The possibility of in vivo $^{17}$O magnetic resonance (MR) imaging of a rat head was evaluated for the first time using the unique 21.1 T NMR/MRI magnet at the MagLab. The very short T1 relaxation time (~ 5 msec) of oxygen-17 enables the MR signal of $^{17}$O to be acquired very quickly. In fact, the $^{17}$O MR signal intensity that occurs naturally in living systems ranks third after only hydrogen and sodium.

A radio frequency (RF) probe was developed by MagLab engineers that features a double-tuned $^{17}$O/$^1$H volume RF coil that covers the entire rat head. The in vivo experiments were performed using three male Fisher 344 rats (~ 200 g). The time course of $^{17}$O MR signal was investigated after intra-venous tail injections of 1 mL PBS solution containing 17% enriched H$_2^{17}$O or 1.5 ml of PBS with 500 mg of 6-$^{17}$O 47% enriched D-glucose. These experiments establish that high field in vivo $^{17}$O MRI is a promising research tool that exploits the capability of NUKEM Isotopes to synthesize $^{17}$O-labeled glucose.

The results indicate that $^{17}$O MR relaxation times depend on the strength of the magnetic field, which correlates with earlier MagLab observations for sodium. A three dimensional MRI of $^{17}$O was acquired in 1.5 minutes with a record resolution of 1 mm$^3$ in the rat head (see Figure). Because of the excessive glucose metabolism in tumors (the Warburg effect), this work demonstrates that in vivo oxygen MRI promises to be a valuable tool for future tumor detection. Future in vivo oxygen MRI will seek MRI biomarkers of tumor resistance to chemotherapy and other forms of cancer therapy.

Figure. Three-dimensional MRI of $^{17}$O in a rat head, acquired one minute after injection of 17.5% enriched H$_2^{17}$O. The yellow line on the left image shows the position of the image presented on the right. The rat’s eye sockets can be seen at the top of the right image. Note the increased perfusion in all areas of the rat brain and in the cortical areas, represented by high illumination. The $^{17}$O water signal decreased with time as the water distributed itself throughout the rat’s body, with an exponential decay time of 11 ± 0.4 minutes (n=2).