My primary research interest is to understand the mechanisms of photosynthesis, in particular, how the chloroplast’s molecular machinery is regulated to efficiently provide the right amount of energy in the right forms, without producing toxic side products. One of my approaches is to develop new methods and instruments to study photosynthesis in action. We have developed a large toolbox of spectroscopic tools to probe how plants, algae, and bacteria convert light energy to the ‘currency of life’ at the molecular level, in addition to identifying photosynthetic physiological functions.

# ATP Synthase

A major focus is the chloroplast ATP synthase, a pivotal enzyme complex that uses solar energy stored in protons to make ATP. My research has shown that this enzyme also plays a central role in regulating the light and the dark reactions of photosynthesis. It manages the flux of protons to balance the efficient harvesting of light and to avoid photodamage. By restricting the efflux of protons, the ATP synthase triggers photoprotective mechanisms that slow down the rate of photosynthetic reactions. When this regulation is disabled in experiments, photosynthetic efficiency increases under mild conditions, but in real world environments (ex: fluctuating light), photosynthetic proteins suffer severe damage. Although scientists are trying to improve photosynthetic efficiency in order to increase crop yields and to feed our expanding population, we show that simply altering photosynthetic regulatory mechanisms may do more harm than good.

# Developing new technologies

Over the years, technological advances have allowed the Kramer lab to produce sophisticated handheld spectrometers at low cost, including an open source cloud-based platform, called [PhotosynQ](http://photosynq.org/), that measures a range of photosynthetic parameters. As part of the PhotosynQ team, I am developing new tools to monitor photosynthesis in the real world. For example, we have discovered the mechanisms of photodamage in the laboratory. Do they work similary in the field? If so, what environmental conditions trigger them? Are there any differences among photosynthetic species?

We are currently developing a new field-deployable instrument, called HyperspeQ, that can also detect chemicals, such as aluminum or fungal toxins, in the soil and in grains.