Strong Materials: Temperature effects?

Before this experiment, familiarize students with famous accidents related to materials properties. A good example is the Liberty ships used in World War II, or even, some say, the Titanic disaster. These ships were built with steels that suffer from ductile-to-brittle transitions, which causes relatively easy cracking at very low temperatures such as those encountered in arctic regions.

You would need some serious mechanical testing equipment to test those carbon steels, but the concept can be visualized using liquid nitrogen and a banana. The banana has a high water content and a clear ductile behavior when squeezed—ask a student to squeeze it, it's messy but fun! However, when dipped into liquid nitrogen, the banana can not only not be squeezed, it will shatter in many pieces if thrown on the floor. You can compare this to the carbon steel hull of the Titanic hitting an iceberg. Of course the metal analogy is far from perfect, but is inspiring.

What do they learn? Temperature affects materials properties by affecting the movement of the atoms, sliding planes, chemical bonds, etc., within the materials. Knowing the expected operating temperature range of a material and developing materials that are strong at those temperatures is the job of a materials engineer.

What do you need? Four-liter cryogenic container, liquid nitrogen, bananas.