

New York Times  
November 28, 2006

## ***Antique Nanotubes***

By [HENRY FOUNTAIN](#)

All hail the great 17<sup>th</sup>-century nanotechnologist Assad Ullah!

Actually, he was a swordmaker, one in a long line of smiths who forged the legendary weapons known as Damascus sabers. They were strong yet flexible and supremely sharp, which European warriors first discovered, much to their misfortune, at the hands of Muslims during the Crusades.

The recipe for making Damascus steel was lost at the end of the 18<sup>th</sup> century, so no one knew the reasons for its remarkable qualities. But an analysis by 21<sup>st</sup>-century researchers in Germany provides a clue: Damascus sabers, they [report](#) in *Nature*, contain carbon nanotubes.

Using a transmission electron microscope, Peter Paufler of the Technical University of Dresden and colleagues looked at a very thin sample of steel from a saber made by Assad Ullah, who worked in what is now Iran. What they saw seemed for all the world like carbon nanotubes, cylindrical arrangements of carbon atoms first discovered in 1991 and now made in laboratories all over the world. Further analysis confirmed that that was what they were.

“If you look at the spacing of the atomic layers in these nanotubes,” Dr. Paufler said, “the spacing is the same as reported by others studying mass-produced nanotubes.”

The steel also contains nanoscale wires of cementite, an extremely hard carbon-iron compound, that were probably formed inside the nanotubes, like the filling in a cannoli. These nanowires give Damascus sabers another distinctive characteristic: a moiré pattern of banding on the steel.

Swordmakers used special high-carbon steel cakes, called wootz, which were made in India from iron ore that contained vanadium and other impurities. Wootz also had a high percentage of carbon, which was introduced by incorporating wood and other organic matter during fabrication. Dr. Paufler said the vanadium and other impurities could have acted as catalysts to turn some of the carbon atoms in the steel into nanotubes during the heating and reheating of forging.

Of course, Assad Ullah and other swordsmiths would have had no idea that they were creating carbon nanotubes. “They just did tremendous empirical work,” Dr. Paufler said. “They optimized the procedure over centuries in order to get the most strength.”

