactylum tricornutum



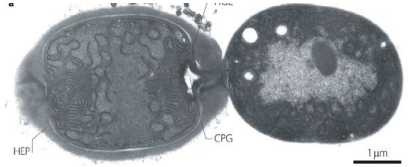
Objectives of the CO_2_CMϕ project

carbonic anhydrase

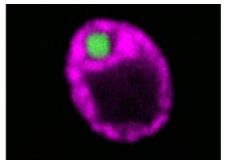
$H^+ + HCO_3^- \rightleftharpoons H_2O + CO_2$



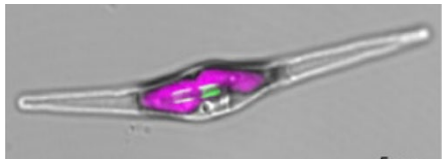
Anabaena PCC 7120



Chlamydomonas reinhardtii

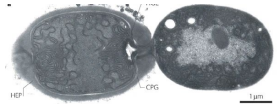
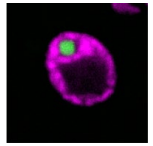
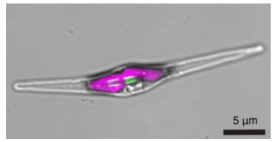
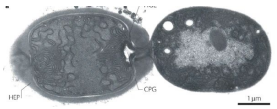
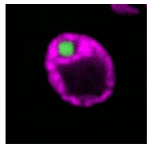
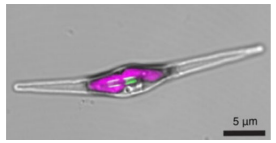


Phaeodactylum tricornutum



- What are the molecular key features that drive RuBisCO condensation?
- What are the physico-chemical properties of the RuBisCO condensates?
- What are the consequences of the liquid-liquid interface on the metabolic flux?
- What are the consequences of RuBisCO location and organisation on carboxylation and oxygenation activities; metabolic and carbon fluxes?

Scientific strategy of the CO_2_CMϕ project

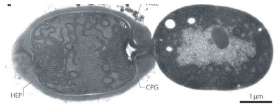
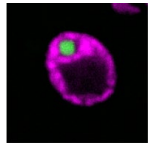
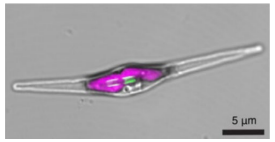
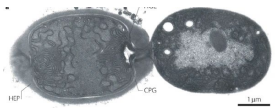
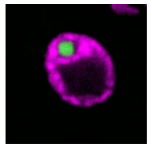
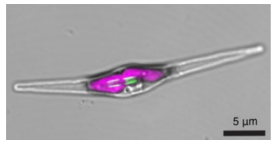
Scaffold protein \ RuBisCO	*Anabaena*	*C. reinhardtii*	*P. tricornutum*
			
Anabaena 	CcmM		
C. reinhardtii 		EPYC1	
P. tricornutum 			PyCo

In-vitro molecular and physico-chemical characterisation

Nuclear Magnetic Resonance

Membrane Inlet Mass Spectrometry

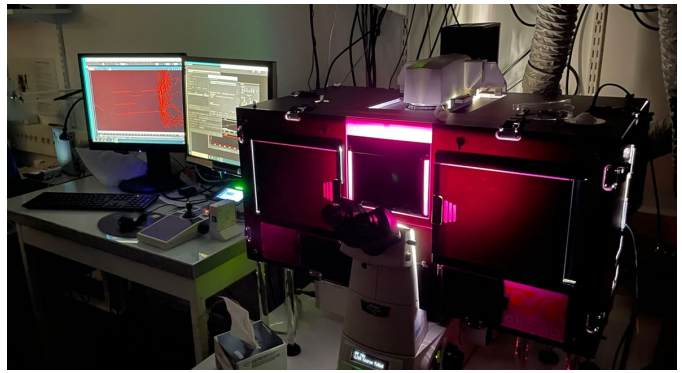
Scientific strategy of the CO_2_CMϕ project

Scaffold protein \ RuBisCO	*Anabaena*	*C. reinhardtii*	*P. tricornutum*
			
Anabaena 	CcmM		
C. reinhardtii 		EPYC1	
P. tricornutum 			PyCo

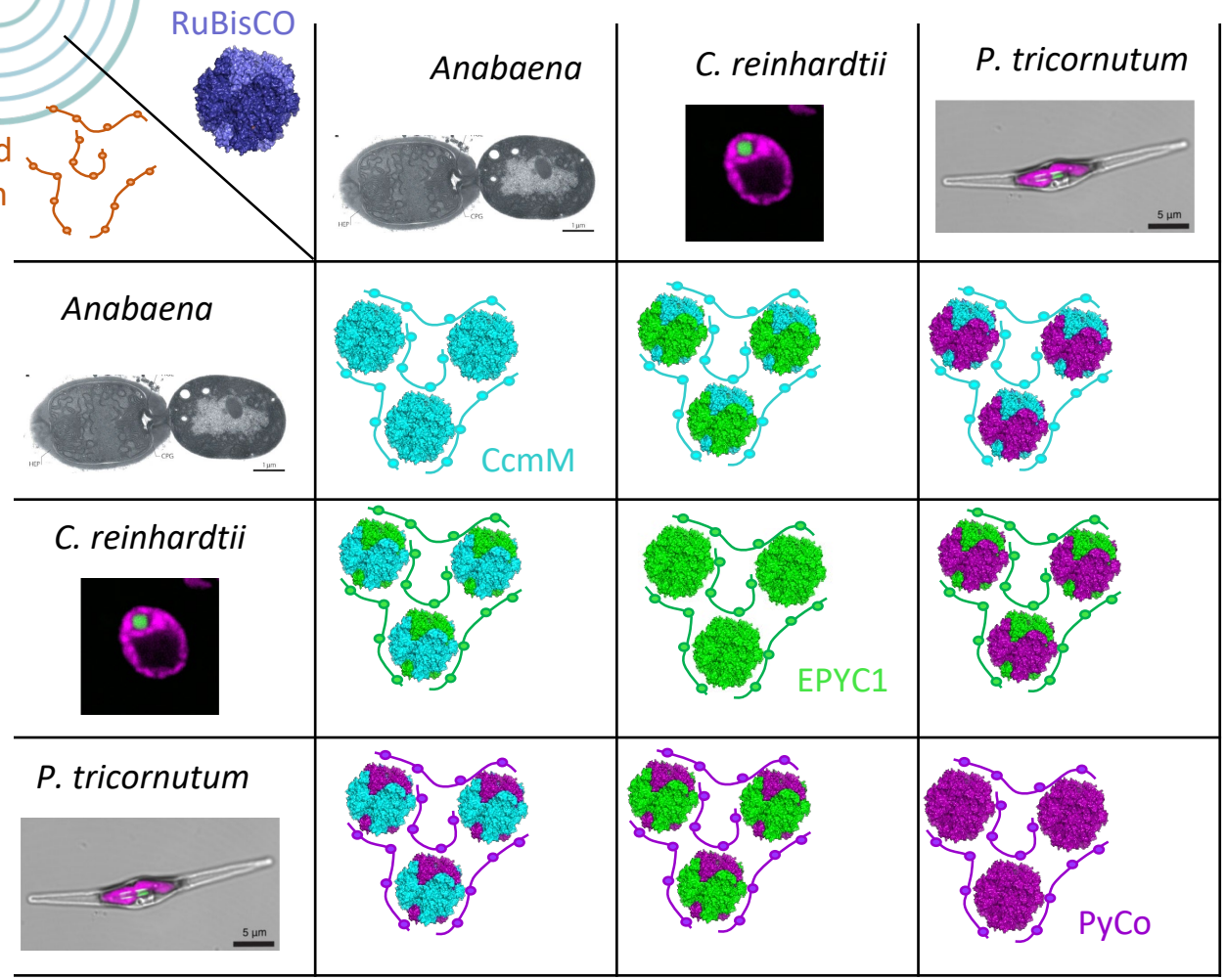
In-vitro molecular and physico-chemical characterisation

In-vivo metabolism and physiological characterisation

Time-lapse microscopy images



Scientific strategy of the CO_2_CMϕ project



In-vitro molecular and physico-chemical characterisation

In-vivo metabolism and physiological characterisation

20 000 ppm → 50 ppm P_{CO_2}

2% → 20% P_{O_2}

$[Nitrogen]$

Expected outcomes of the CO_2_CMϕ project

Modeling Carbon fluxes

- Adequate values of photosynthesis/photorespiration ratio
- Adequate modeling of photoautotrophy

Carbon sequestration

- Biomimetics: Example of biocondensate (protein liquid-liquid separated phase) for CO_2 fixation
- Rational for choice of algal strains for carbon sequestration, and design of new ones

Consortium and CO_2 emission

Biochemists, cell biologists, spectroscopists in PACA

Bioénergétique et Ingénierie des Protéines

Hélène Launay
Frédéric Carrière
Véronique Receveur-Bréchot

Institut de Biosciences et Biotechnologies d'Aix-Marseille

Gilles Peltier
Yonghua Li-Beisson

Laboratoire Chimie Bactérienne

Matthieu Bergè
Amel Latifi

Institut de Microbiologie de Méditerranée

Olivier Bornet

- Local proximity of the consortium → limited travelling and CO_2 emission
- Shared uses of the equipment → limited CO_2 emission