## The Science of Japanese Swords

Japanese swords are made from a composite of different types of steel. Softer lowcarbon steel is used for the core of the blade (*shingane*), while harder high-carbon steel is used for the outer layer (*kawagane*). The material for each section is hand-chosen from pieces of *tamahagane*, which can only be produced via *tatara* smelting.

This combination of metals gives Japanese swords exceptional sharpness and pliability. The outer *kawagane* is hard enough to hold a razor edge, but the inner *shingane* is flexible enough to withstand the impact of a blow. A sword made entirely of high-carbon steel would be brittle and prone to breaking, and one made entirely of low-carbon steel would be blunt and easily bent.

As shown in the chart at the bottom left of the panel, the arrangement of low-carbon and high-carbon steels creates varying levels of hardness in different parts of the blade. The hardness (vertical axis) decreases as the distance from the edge of the blade (horizontal axis) increases, meaning that the hardest steel is found at the blade's cutting edge. In this particular test, the blade was roughly four times harder at its edge than at its core.

This difference can also be seen in the microscopic images displayed on the panel. The starkest contrast is between a cross section of the core (top left) and the surface of the blade near the edge (bottom right). The structure of the low-carbon ferrite core looks sparse compared to the dense, high-carbon martensite edge.