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Improving the efficiency of photosynthesis and nitrogen use in our most important crops

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The path of CO_2 into a leaf takes many twists and turns. Evolution has generated a staggering diversity of biochemical pathways, leaf anatomies, and electron transport capacities across the broadly categorized photosynthetic types (C_3, C_4, and CAM). To feed a growing global population in a changing climate, efforts are underway to improve photosynthesis to boost crop yields while at the same time using less nitrogen fertilizer to mitigate its environmental cost. Understanding the details of photosynthesis and nitrogen metabolism reveal targets for improvement. Professors Asaph Cousins and Mechthild Tegeder and their labs at Washington State University (Pullman) are not afraid to tackle challenging research questions, digging deep into the details of photosynthesis and nitrogen metabolism and shedding light on how two or more processes are related.

Take any paper where the Cousins lab and collaborators are involved and you will likely find a key bridge between innovative techniques and approaches. These techniques include IR spectral reflectance, light and transmission electron microscopy, enzyme kinetics, loss of function mutants, high throughput sequencing, and gas exchange. Gas exchange combined with isotope discrimination analysis is a key technique of the Cousins lab. Plants discriminate against ^{13}C (e.g. CO_2 and HCO_3) via isotope effects, lowering the $^{13}C/^{12}C$ ratio at various fractionation steps during photosynthesis. After measuring ^{13}C discrimination during photosynthesis under various conditions, the Cousins lab then rigorously fits this empirical data to the latest mathematical models to quantify these metabolic processes and parameters in our most important crops.[1-4] Asaph's work and network of collaborators reflects his own well rounded nature; being a mentor to aspiring scientists, helping organize Gordon Conferences, and sitting on the scientific advisory board of Benson Hill. Interestingly, his most cited work is about the dynamics of nitrogen (nitrate) assimilation, which intersects with the research of Professor Tegeder.[5,6]

Professor Tegeder is a world leader in plant nitrogen metabolism and is working to coordinate nitrogen uptake, transport, and allocation in our most important crops to help them use nitrogen more efficiently. Nitrogen metabolism and CO_2 assimilation are intimately intertwined; nitrogen helps build the photosynthetic apparatus that in turn provides the carbon backbone and energy/reductants to reduce nitrogen and continue amino acid and protein synthesis. In soybean, the Tegeder lab upregulated nitrogen export from root nodules, positively feeding back and improving soybeans ability to convert and assimilate atmospheric nitrogen, improving growth, biomass, and bean yield.[7] Currently, the Tegeder lab focuses on amino acid transporters and the dynamic interplay between nitrogen sources and sinks. In peas and *Arabidopsis*, upregulating and knocking out one amino acid transporter can improve yield and overall nitrogen use efficiency; whereas knocking out another can have negative effects on nitrogen allocation and yield.[8-11] In *Arabidopsis*, improved nitrogen uptake efficiency and allocation to leaves led to greater CO_2 assimilation and ultimately seed yield.[11] As the Tegeder lab leads our understanding of the amino acid transport network and how to fine tune it, one theme is emerging: more efficient nitrogen uptake and support of photosynthesis can improve the nitrogen use efficiency of seed yield.[12,13]

Washington State University's School of Biological Sciences has a long history of great photosynthesis research, namely the work of Professors Gerald Edwards, Maurice Ku, and Alan Black. With over 8000 citations between them, the Cousins and Tegeder labs are continuing this legacy. Great research starts with high quality plants. BioChambers (formerly Enconair) is proud to have partnered with Washington State University's School of Biological Sciences, with over 25 years of service.[14-21]

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*Research using BioChambers (Enconair) equipment

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