



**CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY**

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Project Title Fridge Magnets: Magnetocaloric Behavior of Gadolinium at Room Temperatures	
Objectives/Goals A green option for large-scale cooling is Magnetic Refrigeration, based on an aspect of the magnetocaloric effect (MCE), wherein removal of a magnetic field applied to a ferromagnetic material causes a temperature drop. Harnessing this drop avoids high energy demands and environmentally hazardous gases of conventional cooling. Some materials only show the effect near 0Kelvin, but gadolinium (Gd) is practical in that it displays the MCE at room temperatures. This experiment studied temperature drops in Gd upon demagnetization, repeated over a wide ambient temperature range, in order to define working limits for the MCE in Gd. It was hypothesized that there would be increasingly large temperature drops in the sample as the ambient temperature of the test environment approached the Curie point of the sample, 21°C, followed by an abrupt disappearance of the effect at temperatures beyond the Curie point (temperature at which ferromagnetic character ceases).	
Abstract	
Methods/Materials A small apparatus was built using a board with battery clips attached 8mm apart, into which cylindrical magnets fit to produce a 0.5 Tesla field. A tiny sample of gadolinium, a reference piece of copper (Cu), and thermocouple wires were sandwiched between the magnets. As the magnets were snapped in and removed, thermal changes at demagnetization were tracked in the Gd and Cu. Runs were repeated at 32 temperature points between 10°C and 30°C.	
Results Gd clearly behaved in a magnetocaloric fashion, with a sharp drop in temperature at demagnetization, compared with flat thermal behavior of the Cu control in the same environment. Maximum deviation from ambient (deepest point of temperature drop) for the Gd in each test was placed in a scatter plot, to track how magnitude of cooling intensified as ambient temperature neared the Curie temperature of 21°C.	
Conclusions/Discussion The size of temperature drops recorded in the Gd increased as the ambient temperature approached the Curie point of the sample, as hypothesized. What had not been anticipated was an observed continuation of the magnetocaloric effect for several degrees above the Curie point. This more generous ambient temperature range for the cooling effect appears to be of practical use, as the heat sink temperature in a magnetic refrigerator would thus not need to be as tightly controlled, resulting in energy savings.	
Summary Statement Study of magnetocaloric cooling in gadolinium at demagnetization from 0.5Tesla near its 21°C Curie point resulted in an unexpectedly large operating-temperature span, an asset to using Gd for environmentally friendly magnetic refrigeration.	
Help Received Used contact info from journals to email questions to Dr. C. Zimm, Astronautics Technology: Madison, WI, and Prof. K.A. Gschneidner Jr., Ames Laboratories: Iowa State U., who also gave me small Gd foil piece. Dr. C. Nordman of NVE Corp., Minneapolis, explained details of magnetism and thermocouples.	