My primary research interest is to understand the mechanisms of photosynthesis, in particular, how the molecular machinery of the chloroplast 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 probe photosynthesis in action. We have developed a large toolbox of spectroscopic tools to probe how the living plants, algae and bacteria are converting the light energy to the ‘currency of life’ in molecular level, and the physiological functions.

A major focus of topic 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 (Kanazawa and Kramer 2002).  It regulates the flux of protons to balance the efficient harvest of light, and to avoid photodamage. By restricting the efflux of proton through ATP synthase, it triggers the photoprotective mechanisms, and the rate of photosynthetic reaction slows down. When this regulation was disabled, the photosynthetic efficiency increased under mild condition, but caused severe damage to the photosynthetic proteins in the real world environment (e.g. fluctuating light condition, Kanazawa et al. 2017). Many scientists are trying to improve the photosynthetic efficiency for a hope to increase the crop yield to feed the expanding population.  However, simply altering the photosynthetic regulatory mechanisms may do harm than good.

Over the years, advancement of technologies allowed us to make sophisticated handheld spectrometers in low cost. Along with the establishment of an open source cloud-based scientific platform called PhotosynQ (see photosynq.org), we could measure photosynthesis in the real world. Since it was launched 4 years ago, we have more than 2,700 users of PhotosynQ, and 700k data set from all over the world.  Being a part of the PhotosynQ team, I am developing new tools to monitor photosynthesis in the field. My research interest is expanding beyond laboratory. For example, we found the mechanisms of photodamage in the lab. Are they same in the field? If so, what kind of environmental conditions trigger them? Are there any differences among species? We are currently developing a new field-deployable instrument called HyperspeQ that could measure not only the photosynthesis in plants and microbes, but also detect some chemicals in soil and grains such as Aluminum and fungal toxins.