Lung disease may arise from a wide spectrum of genetic, environmental, immunological, or unknown etiologies, and may carry significant lifelong morbidity and high mortality. Research in the Walkup group at Cincinnati Children’s Hospital focuses on the development and clinical application of magnetic resonance imaging (MRI) techniques to assess lung disease. This seminar will focus on hyperpolarized $^{129}$Xe MRI, where image contrast arises from chemically-inert $^{129}$Xe gas which has been “super magnetized” to have MRI signal many orders of magnitude above equilibrium and thus may be imaged during a breath-hold maneuver. The basic physics of hyperpolarized $^{129}$Xe gas production and MRI techniques will be discussed in the context of application to rare-lung diseases, demonstrating how advances in basic science and engineering can be translated “bench to bedside” and manifest as clinical research with large impact.