Quantum optics has had a profound impact on precision measurements. Recently, this has enabled probing various physical quantities, such as magnetic fields and temperature, with nanoscale spatial resolution. Such advancements in ‘quantum sensing’ have brought the elusive dream of performing nuclear magnetic resonance spectroscopy (NMR) on individual biomolecules closer to reality. In my talk, I will discuss the development and application of novel quantum metrological technologies to study biological systems at a single-molecule level. I will start with a general introduction to quantum sensing, with a focus on the detection of an individual 13C nuclear spin. I will then show how we can utilize such sensing techniques to control the temperature profile in living systems with subcellular resolution. Furthermore, I will introduce a multicolor electron microscopy modality that can visualize the absolute location of proteins within the context of cellular ultrastructures with up to ten nanometer spatial resolution. Finally, I will provide an outlook on how quantum sensing and single-molecule biophysics can be combined to perform NMR spectroscopy with unprecedented sensitivity, possibly down to the level of individual biomolecules.