
BIOGRAPHICAL SKETCH

NAME: **Perin, Giorgio**

eRA COMMONS USER NAME (credential, e.g., agency login): **NA**

POSITION TITLE: **Tenure Track Assistant Professor (RtdB) of Plant Physiology**

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
University of Padova, Padova (IT)	BS	10/2010	Biotechnology
University of Padova, Padova (IT)	MSc	10/2012	Industrial Biotechnology
University of Padova, Padova (IT)	PhD	03/2016	Microalgae photosynthesis
University of Padova, Padova (IT)	Postdoctoral	08/2017	Metabolic Engineering of photosynthesis
Imperial College London, London (UK)	Postdoctoral	06/2020	Metabolic Engineering of nitrogen metabolism
Italian national Academy (Lincei), Padova (IT)	Postdoctoral, PI	06/2021	Coordination between C and N assimilation
University of Padova, Padova (IT)	Postdoctoral	01/2022	Photorespiration
University of Padova, Padova (IT)	Postdoctoral, PI	11/2022	Coordination between C and N assimilation

A. Personal Statement

I am currently a Tenure Track Assistant Professor (RtdB) at the Department of Biology (DiBio) of the University of Padova (UNIPD). **I have recently been granted a position as Associate Professor in Plant Physiology** in the same institution, starting 11/11/2025. My **research activities focus on the study of photosynthetic microorganisms**, namely unicellular organisms capable to use the energy from sunlight to fix atmospheric CO₂ into biomass. They play a relevant role in the global primary productivity and represent the major entry point of carbon in the biosphere, being responsible for the generation of approx. 50% of the oxygen we breathe. Studying the metabolism of these organisms is **important to understand the biological mechanisms that control growth in the natural environment, potentially enabling to predict the impact of climate change on their space and time distributions and limit the consequences on the functionality of many natural ecosystems**¹. Beside their relevant ecological role, these organisms have emerged as alternative source of biomass for many applications in industry (e.g. biofuels, biofertilizers, cosmetics, food supplements). Therefore, the study of the metabolism of these organisms is also **important to understand the most important operational parameters controlling biomass productivity at the industrial cultivation scale, thus enabling the identification of robust biological targets for biotechnological optimization**².

Currently my main work focuses on **the metabolism of photosynthetic diazotrophic cyanobacteria**, which, besides being able to use sunlight to fix CO₂ into biomass, show also the **ability to fix atmospheric N₂ into assimilable species** (e.g. NH₄⁺). They are **placed at a strategic intersection between the biogeochemical cycles of both carbon and nitrogen in nature**. The investigation of their metabolism is thus important to predict how perturbations of their natural distribution might affect ecosystems functionality. Given their ability to fix molecular nitrogen into bioavailable forms, they are also placed at the **forefront of biotechnological applications in modern agriculture, for the sustainable generation of nitrogen fertilizers**.

So far, **the metabolism of photosynthetic microorganisms has been investigated studying separately nitrogen and carbon (i.e. via photosynthesis) assimilation pathways**. However, nitrogen assimilation depends on the availability of carbon skeletons generated using energy and

reducing power provided by photosynthesis, whilst photosynthetic functionality depends on the availability of pigments and proteins synthesized after nitrogen assimilation. **The two metabolisms are thus intertwined and photosynthetic microorganisms must have evolved a tight functional coordination to ensure whole-system homeostasis.** Therefore, I think it is time to apply a novel approach in which the metabolism of photosynthetic microorganisms is investigated as the result of the **functional coordination between carbon and nitrogen assimilation pathways.** I am confident that my scientific career is mature enough to fulfill this scientific objective. I dedicated four years of my scientific career to investigate the molecular mechanisms at the basis of the photosynthetic efficiency in microalgae at DiBio UNIPD and three years at Imperial College London to study the molecular regulation of nitrogen assimilation in diazotrophic cyanobacteria.

During my past research experience, I have developed awareness about the potentiality of a system biology approach to investigate the complexity of metabolic homeostasis. I have also learned firsthand the drawbacks of current metabolomic approaches for high-turnover and labile metabolites and I am confident that next-generation metabolomics via fluorescence-based protein biosensors will provide both technical and scientific advancements in the field.

Citations:

1. THE ROLE OF CLIMATE CHANGE IN THE MICROALGAL PHOTOSYNTHESIS

Santin A. and Perin G. (corresponding author)*

In press. Chapter 8 in “Pigments from Microalgae Handbook” – Volume I: Biological Foundations, Environmental Influences and Analytical Methods - 2nd Edition (Springer-Nature Switzerland AG), Editors: E. Jacob-Lopes, M.C. Deprá, M.I. Queiroz, and L.Q. Zepka.

ISBN: 978-3-031-93944-0. DOI: 10.1007/978-3-031-93945-7_8

2. ECONOMIC FEASIBILITY AND LONG-TERM SUSTAINABILITY CRITERIA ON THE PATH TO ENABLE A TRANSITION FROM FOSSIL FUELS TO BIOFUELS

Perin G. and Jones P.R.

Current Opinion in Biotechnology (IF 2019, 8.28; Rank in Biotechnology and Applied Microbiology: 9/156, Q1), 2019, 57, pp: 175-182 – DOI: 10.1016/j.copbio.2019.04.004

Grants:

- **Sept. 2024** Project of the “Giorgio Levi Cases” center for energy studies

Title: “A Multidisciplinary approach to improve Energy-use Efficiency in Agriculture (REENACT)”

Fund: **35,000 euros for 1.5y.** Funded by the “Giorgio Levi Cases” Center for Energy Studies / University of Padova / Italy. **PI. Giorgio Perin**

- **Dec 2023** BIRD2023_DiBio UNIPD

Title: “Investigation of Functional Coordination between nitrogen and carbon metabolism in marine microalgae (ORGANISM)”. Fund: **50,000 euros for 2y.** Funded by the Department of Biology of UNIPD / Padova / Italy. **PI. Giorgio Perin**

- **Nov 2023** PRIN-PNRR 2022

Title: “Unveiling the genetic and metabolic determinants of microbe-induced plant resilience (DOMICIL)”. Fund: **50,000 euros for 2y.** Funded by the Ministry of University and Research / Italy.

PI of UNIPD Research Unit. Giorgio Perin

- **Nov 2023** PRIN 2022

Title: “Tracking root single-cell crosstalks among apocarotenoids, phosphate and arbuscular mycorrhizal symbiosis”. Fund: **70,000 euros for 2y.** Funded by the Ministry of University and Research / Italy. **PI. Giorgio Perin**

- **Feb 2022** Starting Grant_STARS@UNIPD

Title: “Unraveling the Win-Win cooperation Between Nitrogen Assimilation and Photosynthesis (WWBiomass)”. Fund: **160,000 euros for 2y.** Funded by the University of Padova / Padova / Italy.

PI. Giorgio Perin

- **Jul 2020** Grant “LINA RIZZO” for studies in the field of planktology
Title: “Understanding the molecular mechanisms controlling nitrogen assimilation and photosynthesis interaction in marine microalgae”. Fund: **PI salary for 1y**. Funded by the Italian National Academy (Lincei) / Rome / Italy. **PI. Giorgio Perin**

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2024 – 2025	Associate Guest Editor of the Special Issue of "Plant Physiology and Biochemistry" (Elsevier) (IF 2024, 5.7; Rank in Plant Sciences: 24/273, Q1)
2024 – Present	Reviewer of DFG (German Research Foundation) proposals
2022– Present	Tenure Track Assistant Professor (RtdB) in Plant Physiology, Department of Biology, UNIPD, Padova
2022 – Present	Reviewer Editor for Frontiers in Plant Science (IF 2024, 4.8; Rank in Plant Sciences: 33/273, Q1)
2022 – Present	Member of the Italian Society of Plant Biology (SIBV)
2022 – 2024	Member of the Scandinavian Plant Physiology Society (SPPS)
2022 – 2024	Member of the International Society for Microbial Ecology (ISME)
2022 – 2022	Fellow of the University of Padova, STARS@UNIPD Funding Programme
2021 – 2021	Visiting Researcher at Imperial College London, London, UK
2020 – 2021	Italian National Academy (Lincei) Fellow, University of Padova, Padova
2018 – Present	Member of Algal Solutions – from Wastewater to Soil, Field and Landscape
2017 – 2020	Research Associate at Imperial College London, London, UK

Honors

2021	International Bioenergy & Environment Congress (I-BE-C) 16-18/02/2021 (CEA – CNRS – Aix-Marseille University, France), Best talk award for the oral presentation with the tile: <i>“Comparing lab-scale and outdoor-grown algae photosynthetic performances to improve biomass productivity”</i> .
2019	Most read paper Award of <i>Physiologia Plantarum</i> for: <i>“The potential of quantitative models to improve microalgae photosynthetic efficiency”</i> . Perin G. , Bellan A., Bernardi A., Bezzo F., Morosinotto T. <i>Physiologia Plantarum</i> (IF 2019, 4.14; Rank in Plant Sciences: 24/234, Q1), 2019, 166, pp: 380-391 – DOI: 10.1111/ppl.12915
2018	Early career travel award of the International Society for Microbial Ecology (ISME), for <i>13th European Nitrogen Fixation Conference (ENFC) - 18-21/08/2018, Stockholm, Sweden</i>
2017	One-year Scholarship Award from the German Academic Exchange Service (DAAD) / Germany. Renounce the position, opting for Imperial College London

C. Contributions to Science

1. My early research activity, from 2013 to 2017 at UNIPD, focused on the biotechnological optimization of microalgae for the development of a green bio-economy. This project focused on the optimization of the photosynthetic metabolism of marine microalgae of the genus *Nannochloropsis* to improve light-use efficiency in artificial growth conditions of industrial cultivation systems. First, I focused on the following question: **which are the molecular controls regulating microalgae photosynthetic metabolism?** This question was addressed using genome-wide approaches to investigate how light intensity influences carbon partitioning within the cell^a. This information was used to modify the photosynthetic metabolism and improve microalgae photosynthetic efficiency for industrial applications. **This work required a multi-pronged effort where i) effective molecular tools for microalgae genetic manipulation were developed** to both identify and modify the biological traits limiting photosynthetic efficiency at industrial scale; ii) **a large collection of photosynthetic mutants was generated** and mutants showing a larger light-use efficiency and biomass productivity (15-25%) than the parental strain

were isolated^b; iii) **mathematical models to describe microalgae growth at industrial scale were developed** and exploited to predict the effect of genetic modifications to identify the ones with the largest positive impact on microalgae productivity^c. **Overall, this work led to 12 scientific publications throughout the following years^d.**

a. LIGHT REMODELS LIPID BIOSYNTHESIS IN *NANNOCHLOROPSIS GADITANA* BY MODULATING CARBON PARTITIONING BETWEEN ORGANELLES

*Alboresi A. *, Perin G. *, Vitulo N., Diretto G., Block M. A., Jouhet J., Meneghesso A., Valle G., Giuliano G., Maréchal E., Morosinotto T. (*Equal contribution)*

Plant Physiology (IF 2016, 6.45; Rank in Plant Sciences: 11/212, Q1), **2016**, 171(4), pp 2468-2482 - DOI: 10.1104/pp.16.00599

b. GENERATION OF RANDOM MUTANTS TO IMPROVE LIGHT-USE EFFICIENCY OF *NANNOCHLOROPSIS GADITANA* CULTURES FOR BIOFUEL PRODUCTION

Perin G., Bellan A., Segalla A., Meneghesso A., Alboresi A. and Morosinotto T.

Biotechnol Biofuels (IF 2015, 6.44; Rank in Biotechnology and Applied Microbiology: 12/161, Q1), **2015**, 8:161 – DOI: 10.1186/s13068-015-0337-5

c. A MATHEMATICAL MODEL TO GUIDE GENETIC ENGINEERING OF PHOTOSYNTHETIC METABOLISM

Perin G., Bernardi A., Bellan A., Bezzo F., Morosinotto T.

Metabolic Engineering (IF 2017, 7.6; Rank in Biotechnology and Applied Microbiology: 9/161, Q1), **2017**, 44, pp 337-347 – DOI: 10.1016/j.ymben.2017.11.002

d. MODULATION OF XANTHOPHYLL CYCLE IMPACTS BIOMASS PRODUCTIVITY OF THE MARINE MICROALGA *NANNOCHLOROPSIS*

Perin G., Bellan A., Michelberger T., Lyska D., Wakao S., Niyogi K.K., Morosinotto T.

PNAS (IF 2023, 9.4; Rank in Multidisciplinary Sciences: 13/134, Q1), **2023**, 120(25), pp e2214119120 – DOI: 10.1073/pnas.2214119120

2. From 2017 to 2020 I was granted a **Research Associate position at Imperial College London** where my research activities focused on the **metabolic engineering of nitrogen-fixing cyanobacteria to reveal the molecular regulatory network of nitrogen assimilation**. This project focused on the perturbation of the natural nitrogen assimilation machinery in a nitrogen-fixing cyanobacterium, *Anabaena sp. PCC 7120*, and investigated how the whole metabolism adjusts homeostasis accordingly, upon both environmental (i.e. different N sources) and genetic (knock-out of ammonium-uptake transporters) treatments. In this project, I applied innovative proteomics and metabolomics (MRM-MS) to characterize the nitrogen metabolism of this photosynthetic microorganism at a whole-system level^f. Data were instrumental to identify genetic targets for metabolic engineering of nitrogen metabolism with the objective to manipulate the nitrogen assimilation flux towards the external environment of the cell for an effective biofertilization in agriculture^g. **Along this line, in 2018, I co-founded an entrepreneurship venture called Bio-F solutions, with the aim to commercialize the biomass of these photosynthetic microroganisms as sustainbale bio-fertilizer**, which is a spin-off of Imperial College London, UK and won the 2018 EIT Global Food Ventures and Entrepreneurship Prizes

f. CALM ON THE SURFACE, DYNAMIC ON THE INSIDE. MOLECULAR HOMEOSTASIS OF *ANABAENA SP. PCC 7120* NITROGEN METABOLISM

Perin G., Fletcher T., Sagi-Kiss V., Gaboriau D. C. A., Carey M. R., Bundy J. G., Jones R. P.

Plant, Cell & Environment (IF 2021, 7.94; Rank in Plant Sciences: 13/239, Q1), 2021, 44(6), pp 1885-1997 – DOI: 10.1111/pce.14034

g. SUNLIGHT-DRIVEN RECYCLING TO INCREASE NUTRIENT USE-EFFICIENCY IN AGRICULTURE

*Perin G. *, Yunus I.S., Valton M., Alobwede E., Jones P.R. (* Corresponding author)*

3. In the first two chapters of my scientific career, I studied the metabolism of photosynthetic microorganisms focusing on carbon and nitrogen assimilation, separately. **I believe it is time to apply a new approach, where the metabolism is investigated as the result of the coordinated activity between pathways, deploying innovative approaches for an investigation at a whole-system level.**

From 2020 to date at UNIPD, I have been awarded three proposals as PI to study the functional relationship between nitrogen and carbon assimilation in photosynthetic microorganisms.

To address this objective, I have been focusing on two distinct hosts and exploiting different methodologies. On one hand I am using **marine microalgae** of the genus *Nannochloropsis* and I am **isolating loss- and gain-of-function mutants for ammonium transporters**, involved in both uptake and sensing, **to investigate their impact on both nitrogen and carbon assimilation efficiency.**

We recently generated independent KO mutants for all the three genes coding for ammonium uptake transporters in *Nannochloropsis* and the impact of the mutation on growth, ammonium uptake and light-use efficiency were successfully completed^h.

On the other hand, I am using diazotrophic photosynthetic microorganisms and I am using both spectroscopy techniques and next-generation metabolomics. In the first case, **we exposed the biological system to variable metabolic inputs (e.g. light, CO₂ and N availability) and investigated both photosynthetic functionality and nitrogen fixation to infer how the regulation of photosynthesis can shape the relationship between carbon and nitrogen assimilation pathways upon dynamic natural conditionsⁱ.**

On the other hand, I have implemented **genetically-encoded fluorescent probes** in the host **to measure light-induced changes both in i) physical-chemical parameters (i.e. pH and redox status) and ii) the concentrations of universal carries of chemical energy (i.e. ATP), reducing power (i.e. NADH) and carbon skeletons (i.e. 2-OG), whose metabolic orchestration is likely to be at the base of the functional coordination between the two metabolic pathways.** We completed the isolation of strains effectively expressing the probes of our interest and successfully collected both pH and redox status data upon different environmental conditions both in bulk cultures and at a single-cell level. Because I have recently run out of the funds supporting this research activity, the collection of ATP, NAD(P)H and 2-OG concentration data was interrupted, and it is therefore the subject of the submitted proposal.

h. THE PLASMA MEMBRANE AMMONIUM TRANSPORTER2 (AMT2) IS INVOLVED IN AMMONIUM UPTAKE IN THE MARINE MICROALGA *NANNOCHLOROPSIS GADITANA*

Papini F., Santin A., Bellan A., Morosinotto T., Alboresi A. and Perin G. (*Corresponding author)*
In preparation

i. PHOTOSYNTHESIS REGULATION IMPACTS CARBON AND NITROGEN ASSIMILATION IN THE DIAZOTROPHIC CYANOBACTERIUM *ANABAENA* SP. PCC 7120

Santin A. and Storti M., Mezzavilla M., Fortunato A., Arcudi F., Flores E., Morosinotto T. and Perin G. (*Corresponding author)*

Under revision in New Phytologist (IF 2024, 8.1; Rank in Plant Sciences: 12/273, Q1)