Lost Wax
Found Sculpture

Humans have cast bronze into different shapes since the Bronze Age (c. 3300–1200 b.c.). An alloy of copper and tin that usually contains small percentages of other metals as well, bronze has been a primary medium of artistic expression in the Mediterranean and European cultures since the fifth century b.c.

Lost-wax casting is the process that was used most frequently in past centuries to create bronze sculptures. In this process, a model is made out of wax and encased in a ceramic mold. During a dramatic moment in the pour, the wax is driven out of the mold by molten bronze, which then cools and hardens inside the mold. The following exhibition illustrates eight major steps in the process of lost-wax casting according to the contemporary practice of this traditional technique.

The bronze group *Leda and the Swan*, created in Florence, Italy, around 1710 to 1720 by Antonio Montauti (1683–1746), is used to demonstrate the bronze-casting process in this exhibition. The original bronze—a prized sculpture in the collection of the Minneapolis Institute of Arts—can be admired upstairs in the U.S. Bank Gallery, where it is shown along with two other bronzes by the same artist in the special exhibition *Beauty & Power: Renaissance and Baroque Bronzes from the Peter Marino Collection*.

We thank Don Myhre and his team at the Minneapolis College of Art and Design for creating the models that are used in this exhibition to illustrate the different stages of the bronze-casting process.

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Photographs of engravings from the *Encyclopédie* of Denis Diderot (1713–84) and Jean le Rond d'Alembert (1717–83) are included in the exhibition to illustrate the techniques of lost-wax casting for large sculptures. Published in Paris between 1767 and 1772, these plates show the casting process for the twenty-one-foot-high equestrian statue of Louis XIV, king of France, that was cast in 1692 by Balthazar Keller (1638–1702) and François Girardon (1628–1715). Made for Place Vendôme in Paris, the statue was destroyed during the French Revolution.

The degree of sophisticated engineering evident in Diderot's images of large-scale bronze casting helps us to understand why the creation of this equestrian statue of Louis XIV was celebrated as a technological feat as well as an artistic accomplishment of the first order. Indeed, both in terms of its technological complexity within the parameters of the seventeenth century and for the prestige it engendered nationally, the casting of this bronze masterpiece may well be compared to NASA's space program in America during the 1960s and 1970s.

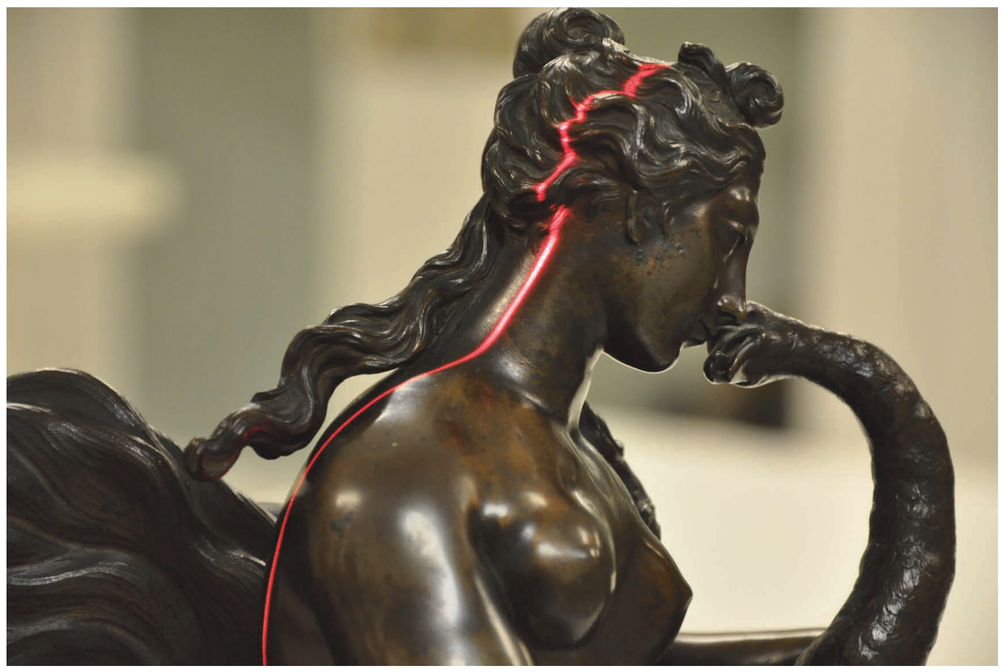
A rare large-scale bronze made about a decade before Girardon's and Keller's equestrian statue, the *Borghese Gladiator* by Joseph Vinache (1653–after 1717), is now on view in the U.S. Bank Gallery. Kindly lent by a private collector, it is being presented to the American public for the first time.

1

The model

Since the Renaissance, most bronzes have been cast using the *indirect* lost-wax technique (shown in this exhibition), in which the actual casting model (which is destroyed during the process) is taken from an initial model that is preserved and may be used to create backups if something goes wrong. More significantly, this initial model may be employed to produce additional casts, turning the work of art into a multiple. During the Renaissance and Baroque, typically only a few casts were made from the same original model.

Conversely, in the much less frequently used *direct* casting process, the casting model is sculpted in wax by the artist, and if something goes wrong, the artist has to restart entirely from scratch. The direct casting process is otherwise identical to the indirect casting process; it just skips the first two steps illustrated in this exhibition.



Laser scanning *Leda and the Swan*

Since *Leda and the Swan*, a three-hundred-year-old bronze from the collection of the Minneapolis Institute of Arts, is used as an example of bronze casting in this exhibition, a half-size gypsum model of the sculpture was printed from a laser scan. Copying the bronze manually or taking a plaster cast from it would have been less precise and in the case of taking a plaster cast would have exposed the surface of the museum's masterpiece to the risk of damage.

2

The mold

Nowadays, flexible silicone molds taken from the original model—as shown in this exhibition—allow artists to take casts of complex and intertwining three-dimensional shapes.

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Until the first half of the twentieth century, it would have been necessary to take several partial plaster casts to capture the different parts and angles of a complex piece in its entirety. Then, when the several casts were put together to form the mold, visible seams between the separate pieces would have been shaved off manually.

3

The casting model

Wax is poured into the mold to create a casting model.

After the model is removed from the mold, small imperfections in the wax are corrected manually, the surface is smoothed, and edges are sharpened. Additionally, detail may be added to the wax figure. It is amazing how much of the detail applied to the wax is actually preserved in the final bronze. Without magnification, this detail might appear to have been applied to the bronze in the cold.

Brian Nigus chasing the wax model

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In the Renaissance and Baroque, most bronzes—of whatever size—were cast hollow in order to reduce their weight and save on precious material. Large-scale bronzes are necessarily hollow casts for technical and structural reasons. Before being cast, hollow bronzes are fitted inside with an iron armature. The iron armature supports the casting model while it is being constructed and during the pour. Hollow areas between the wax and the iron structure are filled with a heat-resistant mixture of plaster, clay, brick, and manure. This mixture, called the *core*, is often cleaned out of the sculpture after casting in order to reduce the weight of the piece and minimize stress on its walls. However, if any of the core remains inside the bronze, it provides valuable material for scientific analysis.

4

Adding the sprues, gates, and vents to the casting model

An exterior circulatory system of *sprues* (channels) is added to the casting model to carry the molten bronze into the mold during the pour. These sprues also provide escape routes for the melted wax and gases that build up in the casting process.

The casting process takes advantage of the force of gravity, so the placement of the pouring cup depends on how the figure will be positioned during the pour.

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In the engraving, the sprues through which the molten bronze flows into the model are marked with the number **1**, those that allow gases and melted wax to escape, with the numbers **2** and **3**.

5

The ceramic investment

A ceramic investment, or shell, is added to the outside of the figure and sprues.

Traditionally, the artist would have applied a mixture of clay and other materials such as sand manually in order to create an investment that could withstand high temperatures during the pour.

Don Myhre dipping the figure into the colloidal silica shell bath

Nowadays an investment, or shell, to protect the model from heat during the pour may be conveniently applied to the model by dipping it a number of times into colloidal silica and stucco. After each layer dries, the dipping is repeated until the desired thickness of approximately one-half inch (twelve to thirteen layers) is reached. As the viscous material dries, it hardens and turns from yellow to white.

The pedestal to the right allows a glimpse into the investment with the model inside. The pedestal to the left shows how the investment would look without the figure. In the actual casting process, the investment fully covers the model and its attachments and constitutes the solid wall within which the liquid materials will enter and exit during the burnout and pour and within which the bronze will cool.

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In the case of large-scale bronzes, the investment mold is secured with a web of iron straps (image on the far right).

The cross section of the mold in the casting pit (image on the near right) shows the interior iron armature surrounded by the core, the sprues, and the outer investment mold.

6

The burnout and the pour

Inside the investment, the mold is baked until all the wax burns away, creating the space into which the molten bronze will be poured.

Molten bronze (at 2100° F) is poured into the cavity left by the wax. The bronze then cools down and solidifies inside the ceramic investment.

The figure in the furnace

Don Myhre pouring the bronze

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The view of the foundry shows the furnace moments before the molten bronze is released into the monumental mold, located underneath the floor. With a long iron pole (indicated by the number **6**), the two men at right are ready to push in the stopper that holds back the molten metal so that it can flow into the shallow reservoir (number **9**) behind them. Simultaneously, two men at the left stand ready to raise a bar to lift the sprue plugs (number **7**) through which the bronze will pour into the mold.

7

Hammering off the investment

The ceramic shell investment is hammered off, and only now can the artist see whether the cast was successful or not. Historically, if the molten bronze did not flow correctly and an individual limb, for example, was missing from a figure, artists tended to cast the missing part separately and mount it onto the sculpture. Alternatively, they might cast the missing part directly onto the figure rather than repeating the entire bronze-casting process.

Hammering off the investment

Sooty surface of the head of Leda

8

Chasing, tooling, and patinating the bronze

Eventually, the figure is cleaned up and worked in the cold.

The sprues are sawed off the figure, the oxide layer is scrubbed off its surface, the sprues' uneven attachment points are leveled, and any necessary repairs (such as filling holes) are carried out.

As the very last step, a coating, or patina, is generally applied to the bronze.

To see the original bronze of *Leda and the Swan* by Antonio Montauti, please be sure to visit the special exhibition *Beauty & Power: Renaissance and Baroque Bronzes from the Peter Marino Collection*, on view upstairs in the U.S. Bank Gallery.

Traditionally many artists sought to work all detail into the wax model in order to minimize the arduous task of finishing the sculpture in the cold. On the contrary, some artists—such as Antonio Susini (1558–1624), who originally trained as a goldsmith—made a point of tooling bronze in the cold to the utmost detail. Often this painstaking process of chasing, filing, chiseling, and hammering was left to specialized workshop assistants.

In the Renaissance, slightly oxidized, greenish patinas suggestive of unearthed archaeological bronzes were initially very popular. Later, with Giambologna (1529–1608), reddish-brown patinas became fashionable and remained so throughout the Mannerist and Baroque periods. Alternatively, it was popular during the Baroque to gild bronzes.