Invited Speakers: Nitrogen Fixation in Plants and Hyperthermophiles

Understanding and manipulating biological nitrogen fixation is of high importance, given our dependence on ammonia fertilizer for agriculture. Ammonia produced by the centralized Haber-Bosch process accounts for 1-2% of global carbon dioxide emissions resulting from human activity (considering the hydrogen required for this process), rivaling emissions from global aviation. Achieving nitrogen fixation in plants would therefore be a major potential advance for humanity. To achieve this, we need to understand how to heterologously assemble active nitrogenases. Further, "bio-inspired" catalyst design requires that we first understand the mechanistic workings of nitrogenase.

Speaker: Dr. Tristan Wagner, group leader at the Max Planck Institute for Marine Microbiology, Bremen, Germany.

Time/place: Thursday April 4th 2024, 15h15 – 16h15, A100 Sciences II

Biological N_2-Fixation at 92 °C: Unveiling the Molecular Secrets of Marine Methanogenic Archaea

Methanogenic archaea contribute to the carbon cycle by generating half the atmospheric methane yearly. Recent studies indicate that methanogens are also important to the nitrogen cycle by fixing N_2 in particular ecological niches. The work of our group is to understand how hydrogenotrophic methanogens, relying on H_2 and CO_2 to derive their cellular energy, cope with the process of N_2 fixation. Combining physiological experiments with comparative transcriptomics and protein biochemistry allowed us to understand the key metabolic reshuffling, allowing the transition towards N_2 fixation. Through structural biology, we obtained snapshots of the N_2 fixation machinery and deciphered the molecular basis of the process that can be transposed to biotechnology.

Speaker: Prof. Luis M. Rubio, Center for Plant Biotechnology and Genomics, Madrid, Spain.

Time/place: Friday April 5th 2024, 10h – 11h, A100 Sciences II

A Synthetic Biology Approach to Engineer Nitrogen Fixation in Cereals

Cereal crop productivity is highly dependent on nitrogen availability. Small farmers in Sub-Saharan Africa who cannot afford the cost of synthetic fertilizers experience extremely low crop yields, leading to poverty and hunger. Our laboratory aims to increase cereal crop productivity by enabling plants to acquire nitrogen from the atmosphere instead of synthetic fertilizers, thereby helping these farmers overcome poverty. Synthetic biology is used to engineer the expression of prokaryotic nitrogenase genes in plants with the aim of obtaining an environmentally and economically sustainable product. Engineering active nitrogenase in plants and other eukaryotes requires managing a large number of genetic parts for nitrogenase assembly and function, as well as addressing nitrogenase sensitivity to O2. Nitrogenase genetic engineering involves by assembling four genetic modules: the Fe protein module, the MoFe protein module, the FeMo-cofactor biosynthetic module, and the electron transport module. Our laboratory uses yeast and tobacco as model organisms and employs a combination of synthetic biology and biochemical complementation assays to investigate the functionality of these modules in eukaryotes. The validated components are subsequently integrated into the rice genome to assemble the complete nitrogenase pathway step-by-step. This process will ultimately lead to the production of nitrogen-fixing cereals.

Please contact ross.milton@unige.ch if you would like to meet with either speaker.