Introduction: The perovskite structure class, one of the most commonly occurring in all of materials science, has the general formula ABX$_3$, where A corresponds to a large electropositive cation, B represents a small transition metal, and X is generally an oxide or halide anion. Sr$_2$FeMoO$_6$ is an ordered double perovskite, with B-cations Fe$^{3+}$ and Mo$^{5+}$ (electron configurations t$_{2g}^3$e$_g^2$ and t$_{2g}^1$e$_g^0$, respectively), which undergoes a ferrimagnetic to metallic transition at approximately 420 K. Although these compounds are metallic, there is significant evidence that electron transport occurs via exchange of the Mo$^{5+}$ d$^1$ electron. This transport is highly spin-polarized – the compound is only metallic when the conducting electron has an opposite spin than the Fe$^{3+}$ d$^5$ electrons. A large inter-grain boundary resistance exists which can be significantly diminished through application of a magnetic field, thus giving this compound its magnetoresistant property.

In this study, the structural, magnetic, and transport properties of several double-perovskites (specifically, Sr$_2$MnMoO$_6$, SrLaMnMoO$_6$, Sr$_2$MnRuO$_6$, SrLaMnMoO$_6$, Sr$_2$VMoO$_6$ and Ca$_2$VMoO$_6$) were studied, in order to achieve a better comprehension of the relative energy levels of the B cations and magnetoresistant properties of these materials. To explain why these compounds lack or portray magnetoresistant properties, we used variable temperature high-resolution synchrotron X-ray and neutron powder diffraction techniques, electrical transport, and magnetic susceptibility measurements. Variable temperature high-resolution synchrotron X-ray measurements were taken to determine the structure-property relationship of the phase transitions.

Methods and Materials: Polycrystalline samples were prepared in air from stoichiometric quantities of CaCO$_3$, SrCO$_3$, MoO$_3$, V$_2$O$_5$, La$_2$O$_3$, and RuO$_2$ using conventional ceramic synthesis techniques. Initial annealing cycles were carried out in air in the 875 – 1100 °C range to decompose the carbonates. After a one hour purge, the molybdenum samples were heated in flowing H$_2$ (5%) / N$_2$ for 8 – 12 hours in the 1000 – 1250 °C. The ruthenium samples were heated in air with final anneal temperatures in the range of 1300 – 1450 °C. Magnetic susceptibility measurements were obtained using a SQUID magnetometer. Variable temperature high-resolution synchrotron X-ray measurements were taken at the X7A beamline. Electrical resistivities were measured on sintered pellets using a four-probe technique in the range 20-300K.