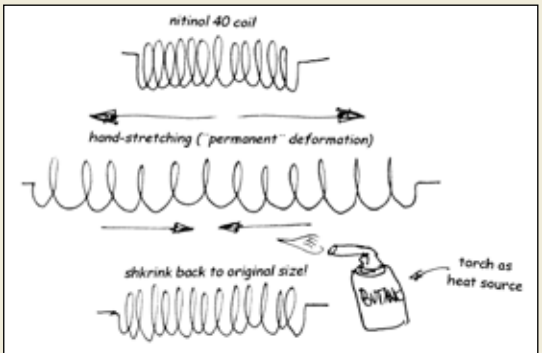
Super Materials: Materials with memory!

Shape-memory alloys are fantastic examples of when materials by themselves can replace entire mechanical setups. In this activity we bring Nitinol 40 (ASTM F2063), a nickel-titanium alloy that can be purchased in a set for about $50. We use coils of this to show that even after deformation, the original shape returns if heat is provided. Making the coil beforehand is very important, do this in your lab. The alloy typically comes in straight wires that are very hard to bend—they "want" to retain the straight shape. Wrap the wire over a ceramic or glass tube roughly ¾ inches in diameter as a form to force it into a coil. Make at least a 3 in. long coil. You will need to use metal clips to help retain the coil shape.

Use safety glasses, because the wire can uncoil and cause injury. With the wires in a coil shape (still on the ceramic rod), place the rod and coil in a furnace at 400°C for 15 min. This will give a new "memory" to the wire. After cooling and removing the ceramic rod, the alloy will remain in the coil shape. Even when pulled, it will quickly return to its coil shape. During the activity in class, show this coil and another one made with a regular steel with the same gage so they look similar. Ask a student to stretch both till they see visible deformation. The Nitinol one will be harder to deform, as it has a strong memory, but make sure the student pull it enough to cause a permanent deformation. Then, use a butane torch (such as those used for dessert preparation) on a separate table away from the students to heat both coils. The Nitinol will retract to very close to its original coil size, the regular steel one will not.

Be careful—the torch is an open flame, and students should not get too close. You also need a fire extinguisher close by. For a more interested audience, you can show slides with schematics of the phase transitions going on in the experiment. You may relate this alloy to dental applications such as braces, and you can "dream on" and speculate other applications in the future for similar alloys, such as in cars that don't need to be mechanically fixed after a crash, but heated to regain their original shape!



What do you need?

Nitinol 40 (ASTM F2063) wires (0.007 inches diameter, 6 ft), furnace for annealing, ceramic tube to hold the coil, metal clips, cooking butane torch, regular steel wire with same gage as Nitinol, small fire extinguisher.

What do they learn? Materials can be designed to show shape memory, which is based on a phase transformation where atoms are positioned in different positions. While this is already used in dental applications, materials engineers can use the concept to create many others.