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FRANCE 2030 — PROGRAMME DE RECHERCHE CARBONE ET ÉCOSYSTÈMES CONTINENTAUX

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PROGRAMME DE RECHERCHE
CARBONE ET ÉCOSYSTÈMES CONTINENTAUX
FairCarboN

CO_2 concentration mechanims in aquatic photosynthetic microorganisms

CO_2_CMϕ

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?

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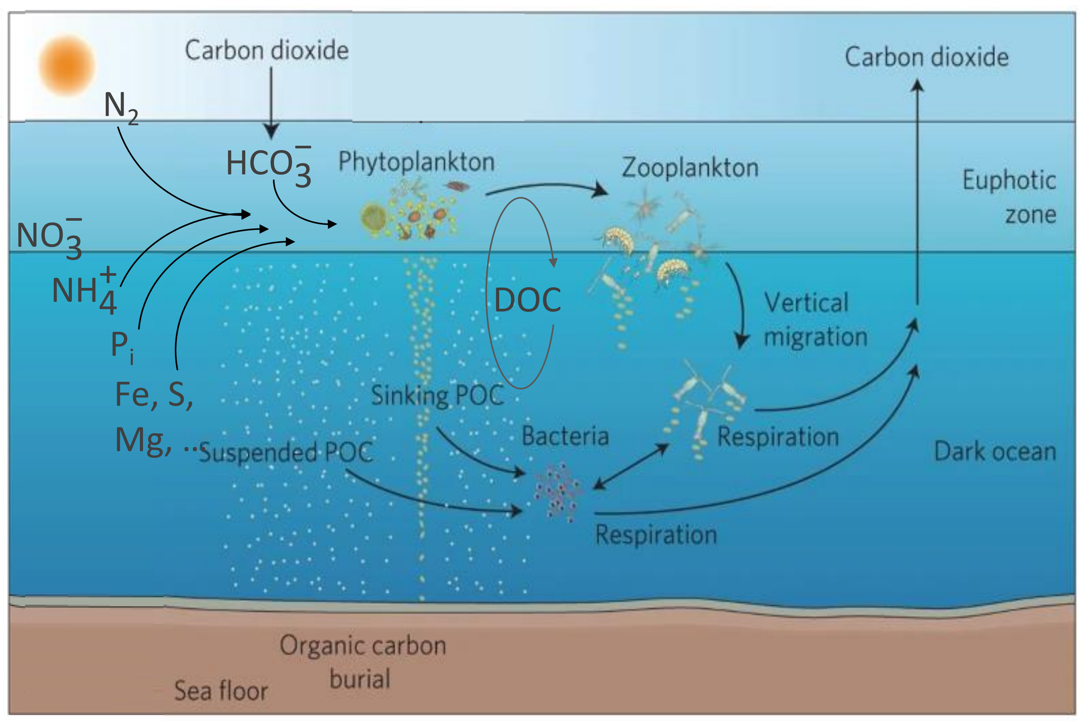
Context

- The oceanic carbon pump relies on the primary fixation of CO_2 by photosynthetic micro-organisms.
- In the open ocean, these are facing scarcity in nitrogen, phosphate and other nutrients, as well as **slow CO_2 and O_2 diffusion**.



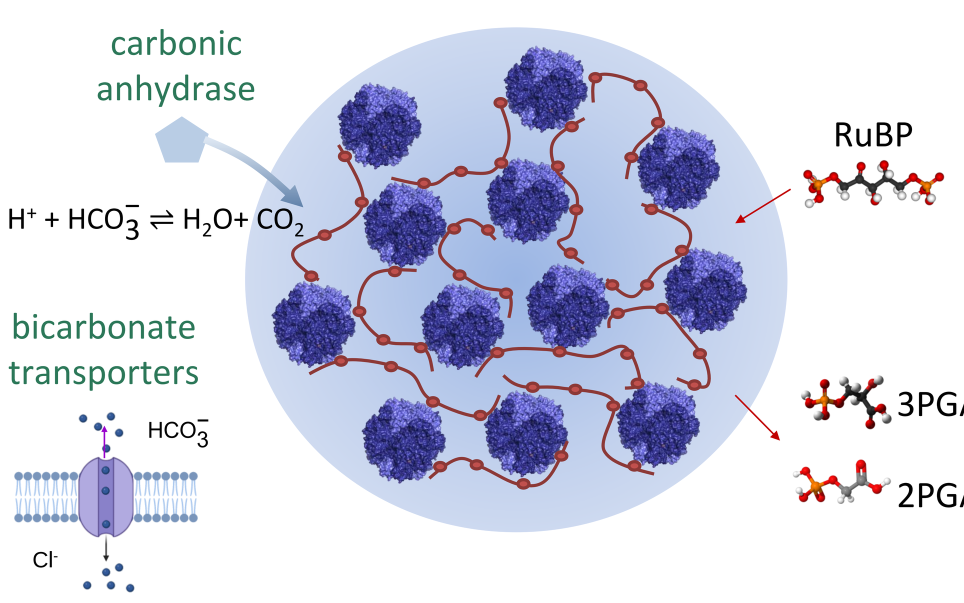
Herndl, Reinthaler, Nat. Geo., 2013
Burd, Ann. Rev. Marine Sc., 2024

POC: Particulate organic carbon
DOC: Dissolved organic carbon

Carboxylation vs Oxygenation
Photosynthesis vs Photorespiration

- The RuBisCO enzyme appeared 2 billion years ago in conditions where no O_2 was present and p_{CO_2} was high.
- RuBisCO can perform both Carboxylation (Photosynthesis) and Oxygenation (Photorespiration).
- Photosynthetic organisms developed mechanisms to adapt to low p_{CO_2} and high p_{O_2} : **Convergent evolution**

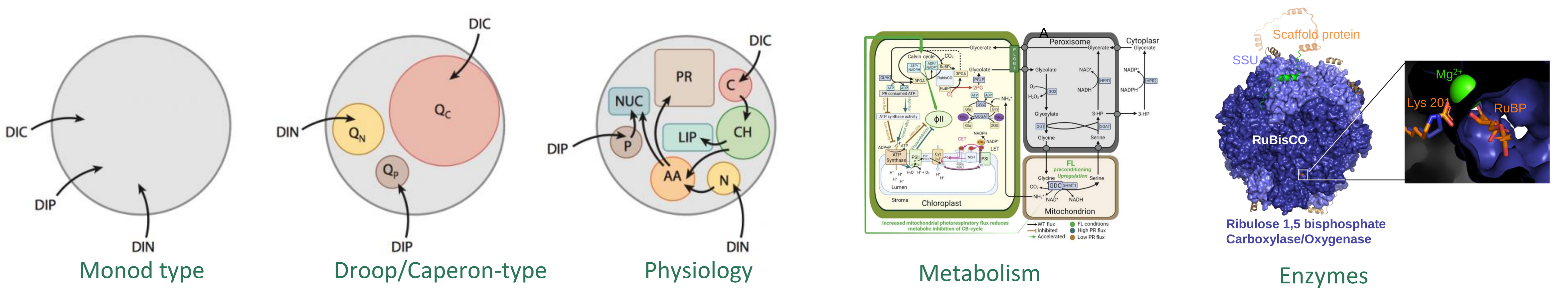
CO_2 concentration mechanisms:
RuBisCO biocondensate in liquid-liquid separated phases (LLPS)



Management

- *Anabaena*, *P. tricornutum*, *C. reinhardtii* are maintained, cultured and transformed in LCB, BIP and BIAM labs respectively and will be used for all biochemical and biophysical experiments
- NMR, microscopy and MIMS experiments are performed by the IMM, LCB and BIAM labs respectively on all microorganisms
- Equipment will be shared as far as possible to avoid CO_2 emissions linked to purchase
- Regular meeting will be eased by the regional proximity of the partners, and with low travel-related CO_2 emissions.

Which model for photoautophic Carbon sequestration?



Follows and Dutkiewicz, 2011
Timm et al, 2024

CO_2_CMϕ

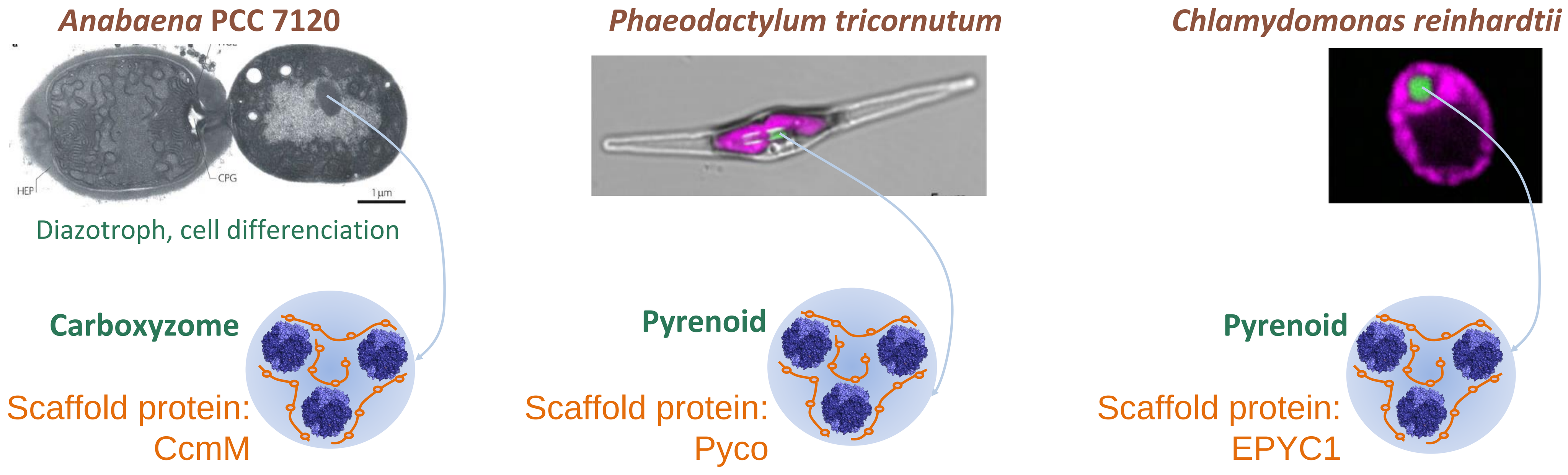
Biodiversity of photoautotropic microorganisms

Adaptation to varying conditions (O_2/CO_2 ratios, nutrients, T…)

Estimated ½ of earth carbon sequestration

Estimated 6% of earth carbon sequestration

Cyanobacteria	Diatoms	Green algae
Anabaena PCC 7120	*Phaeodactylum tricornutum*	*Chlamydomonas reinhardtii*



Objectives

- 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 strategies

In-vitro: reconstituted biocondensates

WP1: Production of proteins and LLPS
Biochemistry, **BIP**

WP2: Physico-chemistry of LLPS
Nuclear Magnetic Resonances (NMR), **IMM, BIP**

WP3: RuBisCO activity in LLPS
Membrane Inlet Mass Spectrometry (MIMS), **BIAM**

Outcomes: Example of LLPS for CO_2 sequestration, biomimetics

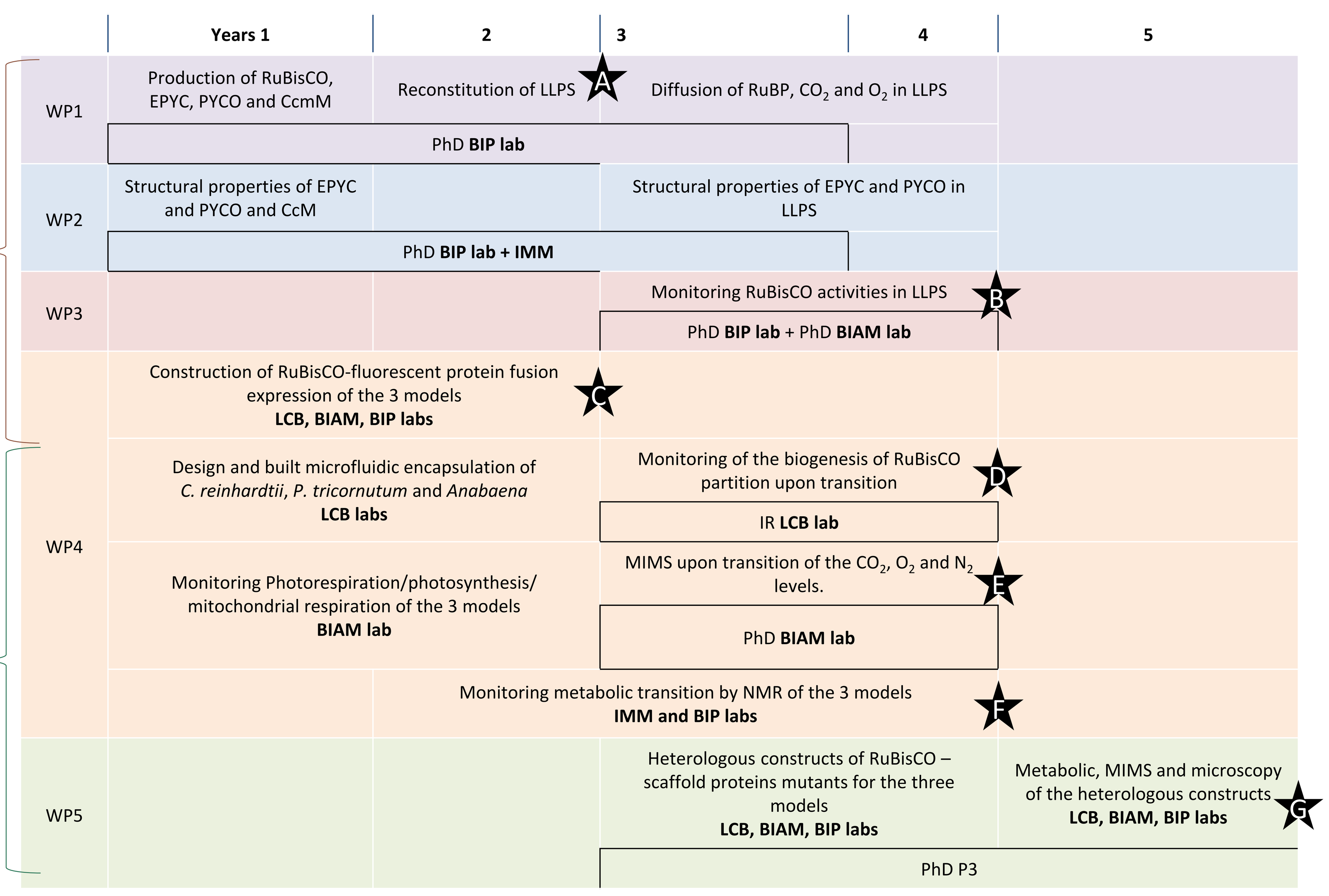
In-vivo: effect of variations of RuBisCO compartimentation

WP4: environmental transitions

WP4a: Monitoring RuBisCO condensation
Microfluidic, microscopy, **LCB**

WP4b: Monitoring RuBisCO activities
NMR, MIMS, **IMM, BIP, BIAM, LCB**

WP5: Engineered transitions
Heterologous LLPS
Molecular biology and all of the above
IMM, BIP, BIAM, LCB



Outcomes: Adequate values for modelling of photoautotrophic carbon capture
Rational for choice of algal strains for carbon sequestration

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