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Cover illustration: Detail of Tullio Lombardo (Italian, ca. 1455–1532), *Adam*, ca. 1490–95. See Figure 1, page 34.

For Julie Jones

A meticulous and probing reader who significantly
broadened the *Journal*'s scope

For Bruce Campbell

An exceptional designer
who lavished his talents on this publication

Contents

Manuscript Guidelines for the *Metropolitan Museum Journal*

The *Metropolitan Museum Journal* is issued annually by The Metropolitan Museum of Art. Its purpose is to publish original research on works in the Museum's collection. Articles are contributed by members of the Museum staff and other art historians and specialists. Submissions should be emailed to: journalsubmissions@metmuseum.org.

Manuscripts are reviewed by the *Journal* Editorial Board, composed of members of the curatorial, conservation, and scientific departments. **To be considered for the following year's volume, an article must be submitted, complete including illustrations, by October 15.** Once an article is accepted for publication, the author will have the opportunity to review it after it has been edited and again after it has been laid out in pages. The honorarium for image costs is $300, and each author receives a copy of the *Journal* volume in which his or her article appears.

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ABBREVIATIONS

MMA	The Metropolitan Museum of Art
MMAB	*The Metropolitan Museum of Art Bulletin*
MMJ	*Metropolitan Museum Journal*

Height precedes width and depth in dimensions cited.

Metropolitan Museum
JOURNAL

VOLUME 49 / 2014

Adam by Tullio Lombardo

LUKE SYSON
Iris and B. Gerald Cantor Chairman of the Department of European Sculpture and Decorative Arts, The Metropolitan Museum of Art

VALERIA CAFÀ
Assistant Curator, Museo Correr, Venice

Tullio Lombardo's marble *Adam* was displayed at The Metropolitan Museum of Art for some sixty-five years, its acquisition in 1936 celebrated as "an occasion for justifiable rejoicing" (Figure 1).[1] Lamentably, early in the evening of October 6, 2002, shortly after closing time, the pedestal supporting this great work buckled and the sculpture fell to the ground, shattering into innumerable pieces. The shock and distress of the Museum staff in the wake of this tragic accident can hardly be overstated. Director Philippe de Montebello described it as "about the worst thing that could happen" in a museum.[2] He and his colleagues quickly decided to undertake a restoration that would, to the fullest extent possible, return the sculpture to its original appearance. With new voices added to the discussion in the years that followed, this resolve has never altered.

In this volume, conservators and scientists describe the methods—many of them pioneering—they employed. Against the odds, *Adam* has survived: the fragments have been joined, the breaks in the stone disguised though not completely hidden, and the (thankfully small and few) losses filled. True, the sculpture is not intact and never can be again; this the Museum acknowledges. Despite the skill and dedication of those working on the restoration project, its success thus cannot be the cause of undiluted celebration. Nonetheless we have been true to our mission: to ensure that Tullio's subtle mastery of his medium, in what is probably his most meditated work, can even now be fully appreciated. This sculpture is extraordinary not just because of its art historical importance as the "first monumental nude of the Renaissance [that] followed closely the idealism of ancient Roman antiquities,"[3] but because it constitutes one of the most profound contemplations of divine and artistic creation, of human beauty and frailty, of temptation and sin and redemption ever realized. One of the principal ways by which its meaning is conveyed is the rendering of the human body as simultaneously perfect and imperfect. To understand this delicate balancing act, we must see *Adam*'s sculpted body in an undamaged state. Only then can we hope to understand something of what the artist and his clients believed and intended. The work's nuanced message is, moreover, entirely indivisible from the fact that it was sculpted at a particular moment in a great artist's career. Timeless though these themes may be, they arose out of a very specific set of historical circumstances. It is that intersection between context and artistic achievement that this article sets out to explore.

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THE FIGURE OF ADAM

The creation of *Adam* was a weighty, complex task that would have entailed profound consideration of God's labor in forming and giving life to the first man. For when, about 1490, the supremely gifted sculptor Tullio Lombardo (ca. 1455–November 17, 1532) was called upon to carve the figure of Adam for the funerary monument of the Venetian doge Andrea Vendramin (1393–1478), he was being asked to use his considerable talents to perform an act of re-creation, to reenact the first moment when divine purpose was given corporeal reality.

This is not merely an art historical trope. The turning of an artist—especially one talented enough to be perceived as divinely inspired—into a metaphor for God himself was a familiar conceit at the turn of the sixteenth century. Most pertinently, it can be found in the treatise *De sculptura*, by the young Neapolitan scholar Pomponio Gaurico (1481/82–1530; often called by the Latinized version of his name, Pomponius Gauricus), which was published in 1504.[4] The

author had seemingly realized that this linking of God and artist would gain potency when embodied by a sculptor—one who worked, as God had done, in three dimensions. Gaurico had studied in Padua, where so much sculpture was made in response to the scholarly and antiquarian culture that flourished at the city's famed university. Moreover, he was a friend of Tullio's and expressly praised him as "among the most skilled sculptors" of all time.[5] Indeed, Tullio's own thinking quite likely informed Gaurico's important theoretical tract.[6] The sculptor may have considered his undertaking all the more charged because his Adam was to be the size of a human being, thereby making this pious act of imitation more precisely emulative. God, in a divine act, "breathed into his nostrils the breath of life; and man became a living soul."[7] Tullio, on the other hand, needed to animate the stone through his talents as a carver. By so doing, he ensured that the viewer would experience an especially vivid encounter with his—and God's—creation.

It might be thought that two prominently displayed sculptural precedents, both of them works associated with the Doge's Palace, would have been important for Tullio in this enterprise. However, Tullio apparently set out to make an Adam that was conspicuously different from both of these, and particularly from the figure carved by his rival, the talented Veronese Antonio Rizzo (ca. 1430–1499), just a few years earlier (Figure 2). For the artist/God metaphor to be expressed meaningfully, Tullio's solution needed to be personal and original. This challenge would have been of special significance for Tullio, operating as he did within the family workshop led by his father, Pietro Lombardo (ca. 1435–1515). Tullio's carving of *Adam* coincided with his assumption of the dominant role within this *bottega*. Thus it is noteworthy that he put his name to this sculpture, the only surviving figure from the Vendramin monument that bears a signature and the first of a sequence of seven known works by Tullio to do so. *Adam* is inscribed *TVLLII.LOMBARDI. O[PVS]*—"the work of Tullio Lombardo." In addition to its metaphorical resonance, this statement of creative authorship had professional significance.

Adam was made, the book of Genesis and later apocryphal accounts relate, in God's own image. So he would have been assumed in Renaissance minds to be perfectly beautiful. In imitating God's creation, Tullio needed to fashion this ideal, and this at a time when philosophers and art theorists were giving much thought to how divine perfection might be seen, imagined, and made physically present. One solution for the modern artist—and Tullio was a pioneer in this respect—was to look closely at examples of

1. Tullio Lombardo. *Adam*, ca. 1490–95. Carrara marble, H. 78¼ in. (191.8 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.163). Photograph: Schecter Lee, The Photograph Studio, MMA, 1985

2. Antonio Rizzo (Italian, ca. 1430–1499). *Adam*, ca. 1471–75. Marble, H. 85⅛ in. (216 cm). Doge's Palace, Venice. Photographs of Figures 2, 3: Scala/Art Resource, New York

3. Antonio Rizzo. *Eve*, ca. 1471–75. Marble, H. 84¼ in. (214 cm). Doge's Palace, Venice

the much-praised sculpture produced by the ancients. (This is the theme of the following article.) But, as others did, Tullio would also have studied the most handsome specimens of manhood he could see around him. This is not a sculpture that ignores real human beauty.

Perfection was not, however, the only necessary ingredient of this work. After all, Adam was also the victim of the Serpent's wiles, tempted to succumb to sensual gratification by Eve, the very woman who had been created his helpmeet. When Adam and Eve ate from the Tree of Knowledge, they established humankind as having the free will to err, sin, feel shame, repent, and sin again. Just as God had created beings that were at once perfect and flawed, Tullio needed to encapsulate not only the story of the Creation of Man but also the story of the Fall. He had to find a way of containing this narrative of human transgression within the image of a God-made ideal. Finally he must have been aware, as Anne Markham Schulz has pithily summarized, that the significance of Adam and Eve on a tomb is that "they refer to man's corrupt state from which the Church is empowered to redeem him through the medium of Christ's sacrifice."[8] The figure would be essential for the overall meaning of the Vendramin monument. Adam's sin stands for that of all humankind, but more specifically of the deceased, who hoped to find salvation after death, as Adam had done, through Christ's mercy. Moreover, it was through the eating of the apple that death entered the world. The theme of death, no less than those of sin and corruption, would be apt for a tomb.

Tullio's patrons were the heirs of the decidedly undistinguished Andrea Vendramin. As doge of Venice from 1476 to 1478, he had exercised, theoretically at least, considerable earthly power, but during his time in office, large tracts of Venetian territory had been lost to the Ottoman Empire

4. Tullio Lombardo and workshop. Funerary monument of Doge Andrea Vendramin, ca. 1488–95. Santi Giovanni e Paolo, Venice. Photographs of Figures 4, 9–13, 15–20, 25: Anne Markham Schulz and Mauro Magliani, 2012

under Sultan Mehmed II, viewed as infidel. Vendramin therefore had much in his worldly existence to be forgiven for. Since the figure of Adam already had a civic context in Venice, Tullio, or those advising him, may have exploited a tradition that identified Adam with Doge and State. The politics of Venice required the city's ruler to be both great and human, so here is another reason why Adam's simultaneous strength and weakness needed to be made evident.

By being placed in a church, Tullio's *Adam* would also have had a specifically ecclesiastical audience. The

Vendramin monument was originally located in the Venetian basilica of Santa Maria dei Servi. It was only after the suppression of the Servites and subsequent demolition of the church early in the nineteenth century that the tomb was moved to the left wall of the choir of Santi Giovanni e Paolo, where it now rises to a height of thirty-one feet. When the monument was reconstructed, the near-naked *Adam* was banished on grounds of religious decorum. Early nineteenth-century ecclesiastical anxiety about displays of nudity in sacred spaces had much in common with the anxieties of the late quattrocento. Servite scruples at the time the sculpture was made may have led Tullio to formulate a synecdoche, whereby Adam's fig leaf stands for the shame he would experience after biting into the apple, though the sculptor chose to represent him before he has committed himself to this catastrophic decision.

THE MONUMENT AND ITS HISTORY

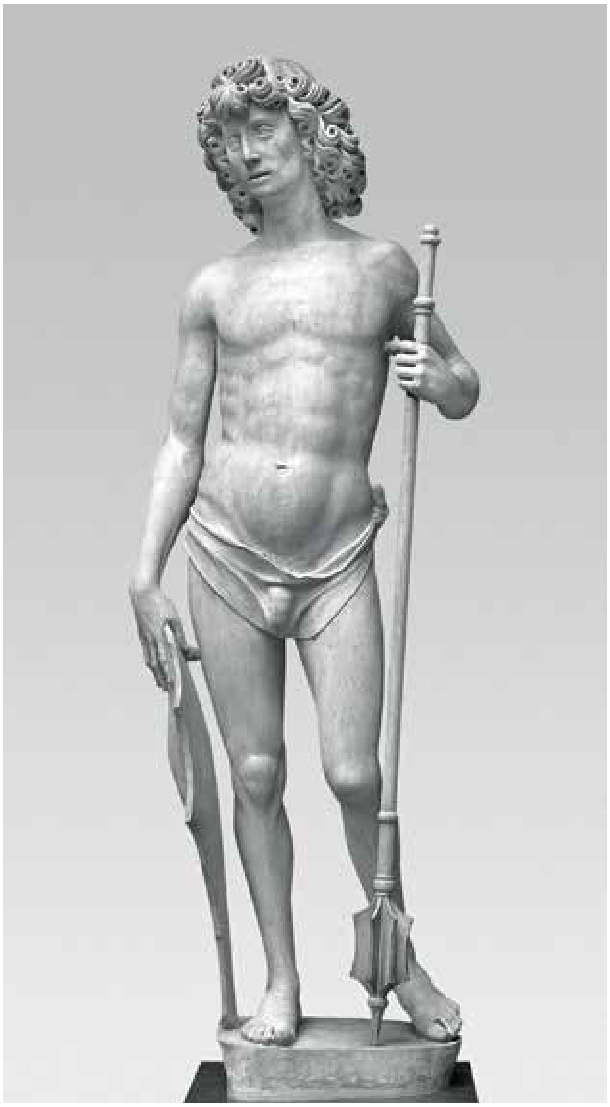
The Vendramin monument evokes an ancient Roman triumphal arch, and particularly the Arch of Constantine, which is the model for the monument's design as well as its decoration. The debt to this acknowledged source is more than superficial. Invoking an established rhetoric of political and military fame, the monument's architectural form and figurative and ornamental vocabularies combine to represent the doge's triumph over death. Vendramin, however, is being celebrated as a distinctly Christian ruler. The monument, like its ancient prototypes, is richly adorned with sculpted figures and reliefs, appropriately *all'antica*, but it is also supplemented with biblical and Christian imagery.[9] The sculptural program narrates the ascent of the soul of the deceased: in life, virtuous but fallible, he struggled against sin; in death, he is united with Christ and the Virgin, achieving eternal salvation.

The design of the monument has a new coherence and sophistication in both its architectural form and its simultaneously complex and unified iconography (Figure 4). The structure rests on a high podium and is articulated by unfluted, garlanded Corinthian columns that rise from elongated bases decorated with *all'antica* reliefs to support a tall, central projecting arch. The paired columns frame the recumbent effigy of Andrea Vendramin guarded by three torch-bearing angels and resting on a bier supported by eagles. The sarcophagus is animated by a series of lively female personifications of the virtues standing in niches. Below, a *tabula ansata* inscribed with an epitaph is displayed by two angels. In the lunette above the frieze is a relief of the Virgin and Child attended by a saint with a book (perhaps the Evangelist Mark, patron saint of Venice, or Saint Andrew, Vendramin's name saint, who often appears with a book as his only attribute), a youthful military saint,

5. Giuseppe Borsato (Italian, 1771–1849), designer; Benedetto Musitelli, engraver. *Monument of Andrea Vendramin formerly in the Church of the Servi in Venice*. From Cicognara 1816, vol. 2, pl. XLII

the doge himself, and another kneeling figure. Crowning the whole edifice is the blessing Christ Child, borne by two typically Venetian sea creatures—sirens or mermaids, albeit with wings. The central arch is flanked by two narrower bays. In the attic story are the figures of the Archangel Gabriel and the Virgin Annunciate in high relief. Below the frieze are niches for statuary surmounted by *all'antica* roundels, and, on the podiums, more "pagan" reliefs. The overall structure of the monument thus depends on tripartite division both vertically and horizontally, with the sarcophagus and effigy at the center of this notional grid.

Following the Napoleonic edicts of 1806 and 1810, when many religious orders in Italy were suppressed, the church and monastery of the Servites were confiscated and sold to a contractor, who demolished their structures for building materials. The works of art contained in the church (paintings, sculptures, altars, and reliquaries) were dispersed. The only known image of the Vendramin monument before it was dismantled and moved to Santi Giovanni e Paolo, an engraving of 1816 (Figure 5),[10] shows that the original configuration of the sculpture on the tomb differs from the present arrangement. Separated from the monument during its translation, the two shield-bearers—near-naked boys—that originally stood at the top of the structure are now in the Bode-Museum in Berlin, where they were severely damaged at the end of the Second World War (Figure 6).[11] They are absent in another



6. Tullio Lombardo. Shield-bearers from the Vendramin monument, ca. 1488–95 (photographed before 1945). Marble, figure on left, H. 66⅜ in. (168.5 cm); figure on right, H. 67½ in. (171.5 cm). Staatliche Museen, Skulpturensammlung, Bode-Museum, Berlin (212-213). Photograph: bpk, Berlin/Skulpturensammlung und Museum für Byzantinische Kunst, Staatliche Museen/Art Resource, NY

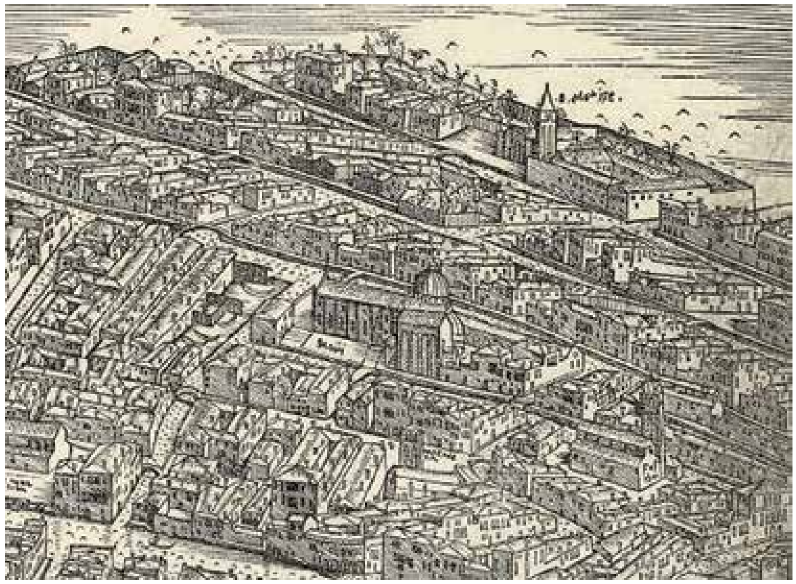
engraving, published five years later,[12] that represents *Adam* and *Eve* still in place. The accompanying text, however, recounts that between the execution of the engraving and the publication of the book, these principal figures were removed, evidently because the nudity of *Adam* and *Eve* had been judged inappropriate for a church interior.[13]

The two female figures by Lorenzo Bregno that now flank the monument were taken from the suppressed parish church of Santa Marina.[14] They displaced two warrior figures in *all'antica* armor that now occupy the niches flanking the columns. Those niches once held *Adam*[15] and, from the end of the sixteenth century, at least, the figure of Eve (about which, more below). According to Anne Markham Schulz, this rearrangement happened surreptitiously on the night of Sunday, April 18, 1819, a week before Easter.

Even in its altered state, this is a truly sumptuous monument, and with Tullio's *Adam* still in place, it must have been triumphal indeed. This is more than can be said for its occupant. Despite the civic preeminence that came at the end of his life, Andrea Vendramin was a long-lived nonentity.[16] Born in 1393, he was eighty-three by the time he was elected doge of Venice in 1476, receiving just the minimum number of votes needed to put him in office. Politically inept and a victim of fortune in Venice's military failures, he became the subject of public resentment.

Vendramin's last wishes were formulated in a will dated March 24, 1472. The document, drawn up before he became doge and nearly six years before he died on May 5, 1478, was quite specific regarding his funerary monument, stipulating the dimensions, quality, and richness of ornament, as well as its placement in the mendicant church of Santa Maria dei Servi,[17] where the Vendramin already had a family tomb.[18] Typically for a will, it did not contain instructions for the tomb's imagery.

Santa Maria dei Servi was located in Venice's Cannaregio district (Figure 7), not far from the Vendramin palaces.[19] Construction of the church had begun in 1330 and continued for more than a century, an effort that was supported by several leading Venetian families—including the Vendramin—who wanted their tombs installed there.[20] With its numerous buildings, the Servite complex was one of the largest religious establishments in Venice.[21] The church itself must have been enormous—it consisted of a single nave with a monumental choir terminating in three deep apsidal chapels, the central one of which, as we see in Jacopo de' Barbari's perspectival plan, was crowned by a circular dome. Patronage rights to its chapels were held by Venetian patrician families such as the Emo (for whom Antonio Rizzo created a tomb, beginning in 1493, with a "living" effigy of the deceased), the Donà, and the Condulmer.[22] According to the most recent reconstruction of the interior of Santa Maria dei Servi, the Vendramin tomb was located on the left side of the nave, near the choir and the door leading to a cloister.[23] The church was officially consecrated in November 1491, at about the time the Vendramin monument was constructed.[24]



7. Jacopo de' Barbari (Italian, active 1497–d. by 1516). *Perspective View of Venice*, detail showing Santa Maria dei Servi, 1500. Woodcut. Photograph: Trustees of the British Museum

Clues to a more precise dating for the monument come from the Venetian diarist Marin Sanudo (1466–1536). The only contemporary to report its construction, Sanudo was sufficiently interested to write about it twice.[25] In 1493 he reported that the monument was underway: "At the Servi, the tomb of Doge Andrea Vendramin is now being built, which will be, I daresay, the most beautiful in this terrain by virtue of the worthy marbles that are there."[26] Sanudo was always precise in his observations, and so it should be remarked that in the first passage he used the verb *fabrichare* (to fabricate or build) rather than the more generic *fare* (to make), and that he focuses entirely on the various marbles used in the monument's construction. Work on the structure must therefore have been sufficiently advanced for the richness of these materials to have been noted particularly. White and veined Carrara marble and ancient red porphyry were being skillfully combined with black marble from Verona and less expensive Tuscan *pavonazzetto*, which was introduced in Venice perhaps as a substitute for the costlier and rarer *pavonazzetto antico* used by the Romans.[27] It may be that the sculptures carved in the round were added only gradually. The rather restrained gilding and polychromy that now appear as decorative flourishes would surely have been among the final tasks.[28]

Sanudo's second account of the tomb, which probably dates from some years later, is slightly more informative. By then almost all the statuary was in place, though the tomb was still missing a sculpture[29] and the epitaph:[30]

> This doge reigned two years, two months, two days; died on 6th May at the 3rd hour of night, 1478, and was buried at the Servi church, where his family's tombs are. They held funeral rites for him [there]; Dottore Girolamo Contarini, son of Messer Bertucci of the knights of St. John of the Templars, gave the funeral oration. He was placed in a temporary tomb in that church, where his remains rested for some time, and then his heirs had made for him in the *coro* a very beautiful marble tomb, into which they have still not put one figure, and it is without any epitaph.[31]

Work on the Vendramin monument is generally believed to have begun in 1488–89, though the start date is hard to determine precisely.[32] There is evidence that Doge Vendramin's heirs first assigned the project to the Florentine Andrea del Verrocchio (1436–1488), a sculptor, painter, and designer who was then at the peak of his fame. Confirmation of Verrocchio's involvement comes in the form of two drawings: one now in the Victoria and Albert Museum, and the other a simplified design in the Louvre that can plausibly be attributed to his chief assistant, Lorenzo di Credi.[33] Probably only after Verrocchio died in June 1488 did the Vendramin commission pass to the Lombardo family—to the workshop founded by Tullio's father.

It is equally difficult to say when work on the monument came to an end. Alison Luchs has noted that there must be some connection between the pair of sirens installed above the cornice at the top of the tomb and a composition described and illustrated in Francesco Colonna's *Hypnerotomachia Poliphili*, published in Venice in 1499, which has mermaids placed rather similarly above a doorway.[34] Which of these works came first cannot be

8. Pietro Lombardo and workshop. Funerary monument of Doge Pietro Mocenigo, ca. 1477–81. Santi Giovanni e Paolo, Venice. Photograph: Cameraphoto Arte, Venice/ Art Resource, NY

firmly established, but Tullio haunts the pages of the *Hypnerotomachia*, and it is likely that the author was inspired by the sculptor.

A FAMILY FIRM

The workshop of Pietro Lombardo, Tullio's father, was among the most successful in Venice. Not only did the master import and furnish materials, marble, semi-finished architectural elements, and labor, he also developed into a much sought-after interpreter in the visual arts of the ambitions of the Venetian ruling class. (His only real competitor in the field of sculpture was Antonio Rizzo.) One of the two *botteghe* of choice for dogal funerary monuments, the Lombardo workshop had executed those dedicated to Nicolò Marcello (1478–79), Pietro Mocenigo (1474–81), and Giovanni Mocenigo (after 1485). The Vendramin heirs desired a certain novelty, as their initial choice of Verrocchio suggests. Tullio may already have impressed them with his powers of innovation while working for his father; however, their selection of the Lombardo workshop probably would have resulted in a more conventional project had Tullio not been at the helm. Certainly, the overall schema for the monument respects family tradition, but it also moves it ahead.

Considered from a certain perspective, then, the Vendramin monument was just one in a line of tomb commissions given to the Lombardo family by the heirs of doges. However, the signature on *Adam*'s base could suggest that the leading role in the workshop had passed to Tullio, who perhaps for the first time was entrusted with overseeing an important project. No known records explain the reasons for this transition or its timing, although a legal document of 1488 names Tullio as the family representative, indicating that it was at about that time that his responsibilities increased.[35] And it is clear that Pietro was then occupied with other significant and notably challenging commissions at the cathedral in Treviso and for the facade of the Scuola Grande di San Marco.[36] He may have been simply too busy to undertake another major project. It is possible, however, that the Vendramin heirs, seeking a result that would be both traditional and new, chose Piero Lombardo's workshop while requesting that a leading role be given to the more artistically progressive and, arguably, more talented son. The innovative nature of the project as a whole is entirely in accord with the radical aesthetic statement made by Tullio's *Adam*.

Though the precise date of Tullio's birth is unknown, he was probably between thirty and thirty-five years old by the time he came to carve *Adam*. His beginnings remain mysterious. He is thought to have begun his professional life between the ages of twelve and fifteen, working more or less anonymously and for well over a decade alongside his father and his younger brother, Antonio (ca. 1458–1516). He was first mentioned in 1475 by the humanist Matteo Colacio, who categorized the two brothers as "emerging."[37] It is usually argued that Tullio's hand can be detected in the ornamentation of the Venetian church of Santa Maria dei Miracoli, which was carried out about 1481. At that time, within the family's workshop, Tullio was also working on the completion of the tomb of Doge Pietro Mocenigo in the church of Santi Giovanni e Paolo (Figure 8). Some twenty years later, Gaurico would enthusiastically claim that by the mid-1480s Tullio had publicly demonstrated his singular talent in his works for the cathedral in Treviso.[38] This may be a literary invention, as Gaurico cannot himself have witnessed the events he describes, but if true, Tullio's success was far from precocious: it seems reasonable to think that by the time Tullio came to carve *Adam*, he had been employed in his father's shop for about twenty years.

Indeed, Tullio was still to be found living and collaborating with his brother in the first decade of the sixteenth century; though the brothers often worked independently, the family firm was still flourishing. It is therefore very likely that Tullio was operating inside the bounds of the Lombardo workshop when it received the Vendramin commission. The scale and complexity of that project are such that its execution would have required considerable collaboration from the other family members and from a team of assistants and pupils. So when Tullio chose, in his early thirties, to sign the *Adam*, using that gesture to proclaim his new status as an autonomous artist, how might this statement of authorship have been read against the rest of the tomb complex? What might it have meant within the context of a collaborative effort?

In accordance with the standard practice of the time, the Vendramin heirs were almost certainly shown a drawing with a proposed design for the monument.[39] Is it possible, then, that the signature on *Adam* should be read as a claim to authorship of the monument's whole design, as opposed to a statement of individual talent within a collective effort? Does it imply that such a drawing would have been executed by Tullio? True, the monument's architectural scheme—the wall tomb treated as a triumphal arch—depends, as we have seen, on a model rooted in the practice of Pietro Lombardo. But in both design and detail, the Vendramin tomb constitutes a new chapter in the history of Venetian funerary monuments and marks a departure from Pietro's prototypes. This is the result of the keenly attuned interest in classical antiquity so characteristic of Tullio's later practice.

Though it is not known how Tullio learned this new language, the professional peregrinations of his father before 1474 must have been important for his cultural and aesthetic formation. In the 1450s Pietro had been active at Padua, where he was employed at the Santo (the Basilica of Saint Anthony). Padua was a lively cultural magnet, drawing students from all over Europe to its renowned university and attracting artists like Donatello and Andrea Mantegna, who created a visual language that corresponded to the city's humanist ideology. Tullio may have received some form of classical education;[40] certainly, his classicizing name suggests his father's lofty ambitions for him. Moreover, Tullio himself may also have traveled. Scholars writing about the large perspectival reliefs he made for the facade of the Scuola Grande di San Marco at the end of the 1480s posit an undocumented trip to Rome, where he would have seen ancient reliefs that provided indispensable knowledge. Any such journey would have proved invaluable when he came to work on *Adam* and the rest of the Vendramin monument.

That the signature on *Adam* was about more than the execution of a single figure is borne out by the style and quality of the other three surviving principal figures: the reclining figure of Andrea Vendramin and a pair of standing warriors. Vendramin's effigy is an odd affair, a masterpiece of illusionism, with just one side "complete," and that designed to be seen only from below (Figure 9). Only its proper right side is fully carved, with the head shifted to the left (as we look at it from above), so as to make it more visible (Figure 10). The body is really not a body at all, resembling instead a rather grand sack of potatoes. Oddly proportioned, the torso is impossibly elongated and the shoulders undefined; a single, large hand emerges from

9. Detail of Figure 4 showing the effigy of Doge Andrea Vendramin

10. Detail of Figure 4 showing the effigy of Doge Andrea Vendramin from above

11. Detail of Figure 4 showing the helmeted warrior on the left

12. Detail of Figure 4 showing the warrior on the right

13. Detail of Figure 11 showing the marble block in the hand of the warrior on the left

nowhere, and the two feet allow the spectator to intuit that the figure has legs, which are in fact missing. Though the all-important dogal costume is described in some detail, it too is carved on just one side. The body is thus reduced to its ceremonial and physiognomical essentials. When observed from the proper distance and angle, however, the effigy reads as a complete figure. This brilliant economy, through which the sculptor manipulates the viewer into believing that an incomplete image fully describes its subject, was a crucial part of Tullio's method, as we will see.

Though the two armored warriors are much more fully conceived, they, too, persuade the viewer of the presence of elements that are not actually there (Figures 11–13). These figures have been universally attributed to Tullio himself, in part because of the newly classicizing, *all'antica* rendition of their armor. Moreover, the younger warrior, on the right, is so close in spirit and handling to *Adam* as to suggest that the Bible's first man is now suited for battle and ready to fight under a Roman imperial flag. His companion, wearing a somewhat incongruous pig's-head helmet, is more tense in both stance and countenance, with larger facial features and a knitted brow that recall, as Wendy Stedman Sheard has pointed out, the animated expression of the young man in Tullio's signed, roughly contemporaneous Ca' d'Oro relief of a couple (Figure 14),[41] as well as those of the figures in the much later relief *The Miracle of the Miser's Heart* in the Santo, signed and dated 1525. Like *Adam*, both warriors raise the little toes of their weight-bearing feet, a pose governed once again by the needs of a viewer looking up at them. Other aspects of Tullio's sculptural method that we have identified in the effigy are present as well. Although both warriors appear to wear cloaks thrown over their shoulders, adding swagger to their poses, the mantles do not in fact extend down their backs, which are only roughly finished. Rather, the garments' continuation is inferred by the mind's eye. The drapery bunched between the (unseen) thumb and index finger of the helmeted warrior might allude to the cloak. This omission preserves the clarity of the sculptures' dynamic contours while permitting the figures to be read as fully dressed in proper ancient fashion. Their poses would also suggest that they are leaning on something. On other Venetian tombs, warrior figures support shields; here the presence of shields is merely implied. Each warrior holds one hand over a small, simple block of marble that describes nothing in particular. In each case, the figure's "leaning" arm, slightly bent at the elbow, would have been at the farthest point from the spectator, so the marble blocks would have been in shadow and the view of the "leaning" sides of the figures would have been obstructed

14. Tullio Lombardo. *Double Portrait*, 1490–95. Marble, H. 18½ in. (47 cm). Galleria Franchetti alla Ca' d'Oro, Venice (inv. sc. 24). Photograph: Cameraphoto Arte, Venice/Art Resource, NY

15. Detail of Figure 11 showing the head on the central decorative element below the breastplate

16. Detail of Figure 11 showing the head on a decorative element below the breastplate

17. Detail of Figure 12 showing the head on a decorative element below the breastplate

18. Detail of Figure 4 showing the head of the angel at the left behind the effigy of Doge Andrea Vendramin

19. Detail of Figure 4 showing the angel at center behind the effigy of Doge Andrea Vendramin

20. Detail of Figure 4 showing the angel at right behind the effigy of Doge Andrea Vendramin

21. Tullio Lombardo and workshop. *A Young Warrior*, 1490s. Marble, H. 34½ in. (87.6 cm). The Metropolitan Museum of Art, The Friedsam Collection, Bequest of Michael Friedsam, 1931 (32.100.155). Photograph: Juan Trujillo, The Photograph Studio, MMA

by the architecture. Very cleverly, Tullio leads us to assume the presence of more palpable supports.

While, as the preceding discussion suggests, Tullio appears to have been responsible for the conception and most of the carving of these figures, he was not alone in fabricating them. Close examination of the little heads that decorate the breastplates of the warriors' cuirasses reveals three distinct hands at work: one can be seen on the helmeted soldier, two on his bare-headed companion (Figures 15–17). This reminds us that much of the ornamental carving elsewhere on the monument would have been delegated, and, indeed, it is immediately evident that many hands were put to work in these parts. It is clear, too, that Tullio received help with the figurative sculpture, with entire figures given over to associates. This is not the place to attempt a detailed taxonomy, but some obvious places where Tullio gave the work over to others should be pointed out.

The three torch-bearing angels arranged around the bier are manifestly by three different stone carvers (Figures 18–20). The angel at the foot of the effigy resembles the *Young Warrior* in the Metropolitan Museum (Figure 21). Both have long, slightly craned necks, massy hair, and birdlike features. While the angel at the center is simply awkward, the one at the head of the catafalque has a classicizing mien that takes us closer to Tullio, though the regularity and slight blandness of its features suggest this figure might be better attributed to his brother, Antonio, who was surely involved in the project, in accordance with the family's working practice. At the bottom, the paired angels holding the tablet with the epitaph might be the result of collaboration between the two brothers, with Tullio responsible for the angel on the right and Antonio for the one on the left. It is possible, too, that their father contributed his skills. In the lunette depicting the Virgin and Child with saints, which was carved in three sections, the center part shows a close kinship with works securely attributed to Pietro. The kneeling figure carved on the right-hand section is by another, more delicate hand, and the portrait of Vendramin, who appears in the lunette as a supplicant, is by another hand again. This part, with the figure of Vendramin, is cruder than the others and is actually unfinished; it is somewhat astonishing to notice that his praying hands are merely roughed out.

22. Lombardo workshop. Detail of a pilaster with carving of Adam and Eve, 1485–89. Stone. Santa Maria dei Miracoli, Venice. From Piana and Wolters 2003, pl. 150

ADAM . . . AND EVE?

It appears, then, that only *Adam* was completely conceived and carved by Tullio himself. There are many good reasons for thinking of this figure as the spiritual and artistic lynchpin of the monument. As the signature announces, it is the piece in which Tullio laid claim to an autonomous professional identity and to the role of artistic creator, two concepts that are here intimately related one to the other. The monument has a sacred character, and by proclaiming his authorship—his creation—of *Adam*, Tullio was boldly likening himself to God and implying, therefore, that he was the creator of the entire monument.

23. Filippo Calendario (Italian, d. 1355). *Adam and Eve*, 1340s. Stone. Palazzo Ducale, Venice. Photograph: Wolfgang Moroder

One mystery remains, however: we know nothing at all of how an Eve carved by Tullio would have added to the meaning of the work, or even if such a figure ever existed. It is impossible to imagine that Tullio and his Vendramin patrons did not intend such a pairing. The couple appears, for example, in the grotesque relief on the east side of the right-hand pilaster of the organ loft in Santa Maria dei Miracoli that was produced by the Lombardo workshop, and thus certainly known to Tullio (Figure 22).[42] This example came from close to home, but the tradition of representing Adam and Eve together was particularly strong in Venice and its mainland territories. They were often depicted on either side of a church entrance[43] or just inside it, as in the eleventh-century mosaics at Torcello. Always referring to the hope for redemption and eternal salvation, their representation in Venice was—rather unusually—also overlaid with political significance. They were depicted twice at the Basilica of San Marco, not only the city's most important ecclesiastical institution but also the palatinate church of the seat of government. They are still to be found inside, in the Genesis cycle mosaic in the first of the cupolas in the narthex.[44] More important, carved figures of Adam and Eve, dated before 1430 and already classicizing in style, are to be seen among other biblical scenes on the extrados of the central archway, providing both a public and a sculptural forerunner for Tullio.[45] (Adam, unfortunately, is missing his head.) Finally and crucially, Adam and Eve appear in the sculptural decoration of the southwest corner of the Doge's Palace (Figure 23).[46] In this elaborate composition, traditionally ascribed to Filippo Calendario (d. 1355), Adam and Eve are represented frontally, separated by the Tree of Knowledge, their intense discussion suggested by their animated gestures. Small, leafy branches cover both figures' genitalia.

The most immediate and important precedent is the project by Tullio's rival, Antonio Rizzo, who carved lifesize figures of Adam and Eve (Figures 2, 3) as well as a classical warrior for the Arco Foscari, just inside the entrance to the Doge's Palace.[47] (These sculptures are usually dated to the first half of the 1470s, though they may well be slightly later, made only shortly before Tullio started work on the Vendramin monument.)[48] While the inclusion of Adam and Eve on that structure would have communicated the canonical message of sin and redemption, the figures' presence also would have recalled and reinforced an established nexus of Venetian civic identity and visual tradition.

Yet, as stated above, it is unknown whether Tullio (or, less likely, a member of the shop) ever carved an Eve. True, by 1821, figures of both Adam and Eve that had come from the tomb were to be found in the Ca' Vendramin Calergi. This beautiful palace and its contents were sold in 1844 to Maria Carolina, duchesse de Berry (1798–1870). The duchess sent many of her works of art to be auctioned in Paris in 1865. These included Tullio's *Adam*, which passed through a number of distinguished European collections, including that of Henry Pereire, who showed it in the entrance hall of his house on the boulevard de Courcelles.[49] The figure of Eve, however, stayed behind in Venice, and it remains to this day at the Ca' Vendramin Calergi. Why it failed to make the journey north is easy to explain: *Eve* is a work of a flagrantly lower quality than *Adam*. Not by Tullio or even a member of his shop, it is by an unknown, rather mediocre sculptor who worked in the late sixteenth century. Long attributed to Francesco Segala (d. ca. 1593), this figure may in fact have been executed by Giulio del Moro (ca. 1555–ca. 1615), as James David Draper has proposed on the basis of its apparent relationship to Giulio's signed *Risen Christ* in the church of Santa Maria del Giglio.[50] This idea might profitably be investigated further.

Whoever the author, his motivation for fabricating an Eve for the monument in the second half of the cinquecento is still not clear. There are three possibilities. It may be that Tullio never started such a figure. Given its iconographic importance, however, this would have been a puzzling omission. Another possibility is that he began or even completed the sculpture, but for some reason it was never installed on the monument. Might there have been an argument over money, as was not unusual for such large commissions? Could Eve's naked body have elicited Servite qualms about female nudity? (Tullio's female protagonist in the Ca' d'Oro relief [Figure 14] is, after all, frank in its sensuality.) If the last of the three scenarios holds true, then maybe Tullio's figure survives and is to be recognized elsewhere, converted, perhaps, into a mythological figure.[51] Either of these circumstances would account for Sanudo's observation that such a figure was lacking. Exactly when he made that statement, however, is uncertain, and scholars have proposed alternative readings of his meaning. One interpretation is that his remark did not pertain to a missing Eve but instead to a minor piece of statuary; another possibility is that *Eve* was then lacking but her figure by Tullio was finished and installed shortly after. Implicit in the latter theory is the coincidence that the figure by Tullio that was not yet installed when Sanudo wrote about the tomb was the very one (and possibly the only one) which was later damaged or destroyed in a natural disaster. Sheard (who believed that it was possibly one of the Virtues that was absent in Sanudo's time) noted that the widow of Zaccaria Vendramin was given permission to make repairs in the Servi in 1563.[52] There had been a devastating earthquake

24. The inscription *TVLLII. LOMBARDI.O* on the base of *Adam*. Photographs of Figures 24, 26, 27–30: Joseph Coscia Jr., The Photograph Studio, MMA, 2014

in Venice in March 1511—strong enough to cause the bells in all the church towers to ring—that was reported by Sanudo, Girolamo Cardano, and Pietro Bembo, among others. Tremors were also felt in 1523, 1570 (with the epicenter in Ferrara), and 1591.[53] It is just possible that one of these dislodged *Eve*, though odd that such an event would have gone unmentioned, and that *Eve* was the sole victim.

SIGNATURE, SIGHTLINES, AND STORY

Tommaso Temanza in 1778 was the first to observe Tullio's signature, *TVLLII.LOMBARDI.O[PVS]*, on the base of the *Adam* (Figure 24).[54] He nonetheless attributed the monument to Alessandro Leopardi because of similarities that he perceived in the base of the Colleoni monument.[55] This attribution persisted in the later literature, following the tomb's move to the church of Santi Giovanni e Paolo and the subsequent removal of *Adam* and *Eve* from their niches. Only in 1893 did Pietro Paoletti first ascribe the monument to Pietro Lombardo's shop and identify Tullio as the artist responsible for its sculpture.[56]

If Temanza doubted that the signature was genuine, he was not the last skeptic in this regard. The placement of the inscription along the base of the sculpture and the anomalous, if not actually irregular, shape of the letters have long puzzled scholars. Some have thought it odd that the signature is organized asymmetrically, starting on the left side of the front face of the base and continuing onto the chamfered corner. Consequently it has been suggested that the base was altered and the last four letters recut at some later time,[57] and alternatively, that the whole inscription was a later addition.[58]

Since we have argued so strenuously for the significance of this signature, it is important to establish its authenticity. Many indicators lead us to believe that it is genuine. First, there was an established tradition of signing works in Pietro Lombardo's shop.[59] In addition, the inclusion of a signature appears to mimic Antonio Rizzo's work on the Arco Foscari; Rizzo carved his name, ANTONIO ⸤ RICO (*sic*; the C means ZZ), on the *Eve*, which, significantly, is his only signed work.[60] While Tullio's seven known inscriptions differ one from another in content, abbreviations, and technique, the word "opus" appears, shortened or in full, on all but one.[61] The irregular shape of *Adam*'s base was determined by the niche's projecting platform, on which the sculpture was placed (Figure 25), so it is both intentional and original. An analysis of the inscription, moreover, reveals a similarity in the execution of all the letters, precluding the possibility that the last four were reworked later. There remains the issue of its lopsided positioning. This turns out to be fundamental for the viewing, and consequently for the reading, of Tullio's *Adam*.

25. Detail of Figure 11 showing the platform of the niche on the Vendramin monument where *Adam* once stood

The siting of the monument in the Servi would imply that visitors to the church, encountering the left side of the monument as they approached from the nave, would first obtain a side view of *Adam*. When they moved forward to stand in front of the effigy, the viewpoint would shift. *Adam* would be seen by looking back to the left. The positioning of the inscription shows that this was indeed considered the principal vantage point. The particular impact of that third view would, however, depend on the figure's first having been seen face on. In these three aspects, Tullio aimed to elicit discrete and sequential reactions to the work. Striking subtly different emotional chords, this one figure could thus come to embody the first two parts of Adam's story.

Though the account in the book of Genesis of the creation of Adam and Eve and of their temptation was—and is—so well known, it is worth rehearsing here the several stages of the narrative. First, the creation of Adam himself: "So God created man in his own image, in the image of God created he him; male and female created he them" (Genesis 1:27). "And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul." For the man whom he had formed, God planted the Garden of Eden as the pleasant and fruitful setting where there grew the Tree of Life and "the tree of knowledge of good and evil" (2:7–9).

This is followed by God's prohibition against eating the forbidden fruit and by the creation of Eve: "And the Lord God commanded the man, saying, Of every tree of the garden thou mayest freely eat: But of the tree of the knowledge of good and evil, thou shalt not eat of it: for in the day that thou eatest thereof thou shalt surely die. And the Lord God said, It is not good that the man should be alone; I will make

26. *Adam*'s left hand with an apple and a leaf

27. *Adam*'s back

him an help meet for him" (2:16–18). "And they were both naked, the man and his wife, and were not ashamed" (2:25).

The account concludes with the narration of the temptation, fall, and punishment—the wily serpent persuading Eve to eat of the tree, her own enticement of Adam, and their realization of their nakedness: "and they sewed fig leaves together, and made themselves aprons" (3:7). Their shame gives them away, and God punishes them: "And the Lord God said, Behold, the man is become as one of us, to know good and evil. . . . God sent him forth from the garden of Eden, to till the ground from whence he was taken" (3:22–23).

Antonio Rizzo chose to show Adam in a state of desperation after the fall. His sinewy, tormented Adam is a man consigned to suffering and labor. His lined face belongs to this flesh-and-blood world, and every detail, from his hand on his breast to his mouth open in frantic entreaty, contributes to the figure's moving naturalism. The taut muscles, a virtuoso anatomical display, transmit the figure's psychological trauma. This Adam is afraid and ashamed, a human being begging God for forgiveness.

Tullio's *Adam* is conceived very differently. Each artist approached this subject in a way that not only told different versions of the story but was also emblematic of his style. As the viewer approaches, *Adam*'s figure appears open and innocent. From the front, Tullio's youthful nude is seen to be standing in classical contrapposto position, his weight on his right leg, and his left bent, resting on the ball of his foot. In accordance with classical precedent, the individual parts of the body are counterbalanced; the bent left arm corresponds to the taut, engaged right leg, and the extended right arm to the relaxed left leg. This leg is pulled back only slightly because the niche for which it was intended is so shallow. The figure's right arm hangs almost straight down; the right hand rests on a stylized branch and, almost imperceptibly, grazes his right hip. *Adam* holds his left forearm in front of him, his elbow away from his torso, and a round fruit—the apple of the biblical account—in his left hand. His head is inclined slightly to his left.

This stance endows the figure with both calm and internal energy, suggesting potential movement in a position of repose. *Adam*'s body is solid, supple, and even gently heroic, but it is also subtly abstracted. Once again, Tullio carefully describes some parts, creating elements that arrest the eye as it travels over the surface of the body, and elsewhere he persuades the viewer that the body is more completely described than it actually is. Thus, for example, the receding navel, so delicately carved, punctuates an abdomen in which the muscles are only just suggested. By not describing every bone and muscle, Tullio ensured that the contours of the body would flow smoothly, with a deliberate, subtle energy. This is a figure with the timeless character of

28. View of *Adam* from the right

29. Detail showing *Adam*'s mouth

ancient sculpture—a carefully calibrated posture, a controlled sense of movement, eternal youth. And this is an Adam whose beauty, both human and ideal, is clearly shown to be God-made.

Framed by thick, full curls carefully arranged across his forehead, his facial features are similarly regular, with a strong nose and jaw. Attention is given to his large eyes, in which the raised pupils are carefully delineated, and to his mouth, with its soft lips slightly open to reveal his upper teeth. As with the body, the face from the front seems calm and slightly detached emotionally.

The element needed to support the figure is seen to his proper right, carved in the form of a tree trunk with ivy and a small serpent wriggling around it. Another little snake emerges from a hollow in the base of the tree. There are ancient precedents for this element, including examples that have the clinging vine, the tiny bird that has just landed toward the top, and the snakes. But Tullio departs from his sources by carving a trunk that comes up only as high as the figure's thigh and that lacks the traditional supporting brace at the ankle. Adam's right hand rests on a branch growing out of the trunk—another element that is completely novel. The same is true of the leaf attached to the fruit in his left hand (Figure 26). This serves as the connecting, supporting, and reinforcing element for his fingers. In stone sculpture, such elements are generally purely functional—simple blocks, spurs, or bridges that are meant to be read out of the sculpture. The leaf is an ingenious visual trick that allows the sculptor to reinforce what would be one of the most vulnerable points in any marble, and to ensure that the orb is understood as a fruit.

Tullio roughly blocked out *Adam*'s hair at the back, since it would not be seen once the sculpture was in position. Similarly, the back of the figure was rather summarily finished (Figure 27). Nonetheless, *Adam* should be considered a sculpture in the round. The back, shoulders, and buttocks are almost fully worked up so as to suggest a solid and believable figure. It is likely that the sculptor needed to represent those parts if he was to give a convincing account of the front and especially of the sides of the body.

One of these side views is fundamental for our understanding of the piece. *Adam*'s pose, seen frontally, at first suggests a calm, untroubled beauty. From this angle, it will be seen as well that the forbidden fruit is similarly unblemished. Sustained examination, however, reveals a certain discomfort in the figure: it becomes evident that the load-bearing and free elements within the body are less balanced than they at first appear, and that the whole pose is in fact a touch unstable. For example, the right hand resting on the branch and the tilt of the head result in a stance that is somewhat uncertain. In this respect, the figure of *Adam*, though conventionally proportioned and with a well-developed musculature, deliberately departs from the classical canon. Adam has apparently already decided on his course of action, and, as he raises the apple to his open mouth, these variations on classical contrapposto begin to convey his troubled state of mind.[62]

Viewed from the right, as the chamfered corner of the base and the placement of the signature direct, this slight uncertainty of *Adam*'s pose is accentuated to become a tense anxiety (Figure 28). His expression, with his eyes raised to heaven, is revealed as supremely uneasy, intense,

30. Detail showing the fig leaf

31. Michelangelo (Italian, 1475–1564). *Bacchus*, 1496–97. Marble, H. 80 in. (203 cm). Museo Nazionale del Bargello, Florence (inv. 10 sculture). Photograph: Erich Lessing/Art Resource, New York

and sad. From this angle, it can be observed that the forefinger on his right hand, which in more relaxed mode would gently curve, is bent at just one knuckle; clearly he is pressing hard into the end of the branch, another sign of his emotional turmoil. And the apple is partly concealed; from here we cannot determine whether or not he has bitten into it, but his nervous state tells its own story. "I was afraid," Adam said after he had eaten and when his transgression was discovered by God (Genesis 3:10). Now his open mouth might be interpreted as speaking (Figure 29). Tullio has very gently moved the narrative on to the point where Adam's fear and frailty are fully revealed. Exploiting ambiguities of pose and gesture and assuming movement on the part of the viewer, Tullio has brilliantly contained the story of the Fall within this single figure.

Tullio was concerned to preserve the clean, gently modulated contour of the body from this angle too. To that end he flattened Adam's right nipple so that it does not break the line of his chest. (His left nipple is carved proud of the body so that it catches the light to animate this part of his torso when the figure is viewed frontally; the chief light source must have been from the left.) And though Adam is provided with his modest fig leaf, there is no additional foliage that would interrupt our view of his body (Figure 30). We are left to imagine the twig that should connect the leaf to the small bough—there, in part, for that purpose—on which Tullio's *Adam* rests his right hand (the twig is supplied in Musitelli's engraving). So habituated are we now to the coy convention of the fig leaf that we often forget that the genitalia are never covered by this means in ancient sculpture; all the fig leaves we see attached to them today are later additions. Thus Tullio's decision to include the fig leaf without explaining its presence—it is neither woven into a loincloth nor attached to a conveniently placed branch—allows him to render it symbolic. Most unusually, Tullio has represented the leaf from the back so as to carve all its veins, making this an area of intense detail. This leaf has become a concealment that draws attention to itself. In this way, Tullio alludes to, but does not actually represent, the denouement of Adam's decision to eat the forbidden fruit. The fig leaf is a synecdoche for his discovery and banishment, the symbol of his disgrace.

Tullio's *Adam* thus distills a series of dramatic moments, and it is precisely by this emotional sequence that we can read the message of redemption. Troubled by his disobedience to God's dictate, Adam's fear increases. The second-century Church Father Irenaeus wrote that "the fear of the Lord is the beginning of Wisdom," and this is precisely the Christian message intended here.[63] Adam knows himself to be guilty, and he repents, a gesture that "signals the *felix culpa* of the progenitors, the beginning of human redemption."[64] There could be no better subject for a funerary monument.

And there could be no better subject for a sculptor bent on demonstrating his creativity. Tullio's *Adam* is the artist's own triumph, a marvelous moment in the history of sculpture. The young Michelangelo, who traveled to Venice in the autumn of 1494, understood its utter novelty and found in *Adam* one of the principal sources of inspiration for his own *Bacchus* (1496–97) (Figure 31).[65] Now that the restoration of *Adam* is complete, it is apparent to all why he was so impressed.

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NOTES

1. Remington 1937, p. 58.
2. De Montebello quoted in Bohlen 2002, p. E1.
3. James David Draper quoted in ibid., p. E3.
4. See "De claris sculptoribus," in Gaurico (1504) 1999, section 8, pp. 246–47.
5. "che egli è il più valente di tutti gli scultori che abbia mai visto alcun'epoca"; ibid., pp. 250–51. Gaurico's friends included other Veneto sculptors such as Riccio, Severo da Ravenna, and the artist who dubbed himself Pyrgoteles.
6. Ibid.
7. Genesis 2:7.
8. Schulz 1983, p. 33.
9. Many of the motifs on this monument have a marine theme. There are marine hybrids everywhere, deriving from ancient coins and cameos as well as Roman sarcophagi. The theme carries both a religious and spiritual significance (water as purification) and a political meaning (Venice's domination of the seas). Water also bore meaning for the Vendramin family, which owed its wealth and relatively late entry into the Venetian patriciate to maritime trade. See Sheard 1971 and Luchs 2007.
10. Engraved by Benedetto Musitelli after a drawing by Giuseppe Borsato that was included in the first edition of Count Leopoldo Cicognara's *Storia della scultura*; see Cicognara 1813–18, vol. 2 (1816), pl. XLII and details.
11. For these figures, see Knuth 2007. Possibly owing to their quasi-nudity, they seem never to have reached Santi Giovanni e Paolo, but instead to have appeared immediately on the antiquarian market.
12. The engraving is by Antonio Bernatti after a measured drawing by Marco Comirato.
13. Selvatico and Lazari 1881, pp. 224–25; Sheard 1971, pp. 108–14; Schulz 1991, p. 175.
14. Schulz 1991, pp. 174–77.
15. Thanks to the examination of *Adam*'s niche undertaken on the occasion of the Metropolitan Museum's photographic campaign in October 2012, we can be certain of the correspondence between the measurements of the sculpture and its original location.
16. Andrea Vendramin was among the richest men in Venice in his day and held the office of Procurator of San Marco before becoming doge. See Sheard 1978, p. 120n8 (with earlier bibliography).
17. Ibid., pp. 122–24, "I wish that a tomb should be made in the center of [or in the nave of] the church [Santa Maria dei Servi] by our family chapel where the Sacrament is kept; the said monument to be placed above one near the said chapel [and should be] of a good size and carefully made and well adorned, in which I wish my body to be placed" ([in Santa Maria dei Servi] voglio siano fato far una archa in [centro] in giexia per mezo [di] la capella nostra dove se tien el sagramento laqual archa [sia posto] sopra uno apresso [la] deta capella [as] a [*assai*] grande e ben f[ato] e asa adorna in laqual voglio sia messo il mio corpo); translation by Wendy Sheard.
18. Sheard (ibid., p. 126) placed the Vendramin family tomb in the monastery's cloister.
19. For Santa Maria dei Servi, see Pavon and Cauzzi 1988 and Urbani 2000; Vicentini 1920 is still useful.
20. Urbani 2000, p. 23.
21. The entire complex occupied about 11,000 square meters; the area of the church has been calculated at more than 1,900 square meters. See ibid., p. 17.
22. For other works in the church, see Pavon and Cauzzi 1988, pp. 57–68. The reliefs by Andrea Briosco, called il Riccio, depicting the Story of the True Cross (now at the Ca' d'Oro) were in this church; they date to about 1500 and reflect in many of their details the character of the Vendramin monument. See Gasparotto 2007.
23. Pavon and Cauzzi 1988; Urbani 2000.
24. Benci and Stucky 1987; Urbani 2000, p. 24.
25. Sheard 1977.
26. "Ai servi è l'archa d'Andrea Vendramin Doxe che al presente si fabricha che sarà dirò cussì la più bella di questa terra per li degni marmi vi sono"; ibid., p. 224.
27. For Veronese black marble, see Lazzarini 2006, especially the table on p. 262. Lorenzo Lazzarini (2006, pp. 258–60) notes that the use of Tuscan *pavonazzetto* in Venetian building projects is a marker for the period 1470–1540.
28. Gilding is found on the doge's robe, for instance, with traces of red pigment, probably bole residue. The rosettes of the arcosolium are also gilded and have a blue ground beneath them.
29. Robert Munman (1968, p. 230) suggested that the missing figure was Eve. Sheard hypothesized (1971, p. 324) that it was a more minor piece, "probably the Charity." Sheard (ibid.) also suggested that it is possible that Tullio never executed the figure of Eve.
30. Debra Pincus (2013, p. 172), gives a late date—1522—for the epitaph, but does not support this with any specific rationale beyond the quality of the inscription itself. The twelve-line epitaph reads, "Andreae Vendrameno Duci/Opum Splendore Claro Sed Ex Mira In Patriam/Pietate Opum usu Longe Clarissimo qui Croia/Turcarum Obsidione Liberata Eorundemq/Irruptione in Carniam Reiecta Felix Insigni/Prole Impletis Omnibus et Fortunae et/Naturae et Virtutis Numeris Principatus/Brevitatem Sempiterna Caeli Gloria Compensat/Vixit Annos LXXXV Menses VIII/Obiit Pridie Nonas Maii/Anno MCCCCLXXIIX/Principatus Sui Anno Secundo" (To Andrea Vendramin Doge, famous for the splendor of his riches, and yet more for his employment of them in devoted loyalty to his country. He liberated Kroja [in north central Albania] from the Turkish siege and drove back the Turkish invasion in Carnia. Happy in outstanding children and filled with all qualities of nature and virtue, heaven's eternal glory compensates him for the brevity of his rule. He lived 85 years and 8 months. He died on the day before the Nones of May in the year 1478, the second of his principate). See Sheard 1978, p. 128n27.
31. "Questo Doge avendo dogato anni due, mesi due, giorni due, morì a dì 6 di Maggio a ore 3 di notte del 1478 e fu sepellito nella Chiesa de' Servi, dove sono l'arche de' Suoi. Gli furono fatte

l'esequie, fecce l'Orazione Girolamo Contarini il dottore di Ser Bertucci Friere di San Giovanni del Tempio. Fu posto in un deposito in quella Chiesa, dove stette certo tempo, e poi pe' suoi figliuoli ivi gli fu fatta nel Coro una bellissima arca di marmo, alla quale ancora manca a mettersi una figura, senza però epitafio alcuno." Sheard 1977, p. 239.

32. Sheard's dissertation (1971) remains the most exhaustive study of the Vendramin monument. For the author's later additions and further considerations, see especially Sheard 1977, p. 243n4, and Sheard 1978. For an excellent summary, see Romano 1985.
33. Verrocchio's involvement is attested to by a pen and ink drawing in the Victoria and Albert Museum, London (inv. 2314). The second, simpler version of this drawing is by another hand, plausibly that of Lorenzo di Credi (Musée du Louvre, Paris, inv. 1788); see Sheard 1978, pp. 133–46, figs. 10, 11. For the relationship between Verrocchio and Tullio, see Sheard 1992, pp. 81–83. For a more recent discussion of Verrocchio's drawing, see Bambach 2003, pp. 255–58, with earlier bibliography.
34. Francesco Colonna's *Hypnerotomachia Poliphili*, 1499, fol. CVIII; reproduced in Luchs 2007, p. 4, fig. 6.
35. Pizzati and Ceriana 2008, p. 32.
36. It is important to note that about 1486, Pietro was held responsible for the collapse of the dome of the Duomo in Treviso and that work there was continued under Tullio's direction. In November 1490 Pietro Lombardo and Giovanni Buora were dismissed from the works at the Scuola Grande di San Marco because of rising costs; they were replaced by the architect Mauro Codussi, who was named head of the project. For the building works at the Scuola Grande di San Marco, see Schofield 2006. For Tullio's appointment by the Vendramin, see also Sheard 1971, pp. 322–23, where it is suggested that the decision was made by the patrons or by Pietro himself.
37. "Habet item statuaries Petrum Lombardum et patrio artificio surgentes filios"; Matteo Colacio's *Laus perspectivae cori in Aede Sancti Antonii* . . . quoted in Pizzati and Ceriana 2008, pp. 271–72 and pp. 309ff., doc. F1.
38. Gaurico (1504) 1999, p. 251; Pizzati and Ceriana 2008, p. 272, doc. F3.
39. This practice is known to have been adopted by the Lombardo family. See various documents published in Pizzati and Ceriana 2008. For the Tomb of Dante drawing attributed to Tullio, see Pincus and Comte 2006 and, more recently, Ceriana 2013.
40. See Matteo Ceriana's suggestion in Pizzati and Ceriana 2008, pp. 315–16.
41. Sheard 1971, pp. 161, 174.
42. Piana and Wolters 2003, pl. 150.
43. For example, on either side of the Lions' Portal (1240) at the cathedral of San Lorenzo in Traù (known today as Trogir) in Dalmatia.
44. Jolly 1997.
45. In Augusti 2008, p. 33, "Luca della Robbia (?)" is offered as a possible maker of these panels.
46. Brown 1996, p. 43.
47. For the Arco Foscari, see Pincus 1976. For Antonio Rizzo, see Schulz 1983.
48. Schulz 1983, and for the Adam and Eve in particular, pp. 32–38, 152–53, where the author considers the relationship between Tullio and Antonio Rizzo.
49. For *Adam*'s provenance, see Wardropper 2011, pp. 36–39, no. 9.
50. James David Draper, email communication with the authors, April 2014.
51. Francesco Caglioti (2013, p. 218) suggests that the figure of Venus in the Giardino di Venere, Villa Brenzoni, Punta San Vigilio (Lago di Garda, Verona), started life as Tullio's *Eve*, a work left unfinished and converted into the Goddess of Love about 1550 by a less competent hand. We await Caglioti's full account of the work with great interest. The sculpture's life size supports his idea, and to judge from old photographs, the work does seem to have the proportions and stance of a female figure conceived about 1500. It is perhaps worrying that the tree stump is on the same side as in the *Adam*, meaning that it would have been in the line of the principal view of the figure. Elsewhere Tullio was careful to ensure that this view was left unimpeded (the warriors' tree stumps are on opposite sides and would have been concealed somewhat in shadow). The contrapposto of this putative Eve also repeats Adam's rather than mirroring it, and consequently so does the line of her shoulders. It may be that we should not be so insistent on symmetry; when Baccio Bandinelli came to carve an Adam and an Eve for the Florence Duomo, he placed tree stumps on the same side of each.
52. Sheard 1971, p. 105, citing Mariacher 1950, pp. 107–9.
53. Baratta 1901, p. 708.
54. Temanza (1778, p. 120) also questioned the attribution to Tullio of the figure of *Eve*. It was attributed to Tullio by Filippo De Boni (1840, p. 578).
55. Temanza 1778, p. 114.
56. Paoletti 1893–97, vol. 2, p. 231.
57. Sheard 1971, p. 392n5; reiterated in Luchs 1989, p. 232.
58. Ulrich Middeldorf 's opinion, as reported in Ruhmer 1974, p. 54.
59. See Pincus 2013, and for Pietro's signatures, see ibid., pp. 162–67.
60. Ibid., p. 165.
61. Tullio's inscriptions are sometimes carved and then colored, sometimes only carved, and sometimes lightly incised into the stone and then painted. In the case of *Adam*, the inscription is carved deeply into the stone, and laboratory analyses have confirmed that it was never pigmented.
62. Sheard 1971, p. 172; followed by Wills (2001, pp. 336–37), who believes that Tullio's *Adam*, like Rizzo's, has not yet bitten into the fruit. We may agree that Tullio's *Adam* has yet to eat, but we should note that the belt of fig leaves Rizzo's *Adam* wears is an incontrovertible sign that he has committed the sin. Rizzo also includes the detail of slightly raised skin on the fruit, which signals the bite.
63. Irenaeus, *Against Heresies*, 3.23.5.
64. Salvadori 2009, p. 275. It is also known as the "Fortunate Fall." See Sheard 1971, pp. 215–22.
65. Sheard 1971, p. 209. This hypothesis is discussed in Smyth 1979, pp. 210–15, and reaffirmed in Ceriana 2005, p. 532; Pincus 2007, pp. 283–84 (where it is suggested that Michelangelo may have made a second trip to Venice in 1529); and Ceriana 2009a, p. 22.

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Ancient Sources for Tullio Lombardo's *Adam*

VALERIA CAFÀ
Assistant Curator, Museo Correr, Venice

The search for antique models for Tullio Lombardo's pathbreaking *Adam* (Figure 1) has occupied many scholars, who have proposed various possible sources in classical and Hellenistic sculpture and in late antique ivories.[1] So far, their quest for a prototype has yielded no definitive answer. Tullio (ca. 1455–1532) remains an elusive historical figure: his artistic formation and influences are still mostly matters of conjecture. What, then, might he have seen and studied that could have inspired his *Adam*?

Identifying ancient sources is rarely a straightforward task. Determining which ancient works were available, either directly or indirectly, to a Renaissance artist is often complicated by the existence of replicas and by uncertain identifications and generic descriptions of the kinds found in sixteenth-century documents. In addition, the condition of ancient sculptures seen during the Renaissance must be ascertained, along with what was known about them and, more important, how they were understood and interpreted.

Venice, where Tullio worked in the studio of his father, the sculptor Pietro Lombardo (ca. 1435–1515), presents its own unique set of challenges for researchers. Information about antiquities collections that were present in Venice in the second half of the fifteenth century is far from complete. Such collections were rarely documented in drawings or by other visual means, and they are now mostly dispersed. An investigation into Tullio's sources is further hampered by the lack of records—contracts or drawings, for instance—that might convey some sense of which ancient works the artist himself studied. Without solid evidence, the best we can do, based on what we do know, is to develop hypotheses about models he may have consulted.

That Tullio and the Lombardo family looked at ancient sculpture is certain.[2] In 1532, the Venetian art collector and connoisseur Marcantonio Michiel (1484–1552) noted that an ancient carving in the collection of the wealthy Milanese merchant Andrea Odoni had once been in Tullio's workshop.[3] In Michiel's words, the "marble figure of a fully draped but headless and armless woman is ancient and had been in Tullio Lombardo's shop, where he reused it a number of times in a number of his works."[4] According to Debra Pincus, the sculpture described by Michiel corresponds to a Greek marble kore, perhaps from Crete, that was in the Contarini collection in the second half of the sixteenth century and is now in the Museo Archeologico Nazionale in Venice (inv. 164-A). The kore may well have been the source of the figures of the Virtues on the Vendramin tomb,[5] the earliest known examples of the Christian Virtues rendered in the form of the ancient Muses. This valuable piece of evidence suggests that there was an ancient sculpture in the Lombardo workshop by the end of the 1480s or the beginning of the 1490s. Combining this information with what is known about Venetian workshops during the Renaissance, from Francesco Squarcione's to Lorenzo Lotto's,[6] we can hypothesize that Tullio was surrounded by genuine antiquities, and not just by plaster casts and reliefs.

Even more direct contact with antiquities would have come through the business of restoring ancient sculpture that Tullio ran with his younger brother, Antonio (ca. 1458–1516).[7] Pincus was the first to note that the second century B.C. *Muse of Philiskos*, the so-called *Cleopatra Grimani*, at the Museo Archeologico Nazionale in Venice (Figure 2) is, in its present state, the result of an early modern restoration that can be attributed to Tullio by reason of its quality and technique. She dates the restoration about 1492–93, very close in time to the carving of *Adam*.[8] This important identification led Marcella De Paoli to study the collection of ancient sculpture at the Museo Archeologico, singling out works that had been subject to restorations. Eight of these interventions she attributed to the Lombardo shop.[9]

It is difficult to imagine that restorations of such historic significance would have been entrusted to Tullio if he had not been reputed to possess a profound knowledge of ancient sculpture. The Neapolitan Pomponio Gaurico (1481/82–1530) wrote in his *De sculptura* (Florence, 1504)[10] a detailed description of the ideal sculptor in which he

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suggests that Tullio, whom he regarded as "the most talented of sculptors" of all time,[11] had a thorough understanding of ancient art. A good sculptor, Gaurico stated, needs to know ancient art, must be able to recognize and distinguish between subjects and iconographical attributes, and has to possess both technical knowledge and what we might call an "archaeological" understanding of antiquities.[12]

In a letter dated July 18, 1526, Tullio, then in his late sixties, argued for the superiority of sculpture over painting by invoking the work of the ancients. Writing to his patron Marco Casolini of Rovigo about the *Madonna della Pietà*, which he was preparing to execute for the church of San Francesco in Rovigo (the sculpture remains there to this day), Tullio asserted, "Painting is an ephemeral and unstable thing, while sculpture is much more incomparable and not to be compared in any way with painting, because the sculpture of the ancients can be seen up to our time, while of their painting there is really nothing to be seen."[13] The letter demonstrates, among other things, that the artist was familiar with the *paragone*, a fashionable topic of debate at the time, and had a command of the vocabulary needed to discuss it.[14]

Tullio's knowledge and sophistication were probably enhanced by travel. Unlike the cities that Venice controlled on the mainland—Verona and Padua, for example, which possess the ruins of ancient theaters and walls as well as collections of inscriptions and fragments of indigenous antique statues—Venice itself has no ancient remains of its own. Any antiquity to be seen in Venice was imported either from elsewhere in Italy—usually Rome—or, more often, from Venetian dominions in the Greek world, especially Crete, Rhodes, and Asia Minor.[15] While it is difficult to reconstruct detailed inventories of antiquities collections that were formed in the Veneto during the Renaissance, that task is even more problematic when it comes to collections formed in Venice itself. Unlike many, much better documented assemblages of antiquities in Rome, Venetian collections, which are known to have existed as far back as the mid-fourteenth century,[16] were dispersed very quickly and at an early date.[17] Some, such as the Roman collection of the Venetian cardinal Pietro Barbo (1417–1471), who became Pope Paul II in 1464,[18] were noted for their quality as well as their variety.

It is reasonable to suppose that Tullio, like many other artists of his time, visited collections in cities such as Padua, Bergamo, Ravenna, Mantua, and Ferrara, as well as in more distant Roman cities, such as Aquileia and Pula, in Istria, the

1. Tullio Lombardo. *Adam*, ca. 1490–95. Carrara marble, H. 78¼ in. (191.8 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.163). Photographs of Figures 1, 3, 4: Joseph Coscia Jr., The Photograph Studio, MMA, 2014

2. *Muse of Philiskos* (known as *Cleopatra Grimani*), 2nd century B.C., restored in the 1490s probably by Tullio Lombardo. Marble, H. 46⅛ in. (117 cm). Museo Archeologico Nazionale, Venice (inv. 53)

3. Detail of *Adam*

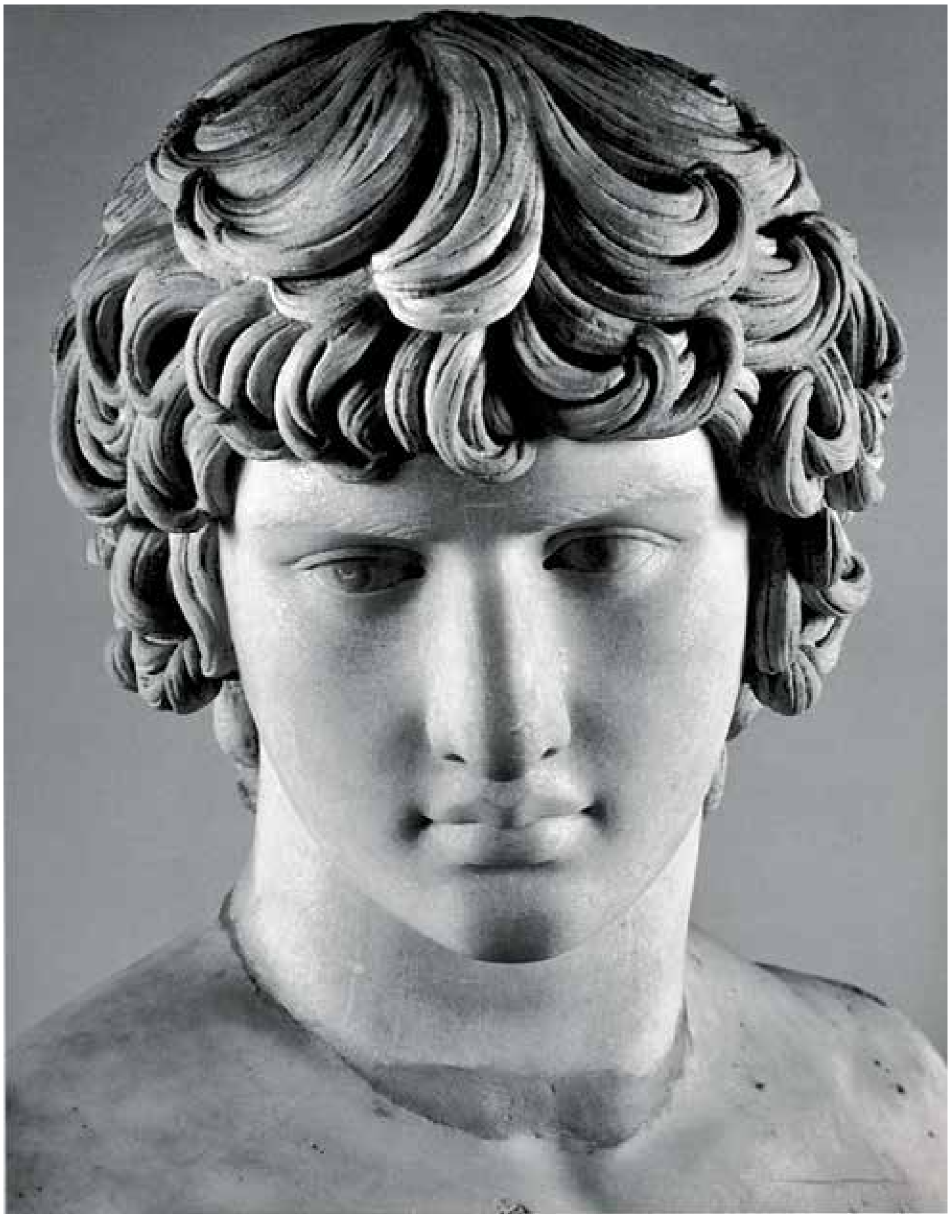
territory that supplied the white stone used by the Lombardo family in Venice.[19] Moreover, as discussed below, there is a chance that Tullio visited Rome before beginning work on Andrea Vendramin's tomb, for which he conceived his *Adam*.

Adam represents a young male nude in a classical contrapposto stance. The figure's weight-bearing right leg is straight, while the relaxed left leg bends slightly and rests effortlessly on the ball of the foot. The right arm descends naturally, with a slight bend, and the right hand, propped on a low branch, barely touches the right hip. *Adam* holds his bent left arm at a slight distance from his torso, his extended forearm slightly raised to show a small, round fruit held with the open fingers of his left hand. The supporting element to the figure's right is carved in the form of a tree trunk, with ivy and a small serpent wrapped around it. *Adam*'s head tilts gently to his left as he casts his gaze upward (Figure 3). His facial features are regular: the eyes large, the nose and jaw prominent, and soft lips slightly open, revealing the upper teeth. His head is crowned by a mop of curly hair, its regular, thick coils skillfully articulated with the use of a drill (Figure 4). The locks are carefully arranged across his forehead, and their luxuriant mass covers his ears, giving his hair the appearance of a helmet, in the style of the time.[20]

The figure's left leg is drawn back only slightly, a placement dictated by the shallowness of the niche for which the sculpture was intended. The body is solid, supple, and full; the linea alba is emphasized, the epigastric arcade is just visible, and the navel recedes inward. The pose, which derives from the *Doryphoros* of Polykleitos, one of the

4. Detail of *Adam*'s locks of hair formed with a drill

5. Head of *Antinous Farnese*, A.D. 130–138. Marble, H. 10¼ in. (26 cm). See Figure 6



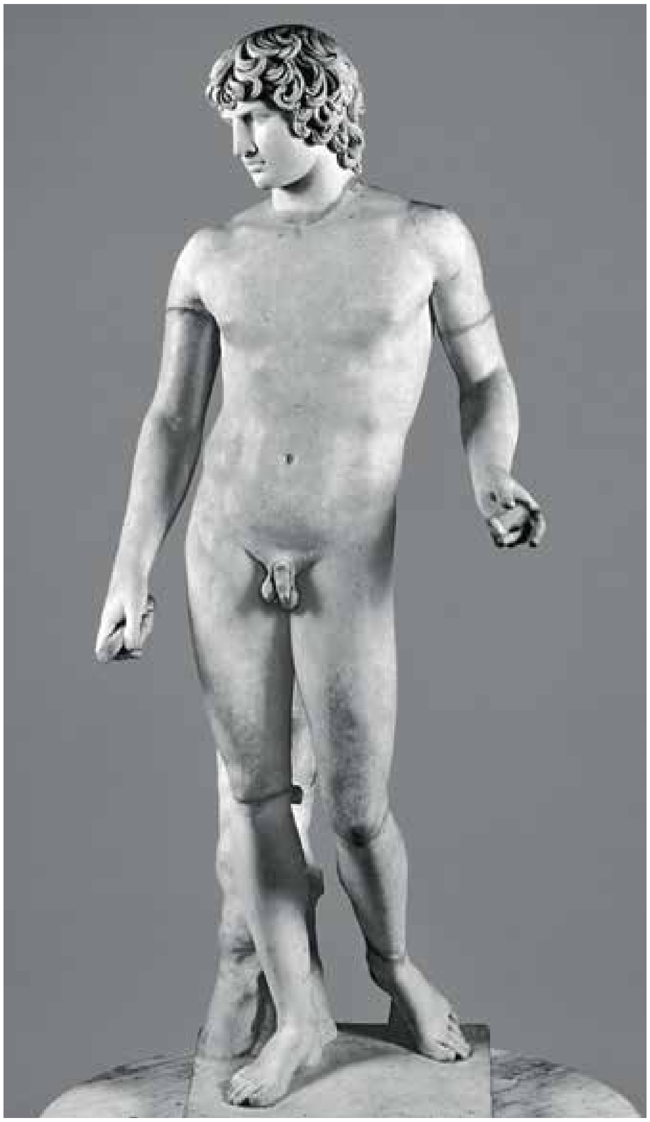
greatest sculptors of classical antiquity, follows that prototype quite literally: the bent left arm corresponds to the taut or engaged right leg, and the extended right arm to the relaxed left leg. Several scholars have observed that an obvious instability in the balancing of load-bearing and free elements in Tullio's *Adam* results in a posture that is on the whole uncertain and unnatural.[21] *Adam*'s cursorily defined back, shoulders, and buttocks probably served Tullio as aids in constructing a solid and believable figure. Although summarily finished, they were not intended to be seen by the viewer.

Among the candidates most often cited as possible sources for *Adam* are portraits of Antinous for their melancholy facial expression, and for their posture and modeling, the *Apollo Belvedere*, the *Mantua Apollo*, and various Doryphoros figures.[22] To these proposed prototypes, we may add the Apollo Lykeios/Bacchus type for the sensual fullness of its pose and the delicate treatment of its surfaces.

Scholars unanimously agree that *Adam*'s head is modeled on that of Antinous, the handsome, much-depicted favorite of the Roman emperor Hadrian (r. A.D. 117–138). Most portrayals of Antinous, especially in their most diffuse form, the *Haupttypus*, are easily recognizable. Their most distinctive feature, the head, has thick, well-defined curls arranged naturally but carefully around a wide, square face with prominent but still boyish features (Figure 5).[23] Some thirty mentions have been found in Renaissance documents of replicas or fragments of Antinous portraits in a variety of collections in Italy, including heads, busts, reliefs, and statues, but not counting ancient coins and gems. The young Antinous appears in diverse poses and roles, from the heroic nude to the dignified figure of an Egyptian pharaoh. But which head of Antinous might have inspired Tullio?[24]

That Antinous was well known in the circles frequented by the Lombardo family can be inferred from a passage in the *De varia historia*, written in 1523 by the Paduan philosopher Niccolò Leonico Tomeo (1456–1531) and published in 1531. The author, who is one of the interlocutors in Gaurico's *De sculptura*, recounts how he recognized Antinous's portrait in one of the "infinite number of medals" he owned, and then narrates the sad events of the youth's life.[25] About that time, Cardinal Pietro Bembo (1470–1547) owned a beautiful marble bust of Antinous, although its provenance remains unknown. It passed to the Farnese after his death and, in the second half of the sixteenth century, was mounted on the ancient torso of the Doryphoros now in Naples's Museo Archeologico Nazionale. The conjoining of the two pieces is so successful that many scholars believe the head and torso originally belonged to the same sculpture (Figure 6).[26]

Tullio's *Adam* resembles the Antinous type particularly in the modeling and inclination of the head, in the facial expression and contemplative gaze, and, more generally, in



6. *Antinous Farnese*, 1st–2nd century A.D. Marble, H. 78¾ in. (200 cm). Museo Archeologico Nazionale, Naples (inv. 6030)

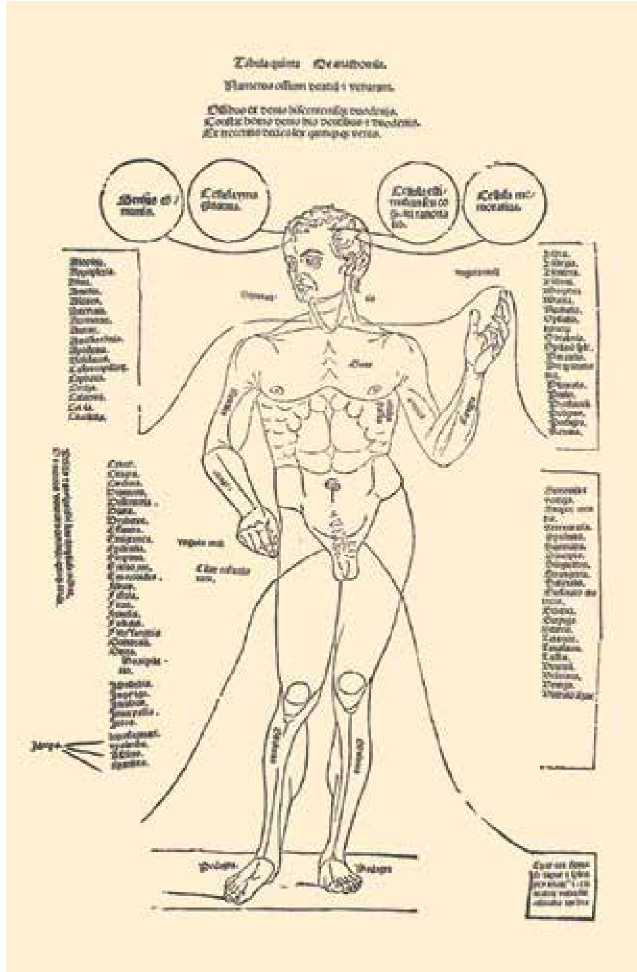
7. *Doryphoros*, 2nd–1st century B.C. Carrara marble, H. 83½ in. (212 cm). Museo Archeologico Nazionale, Naples (inv. 6011). Photograph: Album/Art Resource, New York

the figure's heroic, even proto-Romantic aspect.[27] Specific details, too, come from the ancient Antinous model: the strigilated eyebrows, the structure of the nose, and the fleshy lips. As Matteo Ceriana has noted, the *Adam* is "the most faithful and at the same time the most innovative reading of the ancient Antinous type in the whole of the Italian Renaissance."[28]

Especially relevant to Tullio's conception of his *Adam* are the several extant marble copies of Polykleitos's *Doryphoros* (Spear Bearer), a bronze sculpture dated about 440 B.C. and now lost. The finest and best preserved of the copies is currently in Naples's Museo Archeologico Nazionale and seems to have come from the excavations at Pompeii at the end of the nineteenth century (Figure 7). Originally portrayed carrying a spear in his left hand, the figure poses in mid-stride, following Polykleitos's prototypical example of the use of contrapposto to create a sense of potential movement in a static figure. The right leg supports the weight of the body, while the left leg is bent, with only the ball of the foot touching the ground. Pliny the Elder was the first to assign the invention of contrapposto to Polykleitos (*Naturalis Historia* 34.56). It is worth noting that Pliny was an important source for Tullio and his circle, which included Gaurico and Andrea Vendramin's nephew Ermolao Barbaro (1453–1494), the author in the 1490s of the *Castigationes Plinianae*, and also, some have suggested, one of Tullio's patrons.[29]

The only clearly documented sculpture of the Doryphoros type that Tullio might have known is the *Satyr*, or *Martinori Bacchus*, now in the Ny Carlsberg Glyptotek in Copenhagen (Figure 8). The work is a variant made between the first and second centuries by a Roman copyist who represented

8. *Satyr*, or *Martinori Bacchus*, 1st–2nd century A.D. Marble, H. 79⅛ in. (201 cm). Ny Carlsberg Glyptotek, Copenhagen (inv. 158)



9. *The Sick Man*. Engraving from *Fasciculus Medicinae*. Published by Johannes de Ketham (Venice, 1491), pl. V

Polykleitos's figure as the god Pan, recognizable by the animal pelt tied at his right shoulder. The first mention of this sculpture in Rome is found in the *Antiquarie prospetiche romane*, a pamphlet in verse by an unidentified author generally known as Prospetivo Milanese, who visited Rome between January 1495 and March 1496.[30] The anonymous Milanese (his origins are worth noting, since the Lombardo family, too, was from the Lombardy region) wrote that the *Satyr* was at that time in the collection of the Santacroce family, one of the first among the Roman nobility to create a collection of antiquities.[31] A drawing after this sculpture, from a sketchbook (the so-called Codex Wolfegg, 1500–1503, fol. 47v) of the Bolognese artist Amico Aspertini (ca. 1474–1552), shows the work intact.[32] However, Maarten van Heemskerck (1498–1574), a more reliable recorder of facts than Aspertini, represented it as headless and with broken arms in the sketchbook from his trip to Italy about 1532–36.[33] Although the *Satyr* was not mentioned until about 1495–96, this does not preclude the possibility that the sculpture was discovered earlier.

There may have been a Doryphoros figure in Venice, also. In one of Michiel's several mentions of fragments of walking figures, he notes, for instance, that a "marble, male nude, without head and hands, in the act of walking, which is beside the door" in the Odoni collection "is antique."[34] Michiel's description suggests that the Odoni sculpture could have been a Doryphoros. Moreover, Wendy Stedman Sheard observed that the figure of the *Sick Man* (*Tabula quinta de anathomia*) in a print by an unknown engraver (Figure 9) derives from the Doryphoros.[35] This plate, which Richard Stone was the first to associate with Tullio's *Adam*,[36] is an illustration in the first Latin edition of the *Fasciculus Medicinae*, published in Venice in July 1491 under the name of the Viennese physician Johannes de Ketham.[37] The book, a collection of six short medical treatises, achieved immediate popularity. Although we may never know which

Doryphoros figures Tullio actually saw, the type remains, along with the Antinous and Apollo models, one of his most likely ancient sources.

The possibility that *Adam* descends from the *Apollo Belvedere* rests upon a hypothetical trip made by Tullio to Rome. The white marble *Apollo* is a Hadrianic copy, carved about A.D. 120–140, of a lost bronze original dated 340–320 B.C. and attributed to Leochares, a student of Praxiteles (Figure 10).[38] Discovered in 1489 in Rome in a vineyard "above Santa Pudenziana,"[39] the *Apollo Belvedere* was first displayed in the Loggia del Viridario at the Palazzina della Rovere in the Palazzo dei Santi Apostoli.[40] It was moved to the Belvedere Gardens at the Vatican complex in 1508, several years after Giuliano della Rovere had became Pope Julius II.[41] One of the most admired ancient artworks of all time, the *Apollo* is considered the sculptural embodiment of the ideal male nude and one of the most perfect expressions of classical art. It is also characterized by a sense of organic volume similar to that found in Tullio's *Adam*, which reproduces almost exactly several details of the *Apollo*, including the cleft at the base of the tree trunk from which a small snake emerges.

Could Tullio have seen the *Apollo Belvedere* in Rome before starting work on his *Adam* about 1490? Scholars are cautious on the subject, since there is no evidence that Tullio traveled to Rome at such an early date, but they are inclined to suggest a trip taken prior to 1521, the year of his only documented visit, recorded by Cesare Cesariano.[42] Sheard was the first to suggest one or more Rome trips at the end of the 1470s and in the early 1480s, and certainly before 1485.[43] Since the first visual records of the *Apollo Belvedere* are two drawings in the Codex Escurialensis (fols. 53, 64) that are generally dated between 1491 and 1506–8,[44] it is tempting to think that Tullio visited Rome—and maybe not for the first time—about 1489. Otherwise, it must be supposed that he saw drawings of the *Apollo Belvedere* that predated those in the codex—graphic records that so far have not come to light.[45] Some years later, the *Apollo Belvedere* sculpture had become well known in Venice. The Milanese sculptor and architect Cristoforo Solari, called il Gobbo (1468–1524), carved an Apollo there that was about fifty inches high and "similar to that seen in the garden of the Cardinal of San Pietro in Vincoli [Giuliano della Rovere]."[46]

The extraordinary *Apollo of Mantua* (Figure 11) now in Mantua's Palazzo Ducale can be dated to the first to second century A.D. Carved from Parian marble, this Kassel-type Apollo is in very good condition, but unfortunately, nothing is known of its provenance.[47] Sheard was the first to mention the *Mantua Apollo* as a possible source for Tullio's *Adam*, although no drawings from the late fifteenth century allow us to say that the *Apollo* was known at that time.[48]

10. *Apollo Belvedere*, A.D. 120–140. Marble, H. 88¼ in. (224 cm). Vatican Museums, Vatican City (inv. 1015)

Similarities in modeling and pose prompt the suggestion for the first time here that the Apollo Lykeios could have served as a model for Tullio's *Adam*.[49] It is not clear where the name Lykeios comes from, but this sculpture type (see Figure 12) has been associated with Praxiteles's late work at the end of the fourth century B.C. and is easily recognizable from the position of the right arm, which rests on top of the head in a posture of repose.[50] The figure's weight is on its right leg, leaving the left leg relaxed and angled to the side, creating a twist in the pelvis. There is a supporting element,

11. *Apollo of Mantua*, 1st–2nd century A.D. Marble, H. 60¼ in. (153 cm). Palazzo Ducale, Mantua (inv. 6773). Photograph: Alinari/Art Resource, New York

12. *Apollo Lykeios*, 2nd century A.D. Marble, H. 86⅝ in. (220 cm). Museo Archeologico Nazionale, Venice (inv. 101)

sometimes to the figure's right (as in the case of Tullio's *Adam*) and sometimes to its left, where it is thought to have been situated in Praxiteles's original.

Various fragments of the Apollo Lykeios type survive,[51] as do several representations of it on coins from the first century B.C.—evidence of its longevity as an iconographical type. This type of Apollo is widely diffused and is found in numerous variations, most commonly in representations of the god Bacchus. Tullio's *Adam* shares the Apollo Lykeios type's fullness of form, the position of its right, weight-bearing leg, and especially the position of the left leg, which is slightly bent, in contrast to the *Apollo Belvedere*'s more pronounced flexion. In addition, *Adam*'s right side, like that of the Apollo Lykeios, projects outward. Might Tullio have had direct knowledge of the Apollo Lykeios type?

In all probability, the sculptor knew the figure from statuettes and/or from ancient Greek coins, which were plentiful in Venice and constituted the nuclei of the principal collections of antiquities there in his day. But this is not the only possibility. There are two Lycian Apollos, Greek in origin, in the Museo Archeologico Nazionale in Venice, and both were originally in the collection of Cardinal Domenico Grimani.[52] The first is the monumental *Apollo Lykeios* shown in Figure 12, often considered one of the most complete and faithful replicas of Praxiteles's original work.[53] The other is the figure of Dionysos in the sculpture group *Dionysos Leaning on a Satyr* (Figure 13). This figure of the god is clearly similar in its conception to the Apollo Lykeios type. The Dionysos group (second-to-first century B.C.) was discovered in Rome in the fifteenth century in the area around Porta Maggiore. In 1483 it was noted among the antiquities that Grimani left to the Statuario Pubblico in Venice.[54] When this transfer of ownership took place and what the sculpture's condition was at the time

13. *Dionysos Leaning on a Satyr*, 2nd–1st century B.C. Marble, Dionysos figure H. 80 in. (203 cm). Museo Archeologico Nazionale, Venice (inv. 119)

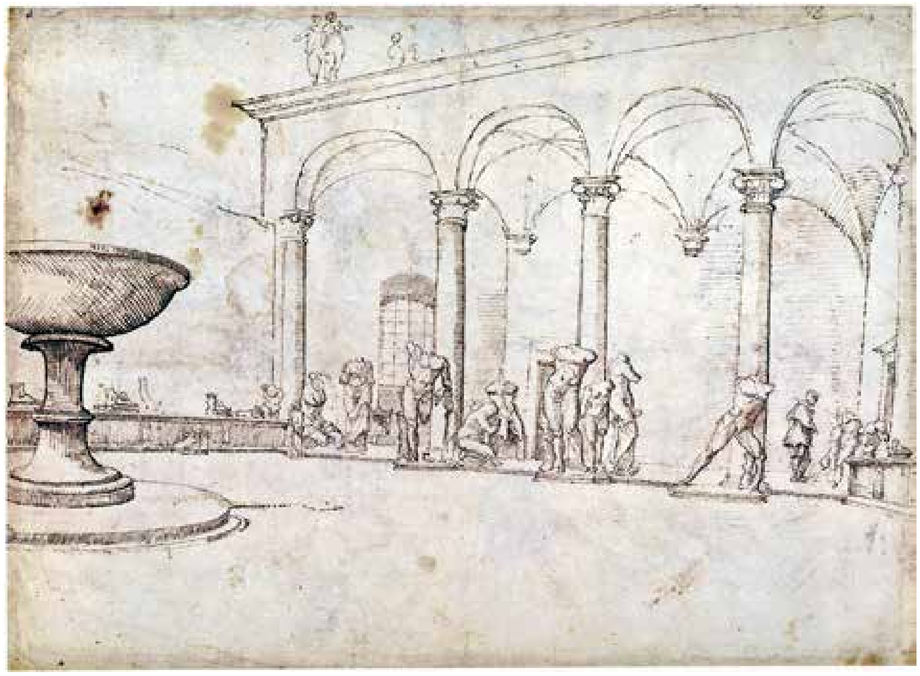
14. *Bacchus and Cupid*, mid-2nd century A.D. Marble, H. 89 in. (226 cm). Museo Archeologico Nazionale, Naples (inv. 6307)

are not known; the work was later extensively restored. The most complete and original parts of the Dionysos figure, the torso and legs, seem to share a softness of modeling with Tullio's *Adam*.

Other examples of this type of Dionysos with a satyr include *Bacchus and Cupid* (Figure 14) and an Apollo Lykeios in the guise of Dionysos, both now in the Museo Archeologico Nazionale in Naples.[55] Sketches in Van Heemskerck's notebooks show these works in fragmentary condition in the vast collection at the Palazzo Medici, later known as the Palazzo Madama, in Rome (Figure 15).[56] There are no surviving records indicating when they were discovered, and nothing is known of their provenance; they are noted here simply to emphasize how widely diffused the Apollo Lykeios type was in Tullio's time.

The many ancient works that Tullio might have known suggest that he drew inspiration for his *Adam* from a wide range of sources, both Greek and Roman, and then combined them in original ways. *Adam* reveals a blending of influences from Praxiteles and Polykleitos: from the latter comes the detail of the left leg resting on the ball of the left foot, and from the former, the overall modeling of the figure. Tullio's use of a drill to mark the irises and the semicircular pupils of *Adam*'s eyes stems from a traditional technique in Roman Imperial portraiture that was adapted in the Lombardo workshop to give expression to a figure's gaze. It also seems plausible that Tullio could have drawn from works in a variety of media, including paintings, medals, bronze statuettes, and coins. The fact that only the head of *Adam* is influenced by Antinous suggests that the sculptor might have had access to no more than a bust of that figure—perhaps a marble head or a likeness struck on a coin.

In borrowing from multiple sources to create an Adam that was manifestly *all'antica* yet whose direct lineage



15. Maarten van Heemskerck (Netherlandish, 1498–1574), *Loggia in the Palazzo Madama-Medici*, 1530s. Pen and brown ink, 8¼ x 11½ in. (21.1 x 29 cm). Kupferstichkabinett, Staatliche Museen, Berlin (79 D 2[a], fol. 48r). Photograph: Scala, Florence/BPK, Bildagentur für Kunst, Kultur und Geschichte, Berlin

would have been impossible to pin down, Tullio was in line with ancient precedents, notably the Greek painter Zeuxis,[57] and could well have been guided by Seneca's and Petrarch's theories of creative imitation. Referring to the art of literature, Petrarch (1304–1374) wrote: "Similarity must not be like the image to its original in painting where the greater the similarity the greater the praise for the artist, but rather like that of a son to his father. While often very different in their individual features, they have a certain something our painters call an air [*umbra quedam et quem pictores nostri aerem vocant*], especially noticeable about the face and eyes, that produces a resemblance; seeing the son's face we are reminded of the father's." He went on to recommend that "the similar be elusive and unable to be extricated except in silent meditation, for the resemblance is to be felt rather than expressed."[58]

Having several sources allows *Adam* to be *all' antica* without citing one celebrated antecedent in particular. If recognized, such a prototype would have conferred distracting associations. *Adam*, after all, could not too closely resemble an Antinous, a Bacchus, or an Apollo without changing the meaning of the work. So instead, Tullio took elements from a variety of sources and transformed them—just, as Lucius Seneca (4 B.C.–A.D. 65) taught, as bees collect pollen from many types of flowers to make honey.[59]

The success of the *Adam* was immediate but relatively brief and limited to a local sphere. In the end, Tullio's experiment with neo-antique classicism did not enjoy widespread or long-lasting favor, and the artist did not revisit it in his ambitious, large-scale projects, such as the Giovanni Mocenigo tomb in Santi Giovanni e Paolo, begun just after the Vendramin monument. Into those he channeled his abiding interest in architecture, evident in works he executed in Venice, Treviso, and Belluno,[60] and in high-relief sculpture, exemplified by two double portraits, one in Venice (see Figure 14 in "*Adam* by Tullio Lombardo," by Luke Syson and Valeria Cafà in the present volume) and one in Vienna, and by the Chapel of Saint Anthony in the Basilica of Saint Anthony in Padua.[61]

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NOTES

1. For research on the antique sources of Tullio's *Adam*, see Planiscig 1937, p. 103, where it is suggested that there is no specific prototype because "It is the spirit of the antique which, having been assimilated, is expressed here" (Es ist der Geist der Antike, der, assimiliert, hier zum Ausdruck kommt), and where *Adam* is characterized as a "soft bacchic ephebe with the Antinous-like face" (bacchische Ephebe mit dem Antinoos-Gesicht); Remington 1937, p. 61, "the work is not a servile copy, it has as yet been impossible to trace the particular statue which may have provided him with the basis of his idea"; Mariacher 1954, p. 370, "a new Greek Apollo" (no type specified); Pope-Hennessy 1958, p. 111, Apollo Belvedere, Capitoline Antinous; Sheard 1971, p. 168, "the Classical rigor of Doryphorus," Mantuan or Kassel-type Apollo, and p. 169, Antinous; Wilk 1978, p. 22, Mantuan or Kassel-type Apollo and (late) Classicistic ivory sculpture for the "unstable contrapposto, unclassical proportions and abstract description of skin surface"; Smyth 1979, p. 212, "an Apollonian, square-shouldered nude in the spirit of the antique, drawing on various Hellenistic and Roman models—types of Apollo and Antinous—and yet by no means a copy"; Huse and Wolters 1990, p. 150, "Apollo of Mantua"; Luchs 1995, p. 45, "Greek and Roman nudes descending from Polykletian models of the fifth century B.C."; Ceriana 2005, p. 532, "the most faithful and at the same time the most innovative reading of the ancient Antinous type in the whole of the Italian Renaissance"; Morresi 2006, p. 67, "neo antique and nude Adam"; Blake McHam 2007– , "The idealized male nude type derives from antique statues of Apollo, although its unstable contrapposto, unclassical proportions and abstract description of skin surfaces also suggest the influence of Late Antique ivory sculpture"; Sarchi 2008, p. 96, "a very graceful version of the tradition of the Apollo Ephebe that decends from Polykleitos." The artist also had other influences, including the work of contemporary painters, and especially their treatment of faces and coiffures. See Luchs 2009, p. 5.
2. It has also been noted, for example, that Antonio Lombardo's relief *Putto Riding on a Dolphin* on the Vendramin tomb derives from an antique cameo owned by the jeweler Domenico di Piero. See Schofield 2006, pp. 161–62, with ample earlier bibliography.
3. For this, see Lorenzo Lotto's *Portrait of Andrea Odoni* (1527) in the Royal Collection at Hampton Court. For Odoni's collection, see Favaretto 1990a, pp. 75–79. For Odoni's house and collection, see Martin 2000.
4. "La figura marmorea de donna vestita intiera, senza la testa e mani, è antica; e solea essere in bottega de Tullio Lombardo, ritratta da lui più volte in più sue opere"; Michiel 1800, p. 60. Michiel's *Notizia d'opere di disegno* was written between 1522 and 1532 but was not published until 1800. It is useful to note that its editor, Jacopo Morelli, pointed out that Bellini, too, owned antiquities, as is also mentioned in *De marmoreo Platonis capite apud Bellinos Venetiis,* a verse work by Piero Valeriano, and in an epigram by Raffaele Zovenzonio, *In Venerem Gentilis Bellini*; see Michiel 1800, p. 194. Michiel's observation was first noted in Planiscig 1921, p. 228. Pietro Aretino also saw the Odoni collection; see Favaretto 2002, p. 130.
5. Pincus 1981. This suggestion was accepted and discussed in Favaretto 1999, pp. 238–39. See also De Paoli 2004, p. 132. For the sculpture itself, see Traversari 1973, pp. 167–68.
6. Favaretto 1990a, in particular for Squarcione; she also cites the workshops of Bellini, Mantegna, and Lotto.
7. Alessandra Sarchi (2004, p. 47n55) hypothetically attributes the restoration of the *Grimani Hermaphrodite* (Museo Archeologico Nazionale, Venice, inv. 198) to Antonio, a suggestion explored further in Sarchi 2007, pp. 355–57.
8. Pincus (1979, p. 38) suggests that this restoration was commissioned by Ermolao Barbaro. See also De Paoli 2004, p. 155, and De Paoli in Ceriana 2004, p. 190 ("Musa, detta Cleopatra Grimani").
9. De Paoli 2004; De Paoli 2007.
10. Critical edition with parallel text in Gaurico (1504) 1999. Pomponio Gaurico's first treatise on sculpture was published when he was not much older than twenty. The Neapolitan's friendship with Tullio is documented; see Paolo Cutolo in ibid., pp. 246–55.
11. "che egli è il più valente di tutti gli scultori che abbia mai visto alcun'epoca"; ibid., pp. 250–51.
12. See Sheard 1979, p. 202, and Pope-Hennessy 1958, p. 112.
13. "la pittura è cosa caduca . . . la scoltura è molto più senza comparatione, et non da parragonar con pittura per niun modo, perché de antiqui se ritrova sino alli nostri tempi de le sue scolture, con pitture veramente nulla si pol vedere"; Ames-Lewis 2000, p. 153. See also Puppi 1972, p. 103, and most recently Collareta 2007. The antecedents are discussed in Sheard 1992, pp. 79–81.
14. Collareta 2007.
15. For the ties between Venice and Greece, see Beschi 1986, pp. 326–38; P. Brown 1996; and Favaretto 2002.
16. Favaretto 2002, p. 126. See Zorzi 1988, pp. 15–24, for collections in the fifteenth century.
17. This topic has been treated widely; see for instance Favaretto 1990a; Favaretto 1990b; Favaretto 2002; and Bodon 2005.
18. For the Barbo collection, which consisted primarily of coins and gems, see Salomon 2003, with earlier bibliography.
19. Sheard 1971, p. 165.
20. See Sheard 1979, where this figure is compared in particular with the youths in Giorgione's work.
21. Wilk 1978, p. 22; Blake McHam 2007– .
22. See note 1 above.
23. See Vout 2005, with earlier bibliography.
24. John Pope-Hennessy (1958, p. 111) suggested the *Antinous Capitolinus* as a reference despite the fact that it was not discovered at Hadrian's Villa in Tivoli until the early eighteenth century. See Haskell and Penny 1981, p. 143.
25. "infinite medaglie," as quoted in Gregory and Woolfson 1995, p. 260.
26. See Michiel 1800, p. 20 (for Bembo's collection); Gregory and Woolfson 1995, p. 254; and Lucherini 2007. On this sculpture, see Bober and Rubinstein 1986, p. 163n128, where it is also suggested that the restoration was carried out in the 1520s, perhaps by Lorenzetto. See also Riebesell 1989, pp. 62–64, and more recently, Anna Maria Riccomini, "Testa ritratto di Antinoo su torso antico," in Beltramini, Gasparotto, and Tura 2013, pp. 332–33 (with earlier bibliography).
27. Sheard 1971, p. 169; Sheard 1985, p. 426. An exhibition dedicated to Antinous was held at Hadrian's villa in 2012. See the catalogue, Sapelli Ragni 2012, and in particular the essay Cadario 2012.
28. "la più fedele e insieme innovativa rilettura del tipo antico dell'Antinoo di tutto il Rinascimento italiano"; Ceriana 2005, p. 532.
29. Sheard (1979, p. 202) offers an interesting hypothesis about the possible contribution of Barbaro, one of the most refined, cultured humanists of his time and an editor of Pliny. Reiterated in Pincus 1979, pp. 28, 40–41, and again in Sheard 1997, p. 164, where

Barbaro is given partial credit for the choice of the Arch of Constantine as a model for the Vendramin tomb. For this, see also Sarchi 2008, pp. 90–91. For Pliny's reception in the Renaissance, see Blake McHam 2013, especially pp. 259–61, for Gaurico's debt to the *Naturalis Historia*.

30. This is the most recent dating; it was suggested by Agosti and Isella 2004, and it is based on information in the pamphlet.
31. Ibid., pp. 67–68. For the Santacroce collection, see Christian 2002 and 2010, pp. 372–74.
32. See Schweikhart 1986.
33. Sketchbook 79 D 2, fol. 23r, and details of the head on fol. 36v; Kupferstichkabinett, Staatliche Museen, Berlin. For other iconographic sources, see Vicarelli 2007, pp. 71–73. It is interesting to note that in the sculpture's restored state, its gestures are very close to those of Tullio's *Adam*: its right hand rests on pipes of Pan, and its left delicately holds an object.
34. "El nudo, senza mani e senza testa, marmoreo, in atto de camminar, che è appresso la porta, è opera antica"; Michiel 1800, p. 60.
35. Sheard 1985, p. 126.
36. Stone (1972–73) also proposes it as a terminus ante quem for dating Tullio's *Adam*.
37. An annotated English translation was published in 1988; see Ketham (1491) 1988. The first vulgate edition, published in 1494, is analyzed in Pesenti 2001, where it is revealed that on June 17, 1496, when Giorgio Ferrari from Monferrato, the doctor who corrected the text, asked the Venetian Consiglio for the privilege, he had already been working on the project for sixteen years.
38. Haskell and Penny 1981, pp. 148–51, no. 8; Erika Simon, "Apollo," in *LIMC* 1981–99, vol. 2, part 1 (1984), p. 198; Bober and Rubinstein 1986, pp. 71–72, no. 28. Today this work is in the Vatican Museums, Vatican City, in the Cortile Ottagono, inv. 1015. For its later reception, see Winner 1998.
39. Christian 2010, pp. 368–69. See also Magister 2002, pp. 536–38; Agosti and Isella 2004, p. 49.
40. Deborah Brown (1986, p. 236) first identified the "cappel genoves" noted by Prospetivo Milanese as the Genoese Cardinal Paolo Campofregoso, who lived at the Palazzina della Rovere from 1496 to 1498, instead of Cardinal Guiliano della Rovere, who was not from Genoa. For the collection of Cardinal della Rovere, see Agosti and Isella 2004, p. 49.
41. For this relocation, see Nesselrath 1998, p. 1.
42. The only mention of a trip to Rome by Tullio Lombardo in contemporary documents is in Cesare Cesariano's translation of and commentaries on Vitruvius's *De architectura* (1521, fol. 48v); this passage was noted in Agosti 1990, pp. 69–70.
43. Sheard 1984, p. 173n58; Sheard 1997, pp. 161, 170. Fabio Benzi (2008, p. 59) reaffirms that Tullio must have visited Rome, perhaps at the end of the 1480s, and posits a "logical" stop in Florence to see Lorenzo de' Medici's collection. For a trip to Rome, see also Sarchi 2008, pp. 88–93, 93–101 (for the detailed references to Roman antiquities).
44. The Codex Escurialensis, a Renaissance sketchbook taken to Spain ca. 1506, is in the collection of the Real Biblioteca del Monasterio de San Lorenzo de El Escorial, Madrid. For a facsimile, see Egger 1905–6; see also Magister 2002, p. 541, with earlier bibliography.
45. *Adam* is not the only figure on the Vendramin monument to have ancient sources. See Pope-Hennessy 1958, p. 112, for the modeling of the two armored warriors and their similarity to the *Mars* in the Musei Capitolini, Rome.
46. "ad similitudinem illius qui in hortis Cardinalis Sancti Petri ad Vincula visitur"; Agosti and Isella 2004, p. 50. This passage from the *Antiquarie prospetiche romane* is also cited by Sheard (1986, p. 9), who suggests that it is perhaps the first written reference to the reception of the *Apollo Belvedere* in Renaissance sculpture.
47. Papini 2008. For the Kassel type, see Gercke 1991; Vierneisel and Gercke 1992; and *Kasseler Apoll* 2007.
48. Sheard 1971, p. 168, followed by Wilk 1978, p. 22.
49. Schröder 1989.
50. Milleker 1987.
51. Erika Simon, "Apollo," in *LIMC* 1981–99, vol. 2, part 1 (1984), p. 193, and vol. 2, part 2 (1984), p. 184.
52. For the Grimani collection, see Perry 1972 and 1978.
53. Traversari 1973, pp. 92–93; Favaretto and Traversari 1993, pp. 70, 72, 74–75.
54. Perry 1972, p. 128; Favaretto and Traversari 1993, pp. 120, 122–23; Favaretto, De Paoli, and Dossi 2004, pp. 64–65.
55. For *Bacchus and Cupid* (inv. 6307), see Carmela Capaldi in Gasparri 2009, pp. 135–36, no. 60; for the Dionysos (inv. 6318), see ibid., pp. 133–34, no. 59.
56. Sketchbook 79 D 2(a), fol. 48r, Kupferstichkabinett, Staatliche Museen, Berlin. For Van Heemskerck's drawings of the antiquities at the Palazzo Medici, see most recently Christian 2012, especially pp. 146–47. For the collection at the Palazzo Medici, see Christian 2010, pp. 332–39. For the marble groups, see Gasparri 2009, nos. 59, 60. For the *Bacchus and Cupid*, see Riebesell 1989, p. 44.
57. Well known in the Renaissance, the legend of Zeuxis and the maidens of Croton tells how the renowned painter, commissioned to paint a portrait of Helen of Troy for the temple of Croton, asks to see the five most beautiful women (naked, of course) of the city. When they were assembled, he drew inspiration from all of them in fashioning his image of ideal beauty, since such a thing was not to be found in one single model. For the ample literature on the topic, see Barkan 2000 and Grafton 2001, pp. 146–48.
58. "curandum imitatori ut quod scribit simile non idem sit, eamque similitudinem talem esse oportere, non qualis est imaginis ad eum cuius imago est, que quo similior eo maior laus artificis, sed qualis filii ad patrem. In quibus cum magna sepe diversitas sit membrorum, umbra quedam et quem pictores nostri aerem vocant, qui in vultu inque oculis maxime cernitur, similitudinem illam facit, que statim viso filio, patris in memoriam nos reducat, cum tamen si res ad mensuram redeat, omnia sint diversa; sed est ibi nescio quid occultum quod hanc habeat vim. Sic et nobis providendum ut cum simile aliquid sit, multa sint dissimilia, et id ipsum simile lateat ne deprehendi possit nisi tacita mentis indagine, ut intelligi simile queat potiusquam dici. Utendum igitur ingenio alieno utendumque coloribus, abstinendum verbis; illa enim similitudo latet, hec eminet; illa poetas facit, hec simias"; Petrarca, *Familiari* 23.19.11–13 (1942, p. 206). For both the English translation by Aldo S. Bernardo (Petrarca 1985, pp. 301–2) and a discussion of the text, see Bolland 1996, p. 481.
59. Seneca, *Letters* 84.3–4, as discussed in Ackerman 2002, pp. 129–31.
60. Guerra, Morresi, and Schofield 2006.
61. Blake McHam 1994.

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The Treatment of Tullio Lombardo's *Adam*: A New Approach to the Conservation of Monumental Marble Sculpture

CAROLYN RICCARDELLI
Conservator, Sherman Fairchild Center for Objects Conservation, The Metropolitan Museum of Art

MICHAEL MORRIS
Independent conservator of sculpture and architecture, New York

GEORGE WHEELER
Director of Conservation, The Historic Preservation Program, Graduate School of Architecture, Planning and Preservation, Columbia University, New York

JACK SOULTANIAN
Conservator, Sherman Fairchild Center for Objects Conservation, The Metropolitan Museum of Art

LAWRENCE BECKER
Senior Conservator, Sherman Fairchild Center for Objects Conservation, The Metropolitan Museum of Art

RONALD STREET
Senior Manager, 3D Imaging, Molding, and Prototyping; Merchandise Development and Planning, The Metropolitan Museum of Art

When the pedestal supporting Tullio Lombardo's marble *Adam* collapsed, there were no witnesses present in the Vélez Blanco Patio where the sculpture was displayed. However, its timing was documented almost to the second by a security camera programmed to scan the galleries at eight-second intervals. Images from the camera showed that on October 6, 2002, at 5:59 p.m. and 30 seconds, the floor was clear; at 5:59 p.m. and 38 seconds, the head of *Adam* was on the floor of the patio.

Museum Security discovered the sculpture that evening, and the tragic consequences of the collapse were immediately apparent. On impact, this lifesize sculpture broke into twenty-eight large pieces and hundreds of smaller fragments. Fortunately, the head, face, and torso, still connected to Adam's right thigh, were relatively unscathed in the fall, but the arms, which bore the brunt of the impact, and the lower legs suffered major damage.

The decision to reconstruct the sculpture and restore this Renaissance masterpiece as closely as possible to its appearance before the accident was made almost immediately. From the outset, however, it was clear that the treatment of the broken sculpture would be a formidable project, posing an unusual, perhaps even unprecedented, series of challenges with little in the way of past practice to draw upon. When faced with reassembling large-scale stone sculpture, conservators are most often dealing with ancient, archaeological sculpture, its surfaces weathered by burial. Because break surfaces have eroded over time, fragments do not fit together securely, if at all. The major challenge for conservators in these cases is to correctly align and join elements with few points of contact. Gaps and losses between fragments are common and often need to be bridged by adhesives or fill materials. In contrast, the Museum's shattered *Adam*, with newly fractured surfaces that in most cases mated perfectly, presented a different set of challenges. Reassembly required a treatment approach that would retain the tightness of the joins. Equally important was a method that would limit handling of the sculpture and position the heavy fragments precisely without abrading the fresh, vulnerable break edges.

Furthermore, the reassembly of large-scale sculpture has historically relied on the use of multiple iron or steel pins bridging each fracture, supplemented more recently by structural adhesives such as epoxy resins. While generally effective in structural terms, these methods have been seen by a growing body of conservators as overly aggressive and

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liable to damage the surrounding stone in the event of later stress on the join. The importance of *Adam* warranted a critical evaluation of the use of pins and adhesives and an investigation into less invasive and more reversible approaches.

The significance of *Adam* and the complexity of reconstructing freshly broken monumental sculpture also warranted a team of specialists from both inside and outside the Museum who could bring the insights of various disciplines to bear on a conservation project so unlike those usually encountered. Thus conservators, conservation scientists, and curators were joined and supported by materials scientists and engineers in an exceptional multidisciplinary collaboration to determine the best course of treatment for the sculpture. Lawrence Becker oversaw the project when he became Sherman Fairchild Conservator in Charge of the Museum's Sherman Fairchild Center for Objects Conservation in 2003. He was primarily responsible for putting together the core Tullio team. Conservator Carolyn Riccardelli, a specialist in the conservation of large-scale sculpture, was the principal conservator and was involved in most every aspect of the project from fragment retrieval to fills. Michael Morris, a sculpture conservation specialist hired specifically for the project, collaborated on all stages of the treatment of *Adam*. Conservator Jack Soultanian, an authority on European sculpture, conducted the examination and had primary responsibility for all aesthetic aspects of the treatment, including cleaning, retouching the fills, and surface integration. George Wheeler, a consulting scientist at the Museum, was primarily responsible for materials research related to the project. Laser scanning, virtual modeling, and collaborative work on finite element analysis was performed by Ronald Street, a specialist in 3D imaging, molding, and prototyping. In addition to a select group of conservators who served as consultants, many curators, interns and fellows, scientists, engineers, designers, media specialists, and administrators contributed immeasurably to the project. Details on their roles are given in the "Acknowledgments" at the end of this article.

From the beginning, our research strategy and testing protocols were directed toward developing a treatment that would join the fragments securely with reversible, stable materials compatible in strength and stiffness with marble, and with minimal drilling to accommodate pins. The methods developed from this effort provided what we believe to be a new model for best practices and standards in the conservation of large stone sculpture. While the specific circumstances of *Adam*—the fragility of the fracture surfaces and the tightness of the joins—dictated our approach, our research and test results are applicable to a broad range of stone conservation problems.

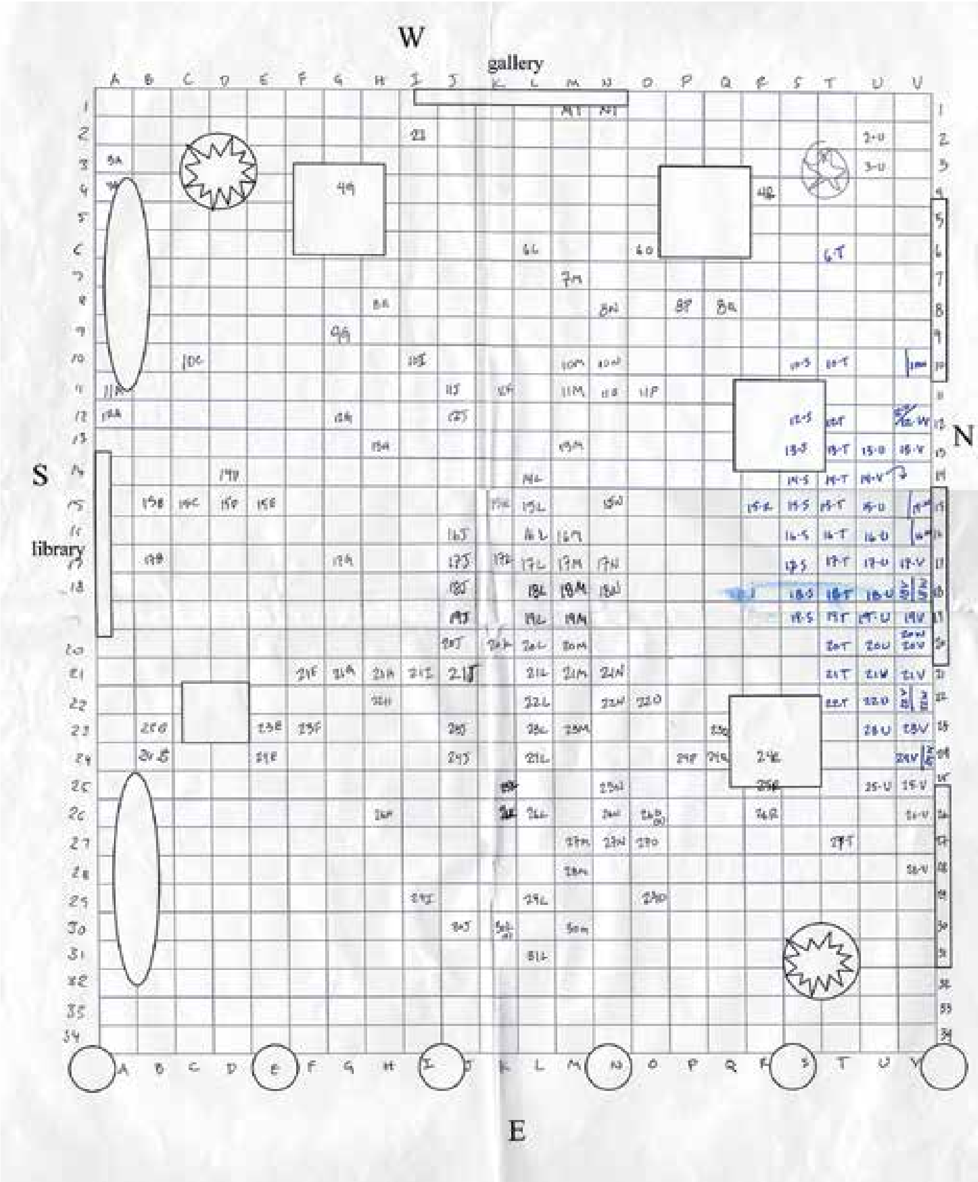
This article describes the innovative treatment of *Adam*, including the use of three-dimensional laser scanning, finite element analysis, materials testing, and empirical studies carried out to determine the optimal adhesives and pinning materials. An explanation is provided about a novel external armature, which minimized the handling of the fragile fracture surfaces of the sculpture. This armature was developed to support the assembled sculpture without adhesive and to serve as the method for clamping the fragments once adhesive was applied. Drilling and pinning techniques are described, as are the challenges related to cleaning the sculpture's surface and to filling losses. The article closes with a summary of lessons learned and conclusions drawn from this extensive multidisciplinary project.

CONDITION OF THE SCULPTURE

To evaluate the condition of the sculpture following the accident, we first had to retrieve systematically and document the fragments and then characterize them so we could determine their location on the sculpture. We sought to understand the nature of the marble and the structural characteristics of the fractures before we began investigation into appropriate adhesives and pinning materials. Knowledge of the marble's properties and of potential stresses on the fractures also helped in the design of an external armature that protected and supported the fragments during our work. We also conducted a surface examination of the sculpture to find evidence of tool marks and surface decoration that would help us gain insight into Tullio Lombardo's carving techniques.

Recovery, Documentation, and Characterization

The sculpture landed on its right side, and the force of the impact on the stone floor was so great that fragments were thrown considerable distances, some stopped only by the patio walls. They ranged in size from the intact torso including the right thigh, measuring approximately 44 inches (112 cm) in length, to small but identifiable pieces, such as a branch of the tree trunk measuring 1¾ inches (4.5 cm) in length, to hundreds of smaller fragments. Because we hoped that the pattern of their scatter on the floor might help point to their location on the sculpture, we developed a systematic mapping and retrieval system to document the position of every fragment. The patio's rectangular floor tiles were the basis of grid locations. Each tile was given a letter and number designation, and each unit of the grid containing even the smallest fragment was marked according to its coordinates (Figure 1). Next, the grid units were photographed (Figures 2a, b). Only then were the fragments collected. They were subsequently laid out on tables in a temporary studio space so they could be studied (Figure 3).



1. Map of the Vélez Blanco Patio indicating the locations of the fragments. The tile pattern of the patio floor was used to create a grid. Tiles were designated “A” through “V” on the horizontal axis, and 1 through 34 on the vertical axis; then each fragment was assigned a letter and number according to its location on the grid. The square elements indicate the location of sculpture pedestals in the gallery. *Adam* was located on the pedestal closest to the northeast corner. Diagrams of Figures 1; 5a–d; 6; 16b; 17a–c; 37; 41; and 58a–c: Carolyn Riccardelli

2a,b. Photographic documentation. To record the scattering of the fragments, each floor tile was individually photographed. Left: the base with fragments of the left leg and upper right arm. Right: fragments of the tree trunk and the right forearm. Photographs of Figures 2a,b; 3; 4; 5a–d; 7; 9; 18; 24; 32; 36; 39; 40; 42; 43b; 44–48; 49a,b; 50–55; 57; 61; 62; 64–75; 77; 78a,b; 79–82; 84 and 85: Carolyn Riccardelli

3. Some of the major fragments arranged on a table in the Tullio studio

Once the Tullio team was fully assembled, we began examining the fragments and planning their reconstruction. It was at this point that the full nature and extent of the damage became clear (see Figure 8). The sculpture's integral base broke away from the legs at the ankles as well as at the base of the tree trunk. We speculated that the primary point of impact for the sculpture was the rear corner of the base just under the tree trunk. This area suffered extensive damage, breaking into dozens of fragments and crushing the marble, causing large areas of loss. This and other direct impact points appear as flattened, burnished areas on the surface that are more opaque than the surrounding stone due to crushing of the marble crystals, or grains. Wherever these points of impact occurred on *Adam*, there was associated pulverization and loss to the marble.

The tree trunk broke into three major fragments, with the base of its branch and the bird carved in relief receiving the most damage. The branch broke into four major pieces and many smaller fragments, a dozen of which were identified and subsequently reattached. A small strut connects the top of the tree trunk to *Adam*'s right hip; this roughly carved block of marble suffered internal pulverization while the surface shattered into many pieces, twenty-five of which were reattached.

4. A sample of small fragments with exterior surfaces. These fragments, which would be used in the reassembly of *Adam*, were placed in protective plastic bags labeled with their original patio number. They were later sorted by color, shape, and tool mark characteristics to locate their position on the sculpture.

The right lower leg broke into two large fragments, one from just below the knee to the middle of the calf and one from the middle of the calf to just below the ankle. The left leg broke into five large fragments with only minor areas of loss, most notably at the top of the knee where there was an impact point with associated crushing of the marble. One of the left leg fragments was a wedge-shaped piece at the knee that was, at its widest, 5 inches (12.7 cm), tapering down to just 1½ inches (3.8 cm) on the inside of the leg. The shape and location of this fragment made it one of the most difficult to manage during reassembly of the sculpture.

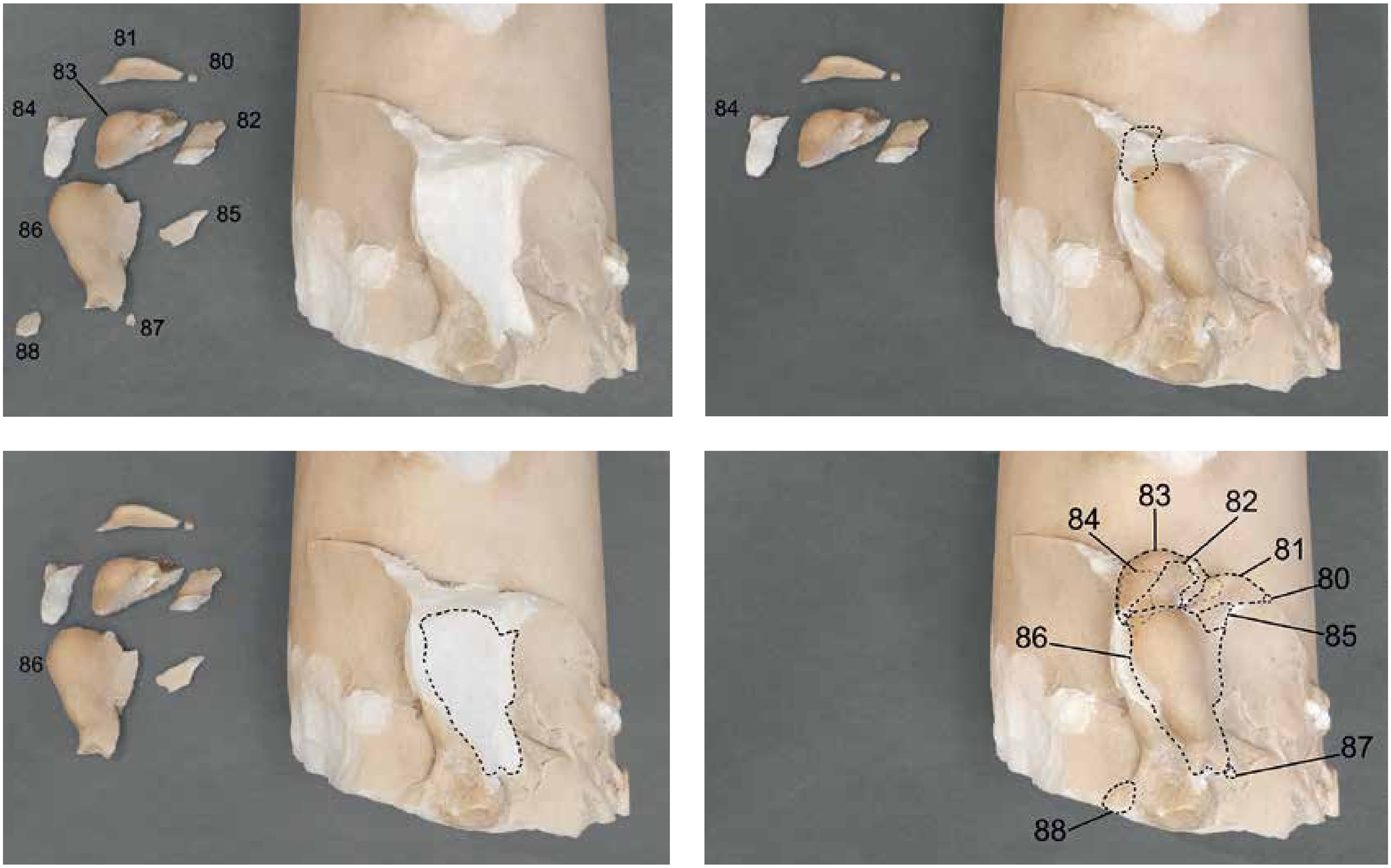
Adam's right arm was among the most seriously shattered areas, breaking into eight major fragments and dozens of minor ones, many of which were not reattachable because the damage to the forearm was substantial. Extensive loss where the arm broke away from the torso in the bicep area indicated that this was another point of impact. The right hand sustained damage from impact, shattering the little finger and adjacent palm, which broke into more than twelve pieces.

The left arm broke from the torso at a nearly vertical angle across the bicep, separating as one large fragment. The left hand broke off as one large piece. However, the upper portion of its little finger was lost to pulverization, and the rest of the digit shattered into many small fragments, eleven of which were reattached.

The head broke away from the torso at the base of the neck. The damage to the head was miraculously limited to a shallow loss along the left side of the nose as well as an impact point in the hair on the right side of the head.

Throughout the reconstruction process, we sorted hundreds of tiny fragments created by the accident, a task that continued until the sculpture was fully assembled in 2013. The initial step was to separate out internal fragments, as they were unlikely to be reused. We recognized that incorporating internal fragments would have produced misalignments on the exterior joins, while any gaps caused by their absence could be filled with an appropriate conservation-grade material. Moreover, lacking any external surface, they gave few if any clues about their original location on the sculpture. In contrast, the alignment of the external fragments was of paramount importance, and so we concentrated on locating those pieces.

The process was painstaking. Through patient examination over a period of years, we took note of the external shape, color, three-dimensional form, inclusions or veining,

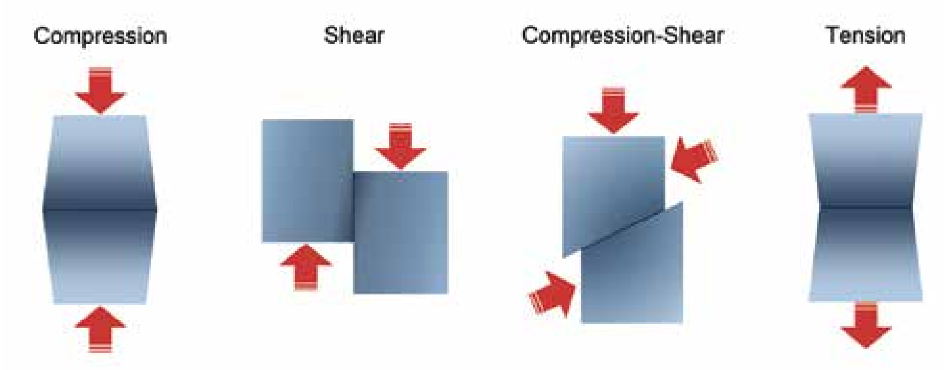


5a–d. Reassembly documentation for small fragments. As the fragments were relocated on the sculpture, their patio numbers were replaced with consecutive numbers. A sequence of annotated photographs was produced to document the location of each small fragment as well as to assist in correctly placing the fragments when it was time to attach them.

and tool marks of hundreds of fragments (Figure 4). As connecting fragments were not found in any particular order, it often took years to fill in any one area of damage with its components. The complex nature of the sculpture's breaks deterred us from adhering fragments in place as soon as we found them. We also recognized that if we joined fragments too soon, we ran the risk of locking out an adjacent fragment that might be found in the future. Although the adhesive we chose for the project is reversible with solvents, we wanted to avoid any unnecessary reversing of joins, as this action can wear on the edges of the stone, especially on tiny, delicate flakes of marble.

It became immediately clear that managing all of the individual pieces would require a custom-tailored method of record keeping and documentation. As the interlocking puzzle of particular areas was solved, the fragments were assigned new, consecutive numbers, while the original patio grid numbers were preserved in a database created for the project. Once an area of loss began to fill in sufficiently, a detailed sequence of photographs was taken and annotated to facilitate reconstruction when the time came to attach the fragments with adhesive, which in most cases was several years later (Figures 5a–d).

Understanding the nature of the forces acting upon the major fragments of the assembled sculpture was a central concern, as it would influence the choice of adhesives, the need for and locations of pins, and the design of the external treatment armature. Compressive forces exist in locations on the sculpture where a bonded fracture, or join, is perpendicular to the forces of gravity, as can be observed when books are stacked flat on a desk. In the stack, the "joins" between the books stay put. But if the books are turned upright, as on a bookshelf, the joins between the books experience shear, or a "slipping" force. Tilt the shelf off level, and the instability due to shear force is clearly evident. In several locations on *Adam*, specifically where the fractures were neither perfectly vertical nor horizontal, we recognized that the fragments would experience a combination of two primary forces, described as "compression-shear." Tensile forces, on the other hand, are those that pull away in opposing directions, as would a sculpture's arm hanging at its side. See Figure 6 for a diagram of these forces.



6. Types of structural forces present in *Adam*. Compression occurs when directly opposing forces are pushing toward one another. Shear, or sliding, forces are opposite one another but parallel to the surface acted upon. Compression-shear is a combination of the previous two forces. Tension is the opposite of compression, and occurs when opposing forces are pulling away from one another.

Many of the fractures in the tree trunk and *Adam*'s legs were essentially horizontal, and thus perpendicular to the force of gravity. When set in place, these fragments would experience compressive loading as the primary force; therefore we knew they could safely be stacked on top of one another during reassembly. Technically, however, each join in *Adam* would ultimately experience some combination of compressive, shear, and/or tensile forces, to a greater or lesser degree. In a few critical locations, the assembled fragments would be under various combinations of forces, experiencing the more unstable shear and/or tensile forces to a significantly greater degree than the rest of the sculpture. The most vulnerable of these fractures occurred at each of the ankles, where the weight of nearly the entire sculpture—that is, 85–90 percent of the sculpture's total weight of 770 pounds (349.3 kg)—rests on what is the smallest surface area.[1] Both of *Adam*'s ankles fractured at acute angles, so the break surfaces that needed joining would be dominated by a combination of shear (slipping) and compressive (pushing) forces from the weight of the sculpture resting on them. Another fracture in which the assembled fragments would be under this combination of forces was the left knee, where the wedge-shaped fragment bridged the calf and the thigh.

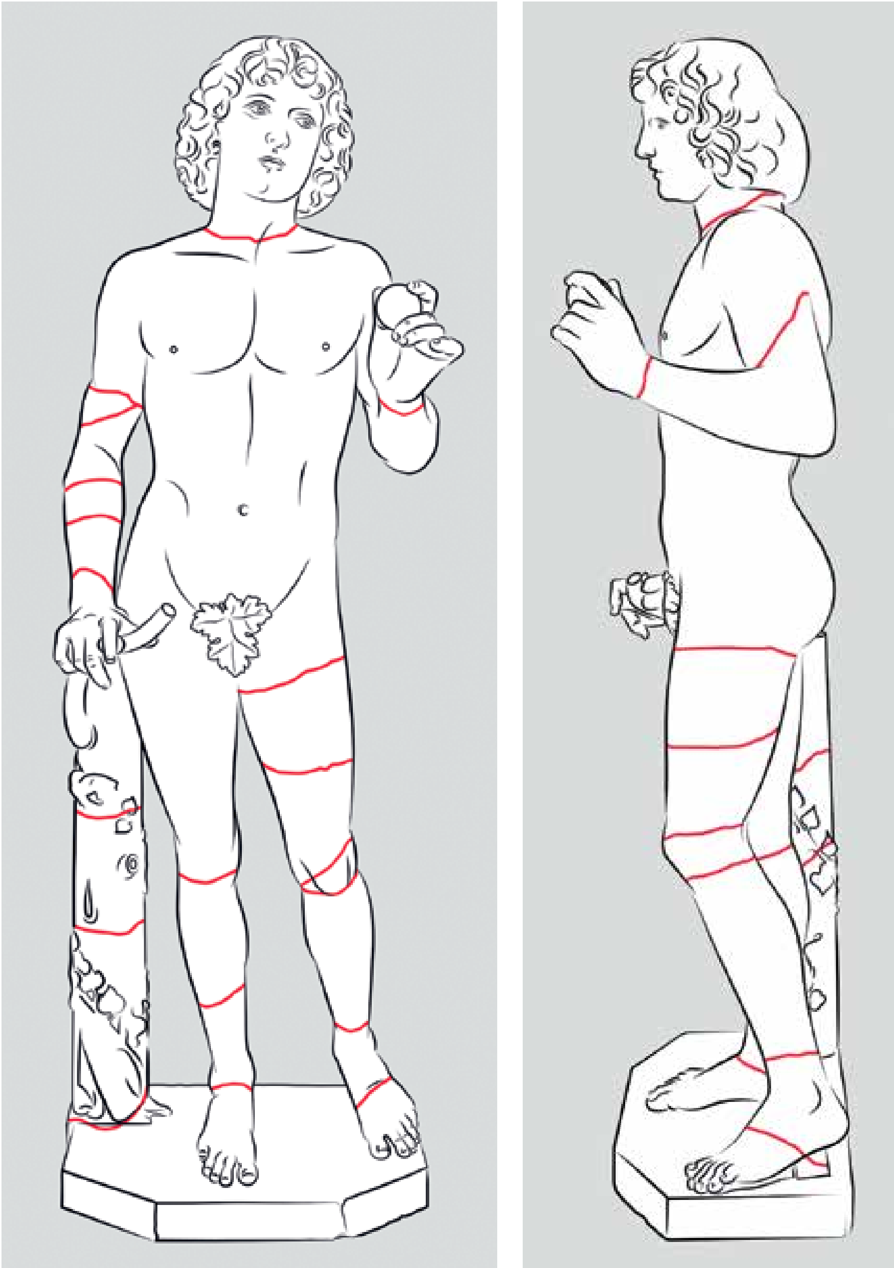
The fractures in compression-shear prompted much of the materials research directed at the choice of adhesive and application technique, and at the need for, size of, and orientation of pins. In the end, the joins in compression-shear were the only places where pins were used in the sculpture's reconstruction. Such minimal pinning marks a major break with the prevailing methods for large-scale marble sculpture conservation and was decided upon only after a thorough investigation into the forces that would be at work on the reconstructed breaks.

Fractures in the neck and the tree trunk were oriented in such a way that, once repaired, those areas would be subject mostly to compressive stress. However, both of the joins connecting the arms to the torso would be mostly in tension (pulling), with the exception of the left wrist, which has a vertically oriented fracture that would have to withstand primarily shear force. The reattachment of the right arm was to be particularly complicated because the arm connects to the torso in two places. The join at the bicep would be in tension, while that between the right hand and hip would be mostly in shear.

By studying the location and position of the breaks, we quickly understood that varied and complex forces would act on each of the joins of the major fragments. It also became clear that finding a way to connect them while applying the compressive force or clamping action required for good adhesion necessitated the development of a custom treatment armature. Finally, addressing the variety of forces present in each join needed to be balanced with an assessment of the physical and aesthetic requirements for assembling the sculpture as a whole. Our task could be accomplished only by entirely rethinking traditional methods of reassembling sculpture.

We also had to rethink the nature of the adhesives we would use in the joins. The high quality of Carrara marble that Tullio used meant that *Adam*'s clean breaks fit together tightly (Figure 7). Therefore the bond line—the space occupied by adhesive at each join—had the potential to cause

7. Joins in the upper left thigh. Where the break edges joined together very tightly, as in this thigh, preservation of the edges was of utmost importance. In this photograph, the leg fragments are supported in the external armature without the use of adhesive.



8. Diagram showing the sculpture's major fractures. Note particularly the asymmetry of the leg breaks; there are twice as many joins in the left leg as in the right. Displacement by adhesives in these joins was a concern addressed in adhesive testing. Diagram: Douglas Malicki

9. Fracture surface of the left calf fragment. This view of the interior surface illustrates the high quality of the Carrara marble, its pure white internal color, and its uniformity. The crisp break edge is in evidence, as well as past surface applications of fats that have penetrated the marble, visible as yellowing along the perimeter of the fragment.

displacement, and so it was a primary consideration in the choice of adhesives and the development of joining techniques. A particular concern was the fact that the right leg had broken into two pieces between the torso and the base, while the left leg had broken into five pieces (Figure 8). Displacement along joins in each leg would be additive, risking a misalignment at the final connections because of the unequal number of joins in the legs. For this reason, adhesive bond thickness was a key element in the materials testing and selection of potential adhesives.

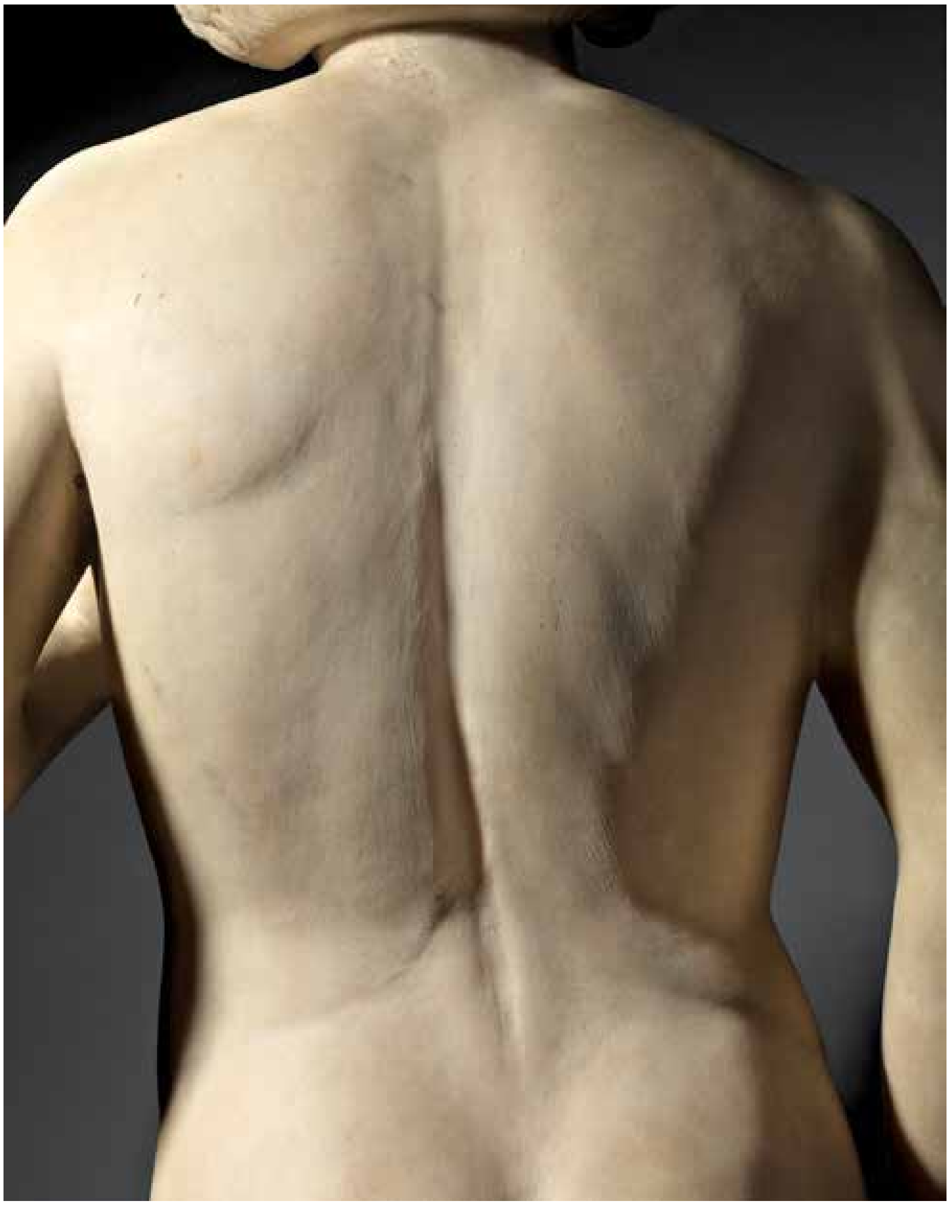
Petrographic Study and Surface Examination

In addition to studying the results of the fall, we undertook a detailed examination of the properties of Carrara marble as well as of Tullio's carving techniques to understand both sculpture and sculptor. Prior to the accident, the sculpture had sustained no fractures and virtually no loss to the carved surface in more than five centuries. The absence of original joins on *Adam* was known, and it indicated that the sculpture was carved from a single block of Carrara marble. Of the three main quarrying districts in Carrara, Italy—Colonnata, Miseglia, and Torano—a petrographic study of a sample of *Adam* suggested that the marble derived from Torano, perhaps the extraction site of Polvaccio, which has the reputation of having the marble of the highest quality, the so-called statuario marble.[2] The astonishing whiteness and homogeneity of the marble used for *Adam* was visible in the fresh breaks exposed by the fall (see Figure 9).

Adam does not retain the abundance of point or flat chisel marks characteristic of many of the figures remaining

10. Tullio Lombardo. *Adam*, ca. 1490–95. Carrara marble, H. 78¼ in. (191.8 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.163). Detail of hair after cleaning and before filling. Drill holes of varying size define *Adam*'s curls. Photographs of Figures 10, 11, 22: Peter Zeray, The Photograph Studio, MMA

11. *Adam*'s hair, left side, after cleaning. The transition from unarticulated hair at the back of the head to fully carved curls around the face is evident.



12. Detail of the back, after assembly and cleaning using raking illumination. Deep rasp marks define the upper back, spine, and lower back, revealing how the front of the sculpture appeared prior to finish. The shoulder blades are more highly finished than the lower back and have been modeled with a fine file. The rasp marks articulate the back muscles in a manner not dissimilar to the shading lines of a draftsman. Photographs of Figures 12–15, 21, 94a–d: Joseph Coscia Jr., The Photograph Studio, MMA

on Tullio's Vendramin monument (ca. 1490–95), from which the sculpture originates and which is now in Santi Giovanni e Paolo in Venice.[3] The hair is fully defined at the front of the head, with tightly wound curls. Tullio employed drills of varying sizes to define the center of each ringlet and gave further definition to the depths of the hair by drilling a sequence of small holes adjacent to one another.[4] In the most completely finished curls, the narrow "partitions" of marble between them had been removed with a tiny chisel (Figure 10). On the back of *Adam*'s head, however, there are no curls; instead, there is a very broadly defined mass of marble for the hair, resembling a snood (see Figure 13). This area has some rudimentary tool work to give the general form but none of the drill holes or blocking out that would indicate the early stages of design transfer. Moving from the back of the head toward the face, there is a transitional area where Tullio drilled holes plotting out the centers of the curls as well as some shallow arcs created with a flat chisel. These curls are superficial, but they begin to take shape as they progress toward the front, with deeper carving and more definition. At the front, a deeply incised outline separates the hair from the face, and both ears are covered by well-defined curls. It is in this sequence from back to front that the roughed-out volumes slowly progress from a flat description of curls to a fully realized form (Figure 11).

The front surfaces of the figure were never highly polished, but thin, faint lines from an abrasive stone or fine file

13. Detail of the back of the head and neck, after assembly and cleaning. The snood shape of the hair is evident as are two deep chisel marks that remain just beneath the hair.

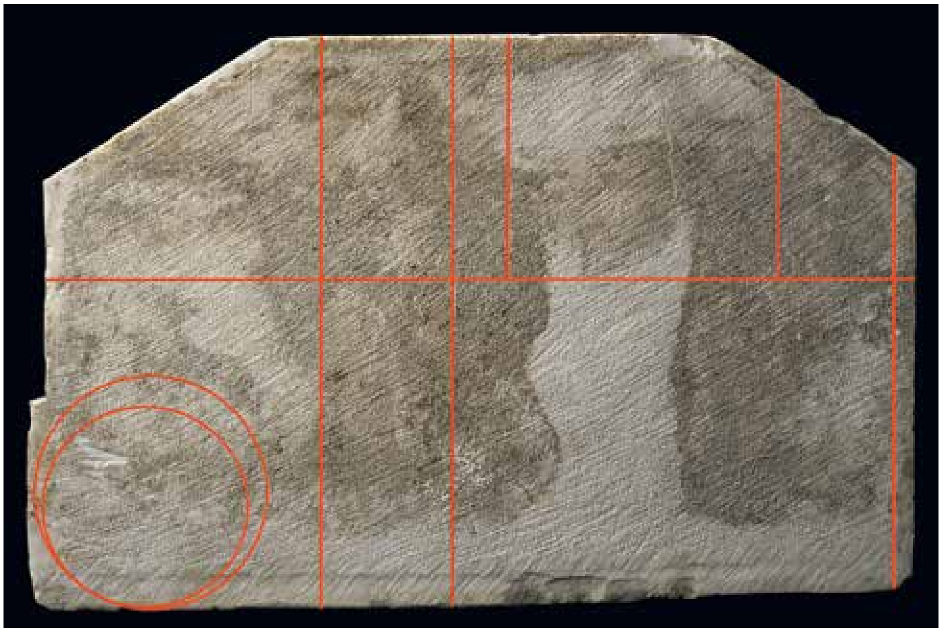
14. Detail of the left armpit, after assembly and cleaning. Between *Adam*'s left arm and torso two drill holes remain, as well as a deeply cut area that may have been a place where the early removal of the stone proceeded too far.

are in evidence. The decision not to polish may relate to the surface appearance of ancient marbles that Tullio would have studied, which would have lost any original polish they may have possessed from burial. Nonetheless, the transition between sculptural forms on this part of *Adam* is so well and so convincingly integrated that it is difficult to see the evidence of earlier carving or rasp work. Denoting the sculpture's intended location within a niche, the back is not as highly finished or as completely articulated as the front, and it is therefore in these dorsal areas that Tullio's carving method becomes more apparent. Deep rasp marks define the upper back, spine, and lower back to the buttocks, and these marks must surely reflect how the front of the sculpture appeared before being taken to its final level of finish (Figure 12). Rasp marks articulate the back muscles in a manner not dissimilar to the shading lines used by draftsmen to indicate shadow and light.

Several chisel marks at the back of the neck remain, just beneath the hair, indicating that earlier in his carving process Tullio used chisels to model larger, broader areas (Figure 13). He followed this chisel work by employing a series of rasps, ranging from coarse to fine, to delineate the muscles. The shoulder blades are more highly finished and protrude from the back, shaped with a very fine rasp that has left faint lines. The deeper recesses of the spine and muscular lower back retain marks of a coarser rasp. Between *Adam*'s left arm and torso two drill holes remain, as well as a deeply cut area that may be evidence that in the initial stages too much marble was removed (Figure 14). Most parts of the hands are carved in great detail, yet some parts remain undescribed. For example, the thumbs, which are mainly hidden from view, have not been articulated to the same degree as the rest of the fingers. They lack thumbnails and are taken no further than summarily formed silhouettes, demonstrating Tullio's economy in carving the less visible areas of the sculpture.

The upper surface of the base displays irregularities in the carving that may simply be unfinished or may represent an attempt at verisimilitude. For example, the tree trunk is finely articulated, but a raised area of point chisel work is clearly defined at its base (Figure 15). Does this area signal lack of completion, or could it be a simulation of a natural form, perhaps moss? It is worth noting that the same point chisel work is found in the hollows of the tree trunk where moss might also logically be located.

15. Detail of the base of the tree trunk, after reassembly and cleaning. At the base of the trunk is a raised area of point chisel work. Directly in front of the tree trunk, an ambiguous square-shaped tooled area sits slightly proud of the surface.



16a,b. Tool marks on the underside of *Adam*'s integral base. Top: RTI capture in the coefficient unsharp mask rendering mode. Bottom: the same RTI capture with the incised lines highlighted in red. RTI: Winifred Murray and Carolyn Riccardelli

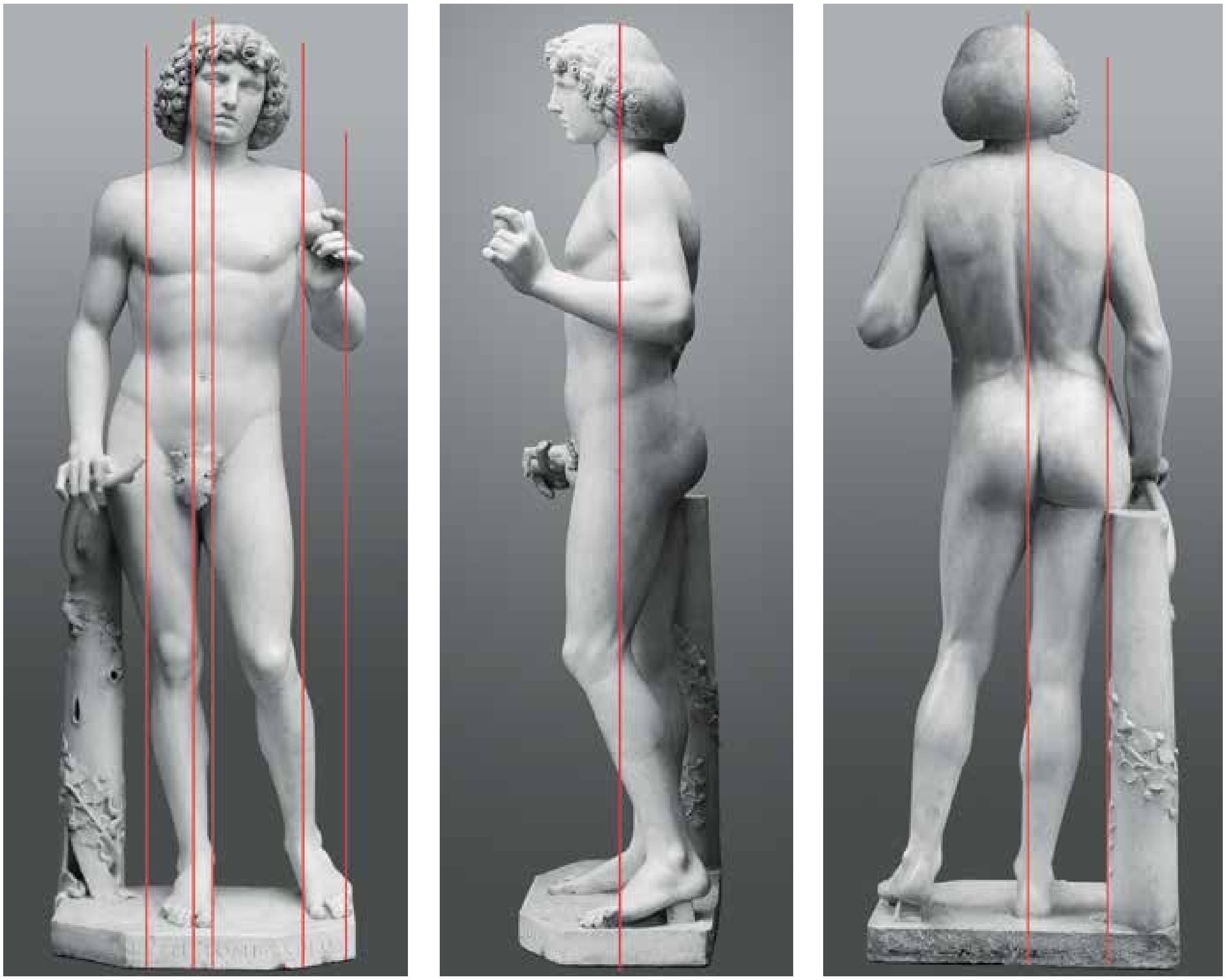
Directly in front of the tree trunk, a faint, square-shaped tooled area is raised slightly above the surface (see Figure 15). It most likely reflects a late change of mind on the part of the sculptor, but a change from what? For structural reasons, and based on tool marks found on the underside of the base, it does not seem to indicate a first placement of the supporting tree trunk, but it might be the remains of an extension of the "moss" that appears at the base of the trunk. Also on the upper surface of the integral base, flat planes carved at varied levels, particularly in the area between the feet, may simulate stone paving or rocks that *Adam* stands on, as has been suggested.[5] These planes or stonelike features were carved with a flat chisel.

Marks from the point chisel and a remnant of flat chisel work are found under the arch of *Adam*'s left foot. The surfaces of the feet, with curiously low arches, are carefully finished using fine abrasive stones or files. There is a suggestion of *Adam*'s weight being pressed down on the right foot, as the big toe widens and flattens. Between the first and second toes of both feet are small, raised remnants of unfinished stone.

The underside of the sculpture's integral base—not easily accessible and therefore previously unstudied—is covered with intersecting tool marks that are difficult to read or record in normal light. To capture them digitally for further study of the subtle variations in surface texture, we used an examination technique called reflectance transformation imaging (RTI).[6] With the RTI capture, it was possible to enhance digitally the tool marks, helping us to confirm that the underside of the base was part of the exterior surface of the original dressed block of marble (Figures 16a,b). Perfectly straight lines were cut with a point chisel at right angles to each other across the surface, indicating the center of the block; it is possible that these lines were intended to demarcate the sculpture's proportions. Two circles, offset from one another, inscribed in the lower left corner denote the diameter and location of the tree trunk. The surface also features a faint, grooved pattern along the edges made with a thin, curved chisel, or roundel. These grooves are the intended perimeter lines for the bottom of the base as laid out on the quarried block. Once those lines were established, the central section of the bottom of the block could be carved into plane. This phase was accomplished with a toothed chisel, which prepared the flat surface under the sculpture.

The rear face of the plinth—the area that would be situated against the back of the niche—is also unfinished and thus may be a remnant of the original block. This surface was flattened with a tooth chisel and is marked with two vertical incised lines, one of which connects at a right angle to one of the lines on the underside of the base. These incised lines (both on the underside and on the back of the base), if projected up the height of the figure, correspond to its center of gravity, and they apparently indicate the position of the hands, which are also the outermost reaches of the sculpture (Figures 17a–c). Visualizing the shape of the block of marble in this way allowed us to deduce the care with which the sculpture had been laid out on the exterior, which was almost certainly marked with many other incised lines and marks.

Tool marks on the top of *Adam*'s head seem to correspond to the toothed chisel marks on the underside of the base. Viewed with raking illumination, these marks are visible within a flattened square area (Figure 18). There are also intersecting lines within this tooled square that appear



17a–c. Diagrams showing vertical extensions of the lines on the underside of the base. Those lines as well as others may have been incised on the marble block before it was carved.

to define the center of the block and are analogous to those found on the underside of the base. It is therefore likely that these lines, made like those under the base on the surface of the dressed block, were maintained by the artist as points of reference throughout the entire carving process. That this center mark remains in place suggests that Tullio carved his figure with the minimum of marble wastage, fitting *Adam* very precisely within the original block. Such economy is achievable only through careful planning.

We also sought to determine whether the marble had ever received any applied decoration. It is known, for example, that the tree trunk and sling in Michelangelo's (1475–1564) *David* were gilded, as was a garland that was made for the statue but may never have adorned it.[7] Similarly, the architectural decoration of Desiderio da Settignano's (ca. 1429–1464) mid-fifteenth-century marble tomb of Carlo Marsuppini in the Basilica of Santa Croce, Florence, was polychromed, and its figures were at least partially gilded.[8] During a recent examination of the

18. Top of *Adam*'s head, photographed with raking illumination. There is a small square of tool marks identical to ones found on the underside of the base. It is possible that these tool marks are the remains of the top of the original dressed block.

19. Vendramin monument, coffered arch. This area, with the kneeling doge, shows gilded decoration. Blue paint is found in the background of the rosettes in the coffers. Photographs of Figures 19, 20: Anne Markham Schulz and Mauro Magliani, 2012

20. Vendramin monument, tondo with Christ Child showing gilded decoration

21. Traces of azurite pigment in the hollows of *Adam*'s tree trunk

22. *Adam*'s left hand. Traces of clay minerals remain on the fruit between the index and middle fingers, which may indicate the presence of a bole used for gilding.

19

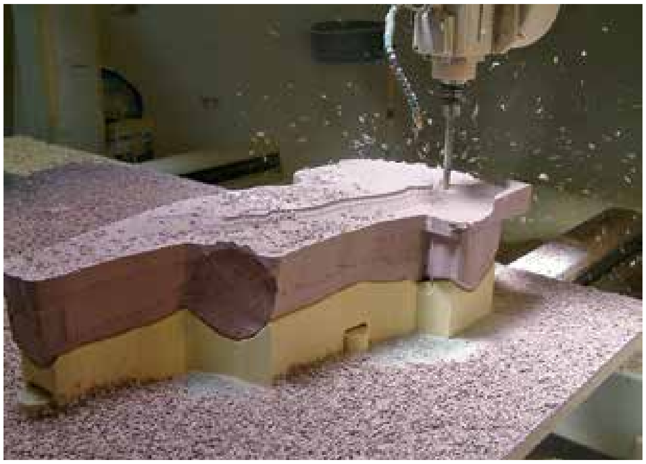
21

20

22

Vendramin monument, we observed blue paint and gilding on the coffered arch above the kneeling figures of the doge and a youth, although it is possible that these were added or renewed later (Figure 19).[9] On the uppermost register of the monument, the gilding appears to be original on the hair, wings, and tails of the sirens and on the tondo containing the Christ Child (Figure 20).

Traces of similar bluish-green paint were found in the hollows of the tree trunk supporting *Adam* (Figure 21). An analysis of the pigment showed it to be azurite.[10] While no gilding is discernible to the naked eye, traces of a reddish-brown material consistent with bole, a preparation for gilding, were found on the fruit held in *Adam*'s left hand (Figure 22),[11] an indication that it was probably highlighted in gold. Significantly, the Christ Child in the tondo at the top of the Vendramin monument holds a gilded orb in a pose that is similar to *Adam*'s, creating a symbolic link between the two figures.



23a,b. Full-scale model of *Adam*'s torso being fabricated in dense polyurethane foam by a computer numerically controlled (CNC) milling machine. This model was used as a mock-up to design the external armature as well as to formulate and rehearse assembly methods. Photographs: Ronald Street

RESEARCH

A guiding principle for the engineering studies and materials testing supporting *Adam*'s conservation was to explore, and indeed challenge, traditional methods for stone sculpture reconstruction. Surprisingly, in making a critical assessment of existing practices, we found few fundamental studies evaluating the properties and performances of adhesives and pinning materials that related to our project. Our general goals, consistent with established principles of conservation theory and practice, were *minimal intervention* and *reversibility*: do only what is necessary and make sure what you do can be undone. Specifically, we wanted to select methods and materials that would allow us to achieve these goals in light of a full understanding of the sculpture as a material and a structural entity.

The sections that follow describe the arc of our research, which was to move from theory to practice, from what is most desirable to what is doable. Going from desirable to doable required that we: (1) achieve a full material and structural understanding of the sculpture; (2) test the specific materials and methods; and (3) evaluate the feasibility and advisability of implementing the outcomes from parts 1 and 2. Accordingly, our team collaborated with imaging specialists, mechanical engineers, material scientists, and conservation scientists throughout our research, but when moving from desirable to doable, we all recognized that the conservators who would perform the treatment would ultimately have responsibility for the reconstruction of the sculpture. Thus the research phase of our project also included empirical research, carried out by the conservators as an application of findings from engineering studies and materials research to the condition of the broken sculpture and the conditions under which it would be reassembled.

For part 1, scanning and imaging specialists along with mechanical engineers used laser scans of the fragments to create virtual models that could be subjected to structural analysis in order to locate, characterize, and quantify existing forces acting throughout the sculpture.[12] For part 2, material scientists provided the guidance to design and interpret experiments to determine the specific properties of adhesives and pinning materials. As described in detail below, we were particularly interested in the strengths of both thermoplastic (reversible) and thermosetting (nonreversible) adhesives, their stability over time (tendency to creep), and displacement of joins (bond-line thickness). For pinning materials, we had concerns from the beginning of the project that the commonly used stainless steel pins were much too stiff to be used for reconstructing Carrara marble. Experiments were designed to test a wide range of pinning materials for their stiffness and modes of failure.

For part 3, to test the results of parts 1 and 2, we used stone specimens designed to mimic the critical joins in the sculpture. These tests provided valuable information not necessarily evident from the earlier testing programs, especially regarding the degree to which drilling pinholes weakens the marble surrounding the join and the need to provide adequate pressure on the join to minimize the bond line. This information was critical for deciding whether pinning should be employed at any join.

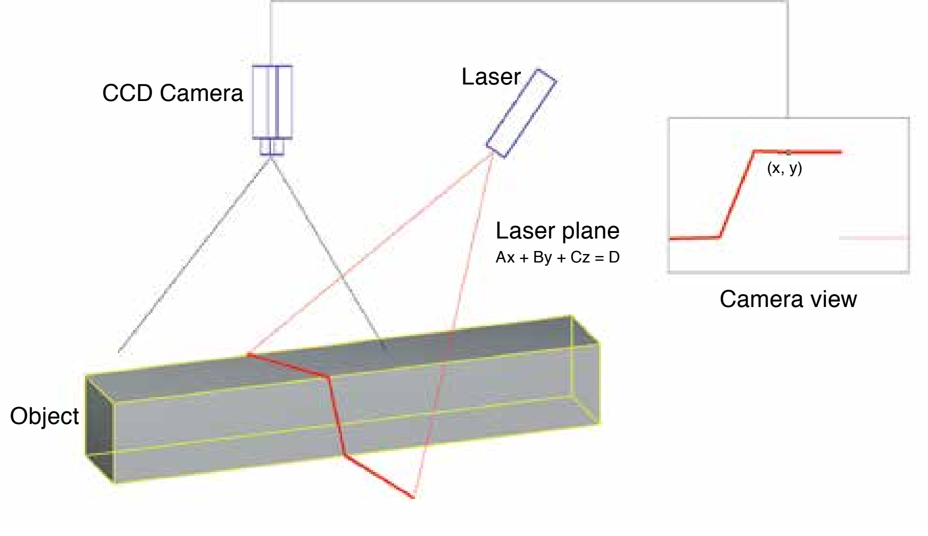
The research that went into planning the reconstruction of *Adam* was long, intensive, and complex because it involved several disciplines. Like many projects—not just conservation projects—this one progressed from thinking about what to do to actual implementation, from a hands-off approach to a hands-on approach, and from virtual reality to material reality.

Engineering Studies

As an early step in preparation for conservation treatment, the Museum undertook a complete three-dimensional (3D) laser scanning of the major fragments. Among other uses,

24. One-fifth-scale epoxy model of *Adam* created from laser scans and 3D printing. The 16-inch (40.6 cm) tall model was easily held in the hand. Model: Ronald Street

25. Diagram showing principles of laser triangulation system. A laser projects a line of light onto the object; the camera sensor detects the shape of the reflected laser light; and 3D point positions are computed by intersecting the line through the sensor pixel location with the known plane of laser light. Diagrams of Figures 25; 28; 31; 56; 60a,b; and 63: Ronald Street



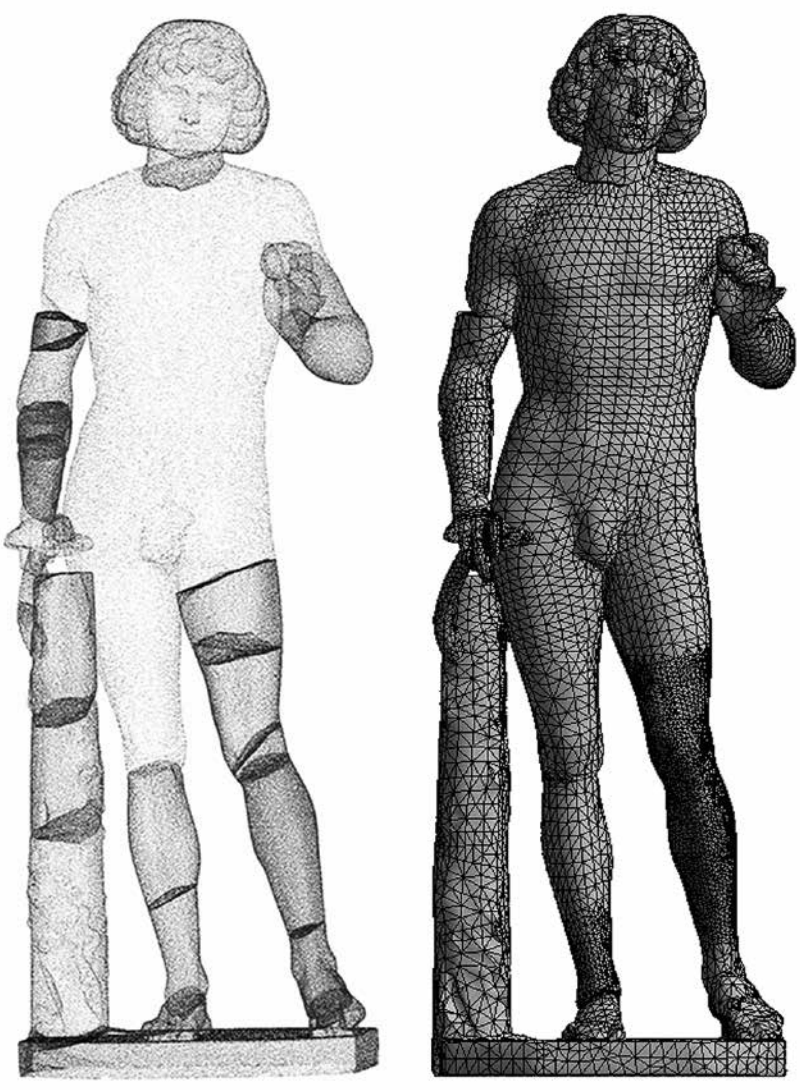
the scanning and the resulting data allowed the team to use computer programs to reconstruct what had become an unwieldy collection of fragments. From this 3D virtual model,[13] several avenues of research could be pursued, the results of which could contribute to decisions about the nature of interventions to be carried out. Not only could a range of computer-based visualizations be performed, but the laser-scan data also made it possible to produce full-scale physical models of each of the major fragments milled out of dense polyurethane foam (Figures 23a,b).[14] In addition, we were able to create a one-fifth-scale epoxy model of the assembled sculpture that could be easily handled and consulted throughout the treatment (Figure 24).[15] These models proved invaluable in planning conservation treatments.

Finally, and perhaps most critically, the virtual models could be used to perform a type of structural analysis known as finite element analysis (FEA), a technique involving computational evaluation and analysis of the responses of materials and structures to applied loads. Our goal for the FEA was to determine the nature and estimate the magnitude of the loads carried across the fracture surfaces in the sculpture. This information would help determine the adhesive strength required for each join and help clarify whether pins would be necessary to stabilize them further.

3D Laser Scanning

Laser scanning is the process of directing a structured laser line over the surface of an object. The surface data are captured by a camera sensor mounted in the laser scanner, which records and positions points in a 3D space (Figures 25, 26a). Three-dimensional imaging of sculpture was initially developed in the 1980s as a form of digital photogrammetry.[16] As recently as 2000, accurate and cost-effective 3D imaging methods were limited; thus it was not easy to record accurate geometric measurements of large objects with a high degree of morphological complexity.[17] In the early 2000s, 3D scanning methods began to be used for problem-solving in art conservation.[18] In recent years, portable sensors and efficient algorithms have been developed, complemented by increased computational power. These advances now permit cost-effective, accurate measurements and high-resolution documentation of objects.[19] However, even taking into consideration recent advances in imaging technology, accurate 3D digital documentation of large, complex objects is far from a simple matter.

A high-speed portable laser-scanning system was used to scan each major fragment of *Adam* from different views. Overlapping scans ensured complete capture of the form and aided in the alignment of the scans.[20] Once the major fragments were digitally rendered, they were then aligned to adjoining fragments using software algorithms and



26a,b. Virtual models originating from the 3D laser scans and finite element analysis. Left: results of laser scanning in the form of a "point cloud." Right: finite element model showing mesh distribution. The density of the mesh in the left leg has been increased in preparation for submodeling pins in the knee. Models: Ronald Street

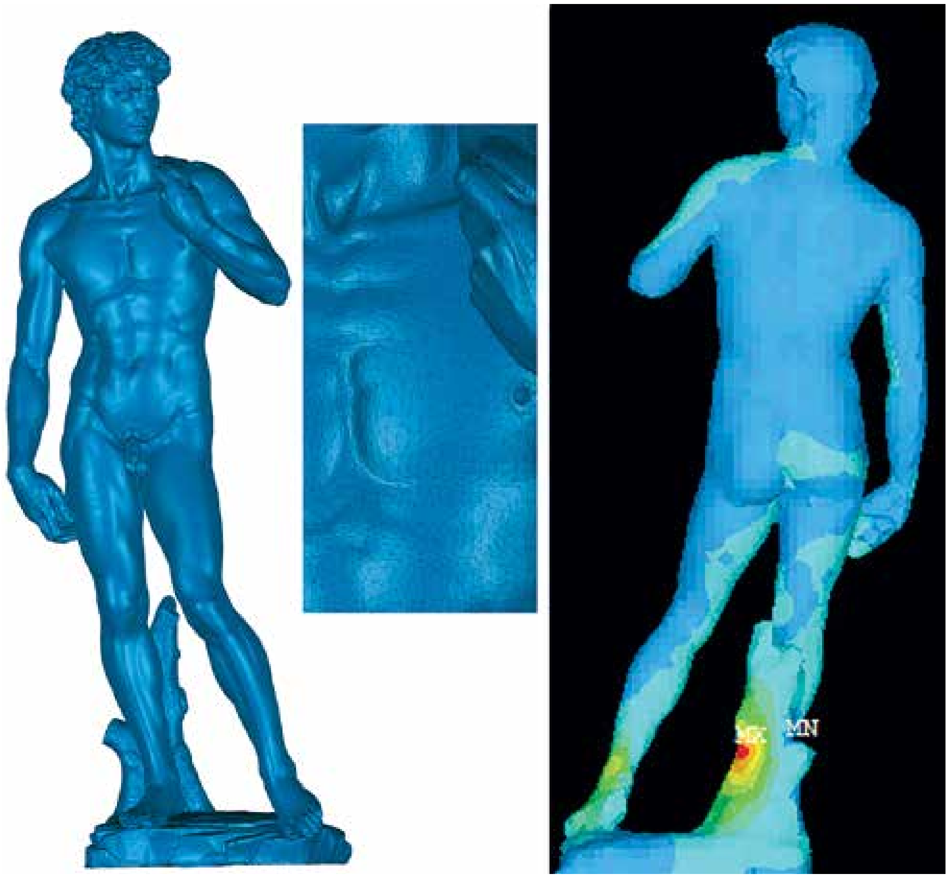
manual adjustments, creating a fully assembled sculpture in 3D virtual space.[21]

Finite Element Analysis

Finite element analysis is a technique used in the engineering field to determine the distribution of deflections, stresses, and strains in a structure—factors that define structural integrity. Finite element modeling is a computer simulation procedure that uses 3D computer-aided design (CAD) geometry, which is broken up into hundreds of thousands of small pieces, called finite elements. Each individual finite element is connected to its neighbors in a "mesh" that makes it possible for the program to determine the distribution of force through the entire structure. The finite element method also calculates the deformation of each of the elements, which is used to calculate the resulting strain and stress in the structure due to the externally applied forces (see Figure 26b).[22]

Using the 3D models derived from the laser scans of the major fragments of *Adam*, an initial finite element model was constructed of the assembled sculpture. The team hoped to use the model to derive both a *qualitative* description of the forces transmitted across the fracture surfaces (described as compressive, shear, and tensile forces) and a *quantification* of the stresses that would be present in the entire sculpture.

Scholarly literature existing at the time we scanned *Adam* offered few references relating to the application of finite element analysis to art conservation. The only published work on the use of this technique in sculpture conservation relied entirely on hand-calculations and described a more generalized method in which discrete areas of a sculpture were modeled.[23] We recognized that manual finite element computations would prove unworkable when applied to the complexities of our fragmented sculpture.



27a–c. Digital model of Michelangelo's *David*. Left: laser-scanned polygon model. Center: detail of the polygon mesh. Right: proof of concept study showing overall stresses. Digital model: Marc Levoy; FEA model: Ronald Street

Lacking prior examples of scanned and digitally reassembled sculptures of *Adam*'s complexity, we undertook a proof of concept study that utilized a dataset taken from a digital model of Michelangelo's *David* to determine whether the laser-scanned data could be organized for finite element study (Figure 27a–c).[24] Indeed, this study proved that individually scanned fragments could be assembled into a virtual model that could then be used to perform finite element analysis. Additionally, the proof of concept study provided a foundation for understanding the complexities of such an operation.

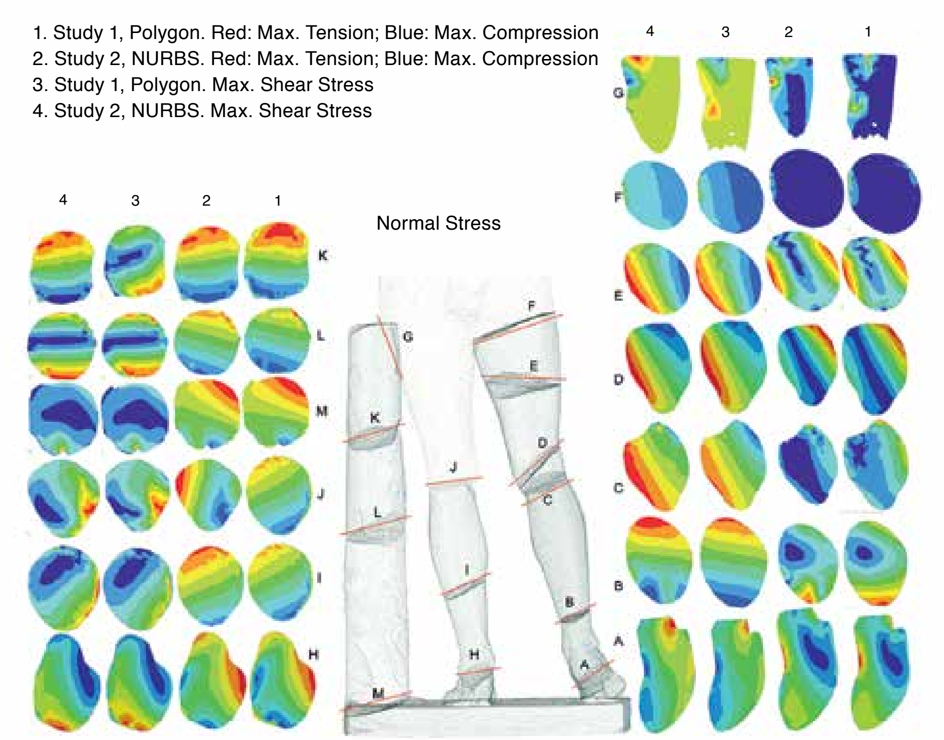
Once we knew we could use the virtual model of *Adam* to perform an engineering analysis of the damaged sculpture, the Museum partnered with Computer Aided Engineering Associates, Inc. (CAE Associates), of Middlebury, Connecticut, to locate and calculate the compressive, shear, and tensile forces transmitted across the fracture surfaces.[25] To get more detailed results, the material characteristics of marble were applied to the model. Because the effectiveness of FEA from a virtual model assembled from individual fragments had never been tested, the analysis was carried out in three phases to determine which type of model would produce the most accurate results.

Study 1: Faceted Model

Study 1 utilized data directly from the laser-scanning process, which produced data in the form of stereolithography (STL) files.[26] This computer file format approximates 3D surfaces with triangular facets, resulting in a series of planes that create a jagged surface when representing curved forms. The analytical model does not represent the true curvature of the original surface and can lead to errors where contact forces and stresses are calculated, such as in the joins of the damaged sculpture.

For Study 1, all the fragments were assembled and virtually bonded together. This approach essentially "healed" the fractures in the sculpture, allowing the maximum load to be distributed throughout the sculpture. Then, to obtain the most accurate numbers from the FEA, predefined material characteristics of Carrara marble, such as density and stiffness (also called "elastic modulus"), were entered into the calculations.[27]

After the FEA model was completed, it was possible to look at a graphical representation of the magnitude and



28. Graphical representation of the results from finite element Studies 1 and 2. Stress plots are represented in columns 1, 2, 3, and 4. The colored bands represent degrees of stress. The plots, or slices, in columns 1 and 2 illustrate compressive (represented by blue and green) and tensile (represented by orange and red) stresses. Columns 3 and 4 illustrate shear forces: here red areas indicate maximum shear stress, decreasing down to blue, which represents the minimum for the slice.

nature of the forces at the location of each break in the sculpture. These FEA diagrams, or "stress plots," illustrate compressive, shear, and tensile loads with their magnitudes represented as colored bands across each fracture. Stress plots are essentially slices taken through the model to allow detailed examination of the forces acting on that cross section. Because the joins were bonded in the Study 1 model, virtual slices were taken just above or below the actual fracture locations as a way to determine approximate forces on each break. The results for Study 1 are graphically represented in columns 1 and 3 of Figure 28. The information gained from these stress plots helped us quantify the forces present in the damaged sculpture and was used to plan adhesive and pinning research.

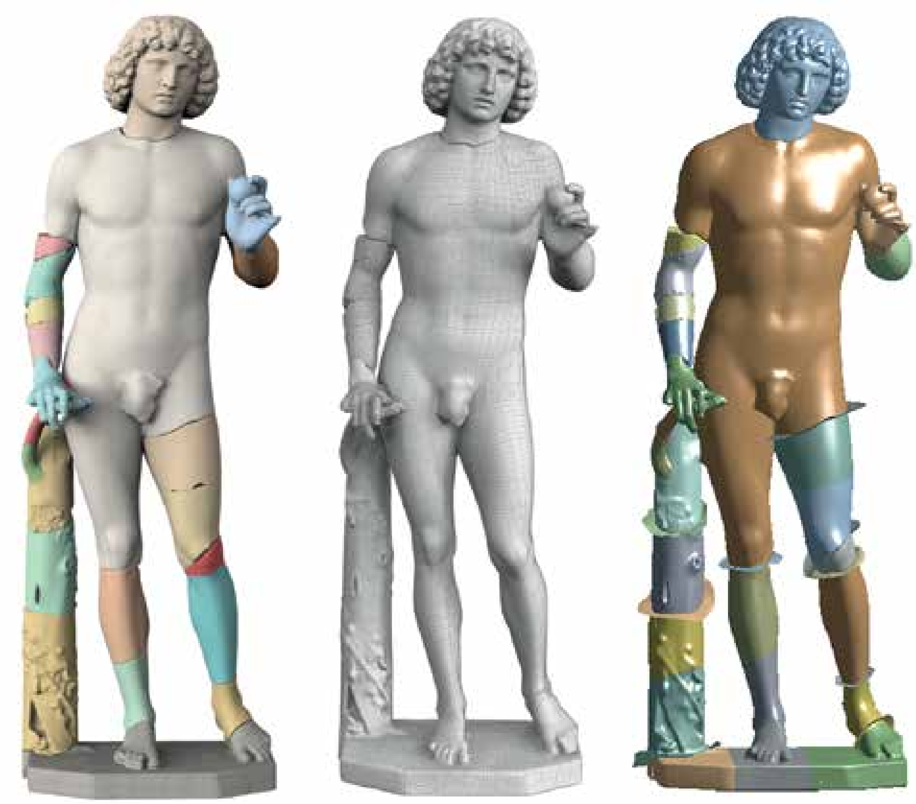
Study 1 also allowed us to look at how the overall sculpture reacts to gravitational force (Figures 29a,b). This portion of the study showed us that the sculpture has a slight tendency to lean forward and twist about its vertical axis. The twisting is such that the left shoulder rotates toward the right shoulder in a clockwise fashion. The fact that the sculpture twists indicates that the legs experience a slight twisting or shearing deformation under gravity's influence. This study provides some insight into the sculptor's challenges when designing and carving a figure in contrapposto. Considering the tendency of a figure in this position to twist and lean, as well as the vast open spaces between the legs and the right leg and the tree trunk, one must marvel at Tullio's masterful achievement in finding the balance between aesthetic concerns and structural necessities.

29a,b. Results of Study 1. Left: finite element model showing overall forces. Right: finite element model showing an exaggeration of the natural clockwise twist present in the sculpture. FEA models of Figures 29, 30: Ronald Street and CAE Associates

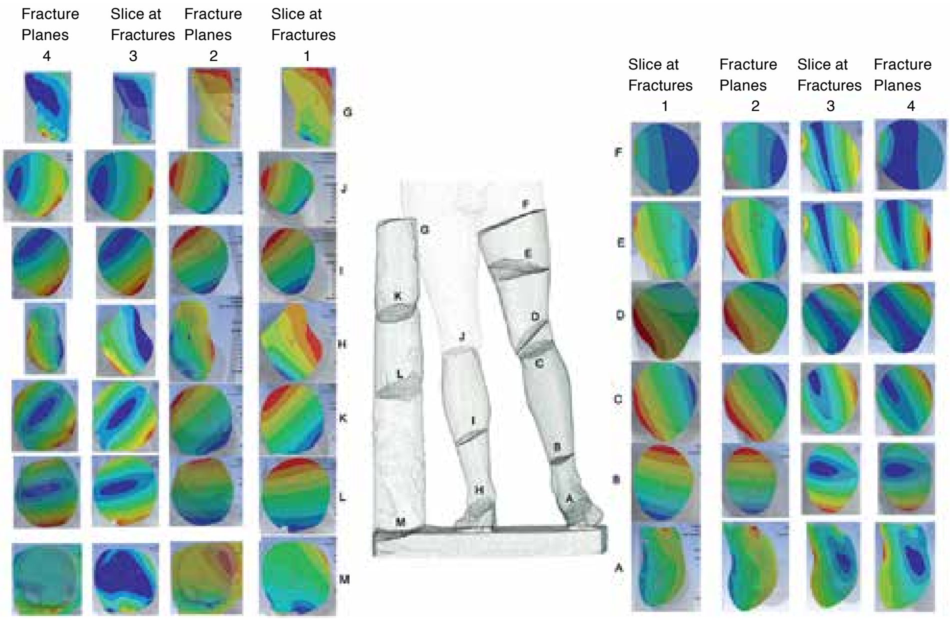
Study 2: Smooth Model

In addition to estimating forces, we also hoped to use the engineering study to develop a model that could be employed to examine the need for pins, their sizes, locations, orientations, and the methods of their insertion. This kind of modeling is not possible with the faceted model created in Study 1, and so a smooth model, or nonuniform rational basis spline (NURBS)–based model, was produced.[28] This format creates a model with smooth surfaces that can more accurately represent curved forms, allowing for subsequent finite element models that can focus in on specific areas of interest (Figure 30a).

The resulting smooth NURBS model represented the sculpture in reassembled condition and was analyzed using



30a–c. Results of Studies 2 and 3. Left: from Study 2, an assembled virtual model in the smooth NURBS format. Center: from Study 3, a continuous NURBS model with bonded contacts. Right: from Study 3, the hybrid model showing imported surfaces from one side of the fracture interface generated from the fragment boundaries of the laser-scanned model, which was utilized to represent fracture surfaces. The imported surfaces look like ruffles extending from the legs.



31. Graphical representation of the results from finite element Study 3. Stress plots are represented in columns 1, 2, 3, and 4. The colored bands represent degrees of stress. The plots, or slices, in columns 1 and 2 illustrate compressive (represented by blue and green) and tensile (represented by orange and red) stresses. Columns 3 and 4 illustrate shear stresses: here red areas indicate maximum shear stress, decreasing down to blue, which represents the minimum for the slice.

the same Carrara marble characteristics as in Study 1.[29] As in the previous study, compressive, shear, and tensile loads across the fracture surfaces were obtained by making virtual slices through the model parallel to and vertically offset from the fracture surfaces. The results of Study 2 agreed well with those calculated in Study 1, indicating that the more functional NURBS format could be used as we began to look more closely at critical sections of the sculpture, in particular the left knee (see Figure 28, columns 2 and 4, for a graphical representation).

Study 3: Hybrid Model

Several years after Studies 1 and 2 were completed, a hybrid model study was organized at the request of the conservators, who had begun their treatment of the sculpture and were formulating pinning concepts that they wished to model. In preparation for modeling these pinning scenarios, CAE Associates performed a comparison of the section stresses from the original analysis (Studies 1 and 2) with an updated NURBS model.[30] In Study 2, the breaks in the legs had been virtually bonded, but the shape of the breaks remained intact within the model. In Study 3, the fracture surfaces in the legs were removed and replaced by one continuous surface (see Figure 30b).[31]

A benefit of the new continuous (unbroken) NURBS model was that it permitted a more accurate examination of stress in fracture locations. Next, an innovative method was devised to isolate the rough shape of the broken surfaces in the faceted (STL) model and import them into the smooth, continuous (NURBS) model (see Figure 30c).[32] This clever approach allowed us to take advantage of the benefits of each type of model, combining them to give a more accurate result. Study 3 confirmed that there were only minor differences among stress plot results of all the analytical studies performed. The results of Study 3 are graphically represented in Figure 31. Once this hybrid model was prepared, the analysis continued by exploring various pinning scenarios in the left knee. The results of this focused pinning modeling are discussed in "Pin Testing," pp. 70–74.

Results of Studies 1, 2, and 3

The overall trends in the forces acting on each join were found to be consistent in the three analyses. By comparing results of the faceted STL, fractured NURBS-based, and continuous NURBS-based models, we determined that the best representation of the forces on each fracture was achieved by creating a hybrid model that could reproduce the fracture surfaces with complete accuracy. The compressive, shear, and tensile forces on each join in the sculpture, as well as the overall stresses in the sculpture, were successfully calculated. The maximum compressive stress occurring in the sculpture is at the base of the left calf fragment toward the front: 134 pounds per square inch (psi) (0.924 MPa). The maximum tensile stress, 76 psi (0.524 MPa), occurs at the back of this same fracture. Finally, the maximum shear stress on the sculpture, 84 psi (0.579 MPa), occurs at the connection between the hip and the torso. The values reported here were used as the foundation around which we designed and interpreted the extensive materials research that followed this structural analysis.

Materials Research

Rods and cramps of lead, copper, iron, and alloys of the latter two metals, anchored with plaster, lead, or natural resins, have been routinely used to attach large fragments of stone sculpture. Current practice favors stainless steel and titanium because of their resistance to corrosion and their thermal expansion coefficients, which are similar to those of the stone. Even with the advent in the twentieth century of structural adhesives, such as epoxy and polyester resins, pinning has remained standard practice. Implicit in this approach is the widespread acceptance that the stabilization imparted by a pin more than compensates for any weakness in the stone created by drilling the holes to insert it. But there are disadvantages. In addition to the effect of removing stone, there is a potential for further damage owing to the fact that steel pins used in combination with epoxy and polyester adhesives are actually much stronger than is required to sustain the loads present in most marble sculptures. So if increased stress is applied later to these joins, failure will occur not at the join line but in the surrounding marble, causing considerably more damage than the original fracture that the pin was intended to repair. Another disadvantage of these traditional stone repair techniques is that they are difficult or practically impossible to reverse without harming the original material. Wishing to take a new approach to the treatment of *Adam* that would help ensure our goal of reversibility, the Tullio team undertook several campaigns of materials testing that covered all aspects of the treatment being considered, from assembly and adhesives to drilling and pinning materials and methods.

Adhesives Testing

Materials testing commenced with an investigation to determine the best adhesive for reconstructing *Adam*. The goals of the adhesive testing were: (1) to evaluate the adhesive's strength and stability; (2) to determine the degree of displacement caused by the adhesive system; and (3) to test reversibility. The materials chosen for the testing came from two general classes of adhesives: thermosetting and thermoplastic resins.

Thermosetting adhesives, which include structural adhesives such as polyester and epoxy resins, cure via a chemical reaction that takes place over a finite period of time; once that reaction has occurred, the molecules are chemically cross-linked and they become insoluble. Hence, thermosetting adhesives are not considered reversible.

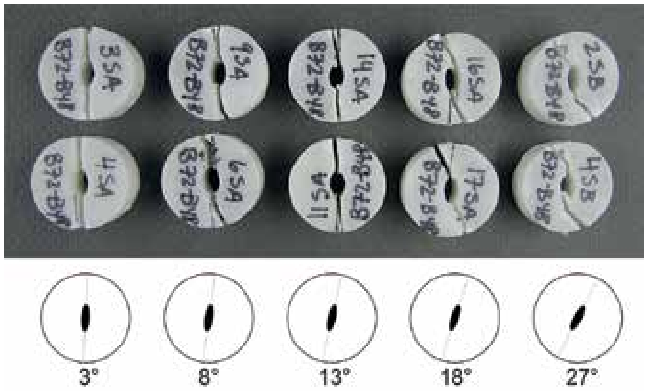
Thermoplastic adhesives, on the other hand, include all resins that can be dissolved in organic solvents, such as the acrylic resin-solvent mixtures used in this testing program. They set by the formation of films via solvent evaporation. A drawback of thermoplastics is that solvent evaporation often occurs slowly and is governed by the physical circumstances of its application, such as porosity of the substrate. The result is that residual solvent is retained over an indefinite period of time and, in theory, could have a plasticizing effect on the adhesive. Moreover, for our project, the broad and closely fitting joins in *Adam,* combined with the density of the marble, meant that there would be only small losses at the edge of joins through which solvent could freely evaporate. Nonetheless, the primary benefit of using a thermoplastic adhesive is that the resin remains soluble in organic solvents, making the adhesive and join reversible.

The Tullio team was therefore particularly interested in thermoplastic adhesives, and specifically in the acrylic resin adhesives Paraloids B-72 and B-48N because of their chemical stability and reversibility.[33] Although considerable research has been carried out on the use of B-72 as a consolidant or coating, little has been published on its adhesive properties.[34] Given the tight joins and unequal number of breaks in the sculpture's legs, displacement—the amount of space occupied by an adhesive within a join—was a critical issue. Any significant displacement caused by adhesive would result in uneven lengths of the legs, making it impossible to align the legs and torso properly. Thus measuring the thickness of the adhesive after setting—the bond line—was an integral part of the testing. To ensure that the test conditions matched those of the proposed treatment as closely as possible, Carrara and Vermont marble, with properties roughly similar to those of the marble of *Adam*, were chosen as the stone substrates for the tests.

Conservator Stephen Koob's 1986 article in *Studies in Conservation* was the first significant publication to advocate the use of acrylic resins as adhesives in conservation, and his instructions for preparing B-72 solutions have become standard in the profession.[35] More significant for the Tullio project was an adhesives study carried out jointly by the J. Paul Getty Museum, Los Angeles, California, and the Nelson-Atkins Museum of Art, Kansas City, Missouri. This research investigated the tensile and shear strength of adhesives, and the article Jerry Podany and his coauthors published in 2001 in the *Journal of the American Institute for Conservation* (*JAIC*) concluded that the practice of making epoxy resin joins reversible by applying a layer of B-72 between the marble and epoxy resin did not weaken the join.[36]

Thus, in recent years conservators have continued to rely on epoxy and polyester resins but have made them reversible by applying a thin barrier coating of B-72 directly to the substrate on both sides of a join and allowing it to set fully. They have then used an epoxy or polyester resin as the final structural adhesive. The result might best be described as a B-72–epoxy "sandwich." The acrylic barrier coating can be dissolved with solvents that have little or no swelling effect on the epoxy or polyester resin. While the rationale for coating the stone surfaces with B-72 may be reversibility, the sustainable bond between acrylic resin and stone is essential to the stability of the entire join. As Podany and his coauthors stated, "Given the strength of epoxy and polyester adhesives, the critical link, therefore, is the B-72, and in large part the integrity of the bond depends upon the strength of this material as an adhesive."[37] Indeed, results of tensile testing in their study showed that there was little difference between the strength of joins in marble specimens bonded with B-72 alone and those mended with both epoxy resin plus a B-72 barrier. However, the same study found that in shear tests, B-72 alone did not perform as well as epoxy and polyester resins used either alone or in combination with a B-72 barrier layer. The researchers believed that this failure might be attributed to the plasticizing effects of the solvent retention discussed above.[38] Nonetheless, aspects of this research encouraged the Tullio team to evaluate acrylic resins as structural adhesives to be used without an epoxy resin partner. Our concern with epoxy resins was not only their excessive strength and irreversibility, but, crucially, the thickness of the join that would be created by using it in conjunction with a B-72 barrier. A brief summary of the adhesive research is presented here; details of the procedure and full observations of all tests performed can

32. Preparation of Brazilian disk sandwiches. A clamping device was designed to mimic the maximum forces found in the sculpture. The specimens were left in the clamps for a minimum of three weeks while the adhesives set or cured.



33. Brazilian disk sandwiches bonded with B-72–B-48N blend after testing. These specimens were used to evaluate interfacial fracture toughness, an indication of adhesive strength. Each marble disk was tested with its elliptical hole oriented at a specified angle. Photograph and diagram: Mersedeh Jorjani and Carolyn Riccardelli

be found in recent publications by Mersedeh Jorjani, Nima Rahbar, Ting Tan, and others.[39]

Interfacial Fracture Toughness (Strength)

The goal of the first adhesives study was to find a system strong enough to withstand the forces in the sculpture while not displacing the joins. We collaborated with Columbia and Princeton Universities to carry out an investigation into the interfacial fracture toughness—or strength—of several established conservation adhesives.[40] In practice, there are two ways of characterizing adhesion. The first is to quantify it by ''strength'' based on stress analysis. The second is to quantify it by "fracture toughness," which describes the ability of a material containing a crack to resist fracture. Although the strength measurement is simpler to carry out, it is well accepted among mechanical engineers that interfacial fracture toughness is a more accurate, quantitative, and reliable measure of adhesion.[41] Significantly, this experiment marks the first time the fracture toughness technique has been used in an art conservation study.[42]

Nine adhesive systems were tested on samples made of Carrara marble, consisting of small disks pierced with an elliptical hole in the center (referred to as "Brazilian disks"), then cut or broken in half.[43] Two categories of sample sets were prepared: one with smooth joining surfaces, and another with fractured surfaces. Joined together with the adhesives under evaluation to create "Brazilian disk sandwiches" (Figure 32), each marble disk was tested with its elliptical hole oriented at a specified angle and stressed to failure with a mechanical analyzer (Figure 33).[44]

This type of testing produces graphs that describe the interfacial fracture toughness of the adhesive and marble interfaces.[45] The graphs of each adhesive system and sample type were compared with those of the control sample set: unbroken marble Brazilian disks tested in the same manner. If the graph, or "energy trend," for a bonded sample set closely matches the control set, then the adhesive has strength compatible to the intrinsic strength of unbroken marble.

The best-performing adhesive was a blend of 3 parts Paraloid B-72 and 1 part Paraloid B-48N, each made first as a 40 percent solution in acetone and ethanol and then combined by volume.[46] This 3:1 blend displayed an energy trend close to that of unbroken Carrara marble. Moreover, although the fracture energy of the B-72–B-48N blend was shown to be slightly lower than that of marble alone, most of these specimens fractured within the marble and not in the adhesive itself. Similar fracture patterns were reported in the study by Podany and coauthors mentioned earlier.[47]

The overall performance of the nine adhesive systems tested, the thermoplastics, including the conservators' favored adhesive, B-72, were found to be nearly as strong as thermosetting adhesives. All the tested systems were determined to have high enough strength for use on Carrara marble. On the basis of these tests, the B-72–B-48N blend was selected for the treatment of *Adam* because of its strength and ease of reversibility.

Bond-Line Thickness

The examination of bond-line thickness—the thickness created by adhesive used to attach two fragments of marble—was an essential aspect of our testing. In the process of preparing the Brazilian disk sandwiches for the fracture toughness tests, waferlike sections of stone were left over, and they were used to measure the bond-line dimensions for each adhesive. Measurements were performed under magnification using a process that allowed many measurements along the join, so that an average bond-line thickness and average deviation could be calculated.[48]

In earlier conservation literature, bond-line thickness studies were carried out by bonding smooth surfaces.[49] Our work revealed that specimens with smooth joining surfaces do not give an accurate indication of an expected bond-line thickness for the fractured-surface joins normally encountered when repairing marble. Our bond-line thickness study was the first to employ sample sets of both smooth and fractured surfaces. It revealed that the specimens with smooth joining surfaces resulted in thinner bond lines than those with fractured joining surfaces.

The thickest bond line in our study was 58 microns for the fractured specimen joined with the B-72–epoxy resin sandwich (epoxy resin coupled with two B-72 barrier coatings).[50] Our preferred adhesive based on the interfacial fracture toughness testing described above, the B-72–B-48N blend, was found to have a bond thickness of only 41 microns, falling in the middle of the range of bond-line thicknesses (Figures 34a,b). Fortunately, the dimensions of the bond lines overall were much smaller than previous literature had led us to anticipate.[51] Indeed, this study showed that the use of any of the adhesives for an object with numerous fractures would not likely result in any perceptible displacement of the joins.[52]

Creep Testing

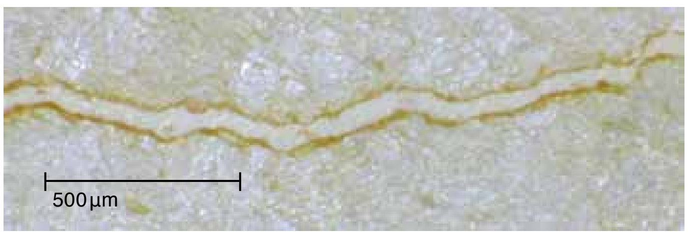
We also examined the long-term stability of the adhesives, specifically, the effects of creep. "Creep" is the term used to describe the permanent mechanical deformation of an adhesive when placed under a load over time. Again collaborating with Columbia and Princeton Universities, we developed a study to look at the creep behavior of various adhesives.[53] This research marked the first time a scientific study of creep was carried out on these conservation materials.[54]

Creep testing was performed using marble Brazilian disk sandwiches prepared in the same way as those used for the fracture toughness study.[55] Again, two sample sets were prepared for each adhesive, one with smooth join surfaces and one with fractured surfaces. The testing setup, in which a sensitive foil gauge was attached to the specimen and the marble disks were stressed in a mechanical analyzer, can be seen in Figure 35.[56] The resulting data were then subjected to mathematical calculations designed to extrapolate short-term laboratory results into predictions of long-term creep life.[57]

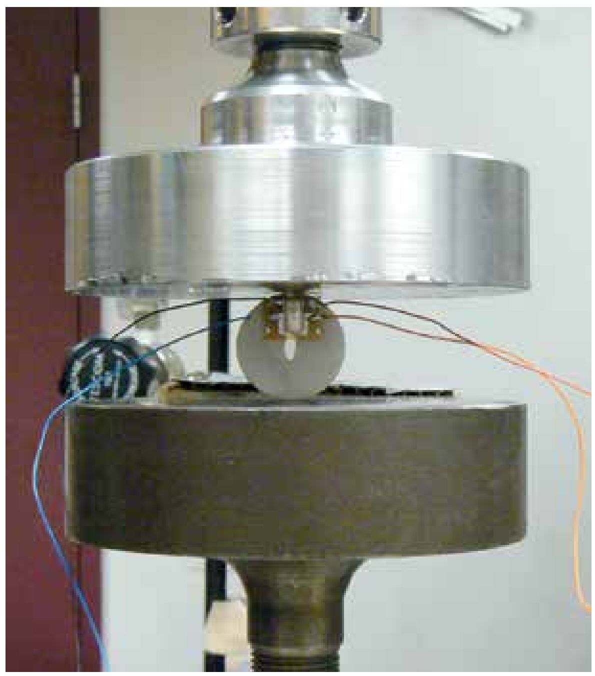
Thermoplastic acrylic resins (B-72, B-48N, and the blend of the two) performed as well as the thermosetting adhesives. The results indicated a very long-term gestation period for adhesive failure caused by creep in both categories of adhesives.[58] This unexpected conclusion goes against the common belief among conservators that thermoplastics have the potential to creep when used as structural adhesives, even at room temperature.

Specimens with the B-72–epoxy resin sandwich performed best in the calculated predictions, with a projected service life of more than 10,000 years. Our calculations predicted several thousands of years of service life for the B-72–B-48N blend, ranking it a close second behind specimens made with a B-72–epoxy resin sandwich. Analysis of the results suggests that the addition of B-48N to a B-72 adhesive may help prevent long-term creep.[59]

In all cases, the smooth specimens outperformed the fractured ones. When we started our testing we anticipated the opposite, thinking the rough surface might provide a greater frictional coefficient, or "tooth," to the join. These studies helped us understand the nature of failure, however, and how it might begin with flaws that exist on a microscopic level. A roughly fractured marble surface has many locations, termed "microvoids," at which failure can start, whereas it is possible to achieve a much more consistent



34a,b. Comparison of bond-line thickness. Top: fractured Brazilian disk sandwich bonded with B-72–epoxy sandwich. Bottom: fractured Brazilian disk sandwich bonded with B-72-B–48N blend. The specimen surfaces were etched and stained with an alizarin-HCl solution to improve contrast. Photographs: Mersedeh Jorjani



35. Creep testing setup. A foil gauge was applied to each specimen and then connected to a voltage meter that could detect small amounts of deformation. The load on the specimen was increased in stages until deformation was detected. Photograph: Andrea Buono

adhesive film on a specimen with a smooth surface with fewer flaws, resulting in a longer predicted service life. This reasoning also highlights the importance of adhesive application techniques, confirming that a continuous, consistent film is critical to a join's strength.[60]

Summary of Adhesive Testing Results

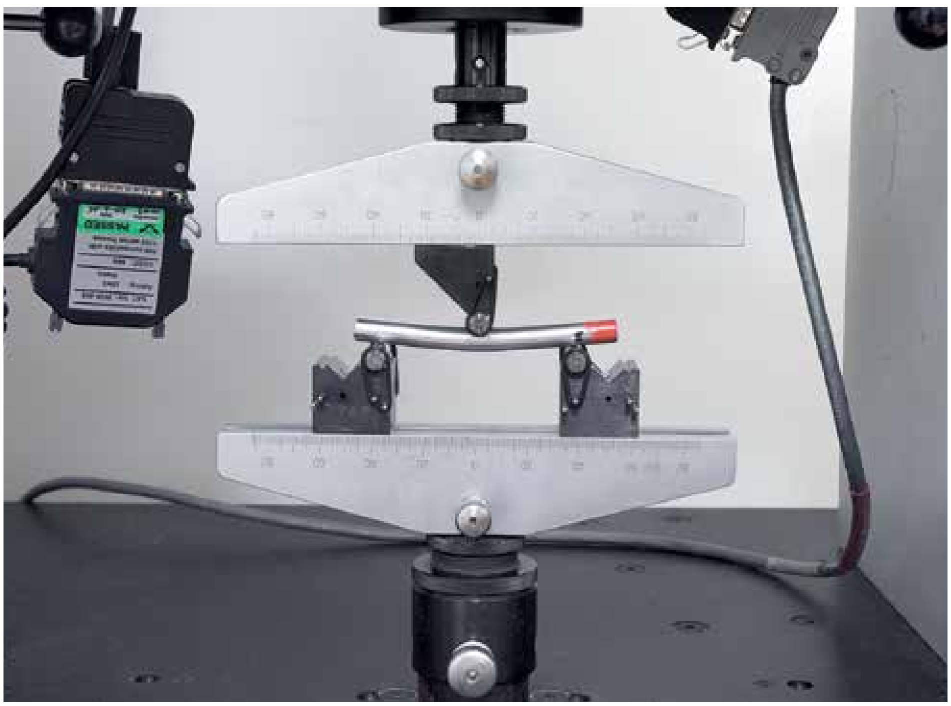
For the treatment of *Adam*, we chose a 3:1 blend of B-72 and B-48N because this system is reversible, has adequate strength without creep, produced a minimal bond line, and has excellent aging characteristics. This adhesive sets by solvent evaporation, and we anticipated that it would require at least four weeks of setting time to reach optimal strength. The matter of solvent retention was further investigated by the Tullio team and is discussed in "Adhesive and Solvent Retention Experiments," pp. 74–77. The combination of these results proved to us that reversible acrylic resins can indeed be trusted as structural adhesives provided certain working techniques are followed. The broader value of these results is that they will inform the conservation community about these familiar adhesives and encourage conservators to use them in new ways.

Pin Testing

Pinning has long been a practice in large-scale sculpture restoration. Certainly it seems to be a technique used ever since the first person joined pieces of stone in antiquity. However, there is little in the conservation literature devoted to the use of pins in sculpture. At the time of our study, the insertion of rigid pins into stone had yet to be thoroughly studied; the most closely relevant studies were related to rebar in reinforced concrete or to pinning blocks of architectural stone.[61] Inserting a pin into a marble sculpture is an entirely different operation, as it involves drilling and thus the removal of original material. In keeping with the goal of minimal intervention, we therefore undertook several studies in collaboration with Columbia and Princeton Universities to examine pinning materials and methods.[62]

Our research centered on the effects of a pin inserted into marble, and specifically on the stiffness of the pin in relation to the surrounding stone. Different pinning materials were tested to gain a better understanding of how they deformed under stress. The ideal pinning material helps to create a join with mechanical properties similar to those of the material being joined. Making the join stronger than the surrounding material runs the risk of further damaging the stone under new or increased stresses.

The hole drilled to accommodate the pin became another focus of testing. Irrespective of a pin's material, a pinhole is essentially a flaw and therefore a weakness in the marble, a site where new breakage can originate. We sought to gain a better understanding of how much a drilled hole might compromise the stone. A more immediate objective of the pinning research was to determine the number and size of the pins needed for *Adam*. We were aiming for minimal quantity and minimum size of drill holes. A brief summary of pin testing is presented here; details of the testing procedures and results can be found in a recent publication by Carolyn Riccardelli and others.[63]



36. Three-point bend testing setup used for determining the flexure modulus of pinning materials. The mechanical analyzer applied downward force until the specimen deformed or failed.

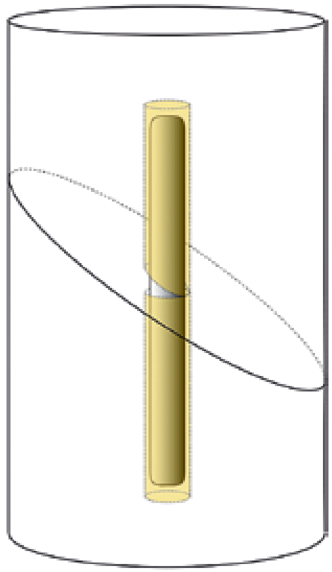
Standardization of the Stiffness Value

The research on pinning began with basic modulus testing. The modulus of elasticity is a measure of the stiffness of a material: higher values indicate stiffer materials. Testing materials were chosen based on their published modulus values ranging from very flexible (Teflon) to very stiff (stainless steel). For most materials, moduli reported in the literature are determined by placing the material under compressive or tensile loading.[64] The assessment of the sculpture's stresses in the finite element analysis showed us that, in *Adam*'s case, *bending* stresses are most critical in relation to pins. Thus, a testing protocol known as the three-point bend was chosen to evaluate these stresses in pinning materials (Figure 36).[65] The results of these tests are plotted on a graph that conveys two essential pieces of information about the pinning materials: the elastic modulus of a material (its stiffness) and its mode of failure.[66]

The moduli obtained through our tests differed considerably from those reported in the literature or by manufacturers. For example, beginning with the stone itself, a set of ¼ inch (0.64 cm) diameter Carrara marble rods was prepared and tested, producing a modulus value several orders of magnitude lower than that normally reported in the geology literature.[67] This higher reported value is commonly considered the standard modulus for marble, but it is actually the elastic modulus in *compression*—describing the stone's ability to withstand downward force such as that experienced by an architectural column. The compressive modulus does not describe the lesser ability of marble to resist bending forces and therefore does not represent the way in which a sculpture actually fractures. Our new, lower modulus value for marble proved to be important to integrate into our analysis focusing specifically on *Adam*'s left knee; see "Additional Finite Element Modeling," pp. 83–85.

Also tested was carbon fiber rod, a composite material made of graphite fibers embedded in resin (vinyl ester). As the reported modulus is significantly higher than the numbers obtained in our tests, we consulted the manufacturer and learned that this modulus is taken from the tensile strength of the fibers themselves and does not reflect the ability of the composite material to resist bending.

We tested another composite material—fiberglass rod, which is made of glass fibers embedded in polyester resin. Our tests determined that its elastic modulus is about twice that of Carrara marble; even so, it represented the closest match. Notably, both composite materials tested have a characteristic kinking behavior upon failure, as distinct from metal pins, which bend due to their ductility. This kinking behavior—a local delamination and buckling process in which the stiff resin component of the composite fails but the fibers remain intact—could potentially be beneficial if the sculpture were ever subjected to a future impact. Because fiberglass rods were determined to have the elastic modulus and failure mode most compatible with Carrara marble, fiberglass became a leading candidate for use in pinning joins in *Adam,* and careful attention was given to its performance in further pinning studies.



37. Diagram of smooth-surface specimen. Carrara marble cores were cut at a 45-degree angle to mimic the shear joins of *Adam*'s left knee and both ankles. The pin was affixed in the marble with epoxy, but the join surface was not bonded.

38. Testing setup for smooth-surface cylinders. The 8-inch-tall assembled specimens were subjected to gradually increasing downward force until there was failure of the pin or the marble. Photograph: Christina Muir

Smooth-Surface Specimens

Following the stiffness tests, we examined the structural behavior of pins when set into marble cylinders. Samples were prepared with the full range of pinning materials and were designed to be representative of the critical shear joins in the *Adam* sculpture.[68] We started by looking at the pin itself and designed a testing sample that would isolate the behavior of the pin without any additional interference from the surface of the join. To this end, this first phase of research looked at how marble behaves when it is joined by a pin set into epoxy resin but without adhesive on the interfacial surfaces.

The specimens were made of 8 inch (20.3 cm) tall, 4 inch (10.2 cm) diameter Carrara marble cylinders, each cut at a 45-degree angle across its center to mimic the shear joins of *Adam*'s ankles and left knee. The angled join surface was sanded smooth to minimize friction between the upper and lower halves, focusing force on the pin alone. For this sample set, the pins were approximately 4 inches (10.2 cm) long, and ½ inch (1.3 cm) in diameter, as recommended by our colleagues at Princeton University, who suggested a length-to-diameter ratio of 8:1 based on their collective experience in fracture mechanics. The rationale was that this ratio would produce an ideal pin that would not be so long as to create focused stress points at its ends but still long enough to ensure an effective mechanical connection between two fragments. When the pins were set into the marble cylinders, the epoxy resin adhesive was restricted to the pinholes and was not permitted to extrude onto the smooth, angled "mating" surfaces of the marble (Figure 37).

Six different materials were tested, including stainless steel, fiberglass, and titanium. Each prepared cylinder was placed in a mechanical analyzer and subjected to gradually increasing compressive force until either the pin or the marble cylinder failed (Figure 38).[69] The downward force combined with the specimens' 45-degree-angle join created an overall compressive-shear loading scenario that reflected the critical breaks in the sculpture. The result of this testing is a stress-strain diagram that describes the maximum load at the moment of failure as well as the mode of failure.[70] The results of two representative sample sets are given here to illustrate the range of our results.

The marble cylinders prepared with steel pins fractured severely during the test, leaving the pin seemingly unaffected (Figure 39). While the force required to reach failure

39. Three smooth-surface marble cylinders with stainless steel pins after testing. This kind of Y-shaped failure was typical for specimens pinned with stainless steel and titanium.

40. Upper and lower sections of three smooth-surface marble cylinders with fiberglass pins after testing. The marble was undamaged when the fiberglass pins were pushed to failure.

in this test[71] was much higher than internal forces within *Adam*, and indeed within most marble sculptures, these results are an indication of what might happen if a sudden impact or a fall were to occur in the future.

On the other hand, when the fiberglass-pinned specimens were pushed to failure, there was no damage to any of the marble cylinders, and all the pins broke cleanly through (Figure 40).[72] As previously stated, the modulus testing showed that fiberglass rods have a flexure elastic modulus about twice that of marble, and the results of the smooth-surface tests confirmed that there is good compatibility between the two materials.

In summary, the smooth-surface testing set showed that the average maximum load trends correspond well to those of the tested moduli of the pinning materials. Metal pins (titanium and stainless steel) with their high elastic moduli proved too stiff, as they caused the marble cylinders to break apart. Plastic pins (polycarbonate, Teflon, and acrylic) with very low elastic moduli did not cause damage to the marble cylinders but failed at loads lower than the internal forces determined to be within the *Adam* sculpture.

Fiber-based composite pins (fiberglass and carbon fiber) failed at relatively high applied loads without damaging the marble cylinders. The carbon fiber pins, which have a much higher elastic modulus than fiberglass pins, failed at a higher load than the fiberglass pins. The smooth-surface testing results indicated that both of these materials would be able to withstand the forces in the *Adam* sculpture without causing damage to the stone in case of impact. The kinking behavior of fiberglass pins that was observed in the modulus testing contributed to this positive result. Rather than failing by deforming and remaining in place, as would a ductile metal, composite pins kink and then break, allowing separation of the join before further damage is done to the marble.

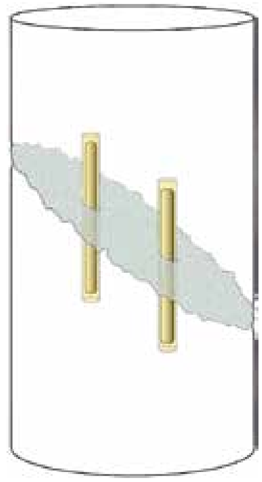
Fractured-Surface Specimens

The next round of samples was designed as mock-ups of *Adam*'s ankle joins, matching them in both size and theoretical mending technique. Based on the results of the smooth-surface tests, we chose titanium, carbon fiber, and fiberglass for the fractured-surface mock-ups.[73] Rather than cutting the cylinders as in the smooth-surface specimens, this sample set was fractured at a 45-degree angle to create a more realistic join. These cylinders were 5½ inches (13.9 cm) tall and 2½ inches (6.4 cm) in diameter, and made of Vermont marble because it is easier to obtain and more affordable than Carrara marble. Two small pins, 2 inches (5.1 cm) long and ¼ inch (0.64 cm) in diameter (thus the same 8:1 ratio), were set into the cylinders using epoxy resin; the fractured surfaces were joined with the B-72–B-48N blend we had already chosen for the treatment of *Adam* (Figure 41).[74] The fractured cylinders were then tested in the same manner as the smooth-surface set.

As was observed in the smooth-surface set, titanium pins caused damage to the fractured-surface marble cylinders (Figure 42). All three specimens were severely fragmented, while the titanium pin inside the sample was only slightly deformed under the relatively high maximum applied load.[75] The carbon fiber pins performed well, but damaged one of the three specimens in the set.

Once again, fiberglass pins performed best, causing no damage to the marble cylinders (Figures 43a,b). In each specimen, both the acrylic resin adhesive blend on the join and the fiberglass pins failed before there was any damage to the marble cylinder, creating an ideal pinning system.[76] All specimens tested in the fractured-surface set showed join-strength several orders of magnitude greater than the loads determined by FEA to be present the sculpture.

Finally, a set of cylinders fractured at the 45-degree angle, but without pins or pinholes, was repaired with the B-72–B-48N blend. This unpinned sample set served as a control of sorts. During testing, the specimens failed along the adhesive join with no consequential damage to the marble. In fact, the average maximum load was slightly *higher* than the fractured-surface sample set made with fiberglass pins.[77] While the difference is not statistically significant, this result affected the way we pondered the necessity of pinning each join, a process described in detail in "The Problem of the Left Knee," pp. 83–86.



41

42

43a

43b

Summary and Discussion of Pin-Testing Results

With such compelling results on which to base our decision, we chose fiberglass rods to be the pinning material for *Adam*'s reconstruction. Carbon fiber rods had promising characteristics during testing but proved to be much stiffer than the marble, cracking one of the testing specimens. Fiberglass was determined to have a modulus (stiffness) more compatible with marble, and testing showed that it would not cause damage in case the sculpture were subjected to an impact. Conventional wisdom suggests that repair materials such as pins or adhesives should have properties, such as strength and modulus, similar to the substrate. Yet stainless steel, with a much higher elastic modulus than that of marble, continues to be the most commonly used conservation pinning material. We believe that our testing results will prompt conservators to consider a wider range of effective pinning materials. For the repair of sculpture that will remain in a controlled museum environment, the reasons for choosing stainless steel—corrosion resistance, coefficient of thermal expansion—become less important. Our testing established that fiber-based composite rods such as fiberglass and carbon fiber outperformed both stainless steel and titanium in that they were of sufficient strength to withstand the maximum static forces of the sculpture and did not damage the marble cylinder before pin failure.

Throughout all our pinning studies, we became keenly aware that the process of drilling into marble introduces a flaw, thereby potentially weakening the stone. And, while we agreed that we had found in fiberglass an ideal pinning material, we had not yet addressed our objective to minimize the number of pins we would ultimately use in repairing the sculpture. Therefore, it was particularly significant that the unpinned fractured-surface cylinders outperformed the sample set prepared with fiberglass rods. These results had profound implications for the eventual selection of which joins in *Adam* we would pin.

Pins and Reversibility

While the final decision on the number and location of pins was still pending, we agreed that *Adam*'s ankles should be pinned, and so we developed a protocol for inserting the pins in a reversible manner. Historically, pins have been set into stone using plaster, shellac, hide glue, or even molten lead. More recently, epoxy or polyester resin adhesives have been used as a way to embed and secure pins. These techniques are difficult to reverse, however, and they typically lead to some kind of damage or risk to the object during the process of removal. Although reversibility can be achieved by the use of acrylic resin adhesives thickened with bulking agents, such as glass microballoons,[78] when setting pins into stone, the depth of the pinhole at the center of a marble join makes for slow solvent evaporation. Judging exactly how long it would take for that adhesive to set before it would be safe to place a load on the join would be problematic.

Epoxy resin adhesives, on the other hand, have a known cure time, and when used in the pinhole can lock a pin in place, making it simple to know exactly when a join is capable of carrying a load. But such joins are very difficult to reverse. So to take advantage of the curing benefits of epoxy but still create a reversible join, conservators in recent years have elected to use a sleeve system in which the pin is set into the stone by mechanical means, either by inserting a metal sleeve or by creating a sleeve with epoxy.

The epoxy sleeve has gained popularity because of its reversibility.[79] By placing a release agent on the pin prior to

41. Diagram of fractured-surface specimen. Vermont marble cylinders were fractured at a 45-degree angle to mimic the shear joins of *Adam*'s ankles. The pin was affixed with epoxy resin and the fractured join surface was bonded with the B-72–B-48N blend.

42. Fractured-surface cylinder with titanium pins after testing. The marble was badly damaged after the specimen was subjected to compressive force. This kind of damage was typical when the stiffness of the pinning material far exceeded that of the marble.

43a,b. Fractured-surface cylinder with fiberglass pins after testing. Left: assembled. Right: separated. The fiberglass pins failed without damaging the marble.

44. Sichuan marble *David* that was used as a mock-up for assembling *Adam*. The replica was also used for testing and in the development of an external treatment armature. The overhead bridge crane can also be seen in this photograph.

inserting it into liquid epoxy, a cast-in sleeve achieves a snug fit between pin and sleeve. The result is not only effective but also prevents focused stress points that can arise from poor conformation between pin and sleeve. Metal sleeves are also reversible, but thin-walled, snug-fitting sleeve-and-pin combinations are not readily available, and therefore it is more difficult to achieve the same excellent conformation with metal sleeves. A further drawback of metal sleeves is that they require a larger pinhole to accommodate both the sleeve and the epoxy resin that holds it in place.

A common alternative to a fully sleeved pin is one that is bonded at one end and sleeved at the other, sometimes referred to as a "potted pin." We used finite element modeling to compare the benefits and drawbacks of both fully sleeved and potted pins (discussed in "Additional Finite Element Modeling," pp. 83–85), and the analysis showed that fully sleeved pins distribute stress across a join more equally than potted pins. Also, because sleeved pins do not create a solid structure inside the pinhole, they would be released from the marble in the event of a further impact or fall. After taking all of these factors into consideration, we decided to create full epoxy sleeves in *Adam*'s pinholes; when paired with the B-72–B-48N blend on the fracture surfaces, we were confident that we would create fully reversible joins. The technique devised for inserting the pins is outlined in "Inserting Pins," p. 92.

Empirical Research

In addition to the studies described above, the Tullio team carried out a series of experiments aimed at evaluating the influence of several parameters purposefully eliminated from the design of the earlier research. Scientific studies yield reliable quantitative results; empirical experiments, on the other hand, offer practical results that can be described as qualitative. The set of experiments related below was designed to incorporate conditions closer to those that exist in the *Adam* sculpture, for example, the additive dimensional effect of stacking fragments of broken stone and the time it might take for sufficient solvent to evaporate from adhesive in a tight marble join before the adhesive reaches full strength. Indeed, these studies were approached systematically, but they also incorporated the working style of the conservator and made accommodation for the inevitable errors or variables that occur in reality and which scientific studies are designed to avoid. The results of such explorations indicate a trend or a relative magnitude and thus contribute to the success of a project by helping conservators build confidence and familiarity with materials and treatment protocols.

Adhesive and Solvent Retention Experiments

Several practical experiments were carried out to explore the concepts of solvent retention in acrylic adhesives. Because thermoplastic adhesives set by a process of solvent evaporation rather than curing by chemical reaction, it is difficult to predict exactly when the solvent will have sufficiently evaporated from the system. Solvent retained during the setting process can act as a plasticizer, keeping the adhesive film soft for a period of time and potentially leading to creep or even join failure. The experiments described below attempted to predict how long it might take an acrylic film to pass beyond the point of any potential creep during setting.

Acrylic Resin Adhesive Experiment: Trial Join

The Tullio team purchased a modern marble replica of Michelangelo's *David*, in a scale similar in size to *Adam*, specifically for the purpose of breaking the stone figure so that it could serve as a mock-up.[80] There were several benefits to having an alternative broken sculpture on hand. It helped us plan the external armature, practice safe methods for handling and orienting large, heavy masses of fragile stone, and test various adhesive and pinning scenarios. The 70-inch (178 cm) tall replica was carved from Sichuan marble, a white stone with gray veining (Figure 44). This marble proved to be less fine and compact than Carrara marble, and it fractured with a granular texture. However, for experimental purposes its properties were close enough to Carrara marble. Moreover, the composition of *David* provided a figure standing in contrapposto position as well as the scale and mass required to be an accurate experimental stand-in for *Adam*.

We used the *David* replica in our consideration of adhesive-only joining options. Our experiment focused on the connection between *Adam*'s left arm and torso because the size and configuration of the proposed external support armature required that this join be one of the first affixed. *Adam*'s left arm had broken off at an almost vertical angle, resulting in a join that would be subjected to a combination of compressive, shear, and tensile forces. The damage and

45

45. Trial join in progress on the *David* replica. The left arm was attached to the torso using acrylic resin adhesives and then allowed to set for three months before a weight was suspended from the arm. One week after the weight was applied, the join began to separate.

46

46. Torso of the *David* replica, photographed after the left arm join failed. The arm is floating by a catch-strap created to prevent it from falling to the floor.

orientation of the fracture along this join caused the team to be hesitant about drilling and pinning in the upper arm.

While considering various adhesive-only joining options, we tested an acrylic resin adhesive join on the *David* replica's left arm. Using feathers and wedges, traditional stone-splitting tools employed by stonemasons, we broke the replica's left arm at an angle similar to the break in *Adam*'s left arm (see "Marble Replica of Michelangelo's *David*," p. 78). The break was not as crisp and clean as that on *Adam*, however, as the use of feathers and wedges necessitated drilling several holes across the join. The fracture was bonded with the B-72–B-48N blend, applied generously, then clamped and allowed to set under pressure for three months. It was thought that this period would provide sufficient setting time for the adhesive, allowing the acetone and ethanol solvents in the adhesive to volatilize fully. The *David* replica's torso with the attached arm was then placed upright and suspended from an external armature support. Next, a 17-pound (7.7 kg) weight was hung from the arm, located away from the join, near the wrist. About a week later the join appeared to be separating on the inside of the break; strings of adhesive were visible in the depths of the fracture, indicating that the film of acrylic resin was stretching apart (Figure 45). After observing this separation, we wanted to see if we could force the join to fail, and three months later the weight was doubled. One month after that, the join failed completely (Figure 46).

Failure of the *David* replica's arm join occurred more quickly than we anticipated, and we agreed that the failure was likely due to solvent retention in the adhesive film, but we also suspected that the adhesive had been applied too thickly. The exposed adhesive on the broken arm join was stretched and stringy, signifying that the film, although well adhered to the marble, had failed cohesively, or within the adhesive layer (Figure 47). Three months had seemed a sufficient time for the adhesive to set fully, but clearly that was not the case with the *David* replica's arm. The results of this experiment confirmed that a thin continuous film of adhesive is far more effective than an overly thick one and

47. Torso of the *David* replica, showing the failed adhesive. Note the stringy, rough nature of the adhesive film, indicating that the overly thick layer had not fully set.

demonstrated that clamping and tightness of a join have a major effect on its ability to hold. The results also suggested that a pin might be needed in shear joins to counteract the short-term risk of creep during setting.

Solvent Evaporation Rate Experiment

Another, more systematic experiment was required to better comprehend the length of time the marble sculpture fragments should remain clamped and supported following attachment. Experience had shown us that, when using a thermoplastic adhesive to repair large stone sculptures, fragments need to be immobilized within an external structural support until the adhesive, through solvent evaporation, reaches sufficient strength to support the marble's weight. The objective of this experiment was to determine the rate of solvent evaporation of the adhesive through a porous substrate such as marble.

For this experiment, a set of Carrara marble disks was fractured across their 2-inch (5.1 cm) diameter and then weighed.[81] Each disk was then mended using the B-72–B-48N blend and weighed immediately after adhesion. Weighing continued at frequent intervals during the initial days of the experiment. As weight changes diminished, measurements were made each week and, finally, after one year.[82] It was not possible to measure the amount of resin and the amount of solvent applied to each specimen, so the weighing actually tracked the change in weight of the adhesive rather than a specific solvent percentage loss.

Each specimen lost approximately 30 percent of its adhesive weight within the first 3 hours. By the end of the first 24-hour period, each had lost an additional 25 percent of its initial adhesive weight. At 54 hours, solvent evaporation began to plateau, averaging a loss of 48 percent of initial adhesive weight.[83] After the first week, evaporation was slow, steady, and continual. A year later, specimen weights had changed only slightly, signifying that only a small amount of detectable solvent had continued to evaporate from the samples. The results of this experiment were enlightening, as the solvent evaporation occurred much faster in the marble disks than was indicated by the trial join experiment. In the end, however, the limitations of the experiment did not enable us to predict more accurately how long it would take a large join to reach full strength.

Creep Experiment: Carrara Cylinder

One final experiment pertained to solvent retention and potential creep. On the same day that we bonded the small, wedge-shaped fragment in *Adam*'s left knee to the adjacent lower left thigh (see "Left Knee Wedge Join," p. 97), we also joined two parts of a similarly sized fractured Carrara test cylinder. This cylinder had been split along its vertical axis so that the fragments could be attached using the B-72–B-48N blend. The intention was to monitor the strength and creep behavior of the experimental join in the cylinder as a stand-in for the newly bonded fragments on the sculpture.

After the marble cylinder's adhesive had set under pressure for three weeks, shear force was applied to the join to try to instigate creep. The test cylinder was arranged in an armature so that downward pressure was directed at only one side of the vertical join, placing the adhesive in shear. A gauge, the same as that used in the creep testing, was attached across the join to detect movement, and then dead weights were applied, subjecting the join to approximately 30 psi (0.207 MPa) of shear stress.[84] This amount of weight was chosen because it reflected the maximum shear force that our analysis determined would be experienced along the top of the left knee wedge in the assembled sculpture. The experiment continued for several months, but no movement was detected along the join.

Discussion of Adhesive and Solvent Retention Experiments

The vastly different results between the *David* replica arm experiment and the Carrara cylinder experiment can be attributed primarily to working technique, and they highlight the value of these additional studies. The interfaces of the replica's arm join mated poorly due to preparation of the fracture and the quality of the Sichuan marble. The thick layer of adhesive applied to the join increased its susceptibility to creep and failed when weights were suspended from the arm. The Carrara marble cylinder fragments, on the other hand, were bonded using a thinner layer of adhesive on cleanly fractured, tightly fitting interfaces and did not experience creep when weight was applied. These results are reflected in a creep experiment carried out by colleagues at the J. Paul Getty Museum, who also found that a thick layer of adhesive tended to creep, while a thin layer underwent very little movement or creep.[85] Podany and his coauthors explained this effect in their 2001 article: "Thicker bond lines increase the dependency upon the cohesive strength of the adhesive, which is often weaker than its adhesive strength and may be insufficient for the stresses placed on the bond by shear loads."[86]

While the solvent evaporation rate experiment indicated that solvent evaporation has the potential to occur significantly faster than had been suggested by the experiment on the *David* replica's arm, the experiment was limited in that it did not provide a means for translating the solvent evaporation performance of small specimens to the large surface area of *Adam*'s legs. Clearly, a large join would take longer to set than a small one. The weight loss in this experiment measured the evaporation of solvent that is free to move out of the adhesive and through the stone. Without knowing the exact amount of solvent that is able to leave the system, it is difficult to guess the endpoint of the experiment.[87] Other studies and our results show that after the initial, easily measurable loss of solvent, what remains is very tightly locked inside the polymer structure.[88] It is this residual solvent that could potentially plasticize the adhesive.[89]

Regardless of the long-term solvent retention issues, the fact remains that acrylic resin adhesives cannot properly sustain a significant load until many weeks after application. Thus the critical role of the proposed external armature was clear, as was the wisdom of the decision to pin *Adam*'s ankles, since pins would counteract potential creep while the adhesive set in the areas where the full weight of the sculpture would be concentrated.

Bond-Line Thickness Experiment: Marble Blocks

Because bond-line thickness was such a critical component of the adhesives we were studying, we carried out an empirical experiment to look at the displacement of the joins due to the addition of adhesive. Three blocks of Vermont marble, approximately 4 inches (10.2 cm) square and 14 inches (35.6 cm) long, were precisely measured.[90] With feathers and wedges, the blocks were then broken at between four and six locations (reflecting the number of breaks in *Adam*'s left leg), reassembled without adhesive, and then measured a second time.

The process of fracturing marble invariably leads to a displacement of grains along the fracture that can prevent the tightest possible fit between fragments. To improve the fit, we carefully cleaned away loose grains of marble from the fracture surfaces before the blocks were reassembled and measured for the third time. Finally, the blocks were mended using the B-72–B-48N blend, clamped under the mass of a 50-pound (22.7 kg) weight, and allowed to set for several weeks (Figure 48). One month later, the blocks were measured for the fourth and final time.

The measurements indicated that the length of the blocks increased not only due to the addition of adhesive (as expected) but also merely from the process of fracturing the stone and putting it back together. Removal of loose grains from the fracture surfaces had a positive effect, reducing increased length. Dividing the change in length of each adhered block by the number of joins provided an average bond-line thickness of 150–200 microns per join, about the thickness of an index card. It was therefore established that even within the tightest join, there was space for adhesive to occupy without causing significant displacement.

Our previous bond-line thickness study with Brazilian disk sandwiches produced even thinner bond lines because the clamping pressure achieved during their fabrication was greater than that of the marble block experiment. These differing results indicate that there is a direct relationship between bond-line thickness and clamping pressure. The amount of clamping pressure applied to the Brazilian disk sandwiches was based directly on the actual pressures present in the sculpture. Therefore, we can infer that the bond-line thicknesses realized in the assembly of the sculpture are closer to those achieved in the Brazilian disk sandwiches than to those in the empirical bond-line experiment.

48. Bond-line thickness experiment in progress. Each marble block was measured, broken into several parts, reassembled without adhesive, and measured again. The block was then bonded together and measured a final time.

PLANNING THE TREATMENT

As we moved from the research phase of the project to planning the treatment—that is, to the implementation of the understandings we had gained—we knew that we would need to design specialized equipment to meet our treatment goals of minimal intervention and of reversibility. And while we had determined to pin the ankles, we had yet to reach a final decision regarding the join at the left knee. Even as we furnished the Tullio studio with equipment that would facilitate the reassembly of *Adam* with minimal handling, we addressed the left knee join through additional research and discussion, and this process is described in detail as a case study in decision making for complex conservation projects.

Specialized Equipment

Taking into consideration the contours, weight, and number of fragments, we knew it would be impossible to use a traditional clamping system to hold fragments of the sculpture in place while the adhesive set. Thus, early in the project, it was proposed that we use the sculpture as its own clamp, assembling it fully every time a major join was made. In this way, the full weight of the sculpture would be brought to bear on each join, providing the clamping pressure required during adhesion. Assembling the full sculpture after each join would have the added benefit of allowing conservators to monitor the alignment of the fragments as the treatment proceeded. Finally, this "self-clamping" method—that is, clamping by using the weight of the sculpture itself—addressed the need to apply sufficient compressive force on the joins to form a thin film of adhesive between the fragments. We knew from our research that the compressive pressure achieved during adhesive setting was directly related to bond-line thickness, and therefore vital to the success of the reconstruction.

The self-clamping method had many benefits, but one potential liability of repeated assembly and disassembly of the sculpture was harming the break edges of the fragments, which were brittle and readily damaged on contact. We needed to minimize handling of the marble to preserve these edges, as they would ensure the ultimate tightness of the joins. The solution was an external armature capable of positioning and precisely aligning the unadhered fragments during repeated assembly and disassembly of the sculpture. Ultimately including carbon fiber straps, ball joints, and a rigid support structure made of metal framing stock, the armature was used in combination with an overhead bridge crane and a custom-designed lift table. Working in concert, the innovative armature and rigging equipment provided an ideal workspace in which to assemble the sculpture. The development of this armature, which was accomplished by utilizing two different full-scale sculpture mock-ups, was probably the most time-consuming part of planning the treatment, and required substantial research and engineering.

The armature proved to be critical to another step in planning the treatment. Following discussions with colleagues at the J. Paul Getty Museum who have extensive experience in the reassembly of large-scale stone sculpture, we determined to undertake a "dry run." Fully assembling the sculpture without adhesive would allow us to find strategic points at which fragments could be bonded together in groups rather than proceeding one join at a time. The dry run gave us the first opportunity to examine the sculpture for any troubling misalignments that had resulted from the damage caused by the accident. Following the dry run, the assembly of the actual sculpture proceeded relatively rapidly.

Mock-ups

We knew we needed mock-ups to design the external armature, and we needed them in any case to plan the treatment of *Adam*. Rather than carry out a variety of theoretical treatment techniques on an original work of art, conservators regularly turn to small-scale, focused mock-ups to gain familiarity with methods and materials. In our case, however, the scale of the *Adam* sculpture and the nature of the damage warranted a commensurate increase in the scale of the mock-up. For many conservation projects, full-scale mock-ups are not feasible due to limited resources, but the potential benefits in our case justified the approach.

Our full-scale mock-ups enabled the conservators to formulate and rehearse assembly methods using the models rather than the sculpture itself. And by substituting the model for the original work, the conservators were also able to design and fabricate supporting armatures for the sculpture that would hold and steady each of the major fragments while they were being joined and allow extremely accurate manipulation and placement of the heavy fragments. In addition, we anticipated that the armature fabrication would involve materials and handling that could potentially soil the surface of the fragments. Using the mock-ups as part of an indirect method thus had the benefit of preventing soilage as well as damage.

Marble Replica of Michelangelo's David

The replica of *David,* described above, served as a mock-up for testing as well as a working model for designing the external support armature. As we had in our trial join of *David*'s left arm and torso (see "Acrylic Resin Adhesive Experiment: Trial Join," pp. 74–76), we used feathers and wedges (Figures 49a,b) to break the marble replica (Figure 50) in the same pattern as the *Adam* sculpture. Some additional modifications were required, specifically the removal of the tree trunk behind David's right leg, to make the mock-up more similar to *Adam*'s stance.[91] With the *David* replica prepared, the goals of the armature needed further definition. Was it required solely to keep the sculpture from falling, and/or to aid in lifting the heavy fragments, and/or for positioning the fragments? These questions were addressed as the replica was put to use.

Full-Scale Milled Model of Adam

As previously mentioned, one of the benefits of the laser scanning was that it allowed us to produce a full-size 3D model of *Adam* by means of a computer numerically controlled (CNC) milling machine (see Figures 23a,b). This machined, or "milled," model was made of dense polyurethane foam that did not replicate the weight of the marble but had mass significant enough to serve as a suitable stand-in. Each of the major fragments except the head and the tree trunk was fabricated. Because the milled *Adam* was identical in form and scale to the marble *Adam*, it could be used to fabricate the components of the external armature that would ultimately support the actual sculpture. The milled model was also used to conceptualize and design the intricate drilling rigs used later in the project. The importance of

49a,b. Preparation of the *David* replica. Feathers and wedges were used to break the replica. This ancient method utilizes a series of drilled holes along the desired break line. Two "feathers" are placed into the holes, and then a metal wedge is inserted between the feathers. To break the stone, the wedges are tapped with a mallet so that a crack is propagated.

50. The *David* replica's torso, after the figure was strategically broken to match the breaks on *Adam*. This marble figure served as a stand-in for *Adam* as the treatment armature was developed.

this full-scale milled model to the many complex aspects of the project cannot be overstated.

External Armature

The goal of safe assembly was met by the development of an innovative external armature, a kind of "exoskeleton." It needed to be strong, be capable of holding the fragments in precise orientations for long periods of time, and allow for macro- and micro-scale adjustability along the vertical plane while the leg fragments and the torso were stacked upon each other. The design also had to allow the pitch, or angle, of each fragment to be adjusted with great precision. Finally, the armature needed to be designed with the capacity to open and close joins without disturbing the relative positions of fragments one to another or causing abrasion or other damage to the fracture surfaces in the process.

Having decided to work indirectly on mock-ups rather than the sculpture itself, we used the *David* replica to explore our early armature concepts. We knew that a key component of the armature would be devices that could securely grasp each individual fragment. After initially attempting to fabricate steel fittings to hold the fragments, we turned to a new material, laminated carbon fiber fabric, to create customized removable straps—collars that were molded and tailored to hold each major marble fragment. Fabricated from layers of carbon fiber cloth laminated with epoxy, this material can be made to conform to any shape.[92] Moreover, it is as strong as steel but one-third the weight. To

51. The *David* replica's torso enveloped in a "corset" designed to suspend it over the legs. The support was made of laminated carbon fiber fabric. We used the *David* replica as a test case for developing the armature for *Adam*.

52. Carbon fiber straps on fragments from the milled model of *Adam*. Hose clamp closures were incorporated around the circumference of the straps, and ball joint fixtures were used to attach the straps to a surrounding rigid support.

gain experience, we fabricated these straps around the *David* replica's fragments, each going through many design iterations before the final format was realized.

One of our main concerns was how to hold the largest and heaviest fragment, *Adam*'s 380-pound (172.4 kg) torso, securely in a fixed position while also providing for the ability to adjust the moment, or angle, with precision. The standard rigging method for handling such large fragments of stone sculpture is to use nylon lifting straps "choked," or tied off from the front and back, to provide an even distribution of weight and a balanced pickup (see Figure 50). While endless nylon slings[93] were useful for moving the torsos of mock-up sculptures and of *Adam* itself, the choked lifting strap method did not produce the refined and accurate movements necessary to put this particular sculpture back together. Our project needed a more adjustable system that would allow us to change the position of the sculpture more subtly.

Ultimately, a lifting armature was designed that would provide full flexibility in moving the torso as it was positioned over the legs. The concept was to have a rigid "corset" around the waist with a flat, shelflike flange extending outward and encircling the torso. The corset would be suspended from an overhead rail by means of threaded rods extending from holes in the flange. To test the concept, we made a two-piece removable carbon fiber version of the corset for the *David* replica's torso (Figure 51). The direct molding process provided a close fit. The corset held the torso at its waist, preventing any movement of the heavy fragment, but could easily be removed by unfastening the bolts that secured its two pieces together. The trial on the *David* replica allowed us to work out issues of the scale and shape of the corset, and the overall methodology of putting *Adam* together.

Once the armature design was more fully evolved, the full-scale milled model of *Adam* was substituted for the *David* replica. Because the milled model was 1:1 in scale, we could use it to fabricate the final armature that would be used with the sculpture itself, thereby minimizing handling of the *Adam* fragments and preventing damage to the fracture surfaces. Once the straps were fabricated on the milled fragments, they could be transferred directly to the sculpture.

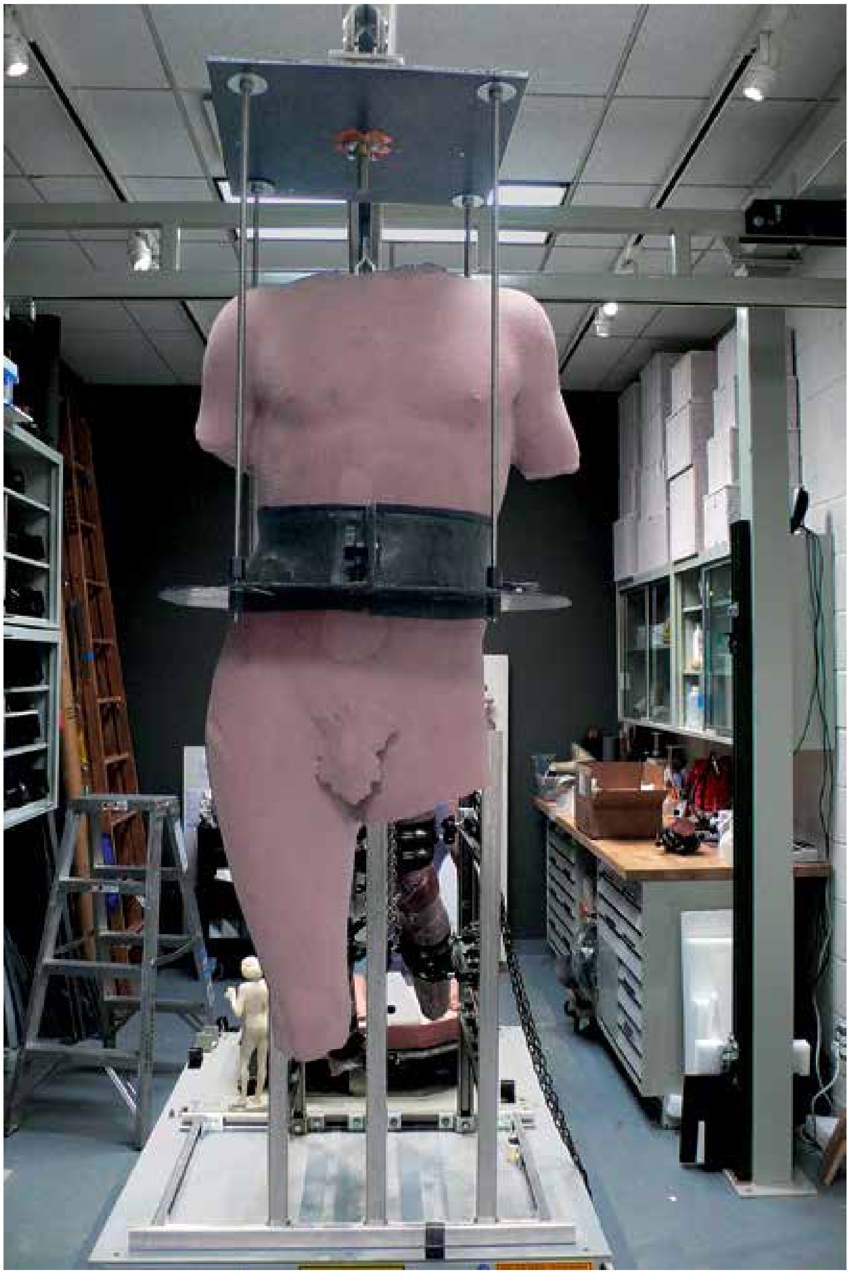
To make the armature straps, the milled fragments were wrapped with a layer of thin foam, followed by a protective layer of plastic wrap. Then several layers of carbon fiber fabric were placed over one another, using epoxy as the laminating medium. After the rough strap had cured, it was cut off the model, further refined, and furnished with an internal layer of thin foam as well as an external hose strap for tightening onto the fragment. Finally, several nuts were affixed around the circumference of the strap, providing points of attachment by means of ball joint fixtures to the rigid framework (Figure 52).[94] The process of laminating carbon fiber fabric and cutting the cured strap off the model was dirty and messy, highlighting for us another benefit of working indirectly using a mock-up rather than on the *Adam* sculpture itself, which was thus protected from both handling and potential soiling.

A rigid, cagelike system was developed to support the leg fragments and their associated carbon fiber straps from all angles. This support structure was made of lengths of stainless steel Unistrut channel, a commercially available modular framing system that provides infinitely adjustable points of attachment along the length of the channel.[95] Each strap had at least four points of connection to the framework by means of ball joints that could be loosened to allow flexibility in positioning and could be tightened to secure the fragments rigidly in place (Figures 53, 54).

The milled *Adam* also served as the form on which the corset was fabricated before it was transferred to the marble torso. Like the corset developed on the *David* replica, the one created for *Adam* was a robust carbon fiber strap composed of two halves fastened with bolts at the front and back. Additionally, there was a wide flange extending perpendicularly from the corset through which threaded rods

53. The full-scale milled model of *Adam*'s torso suspended over the left leg during armature development. The left leg is supported by carbon fiber straps and ball joints. The rigid support is constructed of metal strut channel framing stock.

54. The completed rigid framework of the armature. The Unistrut channel framing system allows flexibility of design and infinite points of attachment.



55. Completed torso corset for *Adam*. The torso was suspended by threaded rods from the overhead plate. Coupling nuts were turned to adjust the pitch of the torso. Adjustability was also designed into the suspension system, allowing fine pivot adjustments of the 380-pound fragment.

56. Freestanding bridge crane. An object can be positioned anywhere within the supports of the structure by means of the movable beam (highlighted in yellow). See also Figure 44.

were inserted. These rods extended vertically to an overhead hanging plate, allowing adjustment of the pitch and pivot of the torso by turning the coupling nuts that held the rods in place (Figure 55). This steel plate hung from the crossbeam of an overhead rail system (see "Bridge Crane and Lift Table"), which allowed the torso to be maneuvered away from the legs when necessary.

A stainless steel pallet, referred to as the "working base," was the foundation of the external armature used to support the sculpture throughout the treatment. Because it could accommodate the prongs of a forklift, it also provided the means to move the sculpture within the Museum as necessary. The pallet was designed to conform to the footprint of *Adam*'s integral base so that ultimately it could be incorporated into the design for the new gallery pedestal (see Figure 77). Two identical bases were fabricated so that one would be available for design, mock-ups, and testing while the other remained under the sculpture to provide support and facilitate its movement. The sculpture simply rests on a conformable lead sheet between it and the working base; no mechanical attachment was used.

Bridge Crane and Lift Table

The armature served as the direct support for each of the sculpture's fragments, but rigging equipment was also needed to manage the overall support and movement of the heavy fragments. As the armature concepts evolved, we realized that a standard lifting gantry would not meet our needs. Instead, a more versatile, freestanding bridge crane was used for the overhead lifting (Figure 56). This structure was extremely stable and equipped with a movable rail, or bridge, from which chain hoists could be attached. From this bridge, the torso hung in its corset assembly, allowing us to position this heavy fragment anywhere within the four supporting posts of the structure and providing the flexibility required for refining the armature functions. Further modifications and additions enabled us to lock the moving parts in place when required.

With the torso hanging securely within its corset and attached to the overhead hanging plate, which was in turn attached to the movable bridge, we needed a precise way to bring the legs—supported in a separate armature—up to meet the torso. We investigated a number of commercially available lift table designs, but none proved adequate. The table we required had to provide a smooth and controlled transition from stationary to moving, with no jerky starts and stops. It also had to have the capacity for slow and precise height adjustment. Moreover, the lift table would have to hold a fixed position for extended periods of time while supporting a load, thus ruling out hydraulic or pneumatic lifting devices, which could potentially leak or drift downward over time. After considering options, we selected a table that lifts by means of a mechanical stacking chain that locks as it builds a stable vertical column under the table deck.

Laweco, a manufacturer of specialized lift systems, designed and fabricated a lift table that met all of our requirements, customizing the electronics to create the smoothest possible lifting action.[96] The table was equipped with a remote control box with a swivel controller for fine speed adjustment (Figure 57). With such a controller, the table could be moved slowly when needed, and stopped accurately and precisely.

The Problem of the Left Knee

As the organization of the armature and equipment in the Tullio studio came together, the focus of attention shifted to the closer investigation of those joins of the sculpture where pins would be required and the precise method of insertion to be used in each case. During the early phases of the project, the Tullio team had agreed to pin both ankles and *Adam*'s left knee, where shear forces acted on the top of the small, wedge-shaped fragment. But as research into adhesives and pinning progressed, and with a clearer understanding of how pinholes weaken stone, we began to ask if it would be necessary to pin the knee, which required a longer pinhole through a fragment that had sustained a direct impact. To investigate pinning options in this key area, we undertook additional engineering studies.

57. Lift table. This custom-designed piece of equipment was instrumental to the successful assembly of the sculpture. A remote controller allowed fine adjustments to the rate of the table's speed.

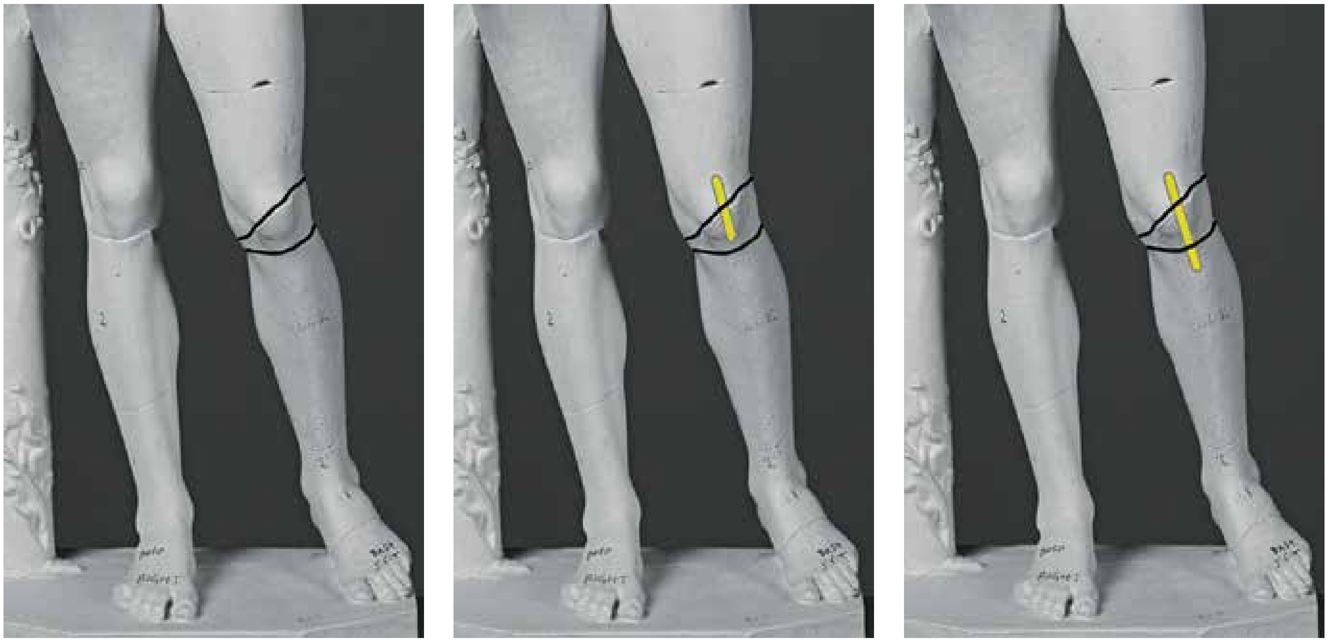
Additional Finite Element Modeling

In addition to determining the general stresses and strains on a structure, the finite element method can be used to test concepts in a specific region of a virtual model. For example, different types of loading scenarios can be introduced into the model, or, as we did with *Adam*, the effects of pins inserted into specific locations on the sculpture can be studied. The virtual model can thus gauge the structure's response to various circumstances, helping to answer questions that might be time-consuming or complicated to answer in a traditional testing protocol.[97]

To help resolve pinning questions, the Tullio team, CAE Associates, the materials scientists at Princeton University, and Simpson Gumpertz & Heger (SGH), an additional engineering firm, collaborated to develop the most comprehensive and thoughtful approach. CAE Associates continued with finite element modeling work it had already started; the Princeton participants performed a peer review role; and SGH provided an overriding organizational and advisory role.[98]

The goal of the study was to answer whether the shear forces present in the sculpture were high enough to warrant a pin in the left knee and, if so, by modeling pins in the virtual representation of the sculpture, to help determine ideal dimensions and position. In addition, because the initial finite element analysis (Studies 1 and 2) had used techniques that were new at the time, the engineers wanted to improve on those models. This reexamination of the virtual model and the forces present on the joins is described in "Study 3: Hybrid Model," p. 66.

Following preparation of the hybrid model, different joining scenarios were modeled to find the least invasive and stress-inducing method of repairing the vulnerable left knee join. Possible options included: adhesive only; adhesive plus a pin connecting the thigh and the wedge fragment (thus counteracting the shear condition of the fracture); and



58a–c. Three proposed joining techniques for *Adam*'s left knee examined with finite element modeling. Left: adhesive only. Center: pin from thigh to wedge. Right: pin from thigh, through wedge, to calf

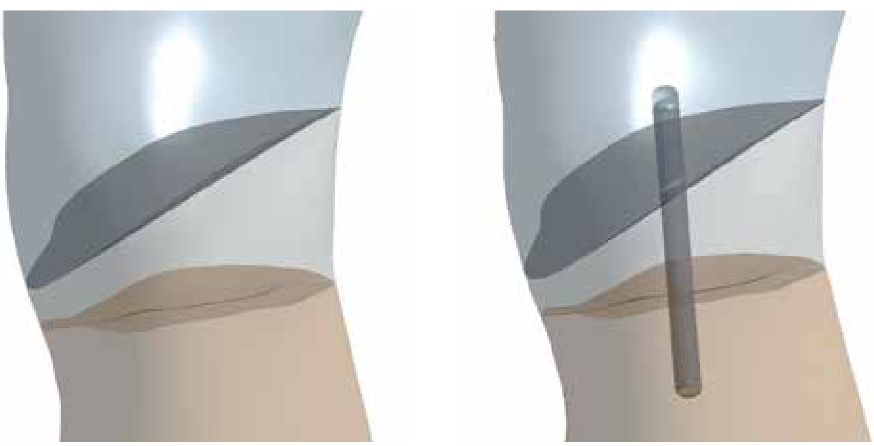
adhesive plus pin starting in the thigh, passing through the wedge, and ending in the calf fragment (Figures 58a–c). In this last scenario, the pin would theoretically transfer the sculpture's load directly from the left thigh to the left calf, preventing additional stress on the wedge-shaped knee fragment. But we needed to know if introducing a pin at this juncture would distribute and/or relieve the stress on the fracture.

Beginning with the existing model from Studies 1 and 2, CAE Associates recommended performing a force distribution study to determine the static load on each leg and on the tree trunk. In "Standardization of the Stiffness Value" (pp. 70–71), we explained that flexure elastic modulus of the marble was determined and that this value differed substantially from the reported elastic modulus of marble in compression. Because the reported value had been incorporated into the models in Studies 1 and 2, and because the newly determined flexure modulus was determined to be a better indication of failure in the sculpture, it was proposed that the results of the modulus as well as the materials testing on the Brazilian disk specimens be integrated into the finite element model.[99]

Once the new marble characteristics were satisfactorily incorporated into the model, the next step was to create a model specifically of the knee, known as a submodel, which could be used to try out various pinning and adhesive options. Finally, the results of the submodel testing were applied to the complete model, thereby predicting the sculpture's response to a pinned knee. The hybrid model previously described (see "Study 3: Hybrid Model," p. 66) was developed specifically for this purpose.

CAE Associates performed several analyses to compare the stresses between a pinned join and one joined with adhesive only (Figures 59a,b). Several models were created to determine which portion of the join is most critical in the knee section: the upper wedge to lower thigh fragment connection or the lower wedge to calf fragment connection. This analysis was performed to determine which of the three aforementioned proposed joining scenarios would be most effective. In addition, the pin was modeled with a low-friction surface to emulate a sleeved pin (see "Pins and Reversibility," pp. 73–74). Running through multiple scenarios helped to build a mathematical model that could gauge a pin's response should either of the joins have a cracked interface and clarify how a crack in the knee would affect the remainder of the structure. What, for example, would happen if the bond should fail between the lower thigh and the wedge? Would the pin safely carry the load? What if there were no pin?

This analysis revealed that failure of the adhesive bond on the upper surface of the wedge would present a far more



59a,b. Examples of finite element submodels of left knee. Left: adhesive-only join. Right: fiberglass pin from thigh, through wedge, to calf. The pin in this model is larger than the one ultimately used in the sculpture. Diagram: CAE Associates serious problem than losing cohesion on the lower surface of the wedge. A failure in the lower wedge surface would cause some redistribution of force, but much of the stress could be carried safely within the knee. Significantly, a loss of cohesion on the upper wedge join would produce a spike in the stress at the tree trunk–hip connection. In other words, the model showed that if there were no pin to hold the knee join in place during such a hypothetical adhesive failure, the hip section would become vulnerable. It was clear that the upper wedge join was one of the most critical in the sculpture and that a pin in this location could safely carry some of the resulting load due to adhesive failure, while the remainder would be distributed evenly throughout the sculpture.

Was a Pin Necessary?

Every engineering project requires the assessment of different goals, a kind of balancing act. In our case we had a new understanding that drilling for the insertion of pins could potentially weaken the marble, an understanding we needed to balance against the knowledge that pins would reduce or eliminate creep while the adhesive sets. These understandings address failure modes at two different stages in the life of the join: the former in the longer-term life of sculpture after conservation, and the latter during the conservation process itself. While the analysis had provided many possible scenarios, the final decision would need to incorporate the accumulated experience and expertise of the conservators as well as the input of our consulting engineers.

The method of pinning under discussion called for a ¼ inch (0.64 cm) diameter fiberglass pin to be inserted into a hole drilled into the thigh fragment, through a hole in the knee wedge, and terminating at a hole in the calf fragment. The exact length of the pin was based on the suggested 8:1 length-to-diameter ratio, but with extra length added to accommodate the insertion through the wedge fragment, yielding a total length of 4 inches (10.2 cm). The proposed join would use the reversible B-72–B-48N blend on the fracture surfaces and cast-in epoxy resin sleeves within the drilled holes.

When the sculpture was first placed in the armature, we had difficulty stabilizing the knee's complicated shear join, and the need for a pin seemed obvious. However, when the time came to make a decision on pinning the knee, the conservators had refined the armature in this area so that it was well stabilized (see "Left Knee Armature Modification," p. 96). Several concerns were then debated. Was a pin necessary to counteract adhesive creep in the initial stages of the joining process? Or would the armature provide sufficient support while the adhesive reached full strength? And would the adhesive alone be sufficiently strong to stabilize the join over the long term? If pins were to be used, it was agreed that fiberglass would have a major advantage over stainless steel if the sculpture should ever encounter another impact. However, the flaw introduced by drilling pinholes was judged to be a serious enough problem to make us reconsider our strategy. Should pinholes be avoided altogether? So important was this decision that in the section that follows we present both sides of the argument—to pin or not to pin—to illuminate the decision-making process and the complexities occasionally encountered during a conservation treatment.

The Arguments for an Adhesive-Only Join

The primary argument against pinning was that the forces acting on the left knee were not substantial enough to justify weakening the marble by drilling holes in it. The maximum shear stress on the wedge fragment's upper surface was determined in the finite element analysis to be approximately 30 psi (0.207 MPa), focused specifically on the rightmost portion of the wedge. The left leg is not an isolated element, but one of a series of interconnected forms that reinforce each other, aided by the two other members (right leg and tree trunk) supporting the weight of the sculpture. For the left knee to creep, the joins on the right leg, hip, *and* tree trunk would also need to creep. It is helpful to imagine *Adam*'s engaged right leg as the anchor of the figure, since it stands within the line of the sculpture's center of gravity. Considering the forces at work in these areas where shear and compressive stress do not exceed 40 psi (0.276 MPa), it seems highly unlikely that any of the adhered joins would fail. Testing had confirmed that the strength of the chosen B-72–B-48N blend would be sufficient under the maximum compressive, shear, and tensile loads present in the sculpture, assuming that the joins were immobilized long enough for sufficient solvent evaporation to occur.

Another argument against pinning concerned reversibility. A drilled hole removes original material that cannot be replaced and thus, by definition, contradicts conservation theory's preference for reversible treatments. Furthermore, introducing a hole in a seriously fractured area like the knee wedge creates risk; it can be considered analogous to the methods of splitting stone. By drilling a hole, one theoretically sets up a condition of infinite stress at the end of the hole; it is this stress that initiates the propagating crack when splitting stone with feathers and wedges. Thus it would not be the presence of the pin that would constitute the risk, but the pinhole itself.

Further supporting the argument against pinning were the good performance of the adhesive-only fractured cylinder specimens, the absence of creep in the Carrara cylinder experiment, and the conservators' judgment, based on trial runs, that the armature would hold the join securely as the acrylic adhesive reached full strength. The conservators' hands-on experience was an important element in weighing the options, since decisions in complex conservation treatments cannot be based solely on numbers, quantification, and engineering, valuable as they are.

The Arguments for Pinning the Join

The argument for pinning rested on a different assessment of the stated risks. As we have seen, the primary argument for inserting a pin was to address the risk of adhesive creep during setting. While some empirical tests showed that the joins were secure after three months, the result of the experiment on the *David* replica's arm proved otherwise. That join had been allowed to set for three months but began to creep almost immediately after a load was placed on it. It is true that this join differed from that in *Adam*'s knee primarily because it had failed in tension, and the forces on *Adam*'s knee would be compressive and shear. Nevertheless, the join had failed, and that result supported the use of a pin.

Additionally, a pin in place would overcome uncertainties about the length of time it would take for the adhesive to set. The solvent evaporation tests remained inexact and were not able to provide precise guidelines for determining when solvent had sufficiently evaporated from the adhesive film for it to be at full strength. We were proposing to set the pins into epoxy resin sleeves and to bond the fracture surfaces with acrylic adhesive. Because epoxy resins have a known cure time, the join is essentially locked in place once the epoxy resin cures inside the pinhole; the pin resting snugly inside its sleeve would then act as a mechanical break against any potential creep during setting. Epoxy's relatively short cure time could thus allow us to move more quickly to the next step in the assembly with the assurance that the join was securely held in place.

Inserting a pin could also address the risk of minor movements within the armature. Although the armature had been modified to hold the knee join in place, it remained a difficult join to assemble securely. The planned sequence of the assembly further suggested that pinning would be prudent. After the legs were fully reconstructed, we planned to attach the arms and head. To do so, the supporting armature and corset would have to be removed and the sculpture would become freestanding. At this point, a pin bridging the join that had been determined by finite element analysis to be one of the most critical in the sculpture would constitute additional insurance against movement.

Drilling a pinhole at the knee was admittedly invasive, but the intervention would be minimal compared to past practice, as the proposed pin would be significantly smaller than those traditionally used, with less stone removed in the drilling. And, unlike the former practice of anchoring pins, the proposed sleeved pinholes provided a measure of reversibility. Hence we could be reassured that any decision to pin had been informed by an exploration of past practices and a mitigation of the problems introduced by traditional methods.

The Decision to Pin the Left Knee

We ultimately resolved to pin the left knee, a decision that flowed from several conclusions reached during our research. We knew the pin would act as a short-term mechanical lock against creep without introducing stress to the surrounding marble. Comparing the materials research results of the fiberglass fractured cylinders with the results of the adhesive-only specimens, we found no significant difference in their performance. Finally, finite element modeling showed that, in case of adhesive failure, the presence of a pin would help distribute the load throughout the sculpture rather than directing stress toward the already compromised tree trunk–hip connection.

Precedent also mattered. A choice for which there is no precedent, as not pinning would have been, would have added a further layer of risk. So past practice also informed the decision to drill holes and pin the knee. Even including the knee pin, the pins used in *Adam* would number only three—an unusually low number for the reconstruction of a damaged sculpture of this size and stature (Figures 60a,b).

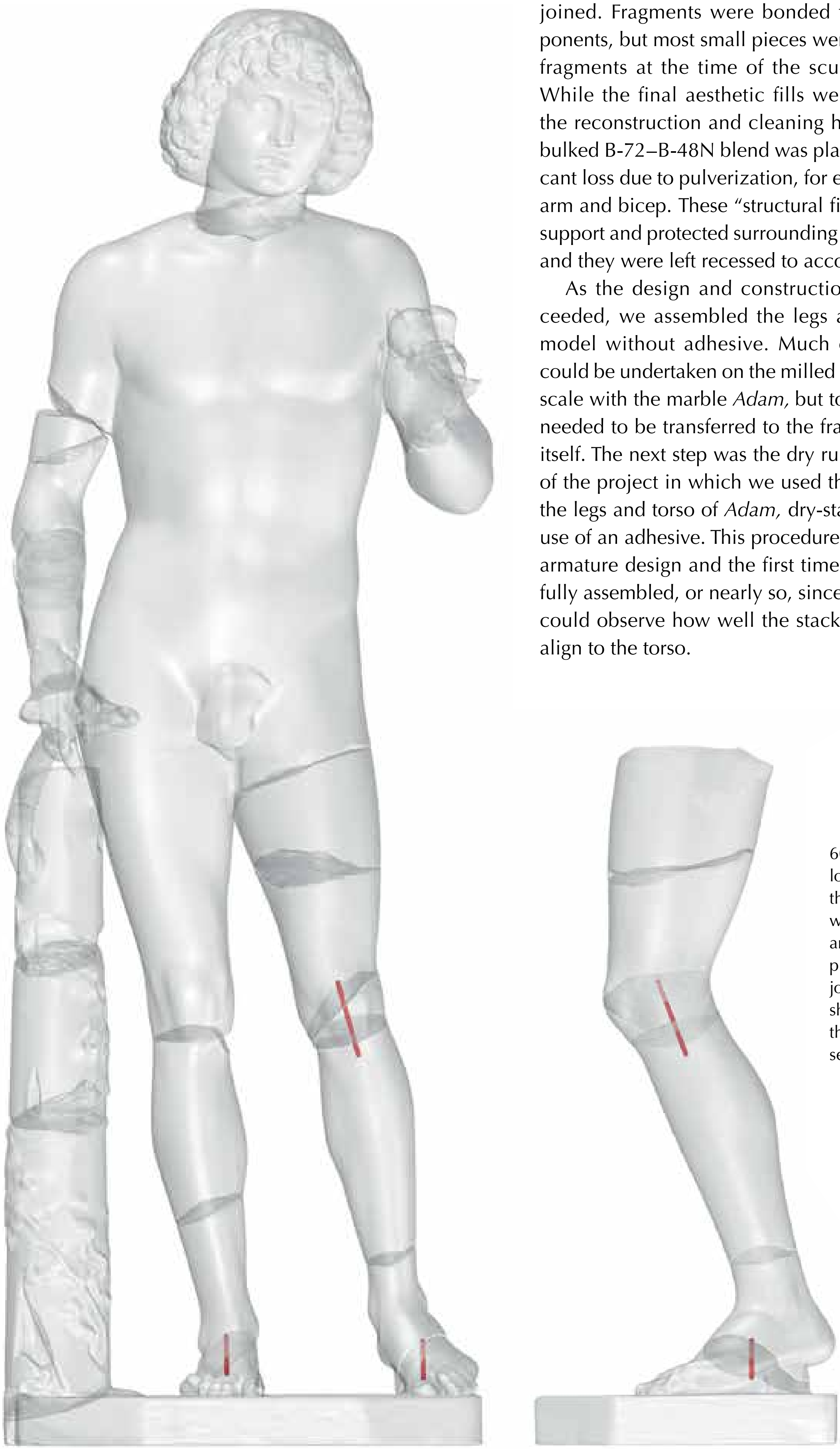
TREATMENT OF THE SCULPTURE

As decisions were finalized, the treatment of *Adam* could begin. It is important to note, however, that the many processes laid out in linear form in this article were actually occurring simultaneously. Testing and analysis took place even as the armature was being developed. Each process informed the others as we moved forward continuously from theory to practice. The treatment of the sculpture involved two distinct phases: reconstruction of the broken fragments, and surface cleaning and filling. The reconstruction, from assembly of the armature to final placement of *Adam*'s head, is described in detail to illustrate the decisions, complications, and subsequent resolutions as the assembly progressed. The methods and philosophical issues related to the cleaning of the marble and its subsequent filling are also highlighted.

Preparation for Assembling the Sculpture

As small fragments with external surfaces were sorted and their locations on the sculpture identified, some were joined, using the same acrylic resin adhesive blend we would use later to bond the major joins (see Figures 5a–d). For example, once the majority of the fragments for the upper portions of the tree trunk were found, they were joined. Fragments were bonded for other isolated components, but most small pieces were bonded to their major fragments at the time of the sculpture's reconstruction. While the final aesthetic fills were not carried out until the reconstruction and cleaning had been accomplished, bulked B-72–B-48N blend was placed in areas with significant loss due to pulverization, for example in the right forearm and bicep. These "structural fills" provided immediate support and protected surrounding fragments from damage, and they were left recessed to accommodate the final fills.

As the design and construction of the armature proceeded, we assembled the legs and torso of the milled model without adhesive. Much of the armature design could be undertaken on the milled model, which was 1:1 in scale with the marble *Adam,* but to perfect it, the armature needed to be transferred to the fragments of the sculpture itself. The next step was the dry run, one of the milestones of the project in which we used the armature to assemble the legs and torso of *Adam,* dry-stacking them without the use of an adhesive. This procedure was a critical test of the armature design and the first time the sculpture had been fully assembled, or nearly so, since the accident. At last we could observe how well the stacked leg fragments would align to the torso.



60a,b. Diagram showing the location and angles of the three fiberglass pins. One pin was inserted into the left knee, and one in each ankle. The pins were located where the joins were under compressive-shear force. Left: seen from the front. Right: the left leg seen from the side

61. *Adam*'s torso being lifted into its armature for the first time. The corset was used to suspend the torso from the bridge crane. Nylon slings were used to reorient the torso before threaded rods were inserted into the corset flange.

Once the dry run had been successfully executed, we rehearsed the processes of assembly, modifying them as necessary to gain confidence in our approach. It was during this preparation phase that the drilling and pin insertion processes were fully developed.

Dry Run: First Trial Assembly

In preparing the joins for the first dry assembly of the legs and torso, we used small needles and scalpels to remove loose grains on the fractured marble surfaces that might have prevented perfect alignment. Next, the leg fragments were placed in their carbon fiber straps and stacked one by one, using the ball joints to secure them into the armature framework. Meanwhile, using a multistep process in which the torso was maneuvered with nylon slings, we brought the torso from a prone to a vertical position and fit its carbon fiber corset snugly around the waist (Figure 61). It was then suspended from the bridge crane with threaded rods terminating with coupling nuts and positioned out of the way of the stacking process. Once the leg fragments were in the armature, the lift table was lowered, and the torso was safely maneuvered into position (Figure 62).

At this point, the lift table could be raised to bring the break edges close together, making it easier to gauge how to rectify the position of the torso. The adjustability built into the armature proved highly functional, as we were able to change not only the pitch and pivot of the torso but also its position—left and right, forward and back. Within an hour, the torso was adjusted into the correct position over the legs, and the lift table was slowly raised to close the joins. Everything aligned, and the armature provided excellent support for the fragments. We noted several areas, primarily on the left leg, that would need further bracing to counteract the shear and tensile forces acting on the joins (see "Left Knee Armature Modification," p. 96).

With the alignment perfected, the fine adjustment capability of the lift table could be exploited to raise the legs a bit more so that they would take on most of the weight of the torso and provide the self-clamping action we planned. In this position, the corset only partially supported the weight of the torso. After the completion of the dry run, the leg fragments were then removed from the armature and laid safely aside until we were ready to drill the pinholes for the ankles.

Drilling Pinholes

Drilling into stone at precise angles for the purpose of connecting two fragments is complicated by the difficulty of aligning the pinholes. On an uneven fracture, it is nearly impossible to hold a drill steadily enough in the hand to guarantee that it remains at the correct angle. Furthermore, when drilled by hand, pinholes are rarely successfully aligned on the first try, and it is often necessary to enlarge the holes with repeated drilling until a pin can be inserted into the marble without affecting the alignment of the fragments. To minimize the size of the pinholes and ensure precision in their creation, we developed a special drilling assembly.

62. *Adam* during the dry run. The sculpture was placed into its treatment armature for the first time, making it possible to check the alignment of the stacked leg fragments with the torso. The large torso fragment could be maneuvered to the right or left by means of the overhead rail system to provide better access to the leg assembly. The small-scale model of *Adam* can be seen on the lower right.

63. Ankle-drilling armature. With the rigid armature resting on the lift table, the ankle fragment was aligned to the base and locked in place with its ball joints. Next, the rigid armature was lifted to allow insertion of the riser (highlighted in yellow), providing space for the drilling assembly (highlighted in tan).

64a,b. Preparing to drill the left ankle. Top: the left ankle fragment rests on the base and the carbon fiber strap has been attached to the rigid framework, locking in its alignment. Bottom: the left ankle fragment is suspended in the armature after insertion of the riser. Red laser lines projected onto the armature were essential to maintain alignment of the fragments.

65. Alignment of the drilling device. Drilling was accomplished with a bench lathe turned on its side and attached to a linear actuator. In this illustration, the drill bit is attached to the lower axle of the bench lathe, prepared to drill downward into the base. The right ankle fragment is suspended above the drilling device.

66a,b. Drilling the left ankle. Left: the pinhole is being drilled down into the base. Right: the corresponding pinhole is being drilled up into the left ankle fragment. Note that the drill is making a hole perpendicular to the base of the sculpture. Water was used to cool the diamond core bit and flush out the marble dust generated during drilling.

Ankle-Drilling Armature

The ankle-drilling armature was designed to take advantage of the existing rigid structure made to support the leg fragments. The insertion of an additional structure beneath it, which acted as a riser, created a space between the ankle and the base while preserving their orientation in relation to each other (Figure 63). With the base and the ankle fragment held apart—immobilized and aligned—a drilling assembly could be inserted between them. The arrangement, which could be used for both the right and left ankles, allowed us to drill up into the fragments and then down into the base without having to realign any of the components. Laser levels capable of projecting plumb lines were critical to the effectiveness of the drilling armature and were used to monitor and maintain the alignment between the ankle and the base, as well as with the drilling armature (Figures 64a,b).

The device used for drilling was a small bench lathe.[100] It proved to be ideal because, when turned on its side, it provided two points of attachment for a drill bit, perfectly aligned along a vertical axis. To convert the bench lathe into a drill press of sorts, it was attached to a linear actuator, a device that creates controlled motion along a fixed axis. By rotating a handle at the top of the device, the external plate holding the bench lathe moved along the length of the unit (Figure 65).[101] In this way, the bench lathe could drill both up and down without the need for flipping or repositioning the device (Figures 66a,b). The armature design ensured that the holes were perfectly aligned within extraordinarily tight tolerances—a clearance of only 1⁄32 inch (0.08 cm) between the 1⁄4 inch (0.64 cm) diameter fiberglass pin and the walls of the drill hole. The drilling itself was accomplished with custom-fabricated diamond core bits, which cut by gently abrading the marble. As drilling progressed, an intermittent stream of water was flowed into the drill hole, cooling the bit and stone while flushing away the marble dust generated during drilling.

Knee-Drilling Armature

A separate drilling armature was designed to make the pinhole in the left knee. This pinhole needed to travel from the lower left thigh, through the wedge, and into the calf

67. Knee-drilling armature. This armature placed the fragments of the left knee in an inverted orientation. The bonded thigh-wedge fragment was stabilized on a custom-fit support, and can be seen here resting on the table. The calf fragment is suspended above it, locked into the rigid framework.

fragment. The knee-drilling armature was similar in concept to the one designed for the ankles except that it oriented the knee and calf fragments in an inverted position. Due to *Adam*'s contrapposto stance, his relaxed left leg is bent forward and also leans slightly inward toward the right leg. The angle of this pinhole had to follow this complex three-dimensional line rather than be placed vertically (see Figures 60a,b). Such an alignment was difficult to achieve even with a special drilling armature. The alignment of the hole in the left knee was further complicated by its length (4½ in. [11.4 cm] overall), requiring the same high precision over a relatively long distance.

To simplify the drilling arrangement, the wedge fragment was bonded to the lower left thigh fragment. Once those two fragments were connected, we had only an upper (thigh-wedge) and a lower (calf) fragment to manage. The upper fragment was inverted in the armature, resting on a support, while the lower fragment, also inverted, was oriented above it, suspended in its own armature of rigid Unistrut framework, carbon fiber straps, and ball joints (Figure 67).

As with the ankle armature, the drilling assembly was placed between the fragments, their precise relative positions maintained by laser level lines. This armature enabled us to make two holes in exact alignment through the knee. When the 4 inch (10.2 cm) long, ¼ inch (0.64 cm) diameter pin was inserted into the hole, the fragments aligned perfectly. There was no need to enlarge the holes.

Inserting Pins

Once the holes were successfully drilled, we could turn to the matter of inserting fiberglass pins by means of cast-in epoxy sleeves. We developed a reliable method for making the sleeves by practicing on small mock-ups. Prior to inserting epoxy resin into the sculpture's pinholes, a thin barrier coating of B-72 was applied to the marble inside the pinhole and allowed to set for several days.[102] This step ensured reversibility of the epoxy within the pinhole and has the additional benefit of preventing the adhesive from optically saturating (darkening) the marble. Another important step in creating the cast-in sleeve was to apply a release agent to the pin prior to inserting it into the epoxy resin–filled pinhole, thereby ensuring that the pin could be removed after the epoxy cured.[103]

To create the sleeve, epoxy was bulked with glass microballoons until it formed a workable putty.[104] The bulked epoxy was then placed inside the upper hole to approximately one-third the depth of the hole. The pin with release agent was inserted into the soft epoxy, displacing it so it filled up the hole just shy of the fracture surface, and then the upper fragment was placed onto its mating fragment. This step allowed the exposed portion of the pin to properly align itself into the lower hole (currently empty) while the epoxy in the upper hole cured. The following day, when the pin was pulled out of the epoxy resin, a cast-in, tightly fitting epoxy sleeve remained.[105] This process was repeated for the lower hole once the upper sleeve had fully cured.

When the join was ready to be finalized, the pin was returned to one-half of its sleeve, and the B-72–B-48N blend was used to bond the joining fracture surfaces. We used full-length cast-in epoxy resin sleeves in all three pinning locations, creating a completely reversible pinning setup. If *Adam*'s pinned joins have to be reversed at some time in the future, conservators need only use solvents to dissolve the acrylic resin adhesive blend on the fracture surfaces, and the pin will slide out of its sleeve.

Assembling the Sculpture

Throughout the project, the logistical plan for assembling the sculpture was intentionally kept fluid. While the overall strategy was to assemble the legs first, then attach the torso, followed by the arms, we reevaluated the proposed order after each join was completed. We expected to start with the ankles, thinking it would be possible to assemble the legs from the feet up to the torso. However, each fragment posed its own complications, modifying our expectations of the joining sequence. Following is a description of the assembly process presented more or less chronologically, noting the challenges and solutions that occurred along the way. All joins were accomplished by at least two conservators working together.

Tree Trunk: Join 1

The first adhesive bond of large fragments carried out on the sculpture was on the tree trunk—on September 16, 2010, nearly eight years after the accident. Because it was not possible to affix all three fragments of the tree trunk to one another *and* to the base, the upper and middle fragments on the tree trunk were bonded first. The trunk connects to the torso at the back of the right hip, and as the legs had not yet been assembled, that join could not be accomplished. Instead, we simply joined the top two fragments of the tree trunk to each other by dry-stacking all three tree trunk fragments onto the base and then applying with a brush the B-72–B-48N blend between the top two fragments.

Because the tree trunk terminates midway up the sculpture, the self-clamping method devised for the legs and the torso could not be used. Thus, to hold the join in place while the adhesive set, a long clamp was applied vertically. Some adhesive squeezed out of the join during clamping—a good indication that it was covered with a consistent film of adhesive. The reversible adhesive chosen does not optically saturate, or darken, Carrara marble, and could be simply wiped away with acetone.

The clamps were removed after one week, but the tree trunk was left assembled on the base for more than a month to allow the adhesive to set fully. At this time, using the acrylic resin adhesive blend, we were also able to attach the many smaller surviving fragments that had come from this upper section of the tree trunk, including those of the bird and at the point of the connection between the now joined parts of the trunk. The joined top two fragments, as well as the lower fragment, were then removed from the base and set aside. The whole tree trunk assembly would have to wait until the trunk could be bonded to both the base and the hip, and that connection could not be made until the leg assembly was completed, two years later (see "Tree Trunk: Joins 2 and 3," p. 99). In short, the reassembly process did not simply start at the bottom of the sculpture and move upward. The progression was complex, needing to account for adhesive setting times, the shapes of the fragments, and the stresses that would be placed on joins as they were accomplished.

Right Arm and Hand Assembly

Because of the trajectory of the sculpture's fall from the collapsed base, elements on *Adam*'s right side were the most severely fragmented. The delicate branch extending from the tree trunk to *Adam*'s right hand snapped into several pieces and suffered extensive losses at its base. The right arm was also badly damaged because it took a direct impact with the full force of the fall, as indicated by the break pattern. The arm broke away from the torso just above the bicep, and the forearm split down the middle, suffering pulverizing losses that left a vertical space wide enough for light to pass through (Figure 68). In all, the right arm and hand broke into seven major pieces with dozens of associated small fragments that make up the wrist and little finger, and the location and documentation of these fragments continued even as materials research progressed and the armature was developed.

68. Fragments of *Adam*'s right forearm, vertically oriented and stacked without adhesive

Because of the multitude of fragments and the position of the right arm, we decided to treat it as a discrete zone, fully assembling it apart from the rest of the sculpture. In any case, it could not be attached to the torso until the corset was removed, so we planned on bonding it to the sculpture as a single unit once the legs and torso were fully assembled, freestanding without the armature. There was some risk in this approach, however, as it would not be possible to check the connections between arm and torso until the corset was removed. Moreover, the right arm attaches to the

69. Right arm assembly armature. The right arm was assembled independently of the rest of the sculpture. To attach the assembled arm to its hand, a small armature was designed to hold the arm vertically while the hand was immobilized in a padded box below.

torso at two places—at the shoulder and via a small strut between the wrist and the front of the right hip—and this dual connection meant that the length of the arm after assembly would be critical to its proper alignment. The degree to which bond-line thickness would add to the length of the arm could not be predicted with absolute precision, but with so many joins in such a small area, the use of an adhesive with a minimal bond line was as crucial here as it was in the legs.

The assembly of the right arm and hand progressed throughout the summer and fall of 2010, commencing with bonding the forearm fragments to the elbow. Where the vertical split in the forearm was so great as to be unstable, plaster was used to create a structural fill between the fragments. The subsequent attachment of the right hand to the forearm was additionally complex because the fragments had broken away from the hand at a sharp angle. Moreover, the fracture surface was smooth, leaving little frictional interface to aid in aligning the fragments. This attachment required the development of a new carbon fiber strap on the lower forearm to hold the large assembled section of the arm upright in a rigid armature.

Once again, a supporting strap was fabricated on the corresponding fragments from the milled *Adam* and then transferred to the marble arm. This small armature also used ball joints to hold the forearm in a vertical position so it could be suspended over the hand, which was braced in a padded box below the arm (Figure 69). Large gaps in the wrist join were filled with bulked adhesive,[106] and to ensure a good join, the assembly was clamped for several weeks. During this time we attached many tiny fragments to the arm. In addition, we further filled the large loss along the repair of the forearm, adding strength to the area (Figure 70).

70. The right arm fully assembled. The fragments surrounding the extensive loss to the forearm were further supported by the addition of a recessed structural fill.

Left Arm Assembly

The next adhesive join was *Adam*'s left arm. It had broken away from the torso in one large fragment at an acute, almost vertical, angle. A combination of forces would act on this join: the downward forces of gravity would create shear forces along the fracture, but the arm extends forward from the body, creating a cantilever in which the arm fragment pulls down and back. As a result, the top of the shoulder join would experience compressive and shear forces, while the bottom of the join would be primarily in tension. Furthermore, the area around the fracture was internally damaged from the impact of the fall.

We considered pinning this join and even went so far as to design a drilling setup for it, but the nature of the break deterred us. We determined that the angle of the fracture was so close to vertical that drilling would be especially risky, and no good location for a pin could be identified. Instead, we decided to affix the join using a B-72–epoxy

71. Bonding the left arm to the torso. The left arm was attached before the torso was placed into its corset. A simple clamping arrangement was used to secure the fragment.

resin sandwich rather than the B-72–B-48N blend.[107] Because the left arm is a terminal element on the sculpture, the increased bond width of a sandwich was not a concern in the way it was with the legs, where the sandwich was avoided because testing determined it would cause an unacceptable amount of displacement. The use of epoxy resin adhesive had the added benefit of providing a known cure time, at which the join would reach full strength.

When the torso was lifted in its corset for the dry run, it became clear that the left arm join needed to be accomplished before the torso was put into its corset. The logistics of supporting and immobilizing the left arm while the torso was suspended in its corset were simply too complicated and would risk further damage to the fragments. The left arm was therefore attached while the torso was lying in a horizontal position. The torso and the arm fragment were oriented so that gravity could be used advantageously; positioning the fracture parallel to the floor greatly facilitated alignment of this large arm fragment (Figure 71). This join was accomplished on November 29, 2010. After the epoxy resin cured, the torso was once again placed in its corset and suspended from the bridge crane, and work on assembling *Adam*'s legs could begin.

Assembly of the Ankles

The ankle pinholes had been drilled in October 2009 (Figure 72), and during November and December 2010 the pins—2 inch (5.1 cm) long, ¼ inch (0.64 cm) diameter fiberglass rods—were inserted into the ankles. At first we had planned to create "potted pins," adhering a pin into one side of the join while preparing an epoxy resin sleeve for the other side. We went forward with the process until results from the finite element modeling of the left knee join led us to opt for fully sleeved pins. Because we had not yet bonded the fracture surfaces of the ankles, we were able to reverse the fiberglass pins potted into the ankles by cutting them back and then drilling them out with a twist drill. We also drilled away the cured epoxy resin, taking care not to enlarge the holes in the marble. We then began the process of inserting fully sleeved pins, but only into the upper fragments. Completion of the lower portion of the sleeves was put on hold until the armature could be further refined.

By September 2011, the armature was fully designed and we were ready to join both ankles. The fiberglass pins, already prepared with the release agent, were inserted into the

72. Overhead view of the base after the ankle pinholes were drilled

73. Completion of the ankle joins. The ankle pins were set into epoxy resin sleeves, and the fracture surfaces were bonded with the B-72–B-48N blend. After the sleeves had cured, the carbon fiber armature straps could be removed.

previously prepared upper epoxy resin sleeves of the ankle fragments. Then the lower pinholes were partially filled with bulked epoxy resin. The B-72–B-48N blend was applied by brush to the upper fracture surface. The amount of adhesive applied was not measured precisely; rather, the focus was on good coverage of all areas of the fracture surface, as we recognized from our testing that a consistent film over the entire surface was critical to a good adhesive join. The fragment with the adhesive layer and the pin in its epoxy resin sleeve was immediately put in place and firmly pressed down by hand, applying a gentle rocking pressure without imparting any significant movement to the fragment itself. This important step helped to move adhesive through the join and thin the adhesive layer by squeezing out the excess.

The ball joints were then put into place, but only lightly tightened down. Once both ankles were in place, the remaining leg fragments were assembled, but without adhesive. As in the dry run, the lift table was slowly raised to bring the legs to meet the torso, just enough to allow the full weight of the sculpture to be applied to the newly bonded joins. By reassembling the sculpture each time adhesive was applied to a fracture, the alignment of all of the fragments could be closely monitored.

The sculpture remained immobilized until the epoxy resin was fully cured around the pins, locking the ankles in place and acting as a mechanical break from creep during setting. After about ten days the carbon fiber straps that were supporting the ankle fragments could be safely removed (Figure 73), but the sculpture was left in place, dry stacked in its armature.

Left Knee Armature Modification

As we have seen, the left knee was one of the most difficult joins. Over time, the armature holding it in place was continually adjusted, but we concluded that the carbon fiber straps and ball joints were not sufficient to fight the shear forces present in this join. The relatively smooth upper wedge join would experience shear force, while the large calf fragment that is angled forward had to be properly supported to prevent separation of the join at the top of the ankle, the back of which would experience tension. All these fragments needed to be locked in place, so in May 2011, special braces made to conform to these areas on the sculpture were attached directly to the armature.

These braces were made of easily conformable epoxy resin putty.[108] Small wads of this putty were applied directly to the metal components of the armature on two sides of the left knee. With a layer of plastic wrap in place to protect the stone, the putty was pushed against the correctly aligned fragments and allowed to cure. This process created small pads to brace the sliding fragments in place. One epoxy resin brace was placed on the left leg just below the kneecap, keeping the large calf fragment from pitching forward. Additional braces were placed on the inner knee to keep the lower thigh fragment from sliding down the slope of the knee wedge (Figures 74a,b; see also Figure 77). This modification added a great deal of stability to the armature and made it simpler to put the fragments back into correct alignment when they had to be taken on and off the armature.

Upper Left Thigh Assembly

With the final modification of the armature around the left knee completed, we were confident that all the fragments were successfully immobilized. We then undertook the join between the upper left thigh fragment and the torso, as this bond would simplify the leg-thigh connection for future joins. This large fragment connects at the very top of *Adam*'s thigh, while a small vertical section connects to the inner right leg. This slight link between the legs made it difficult to raise and lower the leg fragments without causing the torso to shift to the right. Furthermore, the fracture surface at its bottom had a more horizontal geometry, making it a better choice to be the available connection between the legs and the torso as work progressed.

To attach this join, the lift table was lowered, allowing the torso to be maneuvered to one side. Next, the upper thigh fragment was removed and set aside. As before, the join was cleaned with a soft brush to remove any dust or loose grains of marble, and the B-72–B-48N blend was applied. The fragment was put back in place on the assembled leg fragments, the torso returned to its correct position, and then the lift table was slowly raised to close the join. This particular fragment did not have a carbon fiber strap but instead was held in place by the upward pressure of the lift table (see Figure 7). Following attachment of the join, on June 13, 2011, the sculpture was allowed to remain in its closed self-clamping position for more than one month. Then we separated the legs from the torso by lowering the table.

We encountered problems with this join sliding while the adhesive was fresh, and it was difficult to achieve the tight connection accomplished during testing without adhesive. After adhesion, the upper thigh join did not achieve the same tightness as when dry fit. This outcome helped us to appreciate the importance of applying gently rocking pressure by hand to get the tightest possible connection.

Left Knee Wedge Join

On August 17, 2011, the problematic left knee wedge was attached to the lower left thigh fragment in the same process described above, applying adhesive and using the bridge crane and lift table to maneuver the torso and legs and to apply pressure to the join. This very shear join had been hard to align even when dry fit. Although the armature had been modified with braces around the knee, it was still difficult to align and immobilize the wedge fragment with liquid adhesive in the join. As it proved impossible to align it satisfactorily when stacked in place, the wedge and lower left thigh fragments were removed from the armature and taken to the workbench. There the fragments could be inverted—placing the wedge at the top—and gentle rocking pressure was applied by hand until, eventually, excellent alignment and a tight join were achieved. The adhesive was allowed to set for approximately one month before the two fragments, now bonded, were returned to the armature.

Right Calf Assembly

Adam's right leg was broken in just two places, at the ankle and at mid-calf. The top of the calf fragment connects to the torso just below the right knee. With the exception of the ankle join, the remaining two connections in the right leg appeared relatively straightforward, and we undertook these joins on October 5, 2011. However, it took two attempts to attach the right calf to the ankle fragment, as we encountered problems in getting the piece well-seated on its interface. The join rocked slightly after it was put in place, and it was not possible to get the adhesive to move through the interface and achieve a tight connection. We decided to remove the fragment, clean adhesive from the fracture surfaces, and try again the following day.

After rechecking the alignment by dry fitting the fragments in the right calf, we decided to go ahead with attachment because the fragments seemed to be aligning well. We used clamps and tried a strategic arrangement of ball joints to brace the fragment, front and back. Once the supplemental clamping procedure was established, the now standard procedure of maneuvering the fragments and applying adhesive was followed, but this time, we sought to apply a still thinner coating. At last the fragment aligned very well with minimal excess adhesive emerging from the join when hand pressure was applied. With all the other leg fragments in place, we raised the lift table to apply pressure from the torso. The sculpture was left immobile for at least two months before the next join was attempted.

74a,b. Left knee armature modification. Above: the original knee armature was not able to immobilize this complicated join. Left: the addition of form-fitting braces made of gray epoxy resin putty around the knee helped to stabilize the area.

Left Leg: Assembly of Knee and Calf Fragments

By April 2012, the left calf fragment and the wedge-thigh fragment had been placed in the knee-drilling armature and the pinhole had been created, as described in "Knee-Drilling Armature," pp. 91–92. Now it was time to put the left knee pin in place. Once again, we used an epoxy resin sleeve for setting the pin. We made the sleeve in the upper portion of the join first, using a syringe to insert the bulked epoxy resin at the base of the pinhole to avoid creating air pockets.[109] The pin, prepared with a release agent, was then inserted into the epoxy resin. The fragment was inverted and placed on the left calf fragment to ensure proper alignment of the pin, and then the armature was tightened and the leg fragments raised to the torso. Twenty-four hours later, the wedge-thigh fragment was removed from the armature and the pin was pulled out of its hole, revealing the new epoxy resin sleeve.

On June 31, 2012, the base of the left calf fragment was bonded into place. While the difficulties presented by this join had caused some consternation earlier in the project, the immobilization procedure carried out on the armature made affixing this join relatively straightforward. The standard procedure was followed. The join was allowed to set for approximately two months.

After the lower portion of the calf fragment was fully set, we moved back to the left knee to complete the join, including the lower pinhole that passed down into the calf fragment (Figure 75). Because we were setting the pin and adhering the join simultaneously (as was the case with the ankles), we were careful to place sufficient epoxy resin into the lower hole to create a full sleeve but avoid overflow upon pin insertion. On August 21, 2012, the wedge-thigh fragment, with its pin installed and adhesive applied onto the fracture surface, was carefully put in place, and gentle rocking pressure was applied by hand to distribute the adhesive into a thin film. The torso was returned to its correct position, and then the lift table was raised to close the connection between the legs and the torso, putting a slight load on the legs.

Final Leg Joins

On September 20, 2012, one of the milestones in the *Adam* project was achieved, as the last two joins on the legs were bonded. Because this was the final connection between the legs and the torso, both the right and left legs had to be bonded simultaneously. After all the other leg joins had been bonded with adhesive, the two connections remaining were at the middle of the left thigh and just below the right knee. For this procedure, three conservators worked simultaneously: one on each leg, with a third monitoring the overall alignment (Figure 76). Further complicating this procedure was limited access to the fracture surfaces, as the lift

75. Final left knee join. In this photograph, all of the lower leg fragments are bonded, and the pin for the left knee has been temporarily placed in the lower pinhole in preparation to make the epoxy sleeve. The lower portions of suspended torso can be seen at left.

76. Conservators Michael Morris, Lawrence Becker, and Carolyn Riccardelli preparing for the final leg joins. Screenshot from video: Kate Farrell

77. Conservators Michael Morris and Carolyn Riccardelli attaching small fragments at the base of the tree trunk. The braces made to support the left knee are visible in the center of the photograph.

table could not be lowered sufficiently to maneuver the torso out of the way.

The right and left joins were prepared simultaneously with the B-72–B-48N blend, applied this time using a syringe and then spread with a brush to ensure full coverage. The lift table was raised painstakingly, over a half-hour period, allowing the liquid adhesive to be distributed and the joins to close very tightly. Eventually, the lift table was raised to a point at which the torso and corset lifted slightly, signaling that the full weight of the sculpture was now loading the legs, and over the following hours, the joins were monitored carefully. The next day, all the joins were still aligned; small beads of adhesive had formed around the joins—a good indication of a complete coating of adhesive.

Tree Trunk: Joins 2 and 3

With the legs and torso fully bonded together, the bottom fragment of the tree trunk could be attached to the base. This join, accomplished on September 22, 2012, was straightforward and required no clamping. The many small associated fragments that overlaid the major fractures on the tree trunk were attached to the area at this time (Figure 77).

Several weeks were spent studying how to attach the bottom of the tree trunk to the upper portion, now composed of two fragments joined previously (see "Tree Trunk: Join 1," p. 93). In the sculpture the tree trunk stands almost independently, connecting to the right hip by a small strut, approximately 4½ inches (11.4 cm) long. The thin strut was badly damaged in the fall, leaving a small portion attached to the tree trunk and another to the hip but most of it shattering into at least twenty-five small pieces, with much pulverization resulting in areas of loss. When all the large fragments were stacked, it was discovered that the tree trunk did not align perfectly to the hip, although the discrepancy of about 1⁄32 inch (0.08 cm) is not readily observable. We speculated that the misalignment in this area arose from the tree trunk's not having had enough pressure on it when its parts were bonded, making the joins slightly thicker than those in the legs.

The upper trunk was affixed to the lower trunk fragment, and, at the same time, the connection between the tree trunk and the hip was attached using a bulked mixture of the acrylic resin adhesive blend.[110] Bulking the adhesive in this area helped to fill the gap created by the impact. The trunk was clamped horizontally to counteract the slightly shear join between the upper and lower fragments as well as to provide some compressive force vertically. Finally, by November 19, 2012, the small bits of the strut had been bonded in place (Figures 78a,b).

Armature Removal

After the final leg and tree trunk joins had set for more than two months, we could dismantle the armature and remove the corset from *Adam*'s torso. At last, on December 12, 2012, the sculpture was freestanding (Figure 79). It was a triumphant moment.

Left Hand Attachment

The little finger of the left hand was a point of impact in the fall, resulting in substantial loss. However, many fragments survived and were bonded in place in the fall of 2007, and later the area was given a recessed structural fill of bulked B-72 to further protect the small fragments. Because of the vertically orientated connection between

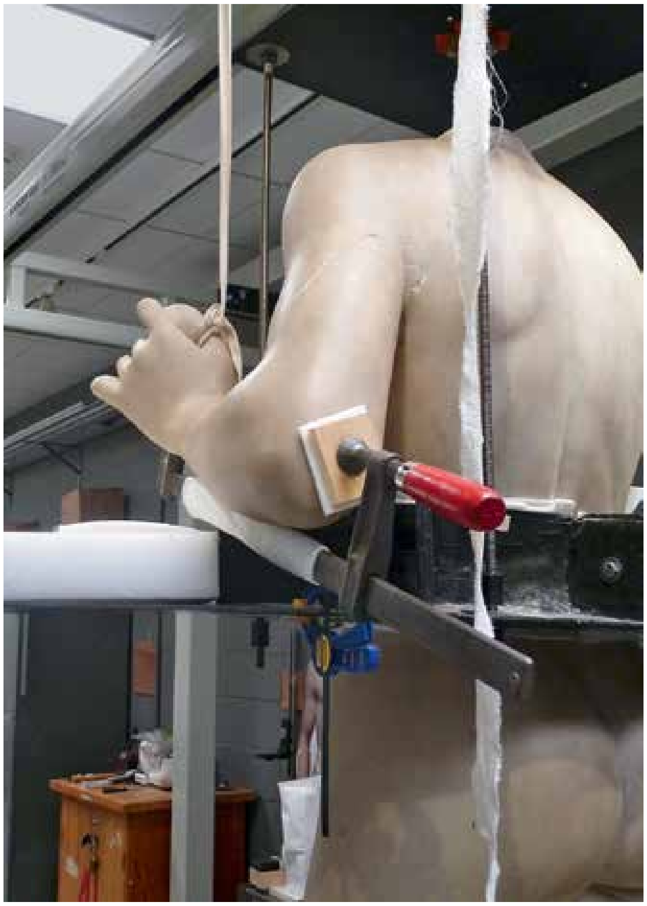
78a,b. Attaching small fragments to the tree trunk–hip connection. Left: the gap between the tree trunk and the hip was filled with bulked B-72–B-48N blend. Right: some of the fragments in place

79. *Adam* after the corset and leg supports were removed. The left hand, right arm, branch, and head are yet to be attached.

the left hand and the arm, the B-72–epoxy resin sandwich was used on this join. The thickness of the join was less of a concern than elsewhere, because the hand is the terminus of the arm. This join did not require a special carbon fiber strap and was simply held in place with a long clamp (Figure 80). To protect the marble surface, a small block of wood was placed where the clamp made contact with the back of the elbow. The elegant area of the palm was protected with a small pad made of epoxy resin putty and silicone rubber molded to the hand while still soft (Figure 81). While the pad cured, a plastic film barrier prevented the material from adhering to or staining the hand. After practicing and perfecting the clamping over a two-week period, the hand was put in place and clamped on December 17, 2012. The clamp remained in place for one week before removal.

Right Arm Attachment

With the armature removed, the focus then turned to determining the best method for attaching the right arm to the torso. After assembly, the right arm was a large, unwieldy fragment that needed to be suspended precisely alongside the torso, tucked under the right shoulder, and aligned at the right hip. It was an especially complicated join, possibly the most difficult in the sculpture. Once again, the milled model of *Adam* was used to fabricate a carbon fiber strap. Rather than being attached to a rigid armature with ball joints, this strap was modeled after the torso corset. A horizontal flange surrounded the strap that allowed the arm to be suspended from the overhead bridge crane by means of threaded rods (Figure 82). This brace had the same adjustability as the torso corset, but the closeness of the arm to the torso and its dual points of attachment made fine-tuning difficult. In this attachment procedure, the arm became the stable element that could be maneuvered away when needed, and the lift table was used to raise or lower the rest of the sculpture to align with the fixed arm.



80. Attaching the left hand. A simple clamping arrangement was used to hold the fragments in place. This image shows a trial setup performed prior to removing the torso corset.

82. Assembly for attaching the right arm to the torso. This carbon fiber support strap was modeled after the torso corset. A flange extended from the strap to accommodate threaded rods that connected to an overhead steel plate. The entire assembly was suspended from the bridge crane, allowing lateral movement of the arm when required.

81. Detail of the left hand while being attached. A small pad made of epoxy resin putty and silicone rubber provided a protective point of attachment for the clamp.

83. Attaching the right arm to the torso. Conservators Carolyn Riccardelli, Michael Morris, and Lawrence Becker work to attach the right arm simultaneously at the bicep and the hip. A cotton twill tape strap clamped the lower portion of the arm to its point of attachment at the hip. Screenshot from video: Stephanie R. Wuertz

On February 6, 2013, we attached the right arm to the torso using the B-72–epoxy resin sandwich. Once again, it was agreed that an adhesive with a known cure time would be crucial to achieving the best result. Taking into consideration the tensile join at the top of the arm as well as the shear join at the wrist-hip and the fact that the join was difficult to immobilize, we believed the epoxy resin was a good solution. To attach the arm, the fracture surface had been prepared with a B-72 layer. Now bulked epoxy was applied to the fracture surface at the shoulder, where there was extensive loss—indeed there were gaps—in the join. However, the connection between the wrist and the hip was tighter, and unbulked epoxy resin was used in addition to a B-72 barrier layer.

The lift table was raised to create space between the arm and the torso, and then the adhesive was applied to both locations simultaneously. The upper join was closed by lowering the table and torso down onto the arm, while the lower join at the hip required an additional clamp to pull it in toward the body. Thus a cotton twill tape strap was tied tightly around the sculpture (Figure 83). After the adhesive had cured for one week, the straps were removed from the sculpture. At this time bulked acrylic adhesive was inserted into the large loss at the top of the bicep. This material acted as a structural fill, helping to increase the bond surface between the arm and the torso.

Branch and Head Attachment

Because there was a lack of overhead clearance in the Tullio studio, it was necessary to move the sculpture off the lift table before the head could be attached. The working base on which the sculpture was assembled was designed so it could be moved with a forklift; thus lowering the sculpture was relatively simple but accomplished with great care. Placed at floor level in the studio, *Adam* seemed completely transformed; we were rewarded with a rare opportunity to see the lifesize sculpture at eye level.

While a strap for supporting and lifting the head was being developed, we attached the branch that extends from the tree trunk to the right hand. The base of the branch had suffered extensive loss, and so it was necessary to add bulking agents to the B-72–B-48N blend to fill resulting gaps (Figure 84). The weight of the branch, composed of many previously assembled fragments, was supported with cotton twill tape tied back to the sculpture. This join was allowed to set for one month before the straps were removed.

While the break at *Adam*'s neck was relatively horizontal, and therefore in compression, it would not have been safe simply to lift the 65-pound head with our hands and place it on top of the torso. Instead, we devised a more controlled method that took advantage of the screw jack on the

84. Attaching the branch from the tree trunk to the right hand. The base of the branch suffered extensive loss in the impact and was filled with bulked B-72–B-48N blend.

85. Lifting strap for attaching head. The basketlike strap was made of cotton webbing and connected to the overhead plate by using buckles to loop the webbing through eye hooks. Visible at the center of the plate is a portion of the screw jack used to raise and lower the head without changing its alignment to the torso.

overhead plate. The screw jack, which allowed movement along the vertical axis, had been installed between the hanging plate and the overhead rail system early in the armature design process but had not yet been put to use. It now provided the perfect way to raise and lower the head once it was suspended from the overhead rail system.

A custom-fit strap system was designed to hold the head in alignment while adhesive was placed on the join, and then the head was lowered down to the torso. With no milled version of the head, we had to work directly on the marble piece. A cotton webbing strap, resembling a basket, was sewn together to ensure that all the connections were tight and could support the load.[111] Four vertical extensions served as points of attachment to the overhead hanging plate; the straps were equipped with heavy-duty buckles to allow adjustment of their length, thereby leveling the head (Figure 85). While on the overhead rail system, the head could be moved away from the sculpture to apply adhesive and then maneuvered over the torso to settle it down into place.

On April 1, 2013, we were ready to join the head. As this was the final join to be closed on the sculpture, the head was attached with some ceremony in the presence of the Metropolitan Museum's director, Thomas P. Campbell, and curators from the Department of European Sculpture and Decorative Arts (Figure 86). Three conservators worked as a team to attach the head. One operated the screw jack to raise the head, which was then positioned to one side to improve access for the application of the acrylic adhesive blend (Figures 87a,b). The head was brought back into place, and then the screw jack was used to lower it onto the torso. Another conservator guided the head down, while the third monitored the position of the strap at the back of the head, preventing it from getting caught within the join. A bit of gentle pressure was applied to the join to ensure the adhesive had spread to a thin layer, but no clamp was used. Because the cotton strap was used primarily for lifting and did not provide a clamping function, it was removed from the sculpture a few days later. Seeing the sculpture at last fully assembled, with the head attached, was enormously gratifying.

Cleaning the Surface

Now that the structural work was completed, it was time to address the aesthetic components of the treatment, which commenced with cleaning the surface. For cleaning, the sculpture was moved to a studio with strong northern daylight. Even before the accident, the sculpture had required cleaning. The surfaces of the marble had darkened with dirt accumulated primarily on the horizontal areas, the tops of *Adam*'s head and shoulders, the base, and the feet (see Figures 88a–d).

86. Preparing to attach the head to the torso. The Metropolitan Museum's director, Thomas P. Campbell (left), is looking on. Photographs of Figures 86, 87a,b: Christopher Heins, The Photograph Studio, MMA

Consideration of the sculpture's cleaning was additionally complicated by past surface applications. Documents as well as analytical results of Renaissance sculptures indicate that fats and oils, among other materials, had been applied to marbles well into the nineteenth century to mitigate salt contamination or to impart gloss.[112] These applications almost always yellow or darken over time. Because marble is unevenly porous and may be carved and finished to various degrees, these fats or oils are absorbed differentially across a sculpture's surfaces. Consequently, those parts of the sculpture that are more porous are likely to have yellowed and darkened more than parts in areas of lesser porosity. Moreover, because these materials were usually not evenly applied, some areas remain lighter. As we observed on *Adam*, the result can be an uneven tonality across the surface. Varying degrees of penetration into the marble were evident upon examination of the break edges of the fragments. In places, the applications had penetrated to a depth of as much as ¼ inch (0.64 cm) into the marble (see Figure 9).

To investigate the surface further, a sample of the yellowed marble was submitted for analysis. The distribution of the fatty acids in the sample suggested the presence of animal fat, perhaps tallow, in addition to alkanes found in wax.[113] Given the relatively deep penetration and insolubility of these materials, it was not possible to extract them from the marble safely. Consequently, a selective cleaning was determined to be the best means for ensuring an even tonality across the marble surfaces. In this way, areas of less yellowing were cleaned more lightly than parts that were more significantly yellowed. A dry—or almost dry—method was chosen: vinyl eraser strips slightly moistened with

87a,b. Conservators Michael Morris, Lawrence Becker, and Carolyn Riccardelli attaching the head to the torso. Left: adhesive was applied to the neck join. Right: the head was lowered into place using the screw jack, which was operated with a hand-held drill.

saliva.[114] This process was considered the most controllable procedure for the cleaning problem (Figures 89a–c). The close conformation of the fragments had caused some excess adhesive to extrude onto the surface, especially at the ankles, and the removal of this adhesive produced a whiter marble surface than deemed desirable for the planned cleaning approach. These areas were toned using pigments in a polyvinyl acetate medium to conform to the level of cleaning of the surrounding areas.[115] Since the torso slid across the patio floor facedown, skid marks were produced on the upper chest and abdomen. The shine of these marks was reduced by dabbing their surfaces with micro-crystalline wax.[116]

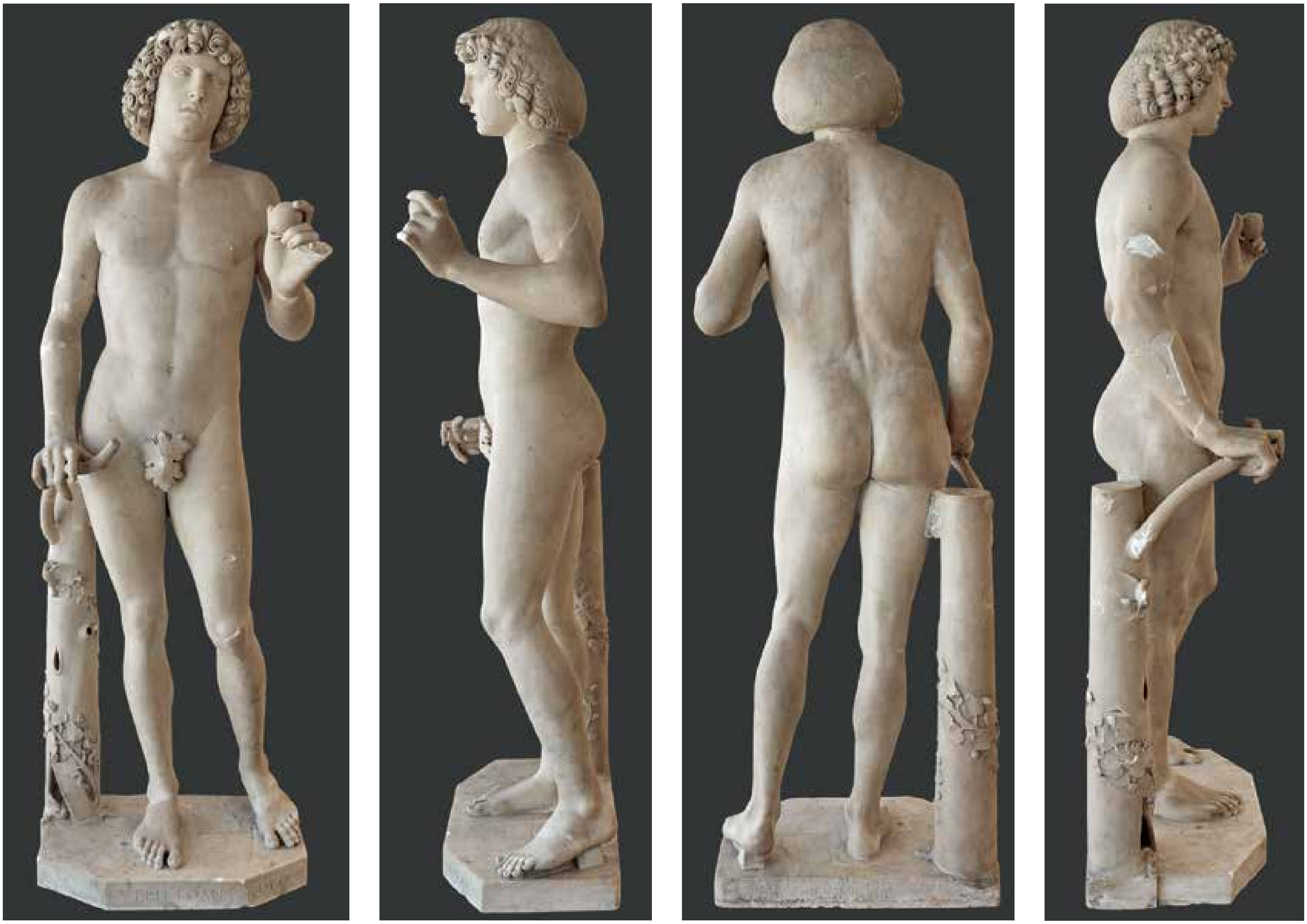
Filling the Losses

Once the cleaning was completed, consideration of the fills could be undertaken. The goal of loss compensation was to integrate the fills as closely as possible with the surrounding stone. We considered this approach necessary in the case of *Adam* for both aesthetic and philosophical reasons. Because the breaks were largely horizontal, if they were left undisguised, they would interrupt the verticality of the figure, so essential to its impact. These interruptions could be corrected only by making the fills less visible. We believed, further, that as the losses were caused by an accident, they did not represent a moment in time that needed to be preserved, or, at least, not by laying the burden of this history on the figure itself. This comprehensive approach to the filling could be further justified by our thorough documentation of the treatment, whereby the sculpture's condition after the accident had been recorded in detail for both scholars and the general public. Indeed, by filling in this way, what art historical opinion of the sculpture would be altered? What attitude of the museum visitor would be changed?

In considering the appropriate filling material for *Adam*, conservators were aided by Julie Wolfe of the J. Paul Getty Museum and by attentive study of her 2009 article in *JAIC* outlining the results of experiments with filling materials for marble.[117] Using her research as a starting point, we experimented with several of her recommended bulking materials mixed with the acrylic resin B-72 prepared in acetone and ethanol as well as several bulking agents commonly used at the Metropolitan Museum.[118] Among the latter, a blend of powdered aluminas proved to be the most useful for our purposes.[119] To this mixture we added various colored materials including natural white earth, pumice, sepiolite, and occasionally rottenstone.[120] In combination with the pure white alumina, these coloring agents created a translucent fill material that approximated marble (Figures 90a,b–93a,b).

To work with this fill material, alumina was added to the prepared B-72 until it formed a stiff paste. It was possible to make the mixture "dry" enough to work into a doughlike consistency that could be flattened into thin sheets between the fingers. In this way, the fill could be slowly built up in thin layers, a method we found beneficial as it allowed solvent to most effectively evaporate from the mixture. Working with a doughlike mixture was particularly useful when building up losses in areas of relief, such as the bird on the tree trunk.

As the depth of the fill neared the level of the surface, it was more effective to apply thin layers of a slightly looser mixture of bulked B-72. After a few hours, the outer layer was hard enough to shape with scalpels, fine riffler rasps, files, and customized micro-sanding tools. These tools proved valuable for precisely shaping the fills without harming the surrounding fragments. When required, riffler rasps

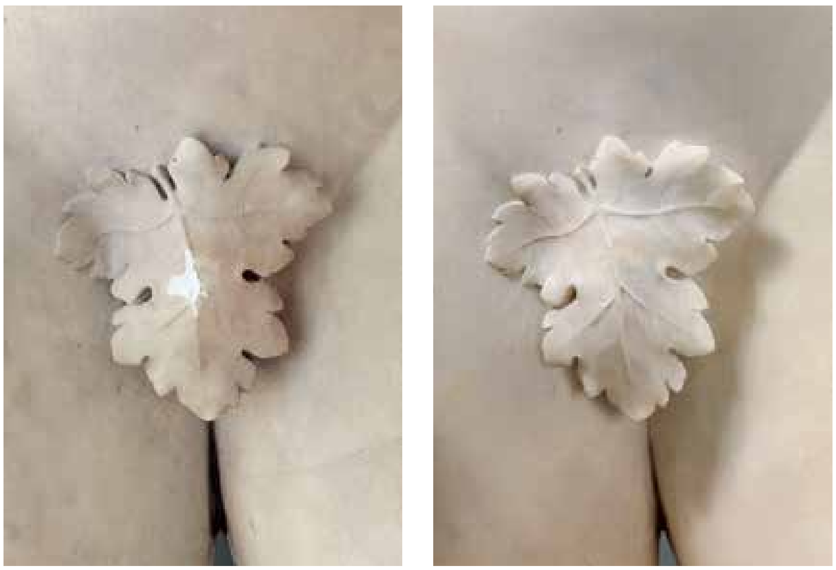


88a–d. *Adam* with structural work completed, before cleaning. Photographs: Anna-Marie Kellen, The Photograph Studio, MMA

89a–c. Details of the cleaning process. Left: top of the base before cleaning. A band of lighter-colored marble across the feet was due to the removal of excess adhesive after joining. Center: right foot before cleaning. Right: right foot during cleaning. Photographs: Jack Soultanian

90a,b. Details of the upper tree trunk. Left: before filling. Right: after filling and retouching. Recessed fills of bulked B-72 were added to areas of substantial loss. These white fills protected the delicate edges of small fragments and provided structural stability. Photographs of Figures 90a,b–93a,b: Anna-Marie Kellen and Joseph Coscia Jr., The Photograph Studio, MMA

91a,b. Details of the lower tree trunk. Left: before filling. Right: after filling and retouching



92a,b. Details of the fig leaf. Left: before filling. Right: after filling and retouching

93a,b. Details of the left hand. Left: before filling. Right: after filling and retouching

and plaster carving tools with serrated edges were used to texture the fill to match the tool marks in the surrounding marble. The fills provided a base color and required retouching in order to integrate them fully with the surrounding marble. The retouching was achieved by using pigments in a polyvinyl acetate medium applied to varying degrees dependent upon the specific part of the marble requiring matching.

Archival photographs of the sculpture, some dating back to the time of its acquisition in 1936,[121] were essential references for reconstructing areas of the most severe loss. The photographs were especially useful when filling areas of carved relief, for example, those on the tree trunk.

In September and October 2014 the fills neared completion, integrating the twenty-eight large pieces and more than two hundred small fragments that now constitute the

94a–d. *Adam* after cleaning, with fills completed. Right side view, during treatment

sculpture. The viewer can see *Adam* whole once again (Figures 94a–d). Installed in a new gallery, Tullio's masterpiece is displayed in a context inspired by the proportions of a Renaissance chapel and within a niche based on *Adam*'s location in the Vendramin monument.

CONCLUSION

Among the unusual aspects of this conservation project was the long period of time between the fall of the sculpture and both the commencement and the completion of its treatment—in all, nearly twelve years. This long gestation period brought several benefits: first and foremost, it allowed for the initial shock associated with the accident to dissipate. Immediate action—following traditional conservation practices—would have been easily explained and understood, but a more considered and deliberate approach was established almost from the start.

As stated earlier, a guiding principle for *Adam*'s conservation was to explore and challenge those traditional conservation practices. Part of that exploration was determining what questions to ask—what we needed to know—to carry out a successful treatment of *Adam*. Establishing the questions to ask involved an expansion of disciplines involved in the project. Conservators and conservation scientists have broad and deep knowledge reservoirs, but what was needed for this project was beyond their capacities.

The reconstruction of *Adam* was fundamentally about its physical and structural properties, so it seemed natural to turn to the world of material science and engineering. In addition, within the engineering community computer science has recently taken on a substantial role in modeling structures through laser scanning and finite element analysis. These innovative approaches were able to provide us with a nearly complete picture of the stresses resident in the sculpture and potential responses to those stresses. Building on this information, material scientists designed methods to evaluate the performance of adhesives and pins and assisted in interpreting the results of these experiments. Several important lessons were learned from these initial collaborations. From laser scanning and finite element analysis, we learned how critical were the joins at the ankles and the left knee. From the testing of adhesives and pins, we learned that reversible, thermoplastic adhesives alone were more than adequate, in both strength and creep behavior, for reconstructing most joins. We also learned that displacement by adhesives along join lines could be minimized without sacrificing strength and that a pinning material should have a bending elastic modulus or stiffness similar to the material being mended, in this case, marble.

In addition to allowing time for testing, the long gestation period provided an opportunity for the results to "sink in"—for their full meanings to be absorbed. This initial testing might be characterized in the language of science as fundamental studies. In moving from theory to practice, the fundamental studies provided background for the next phase of empirical studies—trials of interventions based on the former studies. These empirical studies both confirmed information from the fundamental studies and provided new information. First, we confirmed that bond lines were small enough not to cause displacement problems when joining leg fragments with different numbers of breaks in each leg. Second, we concluded that high modulus pins are not appropriate for reconstructing marble and, in fact, can cause substantial damage to the marble under high-stress scenarios. In addition, the mode of failure of the pin versus the marble is also important. Third, we came to understand that armatures with configurational flexibility would be necessary to stabilize and provide adequate pressure to joins during the setting of the thermoplastic adhesives.

It may be obvious that the multidisciplinary aspect of this project was highly important to its success, but it may be even more important to emphasize the value of creating functional connections between and among the disciplines. Knowledge is created and absorbed from diverse experiences. In the end, conservators had to carry out the reconstruction of *Adam* relying on all the knowledge acquired from the supporting studies but also relying on their experience and their senses. No amount of scientific study could guide them in knowing how well aligned a fragment might be to its mating surface, or whether enough adhesive covered the join or had squeezed out. They knew these things by feel. These different forms of knowledge are sometimes characterized as *comprehensive* (knowledge created by the mind) and *apprehensive* (knowledge acquired through the senses). Perhaps the project's greatest lesson was establishing an arc from virtual reality to material reality and finding and valuing the contributions of each participant in the successful completion of that arc.

In the end, while our approach to the conservation treatment may have preserved the intent and impact of this seminal work of art, the fact remains that as a result of the accident the sculpture is not the same, and never can be; the damage incurred from the fall cannot be reversed, regardless of how securely repaired the structure or carefully integrated the surface. We only hope that the memory of the accident and the image of the sculpture in fragments will fade over time, allowing *Adam* to retain its status as a masterpiece of Renaissance art.

ACKNOWLEDGMENTS

The project began under the supervision of Ian Wardropper—then Iris and B. Gerald Cantor Chairman of European Sculpture and Decorative Arts at the Metropolitan Museum and now director of the Frick Collection—when the Museum was still under the directorship of Philippe de Montebello. We thank both of them for recognizing the importance of the project and supporting the investigative and comprehensive approach to the conservation treatment. We also thank our current director, Thomas P. Campbell, for his continued support, especially toward the completion of the project as we planned conservation-related didactics for the gallery and this article. Luke Syson, Iris and B. Gerald Cantor Chairman, and James David Draper, Henry R. Kravis Curator, both of the Department of European Sculpture and Decorative Arts, kept a close eye on the progress of the sculpture under their charge, and to them we are grateful for their continued support and patience. Valeria Cafà also contributed insight into the sculpture during her tenure as Andrew W. Mellon Postdoctoral Curatorial Fellow, European Sculpture and Decorative Arts, and we thank her for her collegiality.

Critical to the success of the project was close collaboration with many experts from outside the Museum who conducted research that included finite element analysis and materials testing. A team of scientists from the School of Engineering and Applied Science, led by Winston O. Soboyejo, Department of Mechanical and Aerospace Engineering, guided us in designing, executing, and interpreting the many materials research studies for the Tullio project. From the Department of Civil and Mechanical Engineering, Nima Rahbar served as an adviser for the pinning and creep studies with the help of Ting Tan. George Scherer and Joseph Vocaturo were invaluable in designing testing apparatus. To them and to the Princeton School of Engineering and Applied Science in general, we express appreciation for their expertise and thanks for providing access to their mechanical testing instruments. George Wheeler was instrumental in making our connections to the Princeton Engineering team, without which this project would not have been possible. His connections at Columbia University were equally helpful, as we were advised by Norman R. Weiss throughout the pinning testing and by Andrew W. Smyth with regard to vibration reduction, particularly when it came time to move the sculpture within the Museum for the first time after the completion of the structural component of the treatment.

We were fortunate to collaborate with Michael Bak, Patrick Cunningham, and Daniel Fridline, engineers from Computer Aided Engineering Associates, who worked with us to perform the finite element analysis. A team of structural engineers at the firm Simpson Gumpertz & Heger, including Leonard Morse-Fortier, Frank W. Kan, and Omer O. Erbay, played a critical advisory role in interpreting data from the finite element analysis and from the materials research. This large team of advisers worked with us throughout the twelve-year period of the project, meeting regularly to discuss the extensive research and to guide us in our decisions, and we are indebted to them for their hard work on this challenging and unusual project.

Numerous graduate interns from multiple conservation programs provided assistance. Most important were the Columbia University students who undertook Tullio-related studies for their master of science theses in historic preservation; they were Mersedeh Jorjani, Christina Muir, and Andrea Buono, whose work on adhesives and pinning was essential to the project. While it is not covered in this article, the work Laura Michela carried out related to fatigue was immensely helpful. We also are indebted to New York University graduate conservation student Joannie Bottkol, who fabricated the specimens for the fractured-surface pinning tests, and intern Elizabeth Kovich, who not only fabricated specimens for an impact study but was also instrumental in the design and implementation of the study, the results of which will be reported in a later publication. Gregory Bailey, Kari Dodson, and Emily Hamilton, graduate conservation interns from the Art Conservation Program at Buffalo State College, assisted with the modulus testing, and we thank them for their contribution to the project.

We are indebted to our colleagues who contributed advice and sometimes simply acted as sounding boards for the multitude of ideas emerging from our work, most notably Anthony Sigel and Stephen Koob, who followed the project and generously offered their opinions and valuable support along the way. Our colleagues at the J. Paul Getty Museum, Jerry Podany, Erik Risser, and Eduárdo Sanchez, were particularly helpful in the early planning stages of the project. Julie Wolfe was generous with her time and expertise as we prepared for and carried out the fills. We thank the conservators at the Worcester Art Museum, in particular Philip Klausmeyer and Paula Artal-Isbrand, for teaching us about RTI. Winifred Murray traveled to the Metropolitan Museum with the Worcester Art Museum's equipment and helped us carry out the RTI of the underside of *Adam*'s base, for which we are grateful. Gregory Dale Smith of the Indianapolis Museum of Art was generous in performing T_g testing of our acrylic adhesives. He also provided advice for our solvent retention testing, which was carried out by the Museum's graduate intern Ariel O'Connor. We express our appreciation to Lorenzo Lazzarini, Università IUAV di Venezia, for his petrographic analysis of *Adam*'s Carrara marble. We also thank Anne Schulz, whose ambitious photography campaign of the Vendramin monument gave us the unique opportunity to examine it closely.

Many others in the Museum have assisted us and therefore made contributions to the project. From the Department of European Sculpture and Decorative Arts, Erin E. Pick has been steadfast throughout our work, and we express our deep gratitude to her. We extend our great appreciation also to Luke Syson and Peter Bell, whose guidance and leadership contributed to the beautiful exhibition that accompanied the sculpture when it was first displayed after completion of the conservation treatment. In the Design department, Michael Langley, who was responsible for the design of the Venetian Gallery, and Mortimer Lebigre, the graphic designer on the project, have been patient in understanding this complex project and designing a space befitting *Adam*.

We are grateful for the valuable expertise of the Digital Media department, in particular Christopher A. Noey, for taking an interest in the project. He and members of the Creative Production team devoted substantial time and made important contributions to the extensive video documentation of the reassembly of *Adam*. Stephanie R. Wuertz, Kate Farrell, Jessica Glass, and Robin Schwalb each contributed to filming portions of the treatment. A particular note of thanks goes to Maureen Coyle, who served as the project's digital media coordinator, in which capacity she logged and archived the video recording of the project as well as performed, filmed, and edited video interviews of Tullio team members.

The Department of Scientific Research also made valuable contributions to the project. Marco Leona served in an advisory capacity early on in our work, and we thank him for being supportive in the preparation of this article. To Adriana Rizzo and Federico Carò, the research scientists who performed instrumental analysis related to the examination of the stone's surface, we are very grateful. We extend special thanks to everyone in the Sherman Fairchild Center for Objects Conservation. Our dear colleague Richard E. Stone, conservator emeritus, played a crucial advisory role throughout the project, and we have valued his input enormously. Special thanks go to conservator Donna Strahan for suggesting the acrylic adhesive blend of B-72 and B-48N. Our deep appreciation goes to the conservation preparators, Frederick J. Sager, Jenna Wainwright, Mathew Cumbie, and Warren L. Bennett, for being accommodating whenever we popped in to borrow tools or raid their metal stock supply. We also thank Nancy C. Britton, who securely sewed the strap that supported *Adam*'s head during attachment. Dennis Degnan, a freelance conservator who frequently works in our department, was helpful on the day the fragments were collected in the Vélez Blanco Patio, and we thank him for that. We are also grateful to Marika Strohschnieder, who had much to do with the initial approaches to the treatment.

We extend our appreciation to Barbara J. Bridgers and members of the Museum's Photograph Studio, in particular Peter Zeray, who graciously sacrificed his studio space to house the sculpture for several years. Additional thanks go to Anna-Marie Kellen for initial photography of the major fragments, and to Thomas Ling, who introduced us to and equipped us for time-lapse photography. Christopher Heins was also on hand to do still photography as we attached *Adam*'s head, and for his fine documentation of the special day, we are grateful. Lastly, we thank Joseph Coscia Jr. for his masterful photography of the sculpture for this volume.

We thank Taylor Miller for his work in coordinating *Adam*'s move from the ground floor to the fifth floor, and in constructing the Tullio studio. Members of the Museum's Carpentry, Electric, Plexi, and Plumbing Shops all made important contributions to the project. We extend a special note of gratitude to the staff in the Machine Shop, Abdool Ali, Marcel Abbensetts, and Miroslaw Mackiewicz, for being especially accommodating over the years. For their careful attention to our needs throughout the project, we are grateful to Crayton Sohan and his team of riggers: Ray Abbensetts, Michael Doscher, Michael Guercio, Derrick Williams, Raouf Ameerally, Todd Rivera, and Mark Dickinson. Staff from the Registrar's Office, Gerald Lunney, John Laughner, and Benjamin Dillon, designed and built the moving crate to support the sculpture during its first move within the Museum, and we are grateful for their skills. For their work related to the construction of the Tullio studio, we express thanks to the Buildings and Construction Departments, in particular to Tom Scally and Eric W. Hahn, and to Nicholas Nedostup, who served as the project manager.

This project produced a multitude of orders to be placed and contracts to be administered, and to Ashira Loike, David A. Sastre Perez, and Anna Studebaker, we express gratitude for their patience and support. For the design and execution of the beautifully fabricated lift table, we thank Jörg Osterodt and Dietmar Lagemann of Laweco, as well as Douglas Todd and Christopher Cozad of ETK International for carrying out the logistical components of this complicated order. We thank Michael Mielcarek of LodeRail for supplying us with the bridge crane. We worked with David Bassett and Lisa Federici of Scansite, Inc., to accomplish the 3D laser scanning of the fragments, and we are grateful for their expertise. Thanks go to American Precision Prototyping and Fineline Models for their rapid prototyping services. For the fabrication of the full-scale model of *Adam*, we thank Kelly Hand of Satellite Models. For pointing us to the Sichuan *David*, we thank James Welch, marketing director of Wishihadthat, Inc. We are also grateful to artist Dror Heymann, who made modifications to the replica *David* so that we could use it as a stand-in for *Adam*. ABC Stone, the supplier of the Carrara and Vermont marbles used in the testing, was always accommodating to our various requests. We thank Tom Gravel, president of Hydro-Cutter, Inc., for his tireless preparation of water-jet machined marble specimens used in the adhesive testing.

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NOTES

1. The individual fragments (including the tiny pieces and marble dust collected) were weighed after the accident occurred.
2. For details about the petrographic study, see the report by Lorenzo Lazzarini in the Sherman Fairchild Center for Objects Conservation MMA, departmental records for 36.163. For a description of statuario marble, see Dolci 1980, p. 158. For comparison, technical studies of samples taken from Michelangelo's *David* point to the Fantiscritti site of Miseglia as the origin of its marble and are described in Attanasio, Platania, and Rocchi 2005, pp. 1374–76, and Attanasio, Rocchi, and Platania 2004, pp. 130–31.
3. See "*Adam*, by Tullio Lombardo," by Luke Syson and Valeria Cafà in the present volume, for details on the sculpture's origins.
4. Drill holes in the hair range from 2.1 mm to 6.2 mm in diameter.
5. Matteo Ceriana, director, Gallerie dell'Accademia, Venice (now director, Galleria Palatina, Florence), personal communication, 2012.

6. In 2007, when we used this technique, RTI was being actively introduced to the conservation field by Cultural Heritage Imaging (CHI) as an invaluable examination and documentation method, but few museums had yet been trained in the technique. Winifred Murray, Andrew W. Mellon Fellow in Paintings Conservation at the Worcester Art Museum, assisted us in capturing an RTI of the base. For a clear explanation of this imaging technique, see Schroer 2012.
7. Falletti 2004, p. 58.
8. Danti et al. 1998, p. 40.
9. The figure of the youth may be identified as Daniele, grandson of Doge Andrea Vendramin (d. 1478). In his will the doge left a considerable sum to Daniele. The will is published in Sheard 1978, p. 150, app. 1. The examination of the Vendramin monument, undertaken by Michael Morris, Carolyn Riccardelli, and Jack Soultanian, took place in November 2012, when a scaffold was erected in front of it for the Museum's photography campaign, coordinated by Anne Markham Schulz.
10. The analysis was conducted by Adriana Rizzo, associate research scientist, Department of Scientific Research, MMA. Azurite was confirmed by both Fourier transform infrared microspectroscopy (FTIR) and Raman microspectroscopy. FTIR analysis was performed on the samples crushed in a diamond anvil cell (Spectra-Tech). A Hyperion 1000 Microscope interfaced to a Vertex 70 (Bruker Optics), equipped with a 15x FTIR objective and a MCT detector (mercury cadmium telluride), liquid nitrogen cooled, was used. The FTIR spectra were acquired in 64 scans in the range 4000 to 600 cm^{-1} and 4 cm^{-1} resolution. Raman microspectroscopy was performed with a Bruker Senterra dispersive Raman microscope system, with a 1,200 lp/mm holographic grating and a CCD detector. A 785 nm excitation, 50x objective, and 30 second acquisition time were used; resolution was in the range of 3–5 µm and laser power ranging between 1 and 10 mW.
11. Cennino Cennini (ca. 1370–ca. 1430) describes water gilding with bole on stone; see Cennini 1960, pp. 118–19. For our investigation, initial X-ray fluorescence (XRF) analysis was performed by Federico Carò, associate research scientist, Department of Scientific Research, MMA, using a Bruker Tracer III-SD at 40 kV, 12.5 µA and an acquisition time of 30 seconds. The presence of clay minerals with other coarser silicates such as quartz and feldspar, as well as iron oxides, was determined using energy dispersive X-ray spectrometry in the scanning electron microscope (SEM-EDS), also conducted by Federico Carò. SEM-EDS analysis was performed in variable pressure with a Zeiss Σigma HD VP electron microscope equipped with an Oxford Instruments X-MaxN 80T SDD detector.
12. In addition to laser scanning, X-ray computed tomography (CT) scans were undertaken to determine if there were internal fractures stemming from the accident. CT scans were produced with a medical scanner and performed by Georgeann McGuinness, MD, chief, Thoracic Imaging, and by Emilio Vega and Robert Grossman, all at New York University Medical Center. The scans were inconclusive, and so these results are not reported here. Conservators researched the possibility of improving results with a high-energy industrial CT scanner; however, because of logistical and other considerations with transport of the fragile sculpture, this option was not pursued.
13. "3D virtual model" refers to a numerical description of an object. For further explanation, see Bernardini and Rushmeier 2002.
14. The 1:1 fragment models were milled either from 40 lb. density polyurethane fine-celled foam using a computer numerically controlled (CNC) ball end milling cutter at Satellite Models (fabricators of digital fine art sculpture enlargements, Belmont, Calif.), or built in a Zcorps rapid prototyping machine.
15. A 16-inch (40.6 cm) model of the sculpture was produced from the STL scan data on a Multi-Jet Modeling rapid prototyping machine. The model was then molded and cast in epoxy resin.
16. De Roos 2004, p. 25.
17. On this early technology, see Nilsson 1969.
18. This increase in activity was the result of the success of projects reported in the "Digital Michelangelo Project" (Levoy et al. 2000), *Exploring* David*: Tests and State of Conservation* (Bracci et al. 2004), "The 3D Model Acquisition Pipeline" (Bernardini and Rushmeier 2002), and the MMA's laser-scanned production of facsimiles of Bernini's two monumental terms intended for display in the Giardino Segreto of the Villa Borghese (Street 2002).
19. Beraldin et al. 2007.
20. The complete 2GB polygon model of *Adam* contains almost 40 million triangles in 24 binary stereolithography polygon mesh files. Although placing targets on the surface of a sculpture is the preferred method for aligning scans, we opted not to do so due to the risk that adhesives from the targets might affect the surface of the marble. Therefore, each set of scans from one fragment was aligned using an iterative closest point algorithm and grouped into one file within a common coordinate system. Once the individual scans were aligned, a global alignment was performed, and the aligned scans were then merged into one polygon surface model using a mesh integration technique.
21. Besl and McKay 1992. Laser scanning, point cloud data editing, and compilation of polygon models was undertaken by Ronald Street and Scansite LLC (Woodacre, Calif.) using Geomagic Studio 5, ATOS Professional, and Mesh Lab, software programs designed for transforming 3D scanned data into polygon models.
22. Michael Bak in Cunningham and Bak 2013.
23. Podany et al. 2001, p. 17.
24. The digital model of *David* was generously provided by Marc Levoy, director of the Digital Michelangelo Project of Stanford University and the Soprintendenza per Ai Beni Artistici e Storici per le Province di Firenze, Pistoia, e Prato. The analysis for the finite element mesh and proof of concept for the *David* study was generated in ANSYS8, a suite of advanced engineering simulation technology software. The finite element mesh and proof of concept study for the *David* analysis was generated by Ronald Street. The scanned data were imported into SolidWorks and used to create an electronic database of the *Adam* sculpture's 3D geometry. The same laser-scanned data can be translated directly into ANSYS. ANSYS is a finite element simulation code used for a wide variety of engineering analyses. ANSYS has a powerful mesh generation tool to handle a wide variety of complex geometries, can accept laser scanned data (point cloud data), and generate a mesh. Within ICEM is a subroutine tool called Mesh Prototyper, which provides a resurfacing of the point cloud data. Once the mesh is finalized, appropriate load and boundary conditions are applied. Then ANSYS solves for stresses, strains, and deflections.
25. The finite element analysis in Studies 1 and 2 was performed by Dan Fridline of Computer Aided Engineering Associates, Inc. (CAE Associates), Middlebury, Conn.
26. For a detailed explanation of stereolithography file format (STL) and the standard interchange file format that can support STL file features (Additive Manufacturing File Format, AMF), see ASTM 2013.
27. Elastic modulus describes the stiffness of a material and is also known as Young's modulus. In Study 1, an isotropic linear elastic material law was assumed with the following properties: elastic

modulus of 39 GPa, Poisson's ratio of 0.45, and density of 2.7 g/cm^3. The models were supported in all directions at the bottom of the base to simulate the sculpture as placed on a rigid platform. A gravity load was applied to the entire model.

28. Study 2 tested nonuniform rational basis spline (NURBS)–based geometric representations in the form of initial graphics exchange specification (IGES) geometry files; for a more detailed explanation of this format, see Piegl 1991. IGES is a file format that defines a vendor-neutral data format, thus allowing the digital exchange of information among computer-aided design (CAD) systems. NURBS surfacing of original polygon models was undertaken by Ronald Street using Geomagic Studio 6, software for transforming 3D scanned data into highly accurate surface, polygon, and native CAD models.
29. The finite element models for these studies were generated by CAE Associates using the ANSYS Workbench Environment software. This software was selected for its ability to generate robust tetrahedral meshes from NURBS geometry. It automatically detects setup contact surfaces based on proximity of disjointed surfaces. Unlike polygon-based geometry, the addition of midside nodes in the NURBS model allows for more accurate representation of curved geometry. The fracture surfaces were modeled using "perfectly bonded" contact elements. Each contact surface was isolated, and then the distribution of contact normal pressure and shear traction was determined.
30. Study 3 was carried out by Patrick Cunningham and Michael Bak of CAE Associates.
31. Also new in the Study 3 model was the fact that one of the Carrara marble characteristics, the elastic modulus, was updated with an experimentally determined value that more accurately reflected the bending modulus of Carrara marble, the characteristic of greatest concern at *Adam*'s left knee. See "Additional Finite Element Modeling," pp. 83–85.
32. The lower part of each fracture interface from the STL model was imported into the continuous NURBS model. The imported surfaces were attached to their adjacent fragments, resulting in two parallel interlocking faces at each fracture location within the NURBS model. Thus the new interfaces consisted of one side of a fracture interface used as a way to cut through the continuous NURBS geometry.
33. Paraloid B-72 is ethyl methacrylate–methyl acrylate copolymer; Paraloid B-48N is methyl methacrylate–butyl acrylate copolymer. Both are manufactured by Rohm & Haas.
34. See Koob 1986, Horie 1987, pp. 22, 106–9; and Down et al. 1996.
35. Koob 1986.
36. Podany et al. 2001.
37. Ibid., p. 18.
38. Ibid., p. 27.
39. This research has been discussed in detail in the following publications: for interfacial fracture toughness and bond-line thickness, see Jorjani 2007 and Jorjani et al. 2009. For a more technical explanation of the interfacial fracture testing results, see Rahbar et al. 2010. For creep testing, see Buono 2009 and Tan et al. 2011.
40. Mersedeh Jorjani performed the interfacial fracture study for her master of science thesis at Columbia University in the Graduate School of Architecture, Planning and Preservation's Historic Preservation Program. She worked under the supervision of her adviser, George Wheeler, and in coordination with Princeton University's Winston O. Soboyejo in the Department of Mechanical and Aerospace Engineering and Nima Rahbar, then a doctoral candidate in the School of Engineering and Applied Science, Department of Civil and Environmental Engineering. See Jorjani 2007.
41. See Kuhl and Qu 2000; Wang and Suo 1990.
42. Jorjani 2007, p. 17.
43. The Brazilian test is named for its inventor, Brazilian scholar Fernando L.L.B. Carneiro, and is a commonly used testing protocol in the study of fracture mechanics. See Wang and Suo 1990 for further information on this type of testing, and Ma and Hung 2008 for historical background on the testing protocol. The term "Brazilian disk" is used to describe a specimen that is made of a single material, in our case, the unfractured marble control set, while "Brazilian disk sandwich" refers to a specimen that has been split and then bonded. Brazilian disks have specific ratios of diameter to flaw-size, and so precision fabrication was necessary. Our disks were created using an abrasive water-jet machining technology, which couples high-pressure water with a garnet abrasive. The water-jet cutting was carried out at Hydro-Cutter, Inc., North Oxford, Mass.
44. Interfacial fracture toughness testing was conducted using an Instron 8281 dual column mechanical strength analyzer controlled with a proprietary data acquisition software application. For details on the testing procedure, see Jorjani 2007, p. 25.
45. Ibid., pp. 25–26.
46. This adhesive blend was suggested by former Metropolitan Museum conservator Donna Strahan (now head of Conservation and Scientific Research at the Freer and Sackler Galleries, Smithsonian Institution, Washington, D.C.), who uses it at the archaeological site Troy in western Turkey. She has used a blend of 3 parts B-72 to 1 part B-48N on objects such as large pithoi that are stored outdoors and therefore subjected to high ambient temperatures. Strahan's theory for creating the mixture was that the addition of B-48N raises the glass transition temperature (T_g) high enough that the adhesive will not slump in summer temperatures regularly reaching 51°C. The blend, which is a 40 percent solution mixed by weight, is created as follows: make one batch of each adhesive (40 g B-72, 54 g acetone, 6 g ethanol; and 40 g B-48N, 54 g acetone, 6 g ethanol) and then combine by volume 3 parts B-72 and 1 part B-48N.
47. Podany et al. 2001, pp. 26–27.
48. The bond-line measurements were done using a Keyence VHX-500 series digital microscope. The instrument has a measuring feature that records a quantity of measurements. Fifty measurements were taken along the join line of each specimen in increments of approximately 0.02 mm. The work was done at 175x magnification. See Jorjani 2007, p. 26.
49. Bradley 1984, p. 24; Podany et al. 2001, pp. 22–25.
50. These B-72–epoxy resin sandwiches were made by applying thin B-72 barrier coatings (5 percent by weight in acetone) to the marble surface, waiting several days to allow the solvent to fully evaporate, and then bonding the two sides with Epo-tek 301-2, an optically transparent epoxy adhesive manufactured by Epoxy Technology, Inc., Billerica, Mass.
51. Podany et al. 2001, pp. 23–25. See also Bradley 1984, pp. 24–25.
52. Jorjani 2007, pp. 31–34.
53. Andrea Buono carried out the adhesive creep study for her master of science thesis at Columbia University in the Graduate School of Architecture, Planning and Preservation's Historic Preservation Program. She worked under the supervision of her adviser, George Wheeler, and in coordination with Nima Rahbar of Princeton University's School of Engineering and Applied Science, Department of Civil and Environmental Engineering. The study employed a testing procedure developed at the Princeton

Center for Complex Materials at Princeton University. For complete details of sample preparation and testing protocols, see Buono 2009. For a technical examination of the study, see Tan et al. 2011.

54. Risser and Podany 2005. An empirical study of creep behavior carried out at the J. Paul Getty Museum was presented at the American Institute for Conservation Annual Meeting in 2005 but was not published. In general, results of our studies agree with the results of the Getty team.
55. The specimens bonded with epoxy resin were given at least two weeks for the adhesives to cure fully, while the specimens bonded with acrylic resin adhesives were given no less than four weeks to set, allowing sufficient time for acetone and ethanol solvents to evaporate.
56. All testing took place at room temperature.
57. Tan et al. 2011.
58. The thermosetting adhesive tested was Epo-tek 301-2 epoxy. A join made with epoxy resin along with a B-72 barrier (the B-72–epoxy resin sandwich) was also tested.
59. Tan et al. 2011.
60. Riccardelli et al. 2010, p. 98.
61. Some examples are Glavan 2004 and Saikia, Ramaswamy, and Rao 2005.
62. Christina Muir carried out the modulus and pinning studies for her master of science thesis at Columbia University in the Graduate School of Architecture, Planning and Preservation's Historic Preservation Program. She worked under the supervision of her adviser George Wheeler, and in coordination with George Scherer and Joe Vocaturo of Princeton University's School of Engineering and Applied Science, Department of Civil and Environmental Engineering. See Muir 2008.
63. For sample preparation details, pin testing procedures, and results of additional tests not discussed here, see Riccardelli et al. 2010.
64. See, for instance, "More about Steel, Iron, and Tungsten," McMaster-Carr document 88645KAC (available at www.mcmaster.com), for examples of how material characteristics are commonly reported by retailers and distributors.
65. Specimens were tested using an Instron 4201 mechanical strength analyzer, following the procedure for the ASTM Standard Testing Method for Ceramic Whiteware Materials (ASTM 2006), which is a three-point bend test. Rods measuring 9.5 mm in diameter were cut into 100-mm lengths and placed on bearing edges spaced 76.5 mm apart. A load was applied at the midpoint between the two supports. Five specimens of each material were tested until either the material failed or the testing instrument reached full extension.
66. Riccardelli et al. 2010, p. 100.
67. An example can be found in Ondrasina, Kirchner, and Siegesmund 2003.
68. For this portion of the pinning study, the Tullio team and Christina Muir were advised by Winston O. Soboyejo, George Scherer, and Joe Vocaturo of Princeton University's School of Engineering and Applied Science, Department of Civil and Environmental Engineering.
69. The smooth-surface pinned marble cylinders were tested using an Instron 8501 mechanical testing analyzer with a maximum load capacity of 100 kN.
70. Muir 2008, pp. 7–8.
71. Ibid., p. 62.
72. Ibid., p. 59.
73. Titanium has sometimes been used to repair marble sculpture and outdoor stone monuments because of its resistance to corrosion and because its coefficient of thermal expansion is similar to that of marble. Although prior tests showed metal pins to be inappropriate for repairing *Adam*, titanium remained in the testing series to maintain some continuity, as it was being performed as master's thesis research by an architectural conservation student, Christina Muir. See note 62 above.
74. At the time of sample preparation, the Tullio team was considering using two small pins in each ankle to counteract the natural torque of the figure, as was determined by finite element analysis. The team ultimately decided to use a single pin in each of the ankle joins. The fractured-surface specimens were prepared by Joannie Bottkol, a graduate student at New York University Institute of Fine Arts Conservation Center, as part of an independent study in 2009. The specimens were kept in their clamping devices while the adhesives cured or set fully, which, in the case of acrylic resin adhesives, was at least three months.
75. Riccardelli et al. 2010, p. 108.
76. Ibid., p. 109.
77. Ibid.
78. 3M Glass Bubbles K15, manufactured by 3M Performance Materials Division, Saint Paul, Minn.
79. Krumrine and Kronthal 1995.
80. The replica *David* sculpture was purchased from www.wishihadthat.com.
81. This experiment was carried out in 2009 by the Metropolitan Museum's Objects Conservation Department graduate intern Ariel O'Connor. The complete results of her study, "Summary of Tullio Solvent Evaporation Experiment, June 2–August 18, 2009" (last modified September 2013), are in the Sherman Fairchild Center for Objects Conservation departmental records for 36.163.
82. Measurements were made on a Mettler AE163 Delta Range Electronic Analytical Balance.
83. The original adhesive mixture contained 40 g of resin and 60 g of solvent. Theoretically, if all of the solvent were to evaporate from the adhesive, we would expect to see a maximum of 60 percent loss from the initial weight.
84. The analytical portion of the Carrara cylinder experiment was performed by graduate student Jin Dou at Princeton University's School of Engineering and Applied Science, Department of Civil and Environmental Engineering.
85. Risser and Podany 2005.
86. Podany et al. 2001, p. 24.
87. Gregory Dale Smith, senior conservation scientist, Indianapolis Museum of Art, Indianapolis, Ind., personal communication, January 28, 2009.
88. Research at the Getty Conservation Institute found that B-72 retains solvent even in the form of cast films allowed to sit in the open air for six months. See Hansen 1995.
89. Smith, personal communication; see note 87 above.
90. The lengths of the unbroken marble blocks were measured precisely by placing them in the Instron mechanical analyzer and lowering the load cell to the top surface of the block. The resulting gauge length reading given by the Instron software thus corresponded to the length of the marble block.
91. The modifications to the *David* replica's right (engaged) leg were performed by Dror Heymann, a sculptor based in Brooklyn, N.Y.
92. Armature straps were made with carbon fiber fabric and laminating epoxy resin manufactured by Fibre Glast Development Corp., Brookville, Ohio.
93. Throughout the treatment of *Adam* we used undyed Twintex endless slings for the rigging. These were obtained from McMaster-Carr as a special order request following our discovery of dye transfer from purple slings to the *David* replica after a period of

several months. Undyed slings prevent transfer of dye from the sling to the marble surface.

94. We used RAM Mounts ball joints, which are composed of hard rubber ball components and metal clamping components. They are marketed as supports for GPS devices and other electronic equipment. RAM Mounts are manufactured by National Products, Inc., Seattle, Wash., and distributed by e-mounts.com.
95. The strut channel framing system used in this project was produced by Unistrut International, manufacturers of metal framing and telescopic tubing and struts, Harvey, Ill. This system can be used to rapidly assemble rigid framework structures.
96. Laweco GmbH specializes in lift systems, machinery, and apparatus engineering. The table was manufactured at Laweco headquarters in Espelkamp, Germany; the company's U.S. distributor is ETK International, Indian Trail, N.C.
97. Patrick Cunningham in Cunningham and Bak 2013.
98. Simpson Gumpertz & Heger is an engineering firm in Boston, Mass. Consulting engineers on the Tullio project were Leonard Morse-Fortier, Frank W. Kan, and Omer O. Erbay.
99. The raw data (load vs. displacement) from the unbroken marble Brazilian disks were used in creating this finite element model, thus incorporating the failure stress limit of the marble into the model of the whole sculpture.
100. The M.BL Bench Lathe, manufactured by Foredom, has a ⅙ horsepower variable speed motor (500–7000 rpm).
101. The linear actuator was a custom fabrication by MK Automation, based in Lawrenceburg, Tenn., a company that manufactures parts for automated systems such as factory assembly lines.
102. The barrier coating used inside the pinholes was a 10 percent solution of B-72 in acetone.
103. Soap served as the release agent. Orvus WA paste, sodium lauryl sulfate, was applied to the pin and allowed to dry overnight before the pin was inserted into liquid epoxy.
104. Sleeves were made with Epo-tek 301-2 epoxy bulked with 3M glass microballoons.
105. Although Epo-Tek 301-2 epoxy resin achieves full cure after three days, we found it easier to remove the fiberglass pins from the sleeves midway through the curing cycle. At this stage, the partially cured epoxy resin was hard enough to withstand this kind of manipulation without deforming. The sleeves were allowed to cure fully before the pins were replaced.
106. The bulked adhesive consisted of B-72–B-48N blend mixed with 2:1 cellulose powder:glass microballoons.
107. To make the join reversible, a barrier layer of B-72 adhesive was applied to the fracture surfaces (5 percent by weight in acetone). The surfaces were then allowed to sit open for two weeks. After that time, the join was closed using Epo-tek 301-2 epoxy. Research by Podany et al. 2001 and an empirical test undertaken by the Tullio team confirmed that the B-72 barrier layer does indeed make the epoxy join reversible.
108. The epoxy putty was Phillyseal R (a two-part epoxy putty manufactured by ITW Philadelphia Resins, Montgomeryville, Pa.), which is no longer manufactured. A good substitute is Magic-Sculpt (a two-part white epoxy putty manufactured by WESCO Enterprises, Rancho Cordova, Calif.).
109. A relatively wide 16-gauge needle was required to extrude the bulked epoxy resin mixture.
110. The acrylic resin adhesive blend was bulked with equal parts glass microballoons and cellulose powder.
111. The cotton webbing head strap was sewn by the Metropolitan Museum's upholstery conservator, Nancy Britton.
112. Rossi-Manaresi 1996, pp. 26–27.
113. Mutton tallow in a mixture with wax is suggested in a sixteenth-century recipe. See Rossi-Manaresi 1996, p. 26 and n. 60. The sample from *Adam* was analyzed by Adriana Rizzo, associate research scientist, Department of Scientific Research, MMA, using gas chromatography–mass spectrometry (GC-MS) through extraction with chloroform. The solvent was evaporated under a stream of nitrogen. Then an aliquot of heptadecanoic acid in ethanol was added as internal standard. The solvent was evaporated under a stream of nitrogen, and the residue was treated with a solution of Meth Prep II (0.2N in methanol), 1:2 in toluene. The samples were left to react at 60°C in a Reacti-Vap evaporator (Thermo Scientific) for one hour before analysis; 1µl of solution was injected in the gas chromatograph Agilent 6890 coupled with the Agilent 5973 Network Mass Selective Detector. The analysis was carried out in splitless mode. A J&W DB-5MS capillary column (30 m x 0.25 mm x 0.25 µm) was used. The inlet was kept at 300°C and transfer line at 320°C. Helium was used as the carrier gas, constant flow 1.5 ml/min. The GC oven temperature program was: 40°C for 1 min. ramped to 320 at 10°C /min., followed by 11 min. isothermal period. Acquisition was performed in SCAN mode (m/z 35-550). Temperature at MS source was 230°C, and at quadrupole it was 150°C.
114. The vinyl eraser strips are manufactured by Staedtler-Mars Limited, Missisauga, Ontario.
115. Toning was done with Schmincke pigments in a medium of Mowilith-20. Schmincke pigments are manufactured by H. Schmincke & Co., Erkrath, Germany. Mowilith-20, is a polyvinyl acetate resin and is available from Museum Services Corporation, South Saint Paul, Minn.
116. Renaissance Wax is a micro-crystalline wax polish composed of a mixture of Cosmolloid 80 hard and BASF A waxes. Picreator Renaissance Products, Picreator Enterprises Ltd., London, UK.
117. Wolfe 2009.
118. A solution of 60 g B-72, 35 g acetone, and 5 g ethanol was the base material for the fills.
119. Synthetic Onyx is a brand name for a white powder designed for mixing into casting resins. It is a mixture of aluminum oxide Al_2O_3 and aluminum hydroxide $Al(OH)_3$. The source is Alec Tiranti Ltd., Thatcham, Berkshire, UK.
120. Natural white earth is a fine beige powder from Vicenza, Italy. Pumice is a powder composed of finely ground volcanic ash. Rottenstone, also known as tripoli, is primarily ground-weathered limestone or slate. Both pumice and rottenstone are used as furniture varnish polishing compounds. Sepiolite is a natural magnesium-silicate that can be used as a poultice, thickener, or antisettling agent. The source is Kremer Pigments, New York, N.Y.
121. The photographs are in the archives of The Photograph Studio, MMA.

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A New Analysis of Major Greek Sculptures in the Metropolitan Museum: Petrological and Stylistic

LORENZO LAZZARINI

Professor of Applied Petrography, Laboratorio di Analisi dei Materiali Antichi — Sistema dei Laboratori, Università IUAV di Venezia

CLEMENTE MARCONI

James R. McCredie Professor in the History of Greek Art and Archaeology, Institute of Fine Arts, New York University

Interest in the provenance of ancient marbles used in Greek and Roman sculpture is long-standing, going back to the very foundation of the study of ancient art, Johann Joachim Winckelmann's *History of the Art of Antiquity,* published in 1764. In Part 1 of this seminal text, the German scholar addresses the materials selected by Greek sculptors in two important passages. In the introductory chapter, which discusses the origin of art and the reasons for its diversity among peoples, Winckelmann proposes a line of development for ancient sculptors' materials that begins with clay and gradually progresses to wood and ivory, and finally to stone and metal. In Chapter 4, on the art of the Greeks, section 4, devoted to the "Mechanical Part of Greek Sculpture," he addresses first the materials in which Greek sculptors worked and then the manner of their workmanship. In the passage, Winckelmann begins—in keeping with the taste of his time—with marble, and he not only presents the relevant literary sources but also discusses the qualities of different kinds of marble, including texture, consistency, and color. He focuses on marble from the island of Paros but also mentions Thasian, Pentelic, and Carrara marble. He explores the correlation between the qualities of these marbles and their different workabilities and appearances, thus proposing a strong connection between the material and the aesthetic quality of ancient sculpture.[1]

After such a start, it would seem inevitable that the identification of the marbles used in antiquity would have been a constant concern of both historians of ancient art and archaeologists. However, it was not until more than one hundred years after Winckelmann that the German geologist Richard Lepsius developed the first scientifically correct approach, one that can unreservedly be defined as archaeometric in the strict sense of the term.[2]

Archaeometry is a rather new science, officially dating to the end of the 1950s when the University of Oxford's Research Laboratory for Archaeology and the History of Art began publishing a bulletin for the purpose of "fostering the close integration between the physical sciences, archaeology, and art history."[3] The bulletin soon became *Archaeometry,* an international journal now published six times a year that reports on the applications of scientific disciplines, such as biology, chemistry, physics, geology, and informatics, to archaeology, architecture, and art. Among other topics, its contributors discuss methods for determining the age and authenticity of all kinds of artifacts, the nature of their materials, and their sources and manufacturing techniques.

One important application of archaeometry concerns marbles.[4] Technically, marbles are pure carbonatic (calcitic or dolomitic) rocks with a carbonatic content that is usually well in excess of 95 percent. These rocks are crystalline; they may be white or gray, more rarely black, red, or green; and they will have been produced by contact or regional metamorphism. Marbles are quite common throughout the Mediterranean area. We know when some of them were first used by builders and sculptors, and we have information from various sources that enables us to reconstruct at least a partial picture of their distribution and the ways they were traded and transported. In most cases, however, we know very little, mostly because of the fundamental difficulty of reliably identifying marbles when they are found in use as structural or decorative members of ancient buildings, or as sculptures, or when they have been reused in medieval or Renaissance monuments.

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1. Fragment of a funerary stele of a youth, from Athens, ca. 530 B.C. Marble, Hymettian, H. preserved 48 in. (121.9 cm). The Metropolitan Museum of Art, Rogers Fund, 1912 (12.158)


2. Head of a horse, from Eleusis, 575–550 B.C. Marble, Pentelic, H. 13⅜ in. (34 cm), L. 13¾ in. (34.9 cm). The Metropolitan Museum of Art, Bequest of Walter C. Baker, 1971 (1972.118.106). Photographs of Figures 2, 4, 22: Juan Trujillo, The Photograph Studio, MMA

Although some white marbles, such as the Proconnesian, Lunense, and Pentelic holotypes, are so distinctive in color, translucency, and grain size that they can at times be identified with the naked eye, it is much better to confirm their identification with scientific methods and data obtained from laboratory analyses. These methods are still being developed. Despite the application of numerous analytical techniques for "fingerprinting" white marbles and then determining their provenance in antiquity, results have been no more than partial.[5]

Nevertheless, over the last twenty years, many museums housing important collections of marble statuary and institutions responsible for archaeological sites with a substantial number of marble artifacts have launched more or less extensive campaigns of laboratory analysis to determine the quarries of origin of their works. These include, among others, the Museum of Fine Arts in Boston,[6] the Arthur M. Sackler Museum, Harvard Art Museums,[7] the National Archaeological Museum in Naples with its well-known Farnese Collection,[8] the Museum of Art and Archaeology of the University of Missouri, Columbia,[9] and the Villa Adriana near Tivoli.[10]

These scientific studies of marble are extremely important for those immersed in the history of ancient Greek and Roman art as well as for those interested in technical art history more generally, including the study of materials and carving techniques. To archaeometrists, the spate of new studies is of particular significance, as it provides fresh data concerning the opening of ancient quarries and their periods of use, the necessary point of origin—in all senses—of ancient sculpture and architecture.

It is within this context, and with these goals in mind, that The Metropolitan Museum of Art launched an archaeometric investigation of some Greek marbles—especially statues but also architectural elements and one inscription—in its collection. The laboratory methods used for the identification of the marble sources have been based on the combination of minero-petrographic and isotopic analyses, the most suitable and reliable methods to date: the methods are fully described below. When fear of damaging the works in the sampling process ruled out these methods, the identification of the marbles was tentatively made based on systematic visual autopsy, considering the main macroscopic features of the marble artifacts, including color, grain size, and translucency.

EXPERIMENTAL

All determinations were made on a single, very small (a few square mm) fragment of marble removed from areas already broken and hidden, using a sharp little chisel or a spatula as a lever. Part of the sample was finely ground in an agate mortar, and the powder subjected to standard diffractometric (X-radiation CuKα/Nι at 40KV, 20mA) and isotopic analysis. The remaining part was used for the preparation of a thin section for a detailed minero-petrographic study of the marble under a polarizing microscope.

MINERO-PETROGRAPHIC ANALYSES

The purpose of the minero-petrographic examination was to determine the fabric, accessory, and secondary minerals in addition to the calcite and dolomite characteristics that are usually the principal constituents of all types of marble.

More specifically, the following parameters were determined:

1. type of fabric (homeoblastic, with roughly isodiametric grains; or heteroblastic, with grains of various dimensions), in direct relationship to the type of metamorphism (equilibrium, nonequilibrium, retrograde, polymetamorphism, etc.) and metamorphic grade;
2. boundary shapes of the calcite or dolomite grains, also connected to the type of metamorphic event or events that generated the marble;
3. maximum grain size (MGS, the longest dimension of the largest crystal identified in the section), a parameter of significant diagnostic importance because it is linked to the grade of metamorphism achieved by the marble.
4. quality and semi-quantitative determination of accessory minerals (e.g., minerals different from calcite/dolomite present in very small amounts).

For the petrographic description, previous specific studies of ancient marbles[11] as well as classical treatises on petrotectonics[12] were taken into consideration.

ISOTOPIC ANALYSES

The isotopic analyses were carried out on the carbon dioxide derived from small portions (20–30 mg) of the powdered sample subjected to a chemical attack with 100 percent phosphoric acid at 25° in a special vacuum line, following the procedure suggested by J. M. McCrea and Harmon Craig.[13] The resulting CO_2 was then analyzed by continuous flow mass spectrometry. The instrument used is endowed with a triple collector and permits the measurement of both isotopic ratios ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) at the same time.

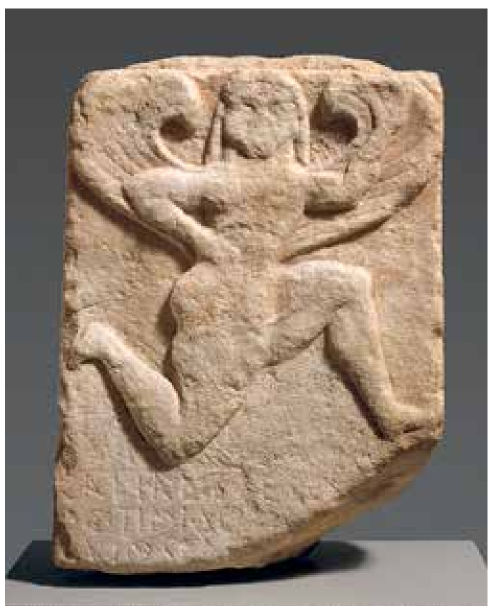
The analytical results are conventionally expressed in δ units, in parts per thousands:

$$\delta = \frac{R\ \text{sample}}{R\ \text{std}} - 1 \times 1000$$

in which R sample and R std represent the isotopic ratio of oxygen and carbon in the sample and in the reference

3. Head of a kouros, from Sounion, 560–550 B.C. Marble, Pentelic, H. 8⅝ in. (21.9 cm), L. of face 6¼ in. (15.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1921 (21.88.16). Photograph: Karin Willis, The Photograph Studio, MMA

4a. Finial of a funerary stele, from Attica, ca. 530 B.C. Marble, Pentelic, H. 12⅜ in. (31.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1944 (44.11.5). 4b: Head of a youth from a funerary stele, from Attica, ca. 530 B.C. Marble, Pentelic, overall 10¼ x 15½ in. (26 x 39.4 cm), thickness at top 15¼ in. (38.7 cm), thickness at bottom 16 in. (39.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1942 (42.11.36)



5. Fragment of the funerary stele of Kalliades, from Spata, ca. 510 B.C. Marble, Pentelic, overall 21½ in. (54.6 cm), H. without tenon 20⅞ in. (53 cm), median thickness 5¾ x 15¾ in. (14.6 x 40 cm). The Metropolitan Museum of Art, Rogers Fund, 1955 (55.11.4)

6. Fragment of a stele with the head of a youth, from Megara, 470–460 B.C. Marble, Pentelic. H. 9¾ in. (24.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1912 (12.59). Photographs of Figures 6, 8, 15, 16, 18: Oi-Cheong Lee, The Photograph Studio, MMA

7. Detail of a funerary stele of an athlete, from Nisyros (Incirli Ada), 480–450 B.C. Marble, H. 72 in. (182.9 cm). Istanbul Archaeological Museums (1142T). Photographs of Figures 7, 10, 13: Clemente Marconi

8. Statue of a lion, from Marathon, 340–330 B.C. Marble, Pentelic, overall 27⅞ x 12 x 50 in. (70.8 x 30.5 x 127 cm). The Metropolitan Museum of Art, Rogers Fund, 1909 (09.221.9)

9. Fragment of a relief with Lapith and centaur, from Attica, late 3rd–first half of the 2nd century B.C. Marble, Pentelic, H. 19⅛ in. (48.5 cm), L. 18⅞ in. (47.9 cm), D. 6¼ in. (16 cm). The Metropolitan Museum of Art, Rogers Fund, 1945 (45.11.5). Photograph: Paul Lachenauer, The Photograph Studio, MMA

standard, respectively. The standard adopted is PDB for both oxygen and carbon (the PDB standard is the rostrum of the *Belemnitella americana* of the Cretaceous Pee Dee Formation of South Carolina).

Isotopic characterization has proved to be very useful in the marble identification of ancient artifacts.[14] Its use is becoming more widespread due to its outstanding sensitivity, the small quantity of material necessary for the analysis, and the availability of a rapidly growing database that permits increasingly reliable comparisons,[15] especially if the isotopic data are evaluated together with the minero-petrographic results from the same samples, as in the present study.

RESULTS AND OBSERVATIONS

The results of the archaeometric analyses are summarized in the Table in the Appendix, with the attribution of each marble to the most probable quarry of provenance. The isotopic signatures of all the marbles analyzed here are reported in Diagrams 1–3 in the Appendix. Considering the results in detail, interesting observations emerge.

Under consideration first is the fragmentary Attic grave stele of a youth (Figure 1),[16] to which join two fragments, one found in 1953 in the Agora area.[17] This stele is datable to about 530 B.C. based on the similarity in the proportions, profile, and rendering of the anatomy of the lower body to the kouros said to have been found at Anavysos in 1936.[18] It is characterized by isotopic data that fall slightly out of the reference isotopic field of the marble of Mount Hymettus (see Diagram 1) but may, nevertheless, be safely attributed to that source. This attribution is based on its petrographic features, which closely match those of the reference samples from the quarries on Mount Hymettus.

The head of a horse statue (Figure 2),[19] which was in the Eleusis Archaeological Museum in 1908 and was presumably found locally, is datable to 575–550 B.C.[20] based on the rendering of the mane, which is comparable to works, especially Late Corinthian vases,[21] of this period. It is made of Pentelic marble, not Island marble, as Waldemar Deonna suggested.[22]

The head of a kouros (Figure 3)[23] is said to be from near Sounion, and it is datable to 560–550 B.C. based on the close similarity with the kouros from Volomandra and a kouros head probably from Aegina.[24] It is made of Pentelic, not Island or Cycladic, marble as suggested, respectively, by Gisela Richter and Dietrich von Bothmer.[25] The authenticity of the Metropolitan Museum's head was previously questioned by Max Wegner, Frank Brommer, and Josef Floren,[26] who regarded the head as a modern forgery after the Volomandra kouros, partly because of the dull appearance of the marble surface. That is very likely due, however, to an improper cleaning done with an acid that has given the surface an artificial sheen, as Richter and

10. Copy of the Ince Athena, from Palestrina, 1st–2nd century A.D. Marble, Pentelic, H. 26½ in. (67.3 cm), L. of face 5⅞ in. (15 cm). The Metropolitan Museum of Art, Fletcher Fund, 1924 (24.97.15)

11. Statue of a kore, from Paros, 525–500 B.C. Marble, Parian, H. 41½ in. (105.4 cm). The Metropolitan Museum of Art, Gift of John Marshall, 1907 (07.306)

Bothmer pointed out.[27] In addition, careful study of the thin section prepared from a sample taken from an internal part of the neck has revealed clear, although weak, traces of intracrystalline decohesion of the calcite grains due to intensive weathering. This finding speaks in support of the piece's authenticity.

Two Attic grave stele fragments (Figures 4a, 4b) consist, respectively, of a finial[28] and of the head of a youth.[29] The first piece is said to have been found in Attica, and dated about 530 B.C. in the literature. The second piece is also said to have been found in Attica and can be dated to the same years based on close similarities to the Peplos kore[30] in the rendering of the anatomy. The two fragments are both made of Pentelic marble, not Parian, as tentatively suggested by Richter.[31] In addition, they were manufactured from the same marble block as demonstrated by identical isotopic ratios (see Diagram 1). This finding proves that the two fragments originally belonged to the same funerary stele, as argued by Richter based on the fact that the two pieces were found "not far" from each other.[32]

Two other pieces attest to the continued use of Pentelic marble down to the early fifth century B.C. The first is the fragment of the grave stele of Kalliades (Figure 5),[33] featuring a running Gorgon. The stele, said to have been found at Spata, Attica, is difficult to date with precision due to the weathering of its surface (we tentatively suggest 510 B.C.). The second piece is a grave stele fragment (Figure 6) said to be from Megara,[34] showing the head of a youth. The relief is datable to 470–460 B.C. based on a comparison with the head of the young athlete on the stele from Nisyros (Figure 7). The material of Figure 6 reinforces its reported provenance from Megara, in the face of skepticism from some who favor a provenance in East Greece, such as Hilde Hiller.[35]

The statue of a lion (Figure 8)[36] said to be from Marathon provides evidence of the later use of Pentelic marble. This statue is datable to 340–330 B.C. based on a comparison of the rendering of its mane with that of the Lion of Chaeronea, a funerary statue honoring the soldiers of the Sacred Band of Thebes fallen in the battle (338 B.C.) against Philip II of Macedon.[37] Also of Pentelic marble is an interesting relief fragment featuring a Lapith fighting a centaur (Figure 9).[38] The sculpture, most likely architectural and possibly from a continuous frieze, is said to be from Attica. It can be dated between the late third and the first half of the second century B.C., based in particular on the rendering of the youth's body. Finally, the upper part of a copy of

12. Pedimental relief of a lion devouring a bull, from Athens, ca. 500 B.C. Marble, Parian, H. 25¼ in. (64 cm), L. 28⅜ in. (72 cm). The Metropolitan Museum of Art, Rogers Fund, 1942 (42.11.35)

13. Relief with animal fight, from Paros, ca. 500 B.C. Marble, Parian, H. 28¾ in. (73 cm). Paros Archaeological Museum (759).

14. Statue of a crouching lion, from Rome, first half of the 5th century B.C. Marble, Parian, H. 31¼ in. (79.4 cm), L. 63½ in. (161.3 cm). The Metropolitan Museum of Art, Purchase, Rogers Fund, and James Loeb and Anonymous Gifts, 1909 (09.221.3)

the Ince Athena (Figure 10),[39] said to have been found in Palestrina and whose original is dated about 400 B.C., is also of Pentelic marble.

The torso of a kore (Figure 11), seen on Paros in the nineteenth century and presumably from that island, is comparable for the rendering of the folds to a series of korai from Delos, and may be dated to the same years (525–500 B.C.).[40] Richter identified the material of the torso as Island marble.[41] Our analysis shows that the kore is in fact made of Parian 2 marble, from the open pit quarries of Lakkoi. These are the quarries that provided by far the largest quantity of marble on the island.

The fragment from the central part of a pedimental relief originally featuring two lions devouring a bull (Figure 12),[42] which joins with a fragment in Athens,[43] is made of marble from the same quarries in Lakkoi. The relief originally decorated a small building in the area of the Olympieion in Athens, where the adjoining portion was found in 1862. It is datable to about 500 B.C., based on a comparison with a relief featuring an animal fight from Paros (Figure 13). It may be noted that the two reliefs may be attributable to the same workshop, as they show a very similar rendering of both animals, particularly their heads.

We can also now assign with certainty a provenance from the Lakkoi quarries at Paros to the marble of a statue of a crouching lion (Figure 14)[44] said to have been found in Trastevere, near Porta Portese, in Rome. The dating of the sculpture is rather controversial, with suggestions ranging from 480–460 B.C. to 400–390 B.C.,[45] and a Roman copy of a bronze original dating to 440 B.C.[46] The different dates derive from varying interpretations of the statues of a lion and a lioness found near the Nereid Monument in Xanthos,[47] which seem to offer the closest point of comparison in terms of style. The sculptures have been regarded as either Early Classical (and belonging to a predecessor of the Nereid Monument) or High Classical but deliberately archaizing in style. Either way, it seems that the statues should not be considered a particularly reliable point of reference toward a down-dating of the Metropolitan's lion. Instead, a sima lion's-head waterspout from Agrigento, which shows very similar features, lends support to a dating of the Museum's piece within the first half of the fifth century B.C. The origin of the marble of the Metropolitan's lion supports its attribution by Madeleine Mertens-Horn to a Parian workshop, based on its Early Classical dating and relationship to the Agrigento sima.[48]

A small homogeneous group of materials from Sardis, donated to the Museum in 1926, is also significant. The group includes a statue of a seated lion (Figure 15),[49] which is datable, along with the very similar lion in Istanbul,[50] to about 500 B.C., based on comparison with a lion statue from Knidos;[51] an inscribed stele with a Lydian inscription (Figure 16),[52] tentatively dated to the sixth century B.C.; the fragment of an abacus of an Ionic capital (Figure 17)[53]; and a

15. Statue of a seated lion, from Sardis, ca. 500 B.C. Marble, Sardis, H. 16¼ in. (41.3 cm), L. 41 in. (104.1 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.9)

16. Stele with a Lydian inscription, from Sardis, 6th century B.C. (?). Marble, Sardis, overall 64¼ x 24½ x 8 in. (163 x 62.2 x 20.3 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.7)

17. Fragment of the abacus of an an Ionic column capital, from the Temple of Artemis at Sardis, ca. 300 B.C. Marble, Sardis, L. 16 in. (40.6 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.199.283)

18. Portion of an Ionic column with base and capital, from the Temple of Artemis at Sardis, ca. 300 B.C. Marble, Sardis, H. 142⅛ in. (361 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.1). Photograph: Joseph Coscia Jr., The Photograph Studio, MMA

19. Relief with a fragment of Nike, late 5th century B.C. Marble, probably Parian, H. 18⅛ in. (45.9 cm). The Metropolitan Museum of Art, Rogers Fund 1918 (18.145.61). Photograph: Rona Chang, The Photograph Studio, MMA

portion of an Ionic column with base and capital (Figure 18). The last two pieces belong to the local Temple of Artemis, dated to about 300 B.C. All of the objects were tested, and they are made of the same medium-grained marble from the quarry of the Mağara Deresi Gorge near Sardis, very likely one of the most important quarries used by the ancient town.[54] This finding is of interest particularly in reference to the seated-lion statue. Floren suggested that, based on its high quality, it might represent an import from East Ionia,[55] but this proposition is disproved by the new analysis.

Finally, the results of a petrographic analysis confirm Olga Palagia's identification of the material of a relief with a fragment of the goddess Nike (Figure 19) as Parian marble, which she based solely on its isotopic signature.[56] The new petrographic analysis included the comparison of a thin section of the relief with sections of marble from the two possible quarries of provenance, Mani, Laconia,[57] and Lakkoi, Paros;[58] the latter proved the more likely point of origin. The relief is without indication of provenance and is datable to the late fifth century B.C. Palagia attributed it to one of the metopes of the Temple of Apollo at Bassai,[59] the sculptures of which offer close stylistic comparisons for the rendering of the drapery.

The accurate macroscopic analysis of a number of other Greek sculptures of the Archaic and Classical periods prompted a series of further observations.

20. Detail of a statue of a kouros, from Attica, 600–590 B.C. Marble, Naxian, H. without plinth 76⅝ in. (194.6 cm), H. of head 12 in. (30.5 cm), L. of face 9 in. (22.6 cm), shoulder width 21 in. (51.6 cm). The Metropolitan Museum of Art, Fletcher Fund, 1932 (32.11.1)

21. Detail showing the head of a kouros from the Sacred Gate of the Kerameikos, 600–590 B.C. Marble. H. 57⅛ in. (145 cm). Kerameikos Museum (1700). Photograph: Album/Art Resource, NY

First, the statue of a kouros (Figure 20)[60] is said to be from Attica (Phoinikia?) and datable to 600–590 B.C. based on a comparison with the Dipylon head[61] and the kouros recently discovered near the Sacred Gate of the Kerameikos (Figure 21). Richter defined the material of the statue in Figure 20 as Island marble.[62] More precisely, it should be regarded as Naxian in origin and very likely of the coarse-grained variety quarried in the central area of the island in the valley of Phlerio near the village of Melanes. The marble is, in fact, coarser than that found in the northern quarries of Apollona, with an average grain size of well above 5 millimeters, sometimes reaching a maximum grain size about 1 centimeter, as observable in this statue.

The head of a youth (Figure 22), said to be from mainland Greece or the islands and datable to 480–470 B.C. based on a comparison with a head from Aegina, has been carved out of a first-quality, perfectly white, fine-grained marble that can be identified as Parian *lychnites*.[63] The piece was notoriously connected with Paros by Ernst Langlotz and Hilde Hiller[64] and, alternatively but less convincingly, with the northeastern Peloponnese (Claude Rolley).[65]

An archaic lamp (Figure 23),[66] which joins to a fragment in Boston,[67] is said to have been found near Thebes, although the Boston fragment is said to come from between Athens and Eleusis. The piece, dated to the second half of the sixth century B.C., is very likely of the fine-grained Parian *lychnites* from the quarries of Stephani,[68] or it may be from the quarry of Karavos on the same island.[69] This identification reinforces J. D. Beazley's attribution of the lamp to East Greece,[70] far from its presumed findspot. In fact, low relief is well attested on Paros, from early on, including a somewhat earlier Gorgon relief.[71]

23. Archaic lamp, reportedly from Thebes, second half of the 6th century B.C. Marble, Parian, H. 2½ in. (6.4 cm), Diam. 6½ in. (16.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1906 (06.1072)

22. Head of a youth, Cycladic, 480–470 B.C., Marble, Parian, H. 9¾ in. (24.8 cm), Diam. 5¼ in. (13.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1919 (19.192.11)

The monumental, well-preserved grave stele of a youth and a young girl with a capital and a finial in the form of a sphinx (Figure 24)[72] joins with fragments in Berlin and Athens[73] and is said to have been found in Attica, possibly Anavysos. The monument is datable to about 530 B.C. based on the comparison between the girl's head in Berlin and the above-mentioned Peplos kore. The stele is made of a marble that has some grayish areas and a medium-grain size, very likely from Lakkoi, Paros. The same holds true for the sphinx on a cavetto capital in Figure 25.[74] The sculpture, said to have been found in Attica, is datable to about 580 B.C. based on a comparison with the first generation of Attic kouroi. Also of marble from Lakkoi, Paros (Island marble, according to Richter),[75] is the cavetto capital (Figure 26)[76] with extensive traces of polychromy, said to have been found in Attica. This capital is datable to 550 B.C. based on the style of the reliefs on a comparable stele capital from Lamptrai.[77]

The lower part of a grave stele of a warrior (Figure 27)[78] is said to have been found in Attica. The sculpture is datable to about 520 B.C., between the dates of the more fragmentary stele shown in Figure 1 and of the warriors and chariots on one of the bases from the Themistoclean wall.[79] The warrior relief is identical to the fragmentary stele, which our analysis shows as being of Hymettian marble. In fact, both sculptures are made of a fine-grained marble characterized by a strong foliation evidenced by iso-parallel gray stripes. The evidence supports the idea that both stelae were produced from the same marble from the same quarry on Mount Hymettus and even in the same workshop, a connection advocated by Floren, who suggested that the two

24. Funerary stele of a youth and a young girl, from Attica, ca. 530 B.C. Marble, Parian, total H. 166¾ in. (423.4 cm). The Metropolitan Museum of Art, Frederick C. Hewitt Fund, 1911; Rogers Fund, 1921; and Anonymous Gift, 1951 (11.185a–c, f, g)

25. Sphinx on a cavetto capital, from Attica, 580 B.C. Marble, Parian, H. with akroterion 28⅜ in. (72 cm). The Metropolitan Museum of Art, Fletcher Fund, 1924 (24.97.87)

26. Cavetto capital, from Attica, 550 B.C. Marble, Parian, H. 25 in. (63.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1917 (17.230.6)

reliefs were carved in the workshop that was also responsible for the kouros said to be from Anavysos.[80]

The two fragmentary stelae (Figure 28)[81] and (Figure 31)[82] lack provenance. The former is datable to 520–510 B.C. based on a comparison with the stele fragment in Rome[83] and the stele of Artistion;[84] the latter is generically dated 510–500 B.C. Both are of a slightly gray marble and are of Athenian origin, either Pentelic or Hymettian.

The upper part of a grave stele with palmette finial (Figure 30),[85] which lacks a provenance and is dated 530–520 B.C. based on a comparison with the similar stele of Antiphanes,[86] is made of a fine-grained marble, very likely Pentelic. The grave stele of Antigenes (Figure 29)[87] is of the same marble, on a base likely of Hymettian marble. The piece, said to be from Attica and dated to 510–500 B.C. based on the type of palmette finial with single volutes, shows the typical Pentelic foliation marked by white mica levels.

Finally, the upper torso of a male statue (Figure 32),[88] which lacks provenance and is variously regarded as a Greek original of the Classical period or, more likely, a Roman copy, is made of a fine-grained marble of a color showing a homogeneous weak gray tonality and a waxy appearance. Both features are typical of Carrara marble. These characteristics, however, are also sometimes present in a type of Pentelic marble not commonly used in antiquity. An archaeometric study of the marble could solve this problem definitively and help determine whether the piece is Greek or a Roman copy.

CONCLUSIONS

Archaeometric and macroscopic studies of the rich collection of Greek sculpture in the Metropolitan Museum produced important results with regard both to individual pieces and to Archaic Greek sculpture in general. We may note preliminarily that in Greek art and architecture there was not only a particular appreciation for white marble in comparison with other kinds of stones[89] but also a clear awareness of the various textural (grain size, hardness, response to surface polish) and aesthetic qualities (degree of whiteness and of sparkling in the light, translucency) associated with the different kinds of white marble, with regard to their workability and surface effect.[90]

A critical text is book 36 of Pliny the Elder's *Naturalis Historia,* which is dedicated to stones and expresses a clear preference for Parian *lychnites* and *lunense* (Carrara) marble for sculpture. This literary source is supported by the material record. There was a preference for certain kinds of imported marble in regions that were otherwise rich in this material, the local output apparently judged to be of lesser value by both sculptors and their patrons. A case in point is

27. Fragment of a funerary stele of a warrior, from Attica, ca. 520 B.C. Marble, Hymettian, overall 56 x 20⅛ in. (142.1 x 51.1 cm). The Metropolitan Museum of Art, Fletcher Fund, 1938 (38.11.13)

28. Fragment of a funerary stele of a warrior, from Attica, 520–510 B.C. Marble, either Pentelic or Hymettian, overall 15¾ x 10 in. (40 x 25.2 cm). The Metropolitan Museum of Art, Gift of Norbert Schimmel Trust, 1989 (1989.281.83)

Attica, where despite the presence of good sources of indigenous marble—both Hymettian, which is fine-grained, but either pale gray or bluish-gray and often with dark streaks, and Pentelic, which is very fine-grained but subject to foliation and sometimes with brownish-greenish streaks—favor was generally accorded, particularly for statuary, to marble from Paros, at least until the end of the fifth century B.C. After that period, Parian marble was still used in Attica for heads of statues or for special commissions; a similar use of Parian marble is found elsewhere, which further attests to the ancient appreciation of the different kinds of white marble.[91]

Greek sculptors and workshops appear to have had a particular predilection for specific kinds of marble. It might be assumed that they would think first of the material in which they had been trained or with which they had more familiarity, as in the case of Aristion of Paros, who carved the statue of Phrasikleia out of marble from his own island.[92] However, the case of the Athenian sculptor Praxiteles—maker of several statues in Parian marble including the Knidia—shows that a sculptor's preference for a certain kind of marble was not limited to his training and experience. The choice may have been related to other factors, including a patron's appreciation of a particular material.[93]

29. Funerary stele of Antigenes, from Attica, 510–500 B.C. Marble, Pentelic, with Hymettian base, H. reconstructed 88½ x 25 x 20 in. (224.8 x 63.5 x 50.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1915 (15.167)

30. Funerary stele with palmette finial, from Attica, 530–520 B.C. Marble, Pentelic, width of shaft 13½ in. (34.3 cm), thickness of shaft at bottom 4⅜ in. (11.1 cm). The Metropolitan Museum of Art, Rogers Fund, 1921 (21.88.179)

31. Fragment of a funerary stele, from Attica, 510–500 B.C. Marble, either Pentelic or Hymettian, overall 8⅜ x 9⅝ in. (21.3 x 24.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1915 (15.167.1)

32. Fragment of a torso of a man, unknown provenance, Roman copy of ca. 450–400 B.C. of Greek original (?), Marble, Pentelic (?), overall 15½ x 22 x 10½ in. (39.4 x 55.9 x 26.7 cm). The Metropolitan Museum of Art, Rogers Fund, 1919 (19.192.38)

The identification of the source of a given white marble is important for a variety of reasons: assessing ancient trade in this material, understanding the evolving ideas of sculptors and patrons about the textural and aesthetic qualities of the different kinds of white marble, validating attributions of works to sculptors or workshops, and helping to detect the probable locations of particular workshops.[94] The last point is the case with the identification of the material of the kouros statue (see Figure 20) with marble from the quarries of Phlerio, near Melanes on Naxos. The finding is influential to understanding the origins of marble monumental sculpture in Attica, as it supports the idea of a Naxian origin of the earliest Attic kouroi (as argued recently by Claude Rolley, Mary C. Sturgeon, and Anna Maria D'Onofrio),[95] while denying the alternative proposal for a Parian origin of the statues (as argued recently by Palagia).[96] This particular connection between Attica and Naxian marble in the late seventh and early sixth century B.C. offers insight into a flat tile of Naxian marble from the Acropolis marked "By" and likely connected with Byzes of Naxos. That individual is cited by Pausanias (*Description of Greece* 5.10.3) as the inventor of marble roof tiles, and some modern scholars attribute the roof of the Oikos of the Naxians on Delos (580–560 B.C.) to him.[97]

Analysis of the two grave stelae shown in Figures 1 and 27 confirms the provenance of their marble as Mount Hymettos. This marble was used for sculpture as early as the second quarter of the sixth century B.C., including the architectural sculptures attributed to the decoration of Temple H on the Acropolis (ca. 570–560 B.C.)[98] and the Moschophoros.[99] Its use is documented throughout the last decade of the sixth century B.C. by three statues of scribes carved in this material.[100] It is generally thought that Hymettian marble was mainly used for the cavetto capitals of funerary stelae, bases of funerary monuments, and possibly statue bases during the sixth century B.C., but the Museum's pieces confirm that it could also be employed for fine reliefs. In fact, very few materials of this marble have, thus far, been subjected to archaeometric analysis and accurate macroscopic study. In light of the difficulty of distinguishing Hymettian from Pentelic marble, it is possible that the former was used more often than is generally assumed. The idea that Hymettian marble had limited use in carving depends on recognizing the predilection for Parian marble in Attica during the Archaic period. Yet the findings in this study show that there are exceptions. It is possible that for Attic Archaic funerary stelae which made significant use of polychromy,[101] Hymettian marble with its color and streaks would have had limited appeal for both sculptors and patrons.

Our analysis not only supports the authenticity of the kouros head in Figure 3 but also confirms that it was made of Pentelic marble. Indeed, it appears to be one of the earliest documented examples of carving in this material.[102] The use of this marble for sculpture in the Archaic period—formerly hypothetical, given the lack of corresponding archaeometric studies—is clearly documented by a series of unfinished sculptures in the quarries at Mount Pentelikon. The quarries are said to have opened in the second quarter of the sixth century B.C., with the kore with the pomegranate from the Acropolis, dated 560–550 B.C.,[103] representing one of the earliest examples. The gradual increase in the use of this material throughout the sixth century B.C., particularly for funerary stelae, is confirmed by the two fragments shown in Figures 4a and 4b (which, according to our analysis, belong to the same monument), the stele of Kalliades (Figure 5), and the relief from Megara (Figure 6). The horse head in Figure 2 provides a further example of the use of Pentelic marble for statuary. The closeness of the isotopic ratio of all the pieces analyzed clearly indicates a unique quarry area, exploited throughout the period, very likely the lower quarries of Mount Pentelikon.[104] The evidence further indicates that Pentelic marble, although already in use during the Archaic period, was still far from being exploited on such a large scale as it came to be between the Classical and Late Classical periods. Once again, the particular appreciation of Parian marble in Attica during the Middle and Late Archaic periods may be one of the factors explaining the more limited use of Pentelic marble.

Regarding Parian marble, a series of pieces attests to the importance of the quarries in Lakkoi (so-called Paros 2 type): these are the kore in Figure 11, the grave stele in Figure 24, the pedimental relief in Figure 12, and the lion statue in Figure 14. By comparison, only two pieces can be identified with *lychnites* (so-called Paros 1 type), namely the head in Figure 22 and the lamp in Figure 23. This ratio agrees with the general rarity of the latter versus the more widespread use of the former.[105] In fact, the importance of marble from Lakkoi during the Archaic and Classical periods is now confirmed by an extensive archaeometric investigation of the marble sculptures from Magna Graecia, Sicily, and Cyrene.[106] From this point of view, the findings of archaeometric analysis give a more nuanced understanding of the appreciation of Parian marble, particularly during the Archaic and Classical periods. Based on book 36 of Pliny the Elder's *Naturalis Historia*, one would assume that Greek sculptors would have made nearly exclusive use of *lychnites*.[107] However, the present study documents that the employment of *lychnites* was not so widespread—understandably so, as it was quarried in an underground cave—while the use of the medium-grained variety from Lakkoi was particularly significant for export to colonies in the West and in North Africa. This is definitely not the case of a material of lesser quality shipped abroad to undiscerning patrons. Lakkoi marble could also be used for local commissions, as demostrated by the kore in Figure 11, or for a clientele familiar with Parian marble, such as the Attic one, shown by the pedimental relief in Figure 12. In addition, Lakkoi marble was used for the Mozia Charioteer, one of the most superbly carved marble statues from Greek antiquity.[108] Thus the relevant pieces in the Metropolitan Museum are especially important for determining that the medium-grained variety of Parian marble was highly regarded by local sculptors and patrons and much in demand abroad.

After these general considerations about the use of Naxian, Parian, Hymettian, and Pentelic marble in the Archaic and Classical periods, we may conclude with two smaller notes. The possible provenance from Paros of the marble of the relief with Nike in Figure 19 supports the identification of the piece as forming part of the decoration of the Temple of Apollo at Bassai. In addition, the analysis demonstrates the extensive use of local marble, specifically from the quarries of the Mağara Deresi Gorge, for the lion statue in Figure 15, the stele in Figure 16, and the architectural elements of the Artemision in Figures 17 and 18, all from Sardis. The use of Sardis marble, a material seldom studied and discussed, appears to have been exclusively local, as it is rather coarse-grained and more suitable for architectural elements than for sculpture.[109]

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NOTES

1. Winckelmann 2006, pp. 244–51.
2. Lepsius 1890.
3. *Archaeometry: The Bulletin of the Research Laboratory for Archaeology and the History of Art* 1, no. 1 (Spring 1958), cover.
4. See Herz 2006 for a general introduction to the studies and techniques for determining the provenance of marbles.
5. Lazzarini 2004.
6. Van der Merwe et al. 1995.
7. Ibid.
8. Lazzarini, Piccioli, and Turi 2002.
9. Kidd, Attanasio, and Tykot 2012.
10. Pensabene et al. 2012; Lapuente Mercacadal et al. 2012a; and Lapuente Mercacadal et al. 2012b.
11. Lazzarini, Moschini, and Stievano 1980; and Gorgoni et al. 2002.
12. Spry 1969.
13. McCrea 1950 and Craig 1957.
14. Gorgoni et al. 2002.
15. Barbin et al. 1992; Gorgoni et al. 2002; and Attanasio, Brilli, and Ogle 2006.
16. See Richter 1954, p. 10, no. 13, pl. 14a; Richter 1961, p. 24, no. 33, figs. 93, 95, and 175; Harrison 1965, pp. 41–42, no. 99, pl. 19; Dörig 1967, pp. 15–19, fig. 4; Frel 1973, figs. 1–3; Floren 1987, p. 285n22; Trianti 1991, pp. 237–40, pls. 77–78; Ridgway 1993, p. 261n6.41; and Brinkmann 2003, no. 306.
17. National Archaeological Museum, Athens (hereafter Athens NAM; 4.808) and Agora Museum, Athens (S 1751), respectively.
18. Athens NAM (3851).
19. Deonna 1908, pp. 195–96, fig. 4; Vermeule 1981, p. 28, no. 3, ill.; Floren 1987, p. 278n8; Mertens 1987, p. 33, no. 18, ill.; Walter-Karydi 1987, pp. 70, 72, figs. 100, 101; Ridgway 1993, p. 214n5.43; Eaverly 1995, p. 82n30; and Picón et al. 2007, p. 420, nos. 76, 79 ill.
20. Elena Walter-Karydi dates the piece 550–525 B.C. See Walter-Karydi 1987, p. 70.
21. For example, the column-krater in the Vatican, Museo Gregoriano Etrusco (126).
22. Deonna 1908, p. 195.
23. See Wegner 1932, p. 200, pl. 46.4; Richter 1954, pp. 2–3, no. 2, pl. 4a–c; Brommer 1963, pp. 439–50, figs. 1–3; Bothmer 1964, figs. 1–4; Brommer 1965; Richter 1970, p. 81, no. 64, figs. 217, 218; Floren 1987, p. 253n11; Spier 1990, p. 626; and Meyer and Brüggemann 2007, p. 217, no. 370.
24. The kouros from Volomandra is in the Athens NAM (1906) as is the kouros head probably from Aegina (48).
25. Richter 1954, p. 3, and Bothmer 1964, p. 615.
26. Wegner 1932, p. 200; Brommer 1963; Brommer 1965; and Floren 1987, p. 253n11.
27. Richter 1954, p. 3, and Bothmer 1964, p. 615.
28. For more on the finial see Richter 1954, p. 15, no. 18, pl. 21b; Richter 1961, p. 31, no. 43, fig. 125; Ridgway 1993, p. 234; and Picón et al. 2007, p. 421, nos. 80, 81 ill.
29. For more on the head of a youth see Richter 1954, pp. 14–15, no. 17, pl. 21a; Richter 1961, pp. 35–36, no. 52, fig. 132; Jeffery 1962, p. 148, no. 5; Tsirivaku-Neumann 1964, pp. 120–21, pl. 65; Stewart 1976; Floren 1987, p. 286n25; Mertens 1987, pp. 12–13, ill.; Trianti 1991, p. 239n20; Ridgway 1993, pp. 234, 238, fig. 105; Brinkmann 2003, no. 313; and Picón et al. 2007, p. 421, nos. 80, 81 ill.
30. Acropolis Museum, Athens (679).
31. See Richter 1961, pp. 31, 35, respectively.
32. Ibid., p. 31.
33. See Bothmer 1958, pp. 187–88, ill.; Karusos 1961, p. 99n76; Jeffery 1962, pp. 136–37, no. 43; Neumann 1979, p. 14n44; Woysch-Méautis 1982, fig. 361; Schmaltz 1983, p. 173; Floren 1987, p. 287n40; Krauskopf 1988, p. 306, no. 238b, pl. 178; Ridgway 1993, pp. 236–37; and Keesling 1999, p. 540n144.
34. See Richter 1954, p. 18, no. 22, pl. 22c; Blümel 1968, p. 16, fig. 6; Hiller 1975, p. 95n116; Floren 1987, p. 311n6; and Walter-Karydi 1987, pp. 124, 127, fig. 200.
35. See Hiller 1975, p. 95n116.
36. See Richter 1910, p. 41; Richter 1954, p. 82, no. 145, pls. 105c–d, 106; Vermeule 1968, p. 100; and Vermeule 1972, p. 50.
37. Ridgway 1997, pp. 144, 166, pl. 37.
38. See Richter 1954, pp. 114–15, no. 231, pl. 160a. Clemente Marconi thanks Kyriaki Karoglou, assistant curator, Department of Greek and Roman Art, for the opportunity to examine closely MMA 45.11.5.
39. See Richter 1926, pp. 127–28, fig. 2; Richter 1954, p. 43, no. 65, pl. 54d–f; Waywell 1971, p. 381, no. 12; and Delivorrias 2011, p. 73, fig. 4.
40. For the torso of a kore (Figure 11), see Richter 1954, pp. 4–5, no. 5, pl. 8; Richter 1968, p. 89, no. 151, figs. 483–86; Pedley 1976, p. 43, no. 32, pls. 20, 21; Floren 1987, p. 166n46, pl. 10.5; Ridgway 1993, p. 169n4.45; Karakasi 2003, pp. 89, 159, pls. 80, 81; and Picón et al. 2007, p. 420, nos. 74, 77 ill. As a comparison, see especially the kore, Archaeological Museum, Delos (A4063).
41. Richter 1954, p. 5.
42. See ibid., pp. 5–6, no. 7, pl. 10a–c; Gabelmann 1965, pp. 96, 122, no. 150a; Bookidis 1967, pp. 54–55, no. P14; Richter 1970, pp. 82–83, 89, figs. 19, 33; Hölscher 1972, p. 73, no. G5; Floren 1987, p. 243n31, pl. 24.2; Mertens 1987, p. 32, no. 17, ill.; Walter-Karydi 1987, p. 159n349; Markoe 1989, p. 101n58, pl. 16; Ridgway 1993, p. 296; Rolley 1994–99, vol. 1, p. 193; Kaltsas 2002b, pp. 69–70, no. 98, ill.; and Picón et al. 2007, p. 423, nos. 91, 87 ill.
43. Athens NAM (1673).
44. See Marshall 1910, pp. 210, 212–13; Richter 1954, p. 46, no. 72, pls. 58, 59; Gabelmann 1965, pp. 76–77, 118, no. 95, pl. 19.1; Vermeule 1968, p. 99; Richter 1970, pp. 75, 77, fig. 6; Vermeule 1972, p. 53; Mertens-Horn 1986, pp. 6–18, pls. 5.2, 6; Kokkorou-Alewras 1993, pp. 92, 94n29, 96, 99–100, pl. 25.3; and Picón et al. 2007, p. 131, no. 144 ill.
45. See Mertens-Horn 1986, p. 18, and Picón et al. 2007, no. 144, respectively.
46. See Vermeule 1972, p. 53.
47. British Museum, London (929, 930).
48. See Mertens-Horn 1986, p. 18. The sima lion's-head waterspout is in the Museo Archeologico Regionale, Agrigento.
49. See Butler 1922, pp. 125–26, figs. 136, 137; Richter 1954, p. 5, no. 6, pl. 9; Vermeule 1968, p. 99; Hanfmann and Ramage 1978, no. 235, figs. 405, 406, 409; and Floren 1987, p. 410n12.
50. Istanbul Archaeological Museums (4028).
51. Pergamon Museum, Berlin (1724). See Blümel 1963, no. 32.
52. *MMAB*, n.s., 26, no. 5 (January 1968), p. [198], no. 6.
53. See Butler 1922, pp. 52–53, fig. 46a–b; Butler 1925, pp. 65–68, figs. 73–76, pls. B, C, Atlas pls. VIII–XI; Richter 1926, p. 7, figs. 1, 10, 11; Richter 1953, pp. 109–10; Richter 1970, pp. 91–92, fig. 36; Mertens 1987, pp. 74–75, no. 55, ill.; and Picón et al. 2007, pp. 181 ill., 446, no. 208.
54. See Ratté, Ramage, and Tykot 2011, pp. 127–32.

55. Floren 1987, p. 410n12.
56. See Pinney 1924, p. 240; Palagia 2002 and Jenkins 2006, p. 139.
57. See Bruno et al. 2002.
58. See Gorgoni et al. 2002.
59. Palagia 2002, p. 382.
60. See Richter 1954, pp. 1–2, no. 1, pls. 1–3; Richter 1970, pp. 41–42, no. 1, figs. 25–32, 60–62; Guralnick 1985; Floren 1987, p. 252n6; Mertens 1987, pp. 28–29, no. 14, ill.; Brinkmann 1998, pp. 70–71, no. D42, fig. 101; Ridgway 1993, pp. 34, 88, 100n3.20, fig. 28; Rolley 1994–99, vol. 1, pp. 165, 167, 280; Kyrieleis 1996, pp. 56–57; Niemeier 2002, pp. 40–53; Vorster 2002, pp. 120–25, 304, fig. 190a–e; Brinkmann 2003, no. 311; Boardman 2006, pp. 13, 15, figs. 8, 21, 24; Palagia 2006b, p. 247; Sturgeon 2006, pp. 36, 38–39; Meyer and Brüggemann 2007, p. 199, no. 299; Picón et al. 2007, p. 419, nos. 67, 70, 71 ill.; D'Onofrio 2008, passim; Kleemann 2008, pp. 35–37; Carter and Steinberg 2010, passim, fig. 2a; Neer 2010, pp. 24–25, figs. 6, 7; and Palagia 2010, pp. 44–45, fig. 15.
61. Athens NAM (3372).
62. Richter 1954, p. 2.
63. See Langlotz 1927, pp. 132, 134, pl. 80; Richter 1954, p. 3, no. 3, pl. 5; Richter 1961, pp. 141–42, no. 172, figs. 505, 506; Hiller 1975, pp. 84, 111, 112n22; Sheedy 1985, p. 621; Rolley 1994–99, vol. 1, p. 325, figs. 333, 326; and Picón et al. 2007, p. 425, no. 100, 95 ill. The head of a youth from Aegina is in Athens NAM (3459).
64. See Langlotz 1927, p. 132, and Hiller 1975, p. 84.
65. See Rolley 1994–99, vol. 1, p. 326.
66. See Beazley 1940, pp. 40–42, fig. 21, pl. 7; Richter 1954, p. 6, no. 8, pl. 11; Gabelmann 1965, pp. 59, 115, no. 57; Comstock and Vermeule 1976, p. 16, no. 24; Mertens 1979, p. 35n70; Vermeule 1981, p. 29, no. 4; Floren 1987, p. 317n52; and Picón et al. 2007, p. 416, nos. 42, 57 ill.
67. Museum of Fine Arts, Boston (01.8212).
68. On the quarries, see Lazzarini 2007b.
69. See Bruno et al. 2000.
70. See Beazley 1940.
71. Paros Archaeological Museum (172).
72. See Richter 1954, pp. 11–13, no. 15, pls. 15–18; Richter 1961, pp. 27–29, 159–65, no. 37, figs. 96–109, 204, ill. 27; Deyhle 1969, pp. 31–33, pl. 1.1; Karuzu 1976; Neumann 1979, pp. 8, 23, pl. 3a; Schmaltz 1983, passim, pl. 1.2; Floren 1987, p. 288n43, pl. 25.3; Mertens 1987, pp. 30–31, no. 16, ills.; Stewart 1990, p. 120, fig. 143; Ridgway 1990, pp. 589–90, figs. 3, 4; Ridgway 1993, pp. 100n3.20, 227, 235, 261–62, 262n6.44, fig. 98; Rolley 1994–99, vol. 1, p. 39, figs. 34, 234; Brinkmann 1998, pp. 28, 44n119; Andreiomenou 2000, pp. 102–6, pl. 5.1; Karanastassis 2002, pp. 211–12, 316, fig. 292a–b; Brinkmann 2003, nos. 304, 305; Sturgeon 2006, pp. 46, 61; Picón et al. 2007, p. 420, nos. 71, 74, 75, ills.; Scholl and Platz-Horster 2007, p. 144, no. 82; and Neer 2010, pp. 27–28, fig. 12.
73. Pergamon Museum, Berlin (Sk 1531); Athens NAM (4518, 4551), respectively.
74. See Richter 1954, p. 8, no. 10, pl. 12; Richter 1961, p. 10, no. 1, figs. 1–7, 191; Floren 1987, p. 283n4; Ridgway 1993, pp. 171n4.57, 232, 255n6.27, 261n6.41; and Sturgeon 2006, p. 62.
75. See Richter 1961, p. 10.
76. See Richter 1954, pp. 9–10, no. 12, pls. 13d–f, 14c; and Richter 1961, pp. 19–20, no. 21, figs. 72–76.
77. Athens NAM (229).
78. See Richter 1954, pp. 13–14, no. 16, pls. 19, 20; Richter 1961, pp. 32–33, no. 45, figs. 126–28, 179; Floren 1987, p. 286n28; Ridgway 1993, p. 237; Brinkmann 2003, no. 312; and Picón et al. 2007, p. 419, no. 68, 72 ill.
79. Athens NAM (3477).
80. Floren 1987, p. 286n28.
81. For more on Figure 28, see Thomas 1988; Milleker 1992, p. 44, ill.; and Ridgway 1993, pp. 260n6.40, 436n10.8, 441n10.26.
82. For more on Figure 31, see Richter 1954, pp. 17–18, no. 21, pl. 22e; Richter 1961, p. 49, no. 72, fig. 170, 49, ill.; Floren 1987, p. 289n47; and Brinkmann 2003, no. 308.
83. Museo di Scultura Antica Giovanni Barracco, Rome (MB 73).
84. Athens NAM (29).
85. See Richter 1954, pp. 15–16, no. 19, pl. 22b, d; Richter 1961, pp. 40–41, no. 55, fig. 141 and ill. p. 40; Jeffery 1962, p. 148, no. 6; and Brinkmann 2003, no. 309.
86. Athens NAM (86).
87. See Richter 1954, pp. 16–17, no. 20, pl. 22a; Richter 1961, pp. 44–45, no. 61, figs. 147, 188, 210; Floren 1987, p. 289n47; and Mertens 2010, p. 133, fig. 44.
88. See Richter 1954, p. 27, no. 32, pl. 30d, e.
89. See Neer 2010, pp. 73–77.
90. See in general Rolley 1994–99, vol. 1, pp. 58–59; and Lapatin 2014, p. 220.
91. See Palagia 2000.
92. Kaltsas 2002a.
93. Corso 2000.
94. Identification of the white marble of some kouroi from eastern Sicily could help specify the location of their originating workshop based in Syracuse; see Basile and Lazzarini 2012.
95. Rolley 1994–99, vol. 1, pp. 165–67; Sturgeon 2006, pp. 43–44; and D'Onofrio 2008.
96. Palagia 2010, pp. 45–46, 61–63.
97. See most recently Ohnesorg 1993, pp. 65–66, 141, no. 1, pls. 6, 37.2.
98. For example, Acropolis Museum (701).
99. Acropolis Museum (624). On the use of Hymettian marble in the Archaic period, see most recently Sturgeon 2006, pp. 44–46, and Palagia 2010, p. 44.
100. Acropolis Museum (144, 146, 629).
101. See Brinkmann 2003 and Brinkmann and Wünsche 2007.
102. On the use of Pentelic marble in the Archaic period, see most recently Sturgeon 2006, pp. 34, 46, 62; and Palagia 2010, p. 44.
103. Acropolis Museum (593)
104. Korres 1995, p. 98.
105. On the use of Parian marble in the Archaic period, see most recently Sturgeon 2006, pp. 34, 44, 48, 62; and Schilardi and Katsonopoulou 2000.
106. Magna Graecia: Lazzarini 2007a; Sicily: Gorgoni et al. 1993; Gorgoni and Pallante 2000; Basile and Lazzarini 2012; and Cyrene: Lazzarini and Luni 2010.
107. "Omnes autem candido tantum marmore usi sunt e Paro insula, quem lapidem coepere lychniten appellare." Pliny the Elder, *Naturalis Historia* (36.14).
108. For more on the Mozia Charioteer, see Gorgoni et al. 1993, pp. 50–52; Gorgoni and Pallante 2000, p. 503; and Marconi 2014. Identification of the marble was confirmed by the more recent analyses of the statue by Jerry Podani at the J. Paul Getty Museum, Los Angeles.
109. See Monna and Pensabene 1977, pp. 177–80; and Ratté, Ramage, and Tykot 2011. A thorough study of the ancient quarries of Sardis and their marbles is in progress by Nicholas Cahill and Lorenzo Lazzarini.

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APPENDIX

TABLE. SUMMARY OF THE MINERO-PETROGRAPHIC AND ISOTOPIC ANALYSES OF SAMPLES
(H, heteroblastic; Py, Pyrite; He, Hematite; +++, very abundant; ++, abundant; +, present; ±, trace)

Figure Number Object MMA acc. no.; Richter (1954) cat. no.	Sample Number	Fabric, Notes	Calcite Crystals Boundaries	Maximum Grain Size (mm)	Quartz
Figure 1 Stele of a youth MMA 12.158; Richter 13	11	H., mosaic, lineated	Curved	0.88	
Figure 2 Head of a horse MMA 1972.118.106	14	H., mosaic , lineated, slight intracrystalline decohesion	Embayed	0.73	
Figure 3 Head of a kouros MMA 21.88.16; Richter 2	6	H., slightly lineated and strained, slight intracrystalline decohesion	Embayed	0.88	
Figure 4a (top) Finial of a stele MMA 44.11.5; Richter 18	18	H., mosaic, polycrystalline quartz	Curved	0.72	+++
Figure 4b (bottom) Head of a youth MMA 42.11.36; Richter 17	17	H., mosaic, slightly lineated	Curved-to-embayed	0.82	+++
Figure 5 Stele of Kalliades MMA 55.11.4	16	H., mosaic, strongly lineated, slight intercrystalline decohesion, Albitic plagioclase ±	Curved-to-embayed	0.90	±
Figure 6 Fragment of a stele MMA 12.59; Richter 22	12	H., mosaic, lineated	Embayed	1.28	
Figure 8 Statue of a lion MMA 09.221.9; Richter 145	1	H., mosaic with fine-grained areas	Curved-to-embayed	0.72	±
Figure 9 Fragment of a relief with centaur and Lapith MMA 45.11.5	9	H., slightly lineated, quartz well rounded	Embayed	0.96	±
Figure 10 Copy of the Ince Athena MMA 24.97.15; Richter 65	2	H., mosaic, slightly lineated	Embayed	1.68	±
Figure 11 Statue of a kore MMA 07.306; Richter 5	10	H., mosaic, severe inter- and intracrystalline decohesion	Embayed	2.08	±
Figure 12 Relief of a lion devouring a bull MMA 42.11.35; Richter 7	15	H., mosaic, slightly strained, severe inter-and intracrystalline decohesion	Curved-to-embayed	1.60	
Figure 14 Statue of a crouching lion MMA 09.221.3; Richter 72	4	H., mosaic, inter- and intracrystalline decohesion	Embayed	2.80	
Figure 15 Statue of a seated lion MMA 26.59.9	5	H., lineated and slightly strained, inter- and intracrystalline decohesion	Embayed to sutured	2.16	
Figure 16 Stele with a Lydian inscription MMA 26.59.7	7	H., lineated and very strained, inter- and intracrystalline decohesion	Sutured	2.64	
Figure 17 Fragment of an Ionic column capital MMA 26.199.283	8	H., lineated and strained	Sutured	3.60	
Figure 18 Portion of an Ionic column with base and capital MMA 26.59.1	3	H., lineated and slightly strained	Sutured	2.42	
Figure 19 Relief with a Nike MMA 18.145.61	13	H., mosaic, intracrystalline decohesion	Embayed	2.24	±

K-mica	Titanite	Apatite	Carbonaceous Matter/ Graphite	Opaque Minerals/ Iron Ore	Dolomite (XRD)	δ ^{13}C (+)	δ ^{18}O (–)	Probable Provenance
+		±	+++	+ Py	±	1.9	0.8	Mount Hymettus (Attica, Greece)
			++	±	–	2.6	7.7	Mount Penteli (Attica, Greece)
			+		–	2.6	7.3	Mount Penteli (Attica, Greece)
			++	+ Py	– Quartz ±	2.8	6.9	Mount Penteli (Attica, Greece)
			++		–	2.9	6.9	Mount Penteli (Attica, Greece)
+++			+++	± Py	–	2.6	6.2	Mount Penteli (Attica, Greece)
++				± Py	–	2.5	8.2	Mount Penteli (Attica, Greece)
			++	±	+	2.8	6.5	Mount Penteli (Attica, Greece)
±			+		–	2.3	6.7	Mount Penteli (Attica, Greece)
		±	+		±	2.8	4.9	Mount Penteli (Attica, Greece)
			++		–	1.9	–0.9	Lakkoi (island of Paros, Greece)
			++		–	1.9	1.3	Lakkoi (island of Paros, Greece)
		±	+		–	2.3	1.1	Lakkoi (island of Paros, Greece)
				+ Py	–	4.5	8.2	Mağara Deresi quarry (Sardis, Sart, Turkey)
				+ Py	–	4.6	6.3	Mağara Deresi quarry (Sardis, Sart, Turkey)
			+++	++ Py	–	4.5	6.5	Mağara Deresi quarry (Sardis, Sart, Turkey)
++	±	+		++ Py, He	–	4.7	7.9	Mağara Deresi quarry (Sardis, Sart, Turkey)
			+		–	2.02	1.22	Probably Lakkoi (island of Paros, Greece)

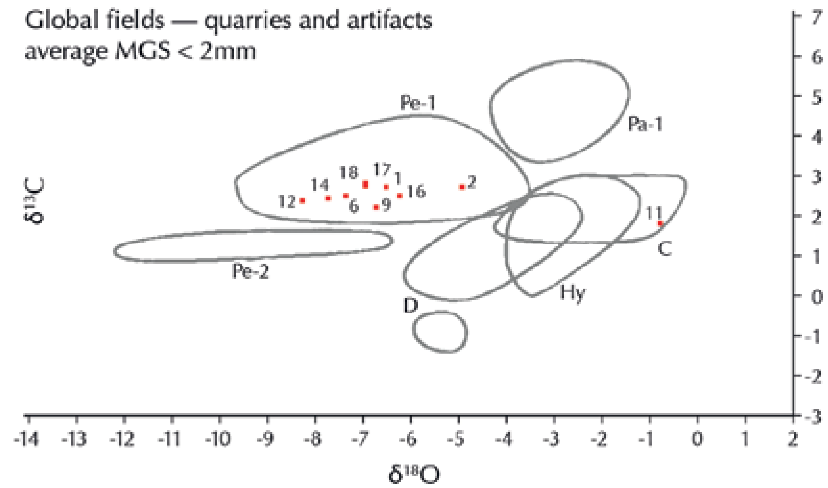

Diagram 1. Isotopic signatures of the marbles analyzed in this article: Hymettian, Paros 1, Pentelic. Diagrams 1–3: Lorenzo Lazzarini

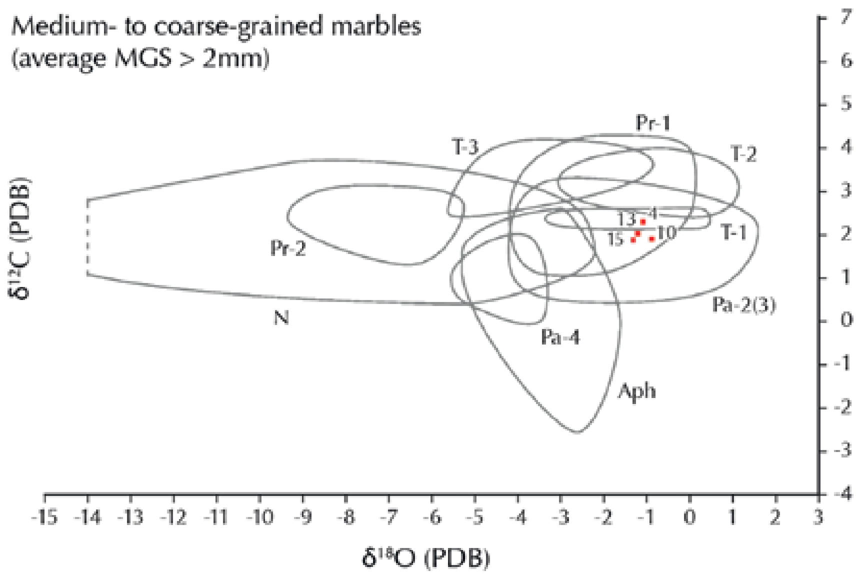

Diagram 2. Isotopic signatures of the marbles analyzed in this article: Paros 2

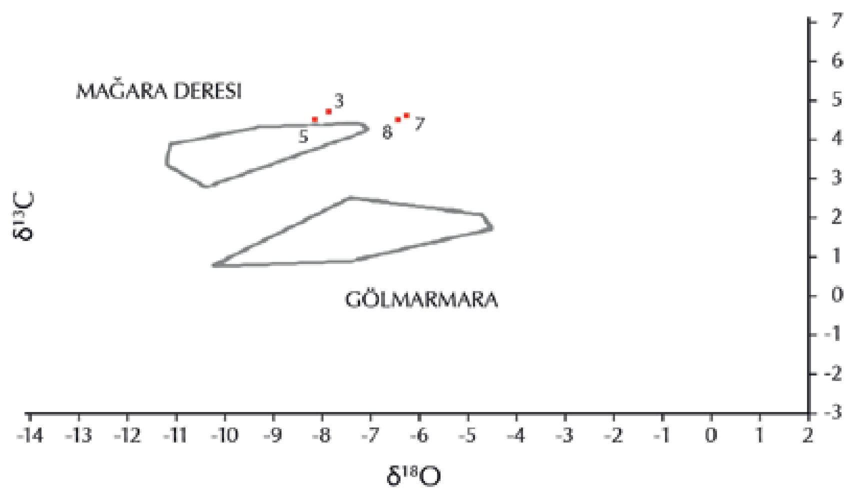

Diagram 3. Isotopic signatures of the marbles analyzed in this article: Sardis

Hellenistic Etruscan Cremation Urns from Chiusi

THERESA HUNTSMAN

Publications Data Manager, Archaeological Exploration of Sardis, Harvard Art Museums, Cambridge, Massachusetts

The city of Chiusi, ancient Clusium in Latin, or Clevsin in Etruscan, lies about 105 miles north of Rome along major trade routes through inland Etruria. Once one of the twelve cities of Etruria and seat of the famous Etruscan king Lars Porsenna,[1] Chiusi and its environs have been occupied continuously from the Bronze Age to the present day. Antiquarian interest and fortuitous discoveries by local farmers in the nineteenth century uncovered hundreds of burials—simple pit tombs to multigenerational chamber tombs—in the area. Excavation practices of the day led to the quick excavation and dispersal of archaeological materials to museums and private collections across Europe and the United States, including The Metropolitan Museum of Art, in the late nineteenth and early twentieth centuries. Objects from a single tomb were usually sold separately, and even if the original context was documented, the information often did not accompany artifacts, especially objects coming to the United States. In some cases, however, inscriptions in Etruscan or other distinguishing features on objects make it possible to determine their archaeological provenance and gain further insight into Etruscan funerary and artistic practices. An analysis of the forms and name inscriptions of a group of six cremation urns from Chiusi at the Metropolitan, never before the subject of a focused study, offers a new understanding of the urns' manufacture and archaeological contexts as well as Etruscan family relationships and the role of burial containers in the Etruscan funerary environment.

The Etruscans of Chiusi preferred to cremate their dead and deposited the ashes in a range of containers. Chiusi is most noted for its production of so-called terracotta "canopic" cremation urns with simple, ovoid bodies containing the cremated remains and with lids in the shape of human heads (Figure 1).[2] This urn form "stood in" for the deceased in tombs of the Orientalizing period (seventh to sixth century B.C.) and was often placed on a high-backed chair or throne and arranged before an assemblage of grave goods related to banqueting. Over the course of the Archaic and Classical periods (sixth to fifth century B.C.), the canopic urn gave way to stone cinerary statues or relief-decorated, square *cippi* (boxes), but these monuments were generally very large, difficult to produce, and available to only a small, affluent portion of the population.[3]

1. Canopic urn. Etruscan, Chiusi, 6th century B.C. Terracotta; H. with cover 21 3/4 in. (55.2 cm), H. without cover 13 1/4 in. (33.8 cm). The Metropolitan Museum of Art, Purchase, 1896 (96.9.50a, b). Photographs of Figures 1–3, 5, 7, 9, 10: Paul Lachenauer, The Photograph Studio, MMA

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2. Urn of *θana : vipinei : ranazunia : creicesa*. Hellenistic Etruscan, Chiusi, 2nd century B.C. Terracotta; H. 28¼ in. (71.8 cm), body 29 x 20½ x 11¾ in. (73.7 x 52.1 x 29.8 cm), lid 12½ x 11¼ x 11⅝ in. (31.8 x 28.6 x 29.5 cm). The Metropolitan Museum of Art, Purchase, 1896 (96.9.223a, b)

The continuing prosperity of Chiusi as a major agricultural and trading hub during the Hellenistic period (fourth to first century B.C.) led to the exponential increase in individuals with access to formal burial, this time with a revised iconography, produced in both stone and terracotta. Incorporating some of the same iconographic and ideological elements as the canopic urns and cinerary statues, these Hellenistic urns relate to banqueting practice. The rectangular boxes are decorated with mold-made relief scenes, while the lids bear three-dimensional figures of the deceased, either reclining in a banqueting posture or fully recumbent on a *kline* (banqueting couch). Across the top of the box or along the edge of the lid is the name of the deceased, written from right to left in Etruscan script. While the Etruscan cities of Volterra and Perugia also produced cremation urns of this type, the tradition began and was most prolific at Chiusi,[4] whose artisans may have brought the traditions to the other cities. More than a thousand Chiusine urns exist in museum collections today, and the six terracotta urns dating from the third to second century B.C. at the Metropolitan Museum are particularly well-preserved examples of known types, bearing inscriptions that connect them to Etruscan family tombs throughout central Etruria.

3. Urn of *av : latini : velsial*. Hellenistic Etruscan, Chiusi, 3rd century B.C. Terracotta, paint; H. 26 in. (66 cm), L. 11 1/8 in. (28.4 cm). The Metropolitan Museum of Art, Purchase by subscription, 1896 (96.18.163a, b)

URN MANUFACTURE, FORM, AND CONDITION

The six urns in the Metropolitan were produced in terracotta workshops at Chiusi (Figures 2, 3, 5, 7, 9, 10).[5] During the manufacturing process for the boxes, the clay was prepared, and a rectangular slab was pressed into a mold of the relief scene to serve as the front.[6] The artisan then applied a layer of liquid clay to fill the concave areas on the reverse of the relief and smoothed it by hand or with wood tools. Next, the relief slab was mounted and attached by hand onto another precut, flat slab that constituted the base. The artisan then applied the two short sides and the back wall of the urn, all attached with liquid clay, pinched by hand and smoothed from bottom to top on the interior seams, and planed with flat tools on the exterior. The corners were reinforced on the interior with additional applied bits of clay. The final component added to the box was the upper surface; this top slab of clay was pierced with a broad ovoid or rectangular hole to introduce the cremated remains, leaving a wide margin to serve as the resting surface of the lid.

Chiusine urns typically support lid figures made from single-part molds for the fully recumbent types (Figures 7, 9), or with a combination of multipart molds for the more complicated reclining figures (Figures 2, 10). The heads of the recumbent figures were molded separately and attached, so that different head types could be applied to the same body type. The proper right side of these heads tends to be broader and the face at a slight diagonal in order to keep the features fully visible after being joined to the body, with the left cheek toward the cushion on which the figure lies. For the reclining figures, the lower body, torso, limbs, and head were produced in separate molds, then assembled with the joints reinforced, for instance by attaching the extended right arm to the element held in the hand, then applying it to the lap of the figure. Joins were made through the application of liquid clay to bind the elements, then smoothed on the surface to render the seams invisible.

Not all aspects of the production process were concealed. Many urn lids are pierced with a hole to allow gases to escape during firing of the small vent in the end of the cushion. Figure 8 shows the hole of Figure 7, which is partially concealed by a layer of slip or a thin, white wash derived from the same type of clay as the box. After firing,

4. Urn lid. Hellenistic Etruscan, 3rd century B.C. Terracotta, 21 x 9½ x 13 in. (53.5 x 24 x 33.4 cm). Museo Archeologico Nazionale, Florence (5583). Photograph: By permission of the Soprintendenza per i Beni Archeologici della Toscana, Florence

artisans applied a layer of this white slip (*ingubbiatura*) to the front of the box and surface of the lid, then applied additional pigments like brown or red for hair, dark brown and brighter red for facial features, yellow for jewelry or weapons, blue or green on costumes or shields, and dark red or black for name inscriptions. Within the greater corpus of urns, the amount of pigment preserved on the Metropolitan's works is significant; because pigments were applied after firing, they were susceptible to flaking and fading.[7]

SUBJECT MATTER ON THE BOX RELIEFS

The relief scenes on the fronts of the boxes include three different subjects: a five-figure combat scene (Figures 2, 3, 5, 6), the so-called plow hero scene (Figures 7, 9), and a gorgoneion, or gorgon's head (Figure 10). The three types appear on numerous terracotta urns from Chiusi, and while the fundamental composition of each subject is consistent, details in the molds and in the application of color vary from one work to the next. It remains unclear whether the five-figure combat scene refers to a specific Etruscan battle or to a mythological narrative, but the poses, dress, and equipment of the warriors clearly come from the same prototype. Following the action from left to right, a nude male in a cape leans to his proper right and holds a shield behind him; the next, bearded warrior in a cuirass also holds a shield and straddles a crested helmet on the ground. Next, a kneeling nude male, cape draped over him, protects himself with his shield as he holds out his right arm, sword in hand. Above the fallen figure is another standing nude

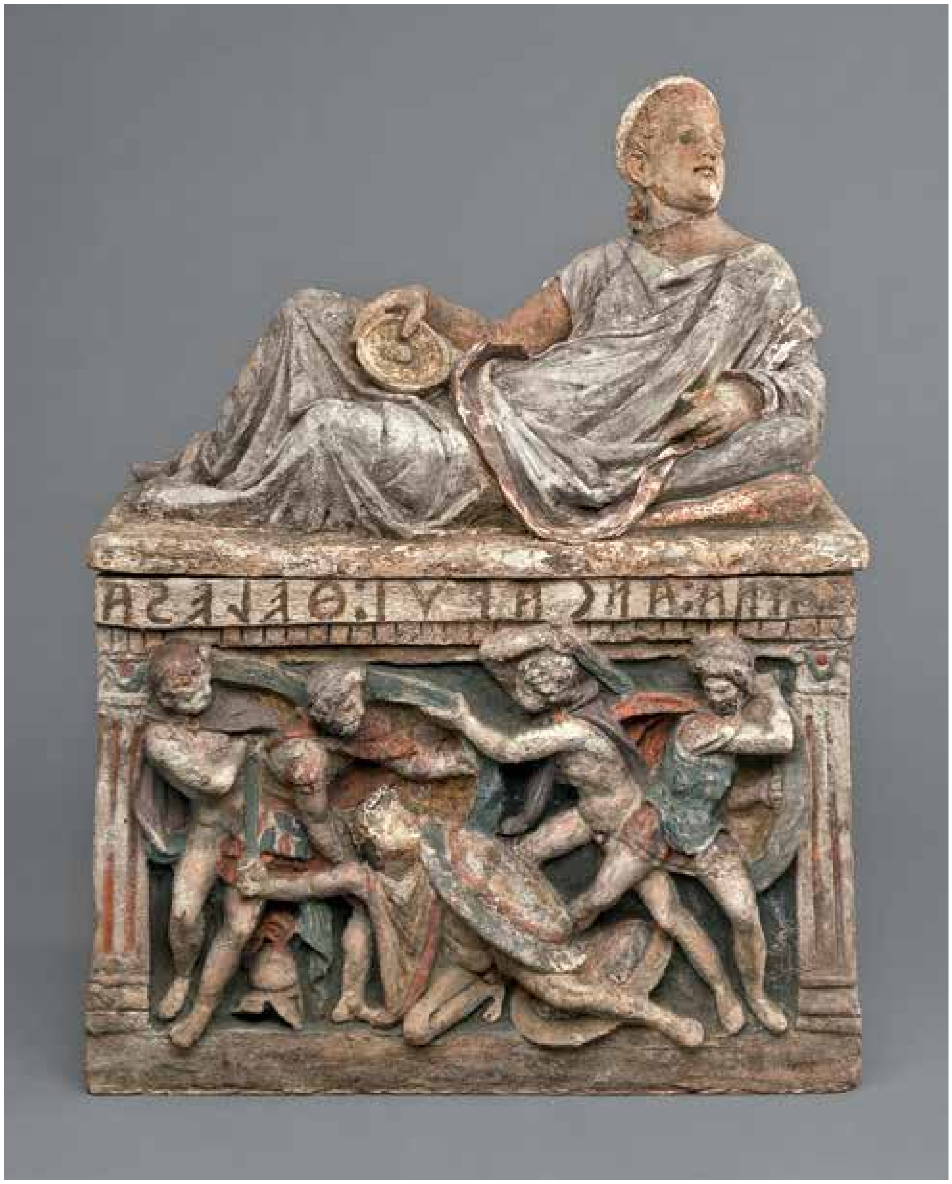
5. Urn of *arnθ : hele : herinial*. Hellenistic Etruscan, Chiusi, 3rd–2nd century B.C. Terracotta, 15½ x 22 x 11 in. (39.4 x 55.9 x 27.9 cm). The Metropolitan Museum of Art, Purchase, Mr. and Mrs. Harry G. Friedman Gift, 1957 (57.11.10)

male, cape behind him, shield on the ground, and right arm raised to deal a blow with his sword as he grasps the shield of the bearded warrior. At the far right, another bearded warrior in cuirass and cape twists his body, holding a shield in his left hand and preparing to deal a cross-body blow with the sword in his right.

Differences appear in the details added after the initial molding of the relief. The hair and facial features of the figures were articulated by hand, visible in the variations in the slashes and dots to represent locks of hair. There are some consistencies in the application of pigment, with blue for the cuirasses, red on the skirts of the short tunics, and yellow on the borders of the shields. However, compare the elaborate designs painted on the shields of Figure 3 to the simple strips of color on Figure 2. The architectural elements that frame the scene differ as well. The pilasters with volute capitals that border the relief on Figure 3 are absent on the other two examples, and the broad yellow dentil molding above the scene on Figure 5 is much more understated on the other two.

The preservation of color and detail on the two reliefs with the "plow hero" scene (Figures 7, 9) is not as significant as on the previous three urns, but the consistencies and variations are still visible. This scene often is identified as the Greek myth of Echetlos, a hero of the Battle of Marathon (490 B.C.) who slaughtered Persian enemies with his plow, but it may represent a local Etruscan hero myth. At far left a nude warrior in cape and crested helmet advances, shield in his left hand and sword in his right. Beneath him a bearded warrior in cuirass and cape kneels on one knee, protecting himself with his shield and preparing to strike a blow with his sword. The aggressor to his right is a nude male seen from behind, a red sash around his waist. He wields a large plow and nearly stabs the crouching figure in the head with it. To the far right is another warrior in a cuirass, holding his shield in front of him and raising his arm back. The color scheme between the two examples is essentially the same but with the areas of red and yellow reversed. Flanking the scene on Figure 9 are red lines representing pilasters with volute capitals, a feature absent from Figure 7.

The gorgoneion on Figure 10, a less common relief type for Chiusine urns, displays a remarkable amount of hand-detailing. Flanked by two ornate pilasters with bases and capitals, as well as a defined dentil pattern above, the molded female head wears a Phrygian-style cap; wings, curving fillets, and curling acanthus leaves extend from either side. Brown pigment is preserved on the hair, but other colors have faded or flaked away. In Etruscan art, as in Greek art, the gorgoneion served as an apotropaic device, and it is possible that the violence of the combat and "plow hero" scenes served the same purpose. The scenes protected the remains of the deceased contained inside the urn.



6. Urn of *θana : ancarui : helesa*. Hellenistic Etruscan, Chiusi, 2nd century B.C. Terracotta, paint, 15¼ x 10¾ x 24½ in. (38.7 x 27.3 x 62.3 cm). The British Museum, London (BM 1926.3-24.124). Photograph: © The Trustees of the British Museum

LID FIGURES

Of the five lids in the Metropolitan's group there are two reclining female figures, one reclining male, and two fully recumbent males. As in all representations of banqueting in Etruscan art, the reclining figures rest on the proper left side, left elbow propped up by cushions and right arm extended and resting on the right side. The figures are draped in long, white tunics and mantles that wrap across the lap or waist, behind the back, and over the left shoulder. The proper right foot of each figure pokes out from the bottom of the garment. As in the relief figures, hand-detailing is most visible in the hair and facial features. The shallow, wavy, irregularly drawn lines in the locks of hair framing the faces of Figures 2 and 3 were rendered by hand with a stylus. The painted eyelids, irises, pupils, and whites of the

7. Urn of *avle: petruni : ath : cutnalisa*. Hellenistic Etruscan, Chiusi, 2nd century B.C. Terracotta, overall (with lid) 13¾ x 13¾ x 8 in. (35 x 34.9 x 20.3 cm). The Metropolitan Museum of Art, Purchase, 1896 (96.9.219a, b)

eyes for all three figures, whether looking straight on (Figures 3, 10) or to one side (Figure 2), provide a sense of liveliness and animation.

Each reclining figure is a variation of an established type produced from molds in terracotta workshops at Chiusi. While there are multiple examples of what appear to be identical lids, the use of multipart molds allowed for a remarkable amount of diversity. In the case of Figure 3, there is a nearly identical example in the Museo Archeologico Nazionale, Florence (Figure 4). The two have the same pose, positioning of arms, and style of tunic, but while Figure 3 has a broad fillet and straight hair and holds nothing in his right hand, the Florence lid figure has curly hair and holds a phiale mesomphalos (libation vessel) in his right hand. Most reclining lid figures hold an implement in the right hand, such as a phiale, garland, or fan; therefore, this urn is a rare example that simply rests the right hand on the thigh. The woman in Figure 2 wears her hair back in a bun, as is the case for all female urn figures, and two pendant earrings; she holds a leaf-shaped fan in her lap, the most common object held by female figures. This type varies in the presence or absence of jewelry, details in drapery folds, and the turning of the head.[8] The veiled female type of Figure 10 is less prevalent than bare-headed figures, but this particular mold shows very little variation. The mantle drapes over the head and hair, bunches around the breast, and makes thick folds on the left shoulder. The figure holds a circular, leafy garland in her right hand and makes an apotropaic gesture known as the "cornetto," or bull's horns, with her fingers. The form is much more compact than those of the other reclining lid figures in the collection; her arms do not extend away from the body, and the veil covers most of the hair and ensures that the head can look in only one direction. In this case a single-piece mold was used, making the type much more uniform than the other reclining figures.[9]

The two fully recumbent figures also lie on their left sides, supported by cushions, and their bodies are entirely enveloped in white tunics.[10] The contour of the proper left arm and the bent right knee is accentuated by the drapery and its folds. Though the bodies are positioned toward the left side, each head turns upward and away from the cushions. At first glance they appear to be sleeping, but the turned heads, along with the brown pigment of the irises and pupils in the open eyes visible on Figure 9, indicate that they are, in fact, awake. Because they were made from single-part molds, the recumbent figures do not show the same dramatic range of variations as the reclining figures, but the Metropolitan's two lids represent common types produced at Chiusi.[11] The male form of Figure 7 is far more voluminous than that of Figure 9, and his features are broader and less defined. On the other hand, it seems as though the body of the latter has sunk into the surface of the lid itself. Additionally, he wears a small, leafy garland around his head, a rare feature for recumbent lid figures.[12]

INSCRIPTIONS AND ARCHAEOLOGICAL PROVENANCE

Most of what scholars know about the Etruscan language, a non-Indo-European outlier in the ancient Mediterranean, derives from funerary inscriptions. Chiusi has produced significantly more of these inscriptions than any other Etruscan site; a large percentage comes from the names of the deceased inscribed on their cinerary urns.[13] The Etruscans used the Greek alphabet, but they adapted the letter forms and the sounds they represented to suit their own linguistic needs. Etruscans wrote right to left, and many of the Greek letters were written backwards. The Etruscan onomastic

8. Detail of Figure 7 showing vent filled with clay wash. Photograph: Karin Willis, The Photograph Studio, MMA

9. Urn of *arntile : afunas : lautni*. Hellenistic Etruscan, Chiusi, 2nd century B.C. Terracotta, overall (with lid) 13¾ x 13¾ x 8 in. (35 x 34.9 x 20.3 cm). The Metropolitan Museum of Art, Purchase, 1896 (96.9.220a, b)

10. Urn of [---]*tra* : cipir*u*[ni] *a*[---]*s*-[?]. Hellenistic Etruscan, Chiusi, 2nd century B.C. Terracotta; H. 17¼ in. (43.8 cm), body 8¾ x 13¼ x 7⅛ in. (22.2 x 33.7 x 18.1 cm), lid 8½ x 14¼ x 8 in. (21.6 x 36.2 x 20.3 cm). The Metropolitan Museum of Art, Purchase, 1896 (96.9.221a, b)

system is conducive to the reconstruction of genealogy and family groups over time and region, as it could include up to six components: praenomen (first name), nomen (family name), patronymic (father's name), metronymic (mother's family name), cognomen (to indicate a particular branch of a family), and in the case of a married woman, a gamonymic to include her husband's name. Women did not take their husbands' last names but rather added them to the end of their maiden names. The role of each onomastic component is made clear by the suffix added to the end of the name root.[14]

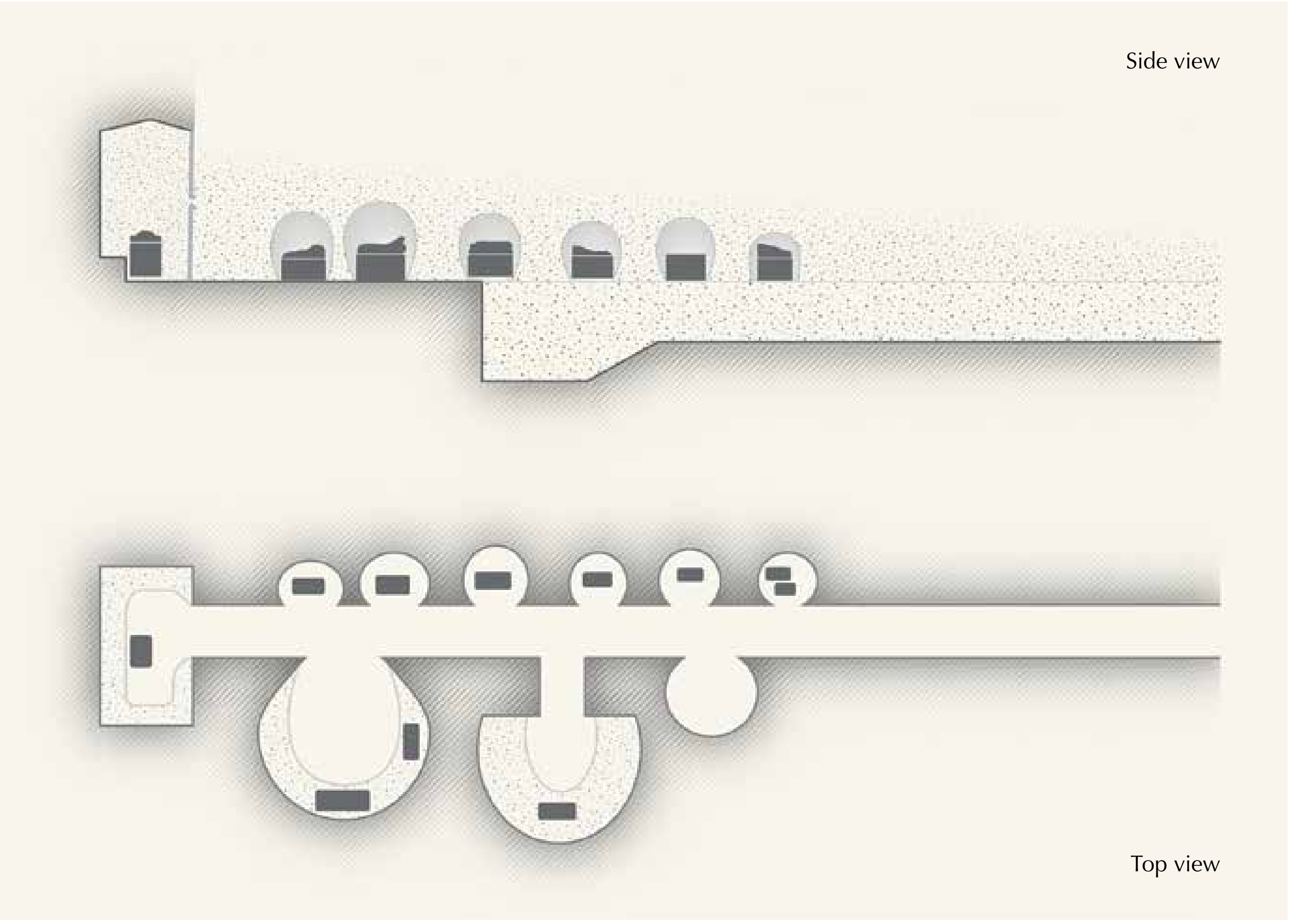
The inscriptions on five of the six urns are recorded in the *Corpus Inscriptionum Etruscarum* and in Helmut Rix's *Etruskische Texte*, the two main corpora of Etruscan inscriptions. Owing to the poor preservation of the pigment on Figure 10, the inscription had never been translated and does not appear in the corpora. High-resolution photographs of the letters indicate that the inscription may read: [---]*tra* : cipir*u*[ni]*a*[---]*s*-[?].[15] The family name *cipiru/cipirunia* is attested at Chiusi, and if the two letters before the *a* of the first name are *tr*, then the individual's first name was probably *setra*.[16] Unfortunately, no other inscriptions with this family name are associated with specific archaeological contexts, so there is no way to know where this urn may originally have been buried.

The inscription on Figure 7 reads: *avle : petruni : ath : cutnalisa* (Avle Petruni, son of Arnth and of [a woman of the] Cutna [family]).[17] Evidence of the *cutna* family's wealth is apparent through the inclusion of a member in the Tomba della Pellegrina, a particularly rich and extensive Hellenistic chamber tomb near the modern city of Chiusi.[18] Additionally, the inscription of a freedwoman of the *cutna* family on another terracotta urn demonstrates that the family had amassed enough wealth to own slaves.[19] The archaeological provenance of this urn remains unknown; members of the *petruni* family were buried in several localities, and the name is probably related to the *petru/petrui* family, which had numerous members around Perugia, another important Etruscan city in the Hellenistic period.[20]

Figure 3 came from Ferdinando Angelotti, an avid antiquarian from Montepulciano (northeast of Chiusi), and most of the objects in his collection were excavated in the vicinity. The name on the top of the box reads: *av : latini : velsial* (Avle Latini, son of [a woman of the] Velsi [family]).[21] A significant number of terracotta urns from Angelotti, as well as from other collections near Montepulciano, belonged to members of the *latini* family. Therefore, a series of family tombs was probably located in a necropolis in the area.[22] Members of the *velsi* family were interred throughout Chiusine territory.

The inscription on Figure 2 was so long that the artist had to paint the gamonymic along the lower left edge of the box. The woman's name, *θana : vipinei : ranazunia : creicesa*, does not include a patronymic or metronymic, but rather a cognomen (*ranazunia*), meaning she was from a particular branch of the *vipi/vipinei* family.[23] Members of

11. Dromos of the Tomba della Gens Rusina, with urns in situ. Drawing: Anandaroop Roy, after Levi 1931, p. 56



other branches of the family were buried near the Lago di Chiusi, and there are numerous women by the name of *θana vipinei*.[24] The family of the deceased probably included her cognomen to differentiate her from others; *ranazu* does not appear often in Chiusine inscriptions.[25] Her gamonymic, *creicesa*, comes from the Etruscan word for "Greek," so she likely married into a family of Greek origin.[26] This urn belonged to Domenico Galeotti, another antiquarian from Chiusi. A Chiusine urn box at the Louvre, Paris, also from the Galeotti collection, is inscribed with the name *θana : vipinei : hermanal*.[27] It is likely that the two urns came from the same context, or at least from the same necropolis.

Figure 9 belonged to a freedman, *arntile : afunas : lautni* (Arntile, freedman of the Afuna family).[28] The "-s" suffix on the name *afuna* indicates it is in the genitive, and the word *lautni* confirms his former servile status. The *afuna* family of Chiusi was immensely wealthy. Their resources are evident not only from the presence of a former slave like *arntile* but also from the elaborate stone sarcophagus belonging to *hasti afunei*, now in the Museo Archeologico Antonio Salinas in Palermo.[29] There are many Hellenistic terracotta urns at Chiusi belonging to freedmen, demonstrating a high level of social mobility at Chiusi not seen in earlier contexts. A freedman could have an urn of the same quality as a member of a wealthy family and be buried in the same tomb.

Finally, the history of Figure 5 brings to light several problematic issues in the study of Chiusine cinerary urns. Because they were produced from molds, many urn lids and boxes are of the same size and type, increasing the likelihood that boxes and lids might have been switched before or after excavation. The swap could happen during the transportation of objects from site to museum, but also at museums, galleries, and in collectors' homes. According to a published account of 1836, an urn with a male figure lid and a box bearing the inscription *arnθ : hele : herinial*, this very box, was excavated at Chiusi between 1834 and 1835 along with an urn bearing a female lid and a box with the inscription *θana : ancarui : helesa*. Based on the names, the two urns belonged to husband and wife.[30] The two boxes were decorated with the same five-figure combat scene, and today the box belonging to the woman is in the British Museum, London (Figure 6).

This box in the British Museum with a female name is currently associated with a male figure lid. In a 1929 publication showing the Metropolitan Museum's urn (Figure 5) when it was in the collection of the Earl of Westmoreland at

Lowther Castle, a female figure lid sat atop the box.[31] As the two urn boxes have the same dimensions and relief subject matter, it would have been easy to switch the two lids as they left Italy and were sold into British collections. The female lid did not come to the Metropolitan Museum and its location is unknown, but the original lid for the urn of *arnθ : hele : herinial* (Arnth Hele, son of a woman of the Herini family) (Figure 5) probably sits atop the urn box at the British Museum (Figure 6).

THE HELLENISTIC FUNERARY ENVIRONMENT AT CHIUSI

Family tombs at Chiusi in the Hellenistic period were not like those of the Orientalizing and Archaic periods at Cerveteri and Tarquinia, with their famous tumulus mounds and elaborate painted decoration. Instead, many were cruciform in plan; a long dromos, or passageway, would terminate in a chamber, or sometimes in a vestibule that opened to multiple chambers (Figure 11). Carved into each wall of the chamber was a low bench upon which urns and sarcophagi were placed along with their grave goods. Over time, the dromos became more than just a passageway; families added niches along either side of the corridor for additional burials. One or two urns and their grave goods would be deposited into each niche, and the niche would be sealed with a terracotta roof tile inscribed with the name of the deceased. As more individuals had access to formal burial in the Hellenistic period, the traditional chamber tombs of the Archaic and Classical periods did not provide enough space to accommodate growing numbers of interments. Adding more and more chambers would have been a labor-intensive, dangerous, and impractical process, and the dromos provided a sufficient amount of space, optimizing the family's resources.

The Chiusine urns at the Metropolitan would not have been buried by themselves, never to be seen again. All lid figure types, whether reclining or recumbent, show indications of actual or imminent action. The reclining figures are waiting for a banquet to begin, and the recumbent figures are in the process of waking up to partake in it. As components of a type of mortuary tableau unique during the Hellenistic period, these effigies symbolically allowed the deceased to take part in important social rites alongside other deceased family members and with the necessary accoutrements. Chamber tombs were often used for several generations, so for each death the tomb would be reopened for the new deposition, providing the opportunity to view the effigies of ancestors. Family members depositing the new urn would walk down the dromos, passing niches and low benches with their reclining or recumbent ancestors' heads turned up toward them to watch them pass. In this way, the living could ensure that each deceased family member, identified through urn, cremated remains, inscription, and effigy, could symbolically participate in the funerary banquet.

NOTES

1. Porsenna's struggle to restore the Tarquins at Rome is described in various ancient accounts, including Tacitus *Historiae* 3.72 and Pliny the Elder *Naturalis Historia* 34.139. Pliny also provides a fantastical description of Porsenna's tomb at Chiusi, based on an account from Varro; ibid., 36.91–93.
2. This urn type is named for its formal resemblance to Egyptian canopic jars but does not serve the same functional purpose.
3. For examples of *cippi*, see Jannot 1984.
4. The Metropolitan Museum has two Volterran urns with figural lids: MMA 96.9.224a, b and MMA 96.9.225a, b; neither of them is inscribed. There are no Perugian urns in the collection.
5. The number of terracotta workshops at Chiusi during the Hellenistic period remains unknown, though considering the high level of consistency in urn production, along with the fact that the objects are not found outside Chiusi's immediate environs, there probably were not very many. See Sclafani 2010, pp. 17–26. For a consideration of the potential number of alabaster urn workshops at Chiusi during this same period, see Stevens 2001.
6. For a full analysis of the terracotta urn production process, see Sclafani 2010, pp. 21–22.
7. For this reason, the inscription on Figure 10 is difficult to read. The flaking of the white *ingubbiatura* took a significant amount of the red pigment of the inscription with it.
8. The closest parallel to the MMA urn is in the Louvre (Cp3775). The painted details of the faces and position of the limbs are nearly identical, but the Louvre urn figure has a sleeve on her tunic, does not wear earrings, and turns her head in the opposite direction.
9. At least nine other examples of this specific lid figure type are known, and the only differences are in the hand-detailed lines and textures of the garment folds, hair framing the face, and the marks on the garland. Lids of this type are in the British Museum, London (1805,0703.177); American Academy in Rome (163); Museo Archeologico Nazionale, Florence (5569); Nicholson Museum at the University of Sydney (NMR.1023.2); Staatliche Kunstsammlungen, Dresden (ZV 87); Archäeologisches Museum, Frankfurt (93,8); Museo Archeologico, Santa Maria della Scala, Siena (no inv. no.); Altes Museum, Berlin (SK 1307); and one in a private collection.
10. In the case of the tunics of these figures, the white color of the *ingubbiatura* was not painted over with additional pigment.
11. The fully recumbent male figure with bare head lid type is the most common produced at Chiusi, with more than 250 examples in museum collections.
12. Only one other recumbent lid figure wears this type of head garland: Altes Museum, Berlin (SK 1311).
13. See Benelli 1998, pp. 229–30.

14. Wallace 2008, pp. 77–94.
15. I thank Daniele Maras for consulting with me on this inscription and for the suggested translation. The unitalicized letters are uncertain.
16. See *CIE* 2005–8/*ET* Cl 1.1504–.1507 and *CIE* 1737/*ET* Cl 1.17 for terracotta roof tiles from tombs inscribed with *cipiru*.
17. Recorded in *CIE* 4905/*ET* Cl 1.2114.
18. For a full description of the Tomba della Pellegrina, see Levi 1931 and *ET* Cl 1.78–.93.
19. The freedwoman of the *cutna* family was buried in a terracotta urn with figural lid, and her name also appears on a terracotta roof tile that would have been used to seal a burial niche. The name, *tinusi : lautni : cutnal*, translates as "Tinusi, freedwoman of the Cutna [family]." See *CIE* 2066, 2067/ *ET* Cl 1.1563.
20. For urns belonging to this gens at Perugia, see *CIE* 3450–60, 3854–63/*ET* Pe 1.30–.37, 1.403–.413
21. Recorded in *CIE* 704/*ET* Cl 1.1076. Many Etruscan names were abbreviated in inscriptions, such as *av* for the name *avle*, or *θ a* for the name *θana*. Abbreviations occurred most frequently in the praenomen and the patronymic. The latter was often simply the praenomen of the father. As in Latin, the number of Etruscan praenomina is very small.
22. See *CIE* 699–707/*ET* Cl 1.1071–.1079.
23. Recorded in *CIE* 2215/*ET* Cl 1.1744
24. Instances of this name include *CIE* 1285/*ET* Cl 1.216; *CIE* 4699/*ET* Cl 1.435; *CIE* 609/*ET* Cl 1.579; and *CIE* 2213/*ET* Cl 1.1719.
25. See *CIE* 2660/*ET* Cl 1.2288; *CIE* 2662/*ET* Cl 1.2289; and *CIE* 4526/*ET* Cl 1.2290. There is also a freedman of the *ranazu* clan, *CIE* 1276/*ET* Cl 1.199.
26. There are more inscriptions at Chiusi with female names and *creicesa* as the gamonymic than males with *creice* as the family name.
27. Louvre, CA 3736. Recorded in *CIE* 2213/*ET* Cl 1.1719. This box is not associated with a lid.
28. Recorded in *CIE* 4900/*ET* Cl 1.1332.
29. See Barbagli and Iozzo 2007, pp. 91–93, no. 112.
30. Recorded in *CIE* 2259/*ET* Cl 1.1778 and *CIE* 2260/*ET* Cl 1.1210; originally published in Mazzetti 1836, p. 28.
31. See Arndt and Lippold 1929, pp. 23–24, pl. 3095.

ABBREVIATIONS

CIE *Corpus Inscriptionum Etruscarum*
ET *Etruskische Texte*

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Redeeming Pieter Coecke van Aelst's *Gluttony* Tapestry: Learning from Scientific Analysis

FEDERICO CARÒ

Associate Research Scientist, Department of Scientific Research, The Metropolitan Museum of Art

GIULIA CHIOSTRINI

Assistant Conservator, Department of Textile Conservation, The Metropolitan Museum of Art

ELIZABETH CLELAND

Associate Curator, Department of European Sculpture and Decorative Arts, The Metropolitan Museum of Art

NOBUKO SHIBAYAMA

Associate Research Scientist, Department of Scientific Research, The Metropolitan Museum of Art

Pieter Coecke van Aelst (1502–1550) was one of the most celebrated Netherlandish artists of his generation.[1] An important panel painter and printer of influential architectural treatises, Coecke was above all a master draftsman-designer, and the primary medium for his artistic expression was tapestry design. Tapestry series based on his cartoons were woven up by the celebrated Brussels-based workshops directed by Willem de Pannemaker and Willem de Kempeneer, as well as lesser-known weavers like Jan van der Vijst and Paulus van Oppenem, and were acquired by the great Renaissance collectors, from Henry VIII to Francis I, Mary of Hungary, Charles V, and Cosimo I de' Medici.

The three securely documented tapestry series that form the core of Pieter Coecke van Aelst's stylistically attributed body of works are the *Life of Saint Paul*, the *Seven Deadly Sins*, and the *Story of Joshua*.[2] These were all phenomenally successful and woven in multiple high-quality editions. The *Seven Deadly Sins*, in particular, is one of the most appealing and inventive series of Renaissance tapestries known, presenting a subversive triumphal procession of the vices across seven tapestries, each devoted to a different sin. Uniquely for tapestries of this period, a written program survives in a manuscript in Madrid, describing the "significance of the seven tapestries of the seven deadly sins by Willem de Pannemaker of which master Pieter of Aelst, painter of Antwerp, made the designs and compositions."[3]

Coecke probably began designing the *Sins* in late 1532, pausing during 1533, when he traveled to Constantinople (in part on a tapestry-selling expedition to Süleyman the Magnificent), completing the design of the series after his return in early 1534. Of the earliest documented edition, woven before 1536, which belonged to Henry VIII, only *Avarice* survives; it is now in the Morgan Library and Museum in New York.[4] Of the three best-preserved *Seven Deadly Sins* editions, one (Figure 1) originally belonged to Mary of Hungary (1505–1558), governor of the Habsburg Netherlands (1531–55). Made before 1544, it is now in the Spanish Patrimonio Nacional. Another (Figure 2), made about 1545, was first acquired by the unfortunate Count Lamoraal van Egmont, prince of Gavere (1522–1568). Following Egmont's execution, it passed to Philip II and is now also in the Patrimonio Nacional. The third, woven about 1548–49 and probably originally in the collection of the dukes of Lorraine, is now in the Kunsthistorisches Museum in Vienna.[5]

Since 1957, The Metropolitan Museum of Art has owned one piece of the *Seven Deadly Sins* that Coecke designed; it represents Gluttony and is the only known survival from this, the fifth known edition (Figure 3).[6] In a breathtakingly colorful sweep of twisting figures, fantastical beasts, and patterned cloth and trappings, the figures unfurl across the tapestry's surface.[7] The textile's well-preserved, vivid palette enlivens the full subtleties of Coecke's design. Owing to the

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1. *Gluttony* from the *Seven Deadly Sins*. Designed by Pieter Coecke van Aelst (Netherlandish, 1502–1550), ca. 1532–34. Tapestry woven under the direction of Willem de Pannemaker (Netherlandish, active 1535–78), Brussels, before 1544. Wool, silk, and precious-metal-wrapped threads, 14 ft. 9⅛ in. × 26 ft. 6⅛ in. (450 × 810 cm). Patrimonio Nacional, Madrid (TA 22/3, A. 360-12154). Photographs of Figures 1, 2, 6 (obverse), 8 (obverse): Bruce White, © The Metropolitan Museum of Art

2. *Gluttony* from the *Seven Deadly Sins*. Designed by Pieter Coecke van Aelst. Tapestry woven under the direction of an unidentified master weaver, Brussels, ca. 1545. Wool, silk, and silver-gilt-wrapped threads, 13 ft. 9 in. × 26 ft. 6 in. (420 × 810 cm). Patrimonio Nacional, Madrid (TA 21/4, A. 257-7427)

description in the Madrid manuscript, we can recognize "Dame Gluttony without worries, holding a pot always ready" in her harpy-drawn chariot, accompanied "by cooks, taverners, entertainers, pastry chefs and all masters and mistresses of sweet cakes"; after them comes Death "like a huntsman," chasing the dissolute and gluttonous to an early grave.[8] The procession features famous gluttons and *bon viveurs* from history: just in front of Gluttony's chariot can be glimpsed "Philoxenus [of Leucas] wanting to have a throat as long as that of a swan in order to be able to savor and taste good wine"; seated backward on her horse is "Cleopatra, queen of Egypt"; also on horseback is "Alexander the Great, the great gourmand"; in front of him, on foot "Thaïs the courtesan"; and "Silenus the drunkard" about to lurch off his donkey and out of the tapestry, into the viewer's space, in a typical Coecke touch. Young Bacchus rides up ahead and carries Gluttony's standard. Tiny figures in the background landscape illustrate as a foil the story of virtuous Judith, who was able to dispatch Holofernes after lulling him into drunken torpor. In this same vein, overhead flies "the beautiful virtue of Temperance."[9]

Although the tapestry's known history stretches back no further than the collection of Leon de Somzee in Brussels in 1901, with putative provenance to Padua, it might originally

3. *Gluttony* from the *Seven Deadly Sins*. Designed by Pieter Coecke van Aelst, ca. 1532–34. Tapestry probably woven in Brussels, between ca. 1550 and 1560. Wool, silk, and silver- and silver-gilt-wrapped threads, 12 ft. 9 in. × 22 ft. 3 in. (388.6 × 678.2 cm). The Metropolitan Museum of Art, Gift of Mrs. Frederic R. Coudert Jr., in memory of Mr. and Mrs. Hugh A. Murray, 1957 (57.62). Photograph: Anna-Marie Kellen, The Photograph Studio, MMA

4. *Gothic Tapestry*. Woven under the direction of William Baumgarten (American, 1845–1906). New York, after 1893. Location unknown. From Candee 1912, fig. facing p. 262

5. Detail of the obverse (left) and reverse (right) of the taverner figure on the left side of Figure 3, showing the hatching effect on the curled hair and the hat. Photographs of Figures 5, 6 (reverse), 7, 8 (reverse), 10: Giulia Chiostrini

6. Obverse (left) and reverse (right) of the right leg of the figure in a green garment on the left side of Figure 3. Double-interlocking was used to bridge color junctures.

have come from one of two additional sets of *Sins*, possibly Coecke's series, traceable in documentary records. The first, a set of "seven pieces of tapestry showing the Seven Deadly Sins" presented to the collegiate church of Saint Michael and Saint Gudula in Brussels in late July 1539 by the nobleman Laurent (or Laureijs) de Blioul, member of Charles V's Privy Council, is probably too early for the Metropolitan's tapestry.[10] But the second, another seven-piece set showing "the depiction of the Seven Deadly Sins," which was confiscated from the estate of the count of Egmont's ally Jan IV van Glymes (1528–1567), marquis of Bergen op Zoom and count of Walhain in Brabant, could be the edition from which our tapestry comes. Descriptions suggest that this edition may have been slightly adapted, with one of the scenes, *Sloth*, marginally different from its counterpart in the other sets.[11] It was probably woven in the 1550s or early 1560s.

Regardless of the intriguing possibility that this tapestry might be a survival from Van Glymes's set, it is invariably overlooked in Coecke scholarship and traditionally has been relegated to secondary status as "inferior in quality and . . . probably considerably later in date."[12] So considerably later, indeed, that a nineteenth-century date had even been suggested, in part because of the unusually narrow border, which in its present state shares many similarities with late nineteenth-century tapestry production (Figure 4).[13] In fact, if elements of the current narrow border are original to the tapestry, as the following analysis implies, they almost certainly composed only one register in a much wider arrangement, comparable to the inner frame with its ribbon-and-flower motif in the count of Egmont's edition (see Figure 2).

A collaborative project undertaken by the Metropolitan Museum's departments of European Sculpture and Decorative Arts, Textile Conservation, and Scientific Research enabled detailed technical examination and analysis of the tapestry. Many questions about the tapestry's genesis are now answered, setting to rest doubts about its probable production date and revealing a trail of historical repair and areas of restoration that help to explain why it looks the way it does and what changes it underwent between its weaving about 1550–60 and its arriving in the museum some four hundred years later. E.C.

TECHNICAL OBSERVATIONS AND CONSERVATION HISTORY

Despite previous critical judgments of *Gluttony*, an assessment of the tapestry carried out by the staff of the Department of Textile Conservation in 2012 proved the high quality of its weave and its place in sixteenth-century Flemish tapestry production. Microscopic analysis of the weaving techniques, identification of the fibers used, and an accurate visual examination and record of the obverse and reverse of the piece were employed. Previous treatments were reassessed, and new conservation treatments were undertaken to prepare it for display. The results of that examination and treatment are outlined here.

The tapestry was woven with dyed wool, dyed silk, and silver-gilt-wrapped silk threads[14] on an undyed wool warp; the warp is made of two yarns with a Z-twist, plied in an S-direction. The weave structure is still tight, demonstrating a count of 8 to 10 warp and 29 to 30 weft threads per centimeter.[15] The harmonious combination of precious materials like metal-wrapped threads with the rich nuances of dyed silk and wool wefts is achieved using sophisticated technical methods. For example, the textures of human features, including the curled hair of the taverner on the left side of the scene, and design elements of figures' dress exhibit hatching in silk, wool, and metallic threads (Figure 5).[16] Fine rows of double interlocking join different gradations of colors (Figure 6), while small details such as the tassels of the drapery on Alexander's horse on the right side of the scene are woven with silver-gilt-wrapped threads in *crapautage* (Figure 7).[17] The preservation of much of the tapestry's original color ensures visual appreciation of the quality of the weaving technique.[18] Distinctive technical effects are achieved by combining two yarns of the same material with no twist and in different colors. Green and red wool threads, for example, are used in the colorful background on the right side of the main scene, while a

7. Detail of the tassel of the drapery on Alexander's horse on the right side of Figure 3, showing the *crapautage* effect

8. Detail of the obverse (left) and reverse (right) of Gluttony's dress on the upper left side of Figure 3. The texture of the weaving is achieved by the use of silk double threads in light blue and red combined with the yellow silk and purple wool weft threads.

9. *Aglauros's Vision of the Bridal Chamber of Herse* from the *Story of Mercury and Herse*. Design attributed to Giovanni Battista Lodi da Cremona (Italian, active 1540–52). Tapestry woven under the direction of Willem de Pannemaker, Brussels, ca. 1565. Wool, silk, silver, and silver-gilt-wrapped threads, 14 ft. 5 in. × 17 ft. 8 in. (439 × 538 cm). The Metropolitan Museum of Art, Bequest of George Blumenthal, 1941 (41.190.135)

combination of light blue and red silk threads model the dark purple dress of Gluttony (Figure 8). The same technique in making weft threads can be observed in details of the border design in *Aglauros's Vision of the Bridal Chamber of Herse*, a Flemish tapestry woven in the workshop of Willem de Pannemaker in the third quarter of the sixteenth century (Figure 9).[19]

The condition of *Gluttony* is generally good, further reflecting the strength of its weave structure. However, its silk wefts are fragile in several areas, and the silver-gilt-wrapped threads have tarnished because of oxidation. The tapestry underwent several restoration campaigns before entering the Museum's collection in 1957. There is no extant documentation concerning most of these treatments. Generally (unless noted below) the quality of the material and the synthetic dyes employed suggest the late nineteenth or early twentieth century as the probable time these restoration campaigns took place.[20] A 12- to 15-centimeter-wide band, tapestry-woven with dyed wool wefts and silver-wrapped threads on undyed wool warps, was joined to the original structure of the tapestry to replace a missing design along the lower border. Although some of its colors have faded, this area is well integrated aesthetically and technically. The inner frame on the lower and upper edges is also a later addition intended to repair a damaged and missing portion of the tapestry, in this case reproducing the design of the original inner frame of which original segments are preserved along the left and right sides of the tapestry.[21] Past restoration of the metallic threads is visible in some areas, including in a group of angels in the upper center; here, copper-wrapped bast fiber threads were used to reproduce the brightness of the original metallic threads.[22] Some sections of loss, such as those in the dog's legs on the left side of the scene, have been rewoven with bright white silk floss that does not compare to the fine quality of the original silk weft threads. Because of this intervention, the figure loses its original fullness and creates a stylistic distortion that is not consistent with the Renaissance character of the other known *Gluttony* tapestries (see Figures 1, 2). Further small lacunae of the weave structure have been filled using the *soumak* technique; one of these areas is visible on a detail of the sausage that Gluttony holds in her right hand on the left side of the scene (Figure 10).[23]

In 1984, the textile conservation laboratory of the Cathedral Church of Saint John the Divine in New York carried out a fully documented conservation treatment of the *Gluttony* tapestry.[24] The piece was wet cleaned and then consolidated. An open tabby mend technique was adopted to replace small areas of silk loss, such as those in the legs of Cleopatra's horse in the center of the scene, and cotton fabric patches were applied on the reverse of the tapestry to support large-dimension lacunae. In 2012, *Gluttony* was reexamined and conserved by the staff of the Department of Textile Conservation in preparation for the exhibition "Grand Design: Pieter Coecke van Aelst and Renaissance Tapestry" at the Metropolitan Museum in 2014–15. None of the previous restoration treatments were removed. However, the lining and backing support attached during the 1984 treatment were replaced with new material.[25]

Following a low-suction vacuum cleaning, nine supportive cotton sateen fabric straps 20 to 26 centimeters wide were vertically stitched to the reverse of the tapestry to support the most fragile areas of the piece. To provide reinforcement during hanging, a cotton sateen fabric band 25 centimeters wide was stitched along the upper edge, while another band 35 centimeters wide in plain-weave cotton fabric was stitched along the lower edge to better protect the tapestry during display. The piece was finally lined with plain-weave beige cotton fabric and fitted with a hanging system incorporating a band of Velcro sewn onto cotton webbing and attached through the new lining along its upper edge. G.C.

ANALYSIS OF DYES

Dyes used on the *Gluttony* tapestry were analyzed by means of high-performance liquid chromatography with a photodiode array detector. Small samples of weft of various colors were taken from the tapestry, and dyes were extracted from those samples for analysis.

There is no definitive evidence to indicate the date of the tapestry based on its dyes, yet some findings support the proposition that the tapestry was created in the middle of the sixteenth century. The dyes used on the main panel were madder (likely *Rubia tinctorum*), weld, indigo dye,[26] cochineal,[27] soluble redwoods (such as sappanwood or brazilwood), dyer's broom, and archil. A similar range of dyes was used on the right and left sides of the inner frame, supporting the technical observation that both sides of the inner frame were woven at the same time as the main panel.

10. Detail of the obverse (left) and reverse (right) of the sausage held in Gluttony's right hand on the left side of Figure 3, showing the *soumak* technique applied during the previous restoration treatment

Table 1 in the Appendix shows a summary of suggested dyes used on the *Gluttony* tapestry and, for comparison, on *Aglauros's Vision of the Bridal Chamber of Herse*. In general, it shows a similarity in the range of dyes: a combination of the major use of traditional European dyes, such as madder, soluble redwoods, weld, dyer's broom, indigo dye, and archil, and the minor use of cochineal for the pink or red parts. These dyes, with the exception of cochineal, had already been in use in medieval Europe.[28] In the mid-sixteenth century new natural dyes from America began to be imported into Europe. The new dyes included cochineal, old fustic, annatto, or logwood.[29] Cochineal was first imported about 1520 and soon became an important article of commerce and the most highly prized of all dyes from America.[30] It appears to have caught on immediately, in contrast to the other dyes, which seem to have been adopted more slowly.[31] Although further analysis is necessary to confirm the tendency to use the American dyes in sixteenth- to nineteenth-century tapestries, *Gluttony* may have been woven in the period when natural dyes from America were just beginning to be used in Europe, in the second half of the sixteenth century.

A useful indicator for dating textiles containing natural dyes is the presence of tin with cochineal, which produced bright scarlet, as opposed to crimson, which was produced with alum.[32] Tin mordant was used with cochineal in Europe from about the 1620s onward.[33] In *Gluttony*, the bright pink on the saddle skirt of Silenus's donkey and the pink and red hues of the flower petals on the side inner frames were

11. Detail of the reverse of the bright pink saddle skirt of Silenus's donkey on the right side of Figure 3. Photograph: Nobuko Shibayama

realized with a combination of cochineal as the main dye and madder as the minor dye. The vivid pink used on the saddle skirt, clearly seen on the reverse (Figure 11), was mordanted with aluminum-based material, not tin, according to the analysis by scanning electron microscope coupled with energy-dispersive X-ray spectroscopy (SEM-EDS).[34] Again, the result does not conflict with the proposed sixteenth-century date of the tapestry.

By contrast, thread samples from the inner frame on the lower and upper edges reveal both natural dyes and early synthetic dyes. The brown thread sample appears to be dyed with natural dyes: tannin dye and probably old fustic. From the blue and purple thread samples, indigo carmine was detected. Indigo carmine, an early synthetic dye, was available from 1740 and is reported to have been in use mainly until the latter part of the nineteenth-century.[35] The yellow thread sample was possibly dyed with an analog of an early synthetic dye, metanil yellow (C.I. Acid Yellow 36), which has been available since 1879. Considering the presence of both natural dyes, which largely lost commercial importance by 1920,[36] and the early synthetic dyes, we can confirm the technical observation that the inner frames on the lower and upper edges were added in the late nineteenth or early twentieth century, indicating that the main panel and both sides of the inner frame were woven before that period.

N.S.

ANALYSIS OF METAL THREADS

Three samples of metal-wrapped threads were collected from selected original areas of the *Gluttony* tapestry[37] in order to characterize their geometry and composition and to compare them with three thread samples from *Aglauros's Vision of the Bridal Chamber of Herse* tapestry (see Figure 9).

The sampled metal threads were first examined and imaged using a polarized light microscope (PLM). They were later mounted on a carbon stub and imaged by means of a scanning electron microscope (SEM).[38] Characteristic measurements were taken with the aid of both instruments, notably the thread width, the metal strip width, the distance between coils, the twist angles, and the number of coils per unit length (Table 2 in the Appendix).

In addition, small fragments of metal threads were separated from the core yarn and embedded in epoxy resin. The fragments were then sectioned, polished with an ion milling system,[39] and carbon coated[40] before being studied by SEM coupled with energy and wavelength dispersive X-ray spectroscopy (EDS-WDS).[41] SEM-EDS-WDS analysis was used to characterize the alloy of the thin metal strips and to measure their thickness and that of the gilding.

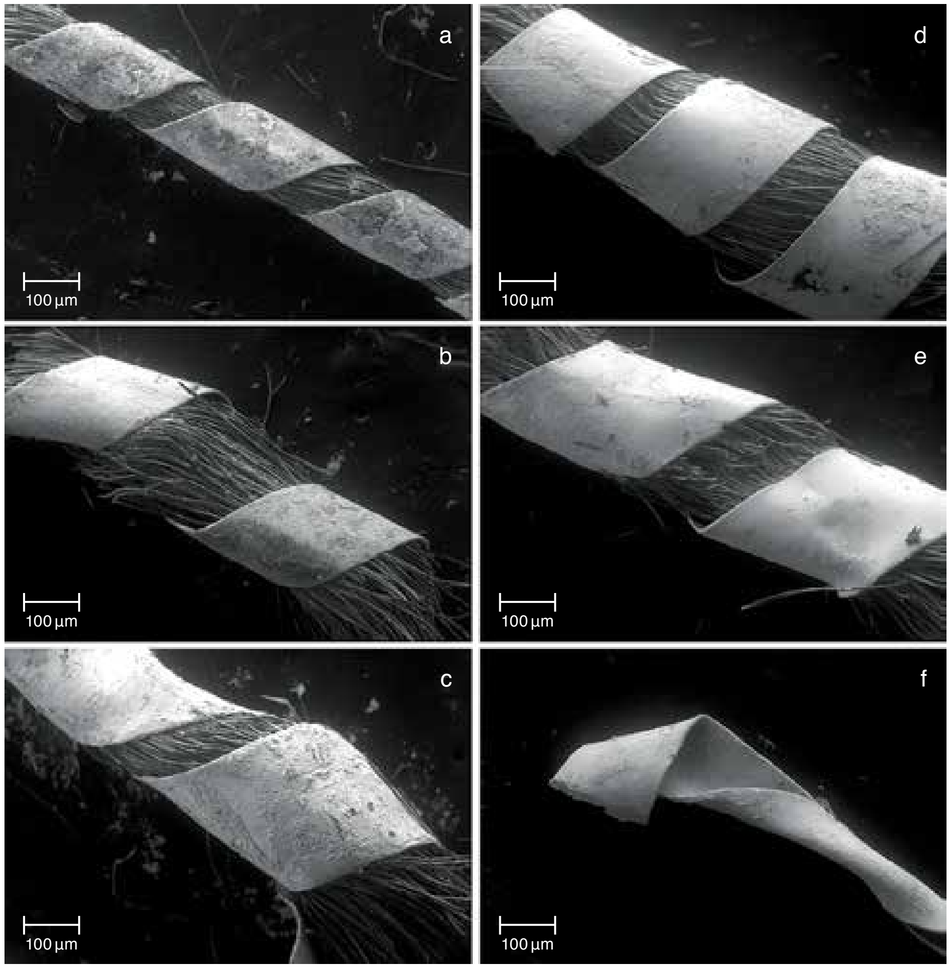
The studied threads share similar technological characteristics, which are consistent with the manufacturing practices in use in sixteenth-century Europe.[42] All the metal-wrapped threads are realized by wrapping a silver-gilt strip with an S-type coil around a yellow-dyed silk core (Figure 12). Though the geometric characteristics of the coils are slightly variable, the strip-metal composition and thread-construction techniques of the two tapestries are quite similar (Table 2). Metal threads from *Gluttony* vary from very regular, evenly spaced coils around a thin silk thread, to more loosely wrapped, larger strips forming a somewhat larger thread. A comparable range of sizes is found in *Aglauros's Vision of the Bridal Chamber of Herse* and is consistent with other metal threads from European Renaissance tapestries.[43] Both low (Figure 12a) and high (Figure 12d) twist angles were measured. The tightness of the strips varies broadly, as a result of the original thread manufacture, its history, and its present state of preservation. Metal strips from both the *Gluttony* and the *Aglauros's Vision of the Bridal Chamber of Herse* tapestries are realized with a similar silver alloy of average composition: Ag = 91±0.9 wt% and Cu = 8.9±0.9 wt%. Lead (Pb) was detected in trace amounts up to 0.8 wt%. All the silver strips have a similar thickness of 14–24μm and are gilded on one side with a thin layer of gold 150–400 nm thick (Figure 13). The presence of a single gilded surface and of edges with sharp angles and flat surfaces (Figure 13) suggest that the strips were cut from a gilded metal foil. This interpretation is also supported by the highly oriented microstructure seen in cross section, typical of a heavily worked silver-copper alloy (Figure 13). No traces of mercury or of copper enrichment at and below the gilded surface were found, suggesting that the foils used for these two tapestries were most likely gilded by welding rather than fire gilded with mercury amalgam or copper soldered.[44] The technique of cutting thin strips from a pregilded silver foil was widely used in the manufacturing of metal-wrapped threads up to the sixteenth century, when the practice was gradually replaced by the use of gilded metal rods, drawn and flattened to obtain thin, double-sided gilded strips.[45]

Two additional metal-wrapped thread samples, believed to belong to later additions, were taken from *Gluttony*'s inner frame and main panel (sample 3, from the bottom border, and sample 4, from the angel on the upper central area of the main panel). These threads consist respectively of a double-sided, silver-coated copper strip wrapped around cotton thread, and of a one-sided, zinc-coated copper strip wrapped around a bast fiber thread. Their composition and construction technique support the hypothesis that they were introduced during later restoration phases.[46] F.C.

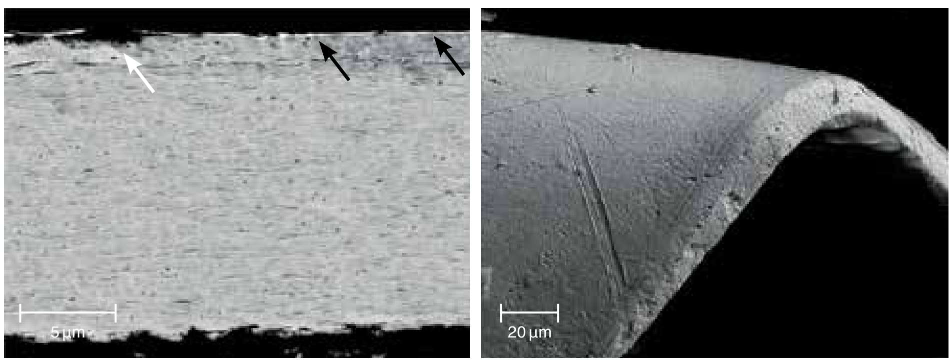
CONCLUSION

This account of *Gluttony*'s weave structure and restoration techniques, of the results of dye analysis of its colored wefts, and of the materials and construction of its metal-wrapped threads reveals that the tapestry is consistent with production carried out about 1550–60, and thus it could indeed have belonged to the lost documented set owned by Jan IV van Glymes. At some point, the tapestry's wide outer border and both horizontal sections of the narrow inner border were removed, resulting in the loss of any record of the weavers' mark and city of production. When the tapestry underwent restoration, probably in the late nineteenth or early twentieth century, the surviving narrow inner borders at the vertical edges were replicated on the horizontal edges, achieving a similar effect but using markedly different dyes and metal-wrapped threads. Previously the subject of conjectural connoisseurship, *Gluttony* can now, through scientific analysis, be recognized as a mid-sixteenth-century work and returned to its rightful place in discussions of Pieter Coecke's tapestry series.

The rehabilitation of *Gluttony* as a work of the mid-sixteenth century confirms the popularity of Coecke's *Seven Deadly Sins* series and represents a third tier of production. This class followed the earliest editions for Henry VIII and Mary of Hungary, woven in virtuoso technique under the direction of Paulus van Oppenem and Willem de Pannemaker, and the second range, still splendid but not as ostentatious, like those acquired by the count of Egmont and, probably, owned by the duke of Lorraine. The distinct



12. Secondary electron images of the studied threads from Figure 3 (a, b, and c, corresponding to samples 1, 5, and 6) and Figure 9 (d, e, and f, corresponding to samples 1, 2, and 3) [see Table 2]. Metal-wrapped threads from Figure 3 show a generally higher degree of corrosion in the form of silver sulfides. Threads were imaged at the same magnification.



13. Left: back scattered electron image of the cross section of sample 1 from Figure 3, in which the gold appears as a bright layer (see black arrows) on top of the silver strip. A corroded surface is visible underneath the gold layer (see white arrow). Right: secondary electron image of sample 2 from Figure 9, showing a flat edge with angular features that are consistent with a cut strip. The core fibers have been masked in this image to remove the visible and disturbing charging effects.

possibility that the Metropolitan's *Gluttony* originates from Jan IV van Glymes's set provides a clear understanding of the appearance and execution of such an edition, when Coecke's cartoons were being used for at least the fifth time. Though the raw materials include some metal-wrapped threads and the weavers attempted sophisticated techniques of *crapautage* and hatching, the ultimate effect is less accomplished than the versions made in the more vaunted workshops. Above all, the weavers' application of a palette markedly different from that of Coecke's cartoon, perhaps reflecting the increased range of dyes available over the intervening decade and a half, demonstrates just how dramatically his design could be transformed in the weavers' translation. Though documentary evidence has long shown that Coecke's series were not woven exclusively for royal patrons but also appeared in re-editions, many of the later versions have been lost or unrecognized. The Metropolitan's *Gluttony* provides a bona fide record of one of the middle-of-the-range, mid-sixteenth-century versions of Coecke's designs, perhaps less splendid but important in their own right by reaching a broader market and perpetuating the master's inventions.

NOTES

1. For discussion of Coecke's work, significance, and patrons, see Cleland 2014.
2. See Guy Demarcel, Stijn Alsteens, Elizabeth Cleland, Concha Herrero Carretero, Iain Buchanan, and Katja Schmitz-von Ledebur in ibid., pp. 124–75 (*Life of Saint Paul* series), and 187–233 (*Seven Deadly Sins* and *Story of Joshua* series).
3. "Signifiance de sept tappis/des sept pechez mortelz pour/guillaume pannemakere desquelz/a faict les patrons et ordonnances/maistre pierre van aelst paintre/d'anvers." Biblioteca Nacional de España, Madrid, MSS 6015, fol. 2r; see Cleland 2014, pp. 198, 371, no. 46.
4. Morgan Library and Museum, New York (AZ130); illustrated in Cleland 2014, p. 190, fig. 150.
5. For dating and stylistic discussion of the *Seven Deadly Sins* series, see ibid., pp. 187–97. For the edition in the Patrimonio Nacional, Madrid, sets 21 and 22, and the Kunsthistorisches Museum, Vienna, set 35, see Campbell 2002, pp. 410–16, no. 47, and pp. 198–204, 208–13, nos. 47, 49, 53.
6. See Standen 1985, no. 13; and Cleland 2014, pp. 204–7, no. 5.
7. I am grateful to my Metropolitan Museum colleagues Florica Zaharia, Cristina B. Carr, and Giulia Chiostrini, Department of Textile Conservation, and to Giovanna P. Fiorino-Iannace and the staff of the Antonio Ratti Textile Center, for first viewing the tapestry with me in June 2010 and enabling the ensuing project, spearheaded by Giulia Chiostrini.
8. "damme gloutonnie/sans souci tenant le pot tousiours preste"; "cuysiniers/taureniers cabarretiers/pastissiers et toutz/maistres et maistresses de friandise"; "La/mort la pourchasse comme veneur." Biblioteca Nacional de España, Madrid, MSS 6015, fol. 7r.
9. "philoxenus desirant avoir le col aussi grant/que dung cygne pour plus longuement percevoir et/gouster le bon vin"; "Cleopatra royne degipt"; "Alexandre le grand fut fort note de gourmandise"; "Thays la paillarde"; "Silenus lyvroigne"; "la belle vertu de temperance." Ibid., fols. 7v, 8r.
10. "seven stucken tapicherijen, wesende de Seven dootsonden." Lefèvre 1970, pp. 141, 144 (quote).
11. "la Deffiguration des sept péchez mortelz." Pinchart 1878–85, pp. 86–87.
12. Standen 1985, vol. 1, p. 113. The tapestry is mentioned only in a note by Georges Marlier (1966, p. 333). Jan Karel Steppe (in Bauer 1981, p. 87) afforded it less than a sentence, remarking that it is "die später […] und auch nicht von so guter Qualität ist" (later . . . and also of not such good quality).
13. Barbara Caen to Elizabeth Cleland, August 18, 2012, and May 17, 2013. I am grateful to Dr. Caen for sharing her knowledge of nineteenth-century tapestries. For the Baumgarten tapestry, see Candee 1912, fig. facing p. 262.
14. The term "silver-gilt-wrapped thread" is taken to mean a thin layer of gold applied on a silver metal strip wrapped around a silk core.
15. According to Masschelein-Kleiner (1993, p. 71), sixteenth-century tapestries from Brussels "are remarkably fine, 7.25–8.25 and more warp threads per centimeter." Moreover, Masschelein-Kleiner specifies that "the warps of Belgian-made tapestries were made of undyed wool spun in Z-twist and plied in S-twist." These technical details correspond with *Gluttony*'s weave structure. In addition, technical aspects of other Renaissance tapestries show similarities with *Gluttony*'s weave features, materials, and warp count per centimeter. For example, see the *Lust* tapestry (before 1544) from the *Seven Deadly Sins* (series 22, no. 2) at the Palacio Real de Madrid in Campbell 2002, pp. 410–16, no. 47.
16. The hatching effect here transitions from one color to another by alternating long and short weft passes.
17. The *crapautage* effect, also called basket-weave, is achieved by metallic weft threads crossing more than one warp thread.
18. Although some areas woven in pink, yellow, and green have lost their tonal intensity, the original colors remain vivid on the piece's reverse. See the discussion below of the dyes employed in *Gluttony*.
19. Observed during a viewing in the Metropolitan's Antonio Ratti Textile Center on April 18, 2013. *Aglauros's Vision of the Bridal Chamber of Herse* was chosen as a comparandum for the technical investigation of *Gluttony* for two main reasons. First, it is certainly dated to the mid-sixteenth century. Second, it was woven under the direction of Willem de Pannemaker in Brussels, the same weaving director who was responsible for one of the *Seven Deadly Sins* sets in Madrid and the set in Vienna. For more information regarding the history of *Aglauros's Vision of the Bridal Chamber of Herse*, see Campbell 2002, pp. 391–94.
20. See the dyestuff analysis below.
21. Technical analysis of the inner frame along both sides of the tapestry shows that the warp thread is the same as that used in the main panel's weave. The inner frame on the upper and lower portions of the piece is a later addition, as is the blue *galon* (the outside border of the tapestry) around its edges. Further evidence is given below.
22. See the discussion and analysis of the metallic threads below.
23. For a description of the *soumak* technique as used in tapestry weaving, see Harvey 1991, p. 135.
24. In 1984 the Morgan Library and Museum requested the loan of *Gluttony* for two and a half years. On May 29, 1984, the tapestry

was transferred from the Metropolitan to the textile conservation laboratory at Saint John the Divine, New York, for treatment. Although the Morgan Library ultimately withdrew its request for the loan, the treatment was completed at Saint John's before the tapestry was transferred back to the Metropolitan Museum in December 1984. For a detailed description of the conservation treatment applied at that time, see Hutchinson 1989, pp. 89–94. An account of the loan request, object transfer, and loan cancellation is in the object file in the Department of Textile Conservation, MMA.

25. Reflecting developing standards in tapestry conservation practice over the last thirty years, cotton upholstery webbing has been superseded at the Metropolitan by light, tightly woven cotton sateen fabric as the tapestry strapping material of choice. See Barnett et al. 2006, pp. 155–62.
26. The term "indigo dye" here refers to any dye plant that produces indigotin, such as woad (*Isatis tinctoria*) or indigo (*Indigofera tinctoria*), and does not specify the type of plant.
27. Carminic acid, a main colorant of American cochineal and Armenian cochineal, was detected in the samples, indicating that they could have been dyed with either of them. However, the tapestry's date makes it seem likely that the American variety was used.
28. See Masschelein-Kleiner 1979.
29. Robinson 1970, p. 32; Brunello 1973, pp. 197–99.
30. Brunello 1973, p. 198; Hofenk de Graaff 2004, p. 76; Cardon 2007, p. 630.
31. Hofenk de Graaff 2004, pp. 167, 183–84, 235; Cardon 2007, pp. 198, 274.
32. Hofenk de Graaff 2004, pp. 77–79.
33. Robinson 1970, p. 32.
34. Several fragments of the pink yarn were mounted on a carbon stub and analyzed by means of SEM-EDS in the Metropolitan Museum's Department of Scientific Research. Analysis identified the presence of sulfur and trace amounts of aluminum but did not detect any traces of tin.
35. Hofenk de Graaff 2004, p. 259.
36. Dronsfield and Edmonds 2001, p. 97.
37. Samples were collected from the taverner's arm on the left side of the tapestry (sample 1), from the floral design element on the left side of the inner frame (sample 5), and from the background area on the lower left side of the main scene (sample 6).
38. Imaging was achieved in both HV and VP mode, at 5 to 20kV, and approximately 9 mm working distance with a LEO 1455VP electron microscope.
39. Hitachi IM4000 argon gun, ion milling system.
40. Technical information about metal thread sample preparation can be found in Costa, de Reyer, and Betbeder 2012; and Gherdán et al. 2012.
41. EDS analysis was performed with a Link Pentafet Si(Li) SATW EDS detector at 20kV, and 15 mm working distance. In addition, WDS analysis was performed by Mark Wypyski, research scientist in the Metropolitan's Department of Scientific Research, with a Microspec WDX-400 WDS spectrometer at 20kV, and 15 mm working distance.
42. Járó 1990; Járó and Tóth 1991, for comparison to metal thread techniques in the seventeenth to nineteenth centuries; Montegut et al. 1992; Hacke et al. 2003; and Hacke, Carr, and Brown 2004.
43. Montegut et al. 1992; Hacke et al. 2003; and Hacke, Carr, and Brown 2004.
44. Enguita et al. 2002; Gherdán et al. 2012.
45. Járó 1990; Járó and Tóth 1991; and Hacke et al. 2003.
46. Járó, Gál, and Tóth 2000.

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APPENDIX
TABLE 1. SUMMARY OF SUGGESTED DYES USED ON FIGURES 3 AND 9

Tapestry	***Gluttony* (Figure 3)**	***Aglauros's Vision of the Bridal Chamber of Herse* (Figure 9)**
Culture	**Flemish, Brussels**	**Flemish, Brussels**
MMA accession number	**57.62**	**41.190.135**
Number of samples analyzed	**30**	**15**
Original/Restoration	**Original (the main panel, the inner frame on the sides)**	**Original**
Colors/Materials	**Wool**	
Red 1	madder	madder
Red 2	cochineal + madder (•)	madder + weld (•)
Pink 1	cochineal + madder (•)	madder + weld
Pink 2	madder + soluble redwoods	
Purple 1	madder + indigo dye	madder (with no indigo dye)
Purple 2	archil + indigo dye	tannins + cochineal(•) + madder(•) + unknown yellow compounds
Orange	madder + soluble redwoods	weld + madder
Yellow	weld	
Green 1	dyer´s broom + weld + indigo dye	
Green 2	weld + indigo dye	
Blue	indigo dye	
Brown 1	weld	tannins + indigo dye
Brown 2	madder + weld	soluble redwoods + cochineal(•) + unknown yellow compounds(•)
Brown 3		unidentified (archil?)
Colors/Materials	**Silk**	
Red	madder + tannins	cochineal + tannins
Pink		cochineal + tannins
Yellow	weld	weld
Green		weld + indigo dye
Brown	soluble redwoods	
Yellow (core yarn of metal thread)	unidentified	young fustic + tannins
Original/Restoration	**Restoration (the inner frame on the upper and lower edges)**	
Color/Materials	**Wool**	
Blue	indigo carmine (early synthetic dye, C.I. Acid blue 74, first prepared in 1740)	
Yellow	early synthetic dye? (possibly an analog of metanil yellow [C.I. Acid Yellow 36], available since 1879)	
Dark purple	indigo carmine + unknown dye, possibly synthetic	
Brown	tannins + probably old fustic	

The symbol (•) indicates that the dye was found as a minor addition. The brown woolen sample from Figure 9 and the light brown silk sample from Figure 3, which were dyed with soluble redwoods, originally may have been red. Tannins used for the purple wool sample and for the brown wool sample from Figure 9 appear to be from a similar type of plant. Tannins used for the red and pink silk samples were probably used for weighting the silk.

TABLE 2. GEOMETRIC FEATURES AND METAL COMPOSITION OF METAL-WRAPPED THREADS FROM FIGURES 3 AND 9

Tapestry	Sample	Twist type	Thread width	Metal strip width	Metal strip thickness	Distance between coils	Twist angle	Coils per unit length	Metal strip composition	Gilding	Gold thickness
			(μm)	(μm)	(μm)	(μm)	(degrees)	(n/mm)			(nm)
Gluttony 57.62 (Figure 3)	1	S	250–300	350–370	20	91	48	1.7	Ag90 Cu10	Gold, one side	200–250
	5	S	350–400	350–380	16–18	185	50	1.3	Ag90 Cu10	Gold, one side	—
	6	S	380–500	550–570	20–22	157	59	1.25	Ag91 Cu9	Gold, one side	150–200
Aglauros's Vision of the Bridal Chamber of Herse 41.190.135 (Figure 9)	1	S	540–600	420–450	18	164	67	1.5	Ag92 Cu8	Gold, one side	200–300
	2	S	500–540	500	14–18	248	52	1.25	Ag92 Cu8	Gold, one side	200–250
	3	S	300–350	340	22–24	227	41	—	Ag91 Cu9	Gold, one side	300–400

Trade Stories: Chinese Export Embroideries in the Metropolitan Museum

MASAKO YOSHIDA

Professor, Faculty of Fine Arts, Kyoto City University of Arts

Three silk textiles embroidered with flower, bird, and animal motifs entered the collection of The Metropolitan Museum of Art in 1929 as part of a single bequest. Nineteen years later, the museum received a fourth textile, with similar characteristics, from another donor. About this group of objects, which are clearly identifiable as Chinese export embroideries, little else is known for certain. The present article is a first attempt at establishing a history of these works, provisionally setting forth their dates and place of origin, the uses they possibly served, and the routes they may have taken on their centuries-long journey from China to New York.

The formats and decorative compositions of the Metropolitan Museum's embroideries are consistent with those of a specific class of Chinese textiles that were produced as bedcovers for the European market between 1550 and 1800. Similar pieces currently preserved in Japan and Europe attest to the fact that such textiles were exported to both East and West; none remain in China. Their popularity led to the production of imitations in countries along the trade routes and to the evolution of an international style that spread as far as the Andes. Thus, the Museum's pieces are part of a larger category of textiles represented in collections around the world.

Embroideries of this type feature at their center a peony encircled by a pair of facing phoenixes. The phoenixes, in turn, are surrounded by flowers, birds, and a variety of animals. Such compositions are found in two basic formats: vertical, with distinct top and bottom; and four-directional, with motifs radiating from the center. The backgrounds of these works are of two types also: in one, the background is covered entirely with gold-thread embroidery; in the other, the unadorned foundation fabric serves as the backdrop. The stylistic analysis presented in this article will focus exclusively on four-directional compositions with gold backgrounds.

The three embroideries that came to the Metropolitan Museum in 1929 were bequeathed by Mrs. H. O. Havemeyer; the fourth, bestowed in 1948, was a gift from Catherine D. Wentworth. The Havemeyer textiles were regarded initially as discrete objects, and each was assigned an accession number. Many years later, however, the Museum's Textile Conservation Department discovered that the smallest of the three embroideries had been pieced together mostly with fragments from the other two, and conservators embarked on a project to detach the mismatched fragments and restore them to their original positions in the two larger embroideries (see Appendix Diagrams 1–3). As a result of this ongoing work, the number of the Havemeyer textiles has effectively been reduced from three to two. (All that remains of the third Havemeyer textile are two long, narrow strips; see Appendix Diagram 3.) These two embroideries will be referred to here as MMA I (Figure 1) and MMA II (Figure 2).

Of the Metropolitan's embroideries, only the Wentworth gift, hereafter referred to as MMA III (Figure 3), is complete. Unfortunately, the work's original appearance was significantly altered during an earlier restoration, and, since no information has come to light regarding when or where the donor acquired the piece, it is difficult to speculate on its travel history. For these reasons, MMA III will be discussed mainly with regard to the place and date of its production.

COMPARATIVE WORKS

Although the Metropolitan Museum's three embroideries are undated, two similar textiles with verifiable dates have been identified. One of these textiles is in Italy, and the other is among the sixteen flower, bird, and animal embroideries with gold backgrounds and four-directional

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1. Panel with flowers, birds, and animals. China, Longqing period (1567–72)—Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 82 x 75 in. (208 x 190 cm). The Metropolitan Museum of Art, H. O. Havemeyer Collection, Bequest of Mrs. H. O. Havemeyer, 1929 (29.100.154). Here referred to as MMA I

2. Panel with flowers, birds, and animals. China, Longqing period (1567–72)—Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 60 x 39¼ in. (152 x 100 cm). The Metropolitan Museum of Art, H. O. Havemeyer Collection, Bequest of Mrs. H. O. Havemeyer, 1929 (29.100.155). Here referred to as MMA II

compositions that are known to be preserved in Japan.[1] These two firmly dated embroideries, together with four more textiles from the Japan group, will serve here as the elements for constructing a chronological framework within which the Museum's works may be situated. The five embroideries that will be analyzed from the Japan group[2] are preserved at the temples Honkokuji (Figure 4), Rinzaiji (Figure 5), Shōkokuji (Figure 6), Saikyōji (Figure 7), and at the Kyūshū National Museum (hereafter KNM) (Figure 8).[3]

An inscription on the Saikyōji embroidery reveals that it was made prior to 1616, during the Wanli period (1573–1619) of China's Ming dynasty (1368–1644). This information enables us to use the Saikyōji piece as a reference for calculating the dates of the other embroideries. The related textile in Italy (Figure 9), also roughly datable, belongs to the Museo Diocesano in Chiavari.[4] Documents affirm that Achille Costaguta, a prosperous aristocrat of the town, donated the embroidery in 1651 to a rosary society affiliated with Chiavari's church of San Giovanni Battista.[5] Moreover, it is known that the embroidery was owned by the Costaguta family between 1644 and 1651.[6] Therefore, we may deduce that the Chiavari textile was made before 1644, most probably during the Wanli period, since the animal and bird motifs on the embroidery closely match design sketches from that time.[7] The present author, following a lead published by Donatella Failla to a work with similar visual characteristics in Japan,[8] examined both pieces in 2008 and found a striking correspondence in their design, materials, and techniques.[9]

MATERIALS AND TECHNIQUES

The materials and techniques used in the Chiavari embroidery and in each of the textiles in the Japan group are essentially the same as those found in the works at the Metropolitan Museum and at Saikyōji (see Appendix Table 1). These shared characteristics are typical of embroideries made in

3. Panel with flowers, birds, and animals. China, first half of Qing dynasty (1644–1912). Silk, embroidered with silk and gilt-paper-wrapped threads, 100 x 80 in. (254 x 203.2 cm). The Metropolitan Museum of Art, Bequest of Catherine D. Wentworth, 1948 (48.187.614). Photograph: Anna-Marie Kellen, The Photograph Studio, MMA. Here referred to as MMA III

4. Panel with flowers, birds, and animals. China, late Jiajing period (1522–66)—first half of Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 77½ x 65 in. (197 x 165 cm). Used in Japan as a hanging in a Buddhist temple. Honkokuji, Kyoto, Japan. From Nishimura 1973, vol. 2, pl. 62

5. Panel with flowers, birds, and animals. China, Longqing period (1567–72)—Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 96½ x 83 in. (245 x 211 cm). Used in Japan as a floor covering in a Buddhist temple. Rinzaiji, Shizuoka, Japan. Photograph: Kōzō Asano

Guangzhou (Canton), China, during the Ming and Qing (1644–1912) dynasties. As noted in Chinese primary sources[10] and as seen in one of the oldest extant Guangzhou embroideries,[11] the salient features of these textiles, known as *yue xiu*, are the following: dense, decorative motifs; strongly contrasted, vivid colors; abundant use of gold thread; birds and animals depicted with the techniques known as *rongmao zhen* (絨毛針)[12] and *yao zhen* (要針);[13] dragon scales and bird feathers rendered in *qilin yaocai* (起鱗要彩);[14] outlining in gold threads and horsehair threads; and the use of peacock feather threads. These characteristics match almost perfectly those of the Japan group, the Chiavari piece, and the Metropolitan embroideries.[15]

SIZE

The dimensions of the Metropolitan's embroideries and those of the comparative pieces are shown in Table 2 (see Appendix). Measuring 77½ by 65 inches (197 x 165 cm), the textile in Honkokuji is the smallest. The rest range from 96½ to 106⅜ inches (245 to 270 cm) in height and 74⅞ to 86⅝ inches (190 to 220 cm) in width.[16]

COMPOSITION

The compositions of all the works considered here—the comparative examples as well as the Metropolitan Museum's pieces—fall into three categories. Type 1, with the fewest number of motifs (Appendix Diagram 4), is represented solely by the Honkokuji embroidery. The work's main elements are a central, eight-petaled medallion (A) with a narrow rim (B) set in a rectangular field (C) that is surrounded by a border (D). The border is bounded by an outer guard (e) that frames the entire piece. Inside the medallion, two facing phoenixes (1) fly around a peony (O). The rectangular field contains two peacocks (2) and two golden pheasants (3), and in the surrounding border there are four peonies (O) and four animals (4, 5, 6, 7).[17] In Types 2 and 3 (Appendix Diagram 5, 6), the central medallion is round (F), an inner guard (G) surrounds the rectangular field, and there are greater numbers of peonies and animals. The central motif corresponds to that of Type 1. MMA I, KNM, and the embroideries at Rinzaiji, Shōkokuji, and Saikyōji belong to Type 2. MMA III is a variation of Type 2; its four corners are decorated with fruit-bearing plants rather than peonies, and it has ten four-legged animals rather than eight.

Type 3 (Appendix Diagram 6), represented solely by the Chiavari piece, is distinguished from Type 2 by its extra border (H) and the clustering of the four-legged animals at the corners of the inner border.

STYLE

The same types of creatures that appear on the embroideries were emblazoned on the rank badges worn by government officials in the Ming and Qing dynasties. Each animal

6. Panel with flowers, birds, and animals. China, Longqing period (1567–72)—Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 106 x 84½ in. (270 x 215 cm). Used in Japan as an altar cloth. Shōkokuji, Kyoto, Japan. From Tokugawa Bijutsukan 1998, pl. 125

7. Panel with flowers, birds, and animals. China, Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 100½ x 76¾ in. (255 x 195 cm). Used in Japan as an altar cloth. Saikyōji, Shiga, Japan. From Kokuritsu Rekishi Minzoku Hakubutsukan 2008, pl. 20

represented a particular position in the administrative hierarchy (see Figure 21).[18] Small in size, the insignia were embroidered in many parts of China. For this reason, regional and period styles and individual embroiderers' skill levels must be taken into account when analyzing rank badges. By contrast, all of the textiles under discussion in this article were made in one place: Guangzhou. Close examination reveals that threads of different colors were used in different parts of the embroideries, suggesting that several hands were involved in the production of each textile. This leads to the conclusion that the stylistic variations that are apparent from one work to another are the results of deviations that occurred over time rather than the consequences of regional peculiarities or the idiosyncracies of individual embroiderers.

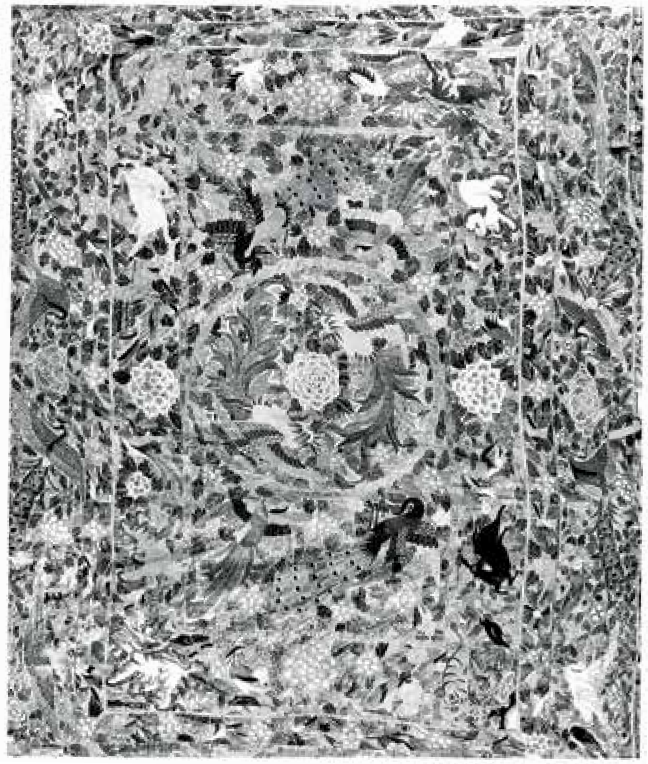
It has been widely observed that copying the same design over many years leads to a stiffening of style and a decrease in three-dimensional illusion, with the original rendering eventually transformed into a flat arrangement of colors and simplified, sometimes exaggerated forms. These effects can be seen in the tiger motif that occurs in all but one of the embroideries discussed here. The stylistic permutations of this shared figure provide a basis for positing the works' chronological order.

The Honkokuji embroidery (Figure 4), the simplest and probably the earliest of the textiles, does not feature a tiger, but it does represent a female lion, or perhaps a lion cub (Figure 10; see also Appendix Diagram 4), that closely resembles the tigers in the other embroideries. The portrayal of the animal is simple and realistic: the embroidery threads are fine, their twist loose, and the floats long. The flow of the stitches deftly simulates the texture of the creature's fur and the roundness of its body.

A quick review of China's role in international commerce is useful in narrowing down a time frame for the production of the Honkokuji embroidery. In the decades after the arrival of the first Portuguese in China, in 1513, Chinese authorities shifted back and forth between allowing and prohibiting trade with the European seafarers.[19] Only in 1554 was Portugal granted official permission to conduct business in China, and its activity was restricted to the area surrounding Guangzhou. It is most likely, then, that the Honkokuji embroidery was produced after 1554. As we shall soon see, the textile probably originated in the second half of the sixteenth century, in the period spanning the late Jiajing period (1522–66) and the first half of the Wanli period (1573–1619).

A new generation of textiles evolved from the Honkokuji model. Larger in size, these embroideries were suitable for use as European bedcovers and were presumably commissioned as such. At their center, instead of the traditional Chinese eight-petaled medallion, was a universally symbolic circle; their greater size accommodated a higher number and wider variety of decorative elements arranged in increasingly complex layouts, such as those seen in MMA I and in the Rinzaiji, Shōkokuji, Saikyōji, and Chiavari

8. Panel with flowers, birds, and animals. China, first half of Qing dynasty (1644–1912). Silk, embroidered with silk and gilt-paper-wrapped threads, 98¾ x 86½ in. (251 x 220 cm). Kyūshū National Museum, Fukuoka, Japan. Photograph: Takeshi Fujimori, Courtesy of Kyūshū National Museum



9. Panel with flowers, birds, and animals. China, Wanli period (1573–1619). Silk, embroidered with silk and gilt-paper-wrapped threads, 103½ x 82 in. (263 x 208 cm). Used in Italy as a canopy for a religious statue. Museo Diocesano, Chiavari, Italy. From Lucidi 1994, p. 287, no. 156

embroideries. Compositions of Types 2 and 3 were both produced during the Wanli era.[20]

Apart from its stripes, the tiger in the Rinzaiji embroidery (Figure 11) so closely resembles the lioness (or cub) depicted in the Honkokuji piece that one can imagine both figures deriving from the same design sketch. The Rinzaiji animal's stance is natural, its front legs cross, and its head faces forward on a diagonal. Following the curves of the body, the stripes on the legs (i) and cheeks (j) describe three-dimensional forms. The stripes on the top of the head (k) are simply rendered. The embroidery threads are thin, with a loose twist and soft, fluffy texture, as are those in the Honkokuji feline. The relatively stiff poses of the other animals in the Rinzaiji embroidery and the complexity of the textile's overall design make it highly likely that this embroidery is of a later date than the Honkokuji textile. The reasons why the Rinzaiji embroidery is thought to predate MMA I as well as the Shōkokuji, Saikyōji, and Chiavari pieces will soon be made clear.

The tiger in MMA I (Figure 12) is stiffer and slightly more stylized than the Rinzaiji tiger. Rather than defining the animal's anatomy, the stripes on the legs and body (l) repeat the same wavy line, and those on the head (m) are arranged in a star shape. The embroidery threads are slightly thicker and have a slightly tighter twist than those used to create the Rinzaiji tiger.

MMA II does not feature a tiger. Although significant portions of the work are missing, the remaining parts are stylistically and technically similar to MMA I. This makes it safe to assume that the two embroideries were produced at about the same time.

The Shōkokuji tiger (Figure 13) resembles the tiger in MMA I, and its stripes repeat the same wavy lines. The ears (n) are filled in with two-color plied threads, conveying the effect of flat areas of color. The similarities in the Shōkokuji embroidery and MMA I include composition, material, and technique, as well as style.[21] The fact that the threads of the Shōkokuji piece are slightly thicker and have a tighter twist than those of MMA I and MMA II is a sign that the Shōkokuji textile may have been made slightly later than the other two.

Turning now to the Saikyōji tiger (Figure 14), produced before 1616, we see that the animal's stance differs somewhat from those discussed above. Its front legs are spread apart and the end of its tail hangs down. The body lacks volume; the eyes, accentuated by what appear to be heavy blue lids, are greatly exaggerated; and the stripes on the head (o), like those on all but the Rinzaiji tiger, are decoratively rendered. Far from a realistic representation, the Saikyōji tiger is flat and patternized, and its features are distorted.

It is probable that the tiger in the Chiavari piece (Figure 15), produced before 1644, is based on the same prototype as the tigers in the Rinzaiji, MMA I, and Shōkokuji embroideries. However, the stylized stripes on the cheek of the Chiavari tiger (p) have no relation to the creature's anatomical curves; the stripes on the head (q) converge in a decorative motif; and spots (r) have been added to the paws. Here, the tiger's natural appearance has been schematized rather than realistically rendered.

The even greater degree of stylization that occurs in MMA III and in the KNM embroidery suggests that these works were made later than the Chiavari piece. The distribution of motifs in MMA III shows the composition to be a variant of Type 2, with ten mammals—more than in any other piece examined here—occupying its borders. The presence of threads added during an earlier restoration makes it difficult to envisage the tiger as it originally appeared; however the creature's overall form (Figure 16) is close to, if even less realistic and more patternized than, that of the Chiavari tiger. For this reason, it is highly probable that MMA III was made after the Chiavari embroidery, possibly during the first half of the Qing dynasty. More precise dating will depend upon the eventual discovery of comparative pieces from this period or documentation that permits us to trace the origins of MMA III.

The KNM tiger (Figure 17) appears to be based on the same prototype as the Saikyōji tiger, but its legs are set closer together, giving it a rather unnatural stance. Moreover, its ears are highly schematized—the animal's proper right ear (s) is defined by the outline of the head—and the mottled diagonal strip above the proper left eye projects outward like an eyebrow (t), giving the animal a cartoonlike expression. Yet overall, the KNM tiger so closely resembles its Saikyōji counterpart that it could well be a distant iteration of that figure, the product of multiple retracings of the drawing on which the Saikyōji tiger is based. This process, as we have seen, gradually resulted in a flattened, simplified, and distorted version of the original model. The KNM embroidery's threads are thicker and more tightly twisted than those of the Saikyōji piece; in addition, its stitches are shorter and its color scheme more complex, characteristics consistent with textiles of later production than the Saikyōji embroidery. Thus, we may deduce that the KNM piece was made later than the work at Saikyōji, possibly in the first half of the Qing dynasty; but again, lacking firmly dated comparative pieces, it is difficult to close in on a production date.

To recapitulate, MMA I and MMA II predate the Saikyōji embroidery and were probably made in the late sixteenth century, while MMA III exhibits characteristics of a later date.

THE MIGRATION OF MMA I AND MMA II

Fortunately, reliable donor information for the Saikyōji piece as well as for a similar textile at Jōdenji, in Japan's Tottori Prefecture, allows us to extrapolate the circumstances behind the importation of those two textiles to Japan, circumstances that may apply to the MMA I and MMA II embroideries also.

An inscription on the back of the Saikyōji piece relates that the magistrate of Nagasaki, Hasegawa Fujihiro (1567–1617), donated the work to the temple in 1616 in honor of the first Tokugawa shogun, Ieyasu (1542–1616). Fujihiro owed his high office to his sister, who was one of Ieyasu's concubines. As magistrate, Fujihiro was responsible for overseeing administration, justice, and international trade in the port city. He received merchant vessels' cargo lists and acted as the shogun's surrogate, prioritizing the purchase of articles on behalf of the shogun and bargaining over their prices.[22]

Fujihiro supervised trade with Portugal, Spain, the Netherlands, and England. Of these countries, only Portugal then had a trading post in China. It was located in Macau, on the route connecting Lisbon and Goa to Nagasaki.[23] Products made in Guangzhou were taken to Macau—a distance of about sixty-eight miles—by Chinese merchants. The goods were then shipped out of Macau on Portuguese sailing vessels that plied the international trade routes.[24]

The peak period of trade between Macau and Nagasaki (1569–1635) overlapped with Fujihiro's term as magistrate (1606–14). This information, together with the fact that pieces similar to the Saikyōji embroidery are preserved in Lisbon and India, makes it likely that the Saikyōji piece was shipped from Macau to Nagasaki on a Portuguese carrier. However, it cannot be ruled out that a Portuguese or Chinese vessel might have transported the work to Southeast Asia, where it could have been purchased by Spanish, Dutch, English, Ryūkyūn, or Japanese merchants, who then took it to Japan. By whatever means the embroidery arrived in Nagasaki, Fujihiro likely acquired the precious work while he was serving as magistrate. During that time, the international textile trade was limited almost exclusively to recently made goods. Therefore, the Saikyōji embroidery probably dates from about 1606 to 1614.

It has long been said that the flower, bird, and animal design embroidery with vertical composition preserved at Jōdenji was donated by Korenori (1557–1612), the first head of the Kamei family.[25] Only Korenori could have procured such a luxurious import item and gifted it to this temple so far removed from the central seat of power.[26] He was a trader as well as a *daimyō* (feudal ruler) and thus was in a privileged position to procure foreign-made luxury goods. It can be assumed that he donated the embroidery between 1581, when he was installed as a lord of the Kita district, in what is today's Tottori Prefecture, and his death in 1612.

In the mid-sixteenth century, pirates roamed the China Seas. Called *wakō* (Japanese pirates), the marauders in fact came from many countries. The Ming court feared them and prohibited official trade with Japan, but the Japanese

10. Lioness or lion cub in the Honkokuji embroidery (Figure 4). Photographs in Figures 10, 11, 14, 15, 17, 19, 24–27, 30, 32, 33, 35: Masako Yoshida

11. Tiger in the Rinzaiji embroidery (Figure 5)

12. Tiger in MMA I (Figure 1). Photograph: Minsun Hwang

13. Tiger in the Shōkokuji embroidery (Figure 6). From Nishimura 1973, vol. 2, 1973, fig. 63

government, despite the danger posed by the *wakō* and partly to counter them, issued trade permits to select private ships, enabling them to conduct informal trade with China and Southeast Asia. The permits were stamped with a red seal (*shuin*) and the vessels that carried them were known as red seal ships (*shuinsen*).

Korenori received red seal permits on three occasions. The first was in 1607, when he sailed for South China.[27] On the second and third occasions, in 1609 and 1610, he went to Thailand (Siam).[28] Korenori may have acquired the flower, bird, and animal embroidery in South China in 1607, or in Thailand in 1609 or 1610, since private Chinese merchant ships carried Chinese goods to Thailand to be traded on the Asian market. It is also possible that Korenori's son, Suzuki Hachirōzaemon, bought the piece while trading with foreign ships in Nagasaki.[29]

MMA I and MMA II, like the embroideries owned by Fujihiro and Korenori, are typical examples of the textiles that were highly prized at the beginning of the China trade during the Age of Exploration—textiles now preserved in greatest number in Japan. As explained below, facts known about the donor of MMA I and MMA II seem to support the possibility that these two works were also once in Japan, and that they followed the same route there as the one taken by the embroideries of Fujihiro and Korenori.

THE TASTE FOR GOLD

A common characteristic of the Metropolitan Museum's pieces and the works in the Japan group is an abundance of gold thread. With only one exception,[30] the twenty-six flower, bird, and animal embroideries known to be preserved in Japan have gold backgrounds, whereas the number of gold-background embroideries that have survived in Europe is very small.[31] Here we will consider some possible causes of this imbalance, notably those pertaining to contemporary tastes and utilitarian functions.

Most of the works in the Japan group were imported between the late sixteenth and early seventeenth centuries, a time when gold was used lavishly in Japanese architectural

14. Tiger in the Saikyōji embroidery (Figure 7)

15. Tiger in the Chiavari embroidery (Figure 9)

16. Tiger in MMA III (Figure 3)

17. Tiger in the Kyūshū National Museum embroidery (Figure 8)

interiors and clothing materials. Indeed, the Momoyama period (1573–1615) marks the height of gold-ground bird-and-flower paintings, many of which decorated the walls and sliding doors of ceremonial rooms in temples and castles. Noh costumes (*nuihaku*) from the Momoyama period also reflect the popularity among the upper classes of bird-and-flower motifs on gold-leaf ground.[32] It follows that Japanese traders would have catered to the taste of the elite by importing gold-ground bird-and-flower textiles.[33] What is more, Europeans who traveled to Japan hoping to expand their nations' trading rights and gain political advantage adopted the local custom of presenting textiles as gifts to Japanese officials. For reasons such as these, Chinese embroideries originally produced for the European market were increasingly imported to Japan.

MULTIPLE USES: SECULAR TO SACRED

Although the dimensions and shapes of the embroideries in the Japan group suggest that these textiles were intended as European bedcovers, the Japanese adapted them to their own purposes.[34] Initially they may have displayed the embroideries in various ways, but eventually the works were treated as sacred objects, which largely explains why they have been so carefully preserved.

The majority of the surviving embroideries were donated to Buddhist temples after the death of their owners, a fact explained by the custom of offering precious items related to the deceased in supplication for his or her well-being in the afterlife. Inscriptions added to these embroideries indicate that, once in a temple's possession, they were used as hangings, altar cloths (*uchishiki*), or wrappings for Buddhist ritual implements (*fukusa*).[35] The textile in Hōjōji was divided into three sections and refashioned as a curtain for a hall devoted to the Bodhisattva Avalokiteshvara, or Kannon Bosatsu (Figure 18).

Some of the embroideries remained in private hands into the latter half of the Edo period (1603–1868), when members of the prosperous merchant class began buying them and eventually donating them to local religious festivals, in which

18. Bird, flower, and animal design embroidery reconfigured into hangings for the hall devoted to the Kannon Bosatsu at Hōjōji, Otsu, Japan. Photograph: Courtesy of Hōjōji

19. Flower, bird, and animal design embroideries (reproductions) decorating the Sesshōsekizan float at the Otsu Festival, Japan

the embroideries would play conspicuous parts in parades of splendidly adorned floats. The role of sumptuous fabrics in such festivals dates far back to the time when it was believed that eye-catching materials could be used to lure demons, which could then be captured and exorcised. During the Middle Ages, decorative textiles were hung from multistoried floats (*yamaboko*) in Kyoto's Gion Festival, which was given four flower, bird, and animal embroideries that were employed for centuries in that yearly event.[36]

Eight textiles with flower, bird, and animal designs can still be seen today adorning floats in the Otsu Festival, which has been held annually for more than four hundred years in the area surrounding the Tenson Shrine. Of the eight textiles, seven are copies (Figure 19) of original embroideries that are now kept in storage owing to their fragile conditions.

In Italy, the Chiavari embroidery performed a comparable function. At festival time, it was draped as a canopy over a palanquin bearing a statue of the Virgin.[37]

MOTIFS AND THEIR SYMBOLISM

For their Chinese creators, the flowers, birds, and animals depicted in the embroideries had specific meanings. The following examples of common motifs give an idea of the auspicious characteristics of the elements that decorated these compositions.

During the Tang dynasty (618–906), the peony, king of flowers, and the phoenix (*fenghuang*), king of birds, were paired in a design called "phoenixes playing with peonies" (*Feng xi mudan*) and "phoenixes passing through peonies" (*Feng chuan mudan*), symbolizing prosperity and good fortune (Figure 20).[38] In the Ming dynasty (1368–1644), *Feng xi mudan* was adopted as an insignia for princesses; when associated with ordinary citizens, the motif denoted harmony and conjugal happiness.[39]

The peacock, bird of virtue, signified love[40] and also symbolized the power of civil officials in the imperial court. The same meaning was ascribed to the golden pheasant, which was represented on the rank badges of the highest civil officials and also on the ceremonial robes of the empress.[41]

Tigers, emblems of bravery and the power to repel evil,[42] were also associated with advancement in the government hierarchy. The deer, symbol of longevity, denoted wealth, since *lu* (deer) is homonymous with the Chinese word for "stipend."[43] Goats and sheep were seen as felicitous because their names, *shanyang* (goat) and *mianyang* (sheep), share the character for *yang* found in *jixiang* (auspicious).[44]

Xiezhi, a mythical unicorn, was believed capable of distinguishing right from wrong[45] and figured on the rank badges of the Censorate in the Ming dynasty (Figure 21).

The *qilin*, an imaginary animal, was said to appear during the reigns of emperors who governed virtuously.[46] When depicted on common objects, the *qilin* often symbolized the user's wish for children who would bring success to the family.

GLOBAL PRODUCTION AND THE TRANSFORMATION OF MOTIFS

With the expansion of the trade routes, copies of Chinese embroideries began to be made at culturally diverse sites, where the symbolism of the original designs was unknown. As a result, the motifs mutated. Evidence of this transformation can be seen by comparing the Chinese-made originals in the Metropolitan Museum and the Japan group with foreign-made—in Europe, India, and the Andes—versions of the same designs.

20. Detail of MMA II (Figure 2) showing a pair of phoenixes circling a peony

India

In 1973, John Irwin, then Keeper of the Indian Section at the Victoria and Albert Museum, published a textile—either a canopy or a bedcover—produced for the European market in Gujarat in the late seventeenth or early eighteenth century (Figure 22).[47] Failla demonstrated in 1982 that the work belongs to the same category of textiles as the flower, bird, and animal embroideries.[48]

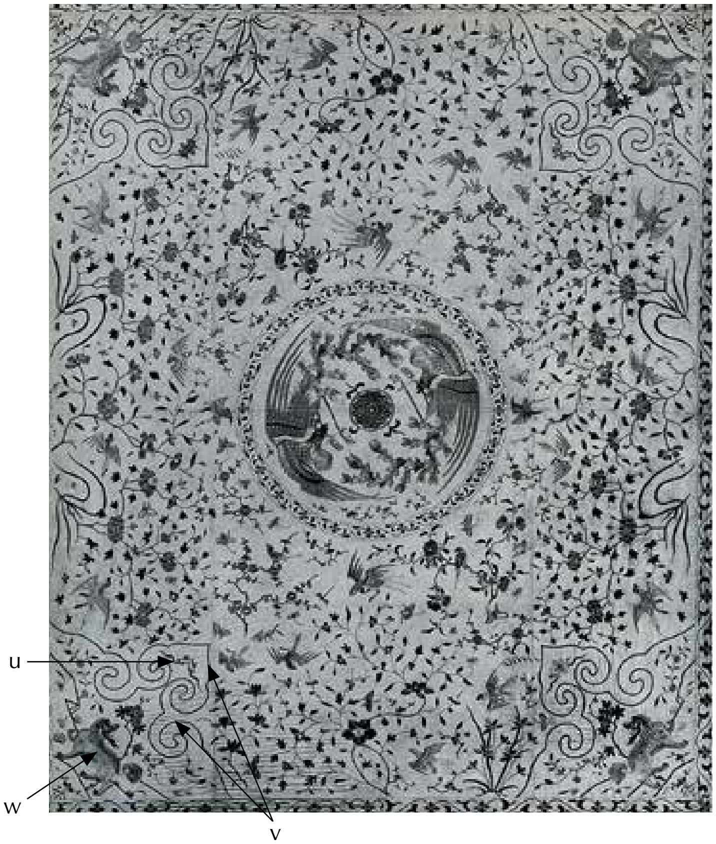
Comparison of the Indian work with the Guanzhou embroideries in the Metropolitan Museum and the Japan group reveals the phoenixes in the Indian-made piece to be distant variants of the *fenghuang* in the older Chinese works (see Figure 20).[49] Other Chinese motifs in the Indian embroidery include the musical instrument *qing* (u) and a cloud-shaped corner embellishment (v). The lion (w), too, although stiff and stylized, derives from Chinese sources.

Indian textiles with designs similar to the one discussed here are preserved at the Cooper Hewitt, Smithsonian Design Museum, in New York and the Royal Ontario Museum in Toronto.[50] The existence of these three works suggests that a Chinese prototype was taken to India, where copies were produced for the European market.

21. Rank badge with *xiezhi*. China, Ming dynasty (1368–1644). Tapestry-woven silk and metal-wrapped threads, 13¾ x 14½ in. (34.9 x 36.8 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.65.29)

Europe

A large flower, bird, and animal embroidery (Figure 23) owned by the Fundação Ricardo do Espírito Santo Silva (FRESS) in Lisbon is commonly thought to have originated in eighteenth-century China. However, an examination of the embroidery by the present author in 2007 brought to light strong evidence that the work was probably produced in Europe from Chinese models.[51]



22. Canopy or bedcover. India, for the European market, late 17th–early 18th century. Cotton, embroidered with silk, 91¾ x 76 in. (233 x 193 cm). Calico Museum of Textiles, Ahmedabad (702). From Irwin and Hall 1973, vol. 2, pl. 20, no. 41

23. Panel with flowers, birds, and animals. Europe, 18th century. Bast fiber embroidered with silk and metal-wrapped threads, 110¼ x 119 in. (280 x 304 cm). Fundação Ricardo do Espírito Santo Silva, Lisbon (176). Photograph: Courtesy of Fundação Ricardo do Espírito Santo Silva, Lisbon

Significant differences in motifs and materials distinguish the FRESS embroidery from the Chinese originals in the Metropolitan Museum and the Japan group. Whereas the works in New York and Japan feature only traditional Chinese flowers, such as peonies, lotuses, and chrysanthemums (Figure 24), the FRESS piece includes carnations and tulips (Figure 25), flower types often represented in European embroideries. Another clue to the FRESS embroidery's European origin is found in the figure of the monkey (Figure 26). Unlike its simian counterpart in the Chinese embroidery that for many years decorated the Sesshōsekizan float in the Otsu Festival (Figure 27), the FRESS monkey wears a belt and a dangling ornament similar to those seen on monkeys depicted in Western chinoiserie. The foundation textile of the Chinese-made embroideries is silk, whereas that of the FRESS embroidery is woven from a bast fiber, most likely linen, a material commonly used in European embroideries. The metallic thread of the Chinese works consists of thin strips of paper gilded with the use of lacquer adhesive and wound in a Z direction around a silk-thread core (see Appendix Figure 1). This technique for creating gold thread was used in China in the sixteenth through the eighteenth centuries. In the FRESS piece, the metallic thread was formed by winding narrow metal strips directly around a silk-thread core in an S direction (see Appendix Figure 2), a technique commonly employed in Europe during that same period.

These findings lead us to conclude that the FRESS embroidery was made in Europe and that its layout and motifs derive from the same style sketches that were used for the Japan group. It is probably based on complex models dating from the middle of the Qing dynasty.

The Andes

In 1964 Schuyler Cammann published several Chinese-influenced tapestries that were made in the colonial Andes. One of these (Figure 28), a Peruvian-made piece in the collection of the Museum of Fine Arts in Boston,[52] was later identified by Failla as belonging to the same textile category as four-directional flower, bird, and animal embroideries.[53] Subsequent research by the present author revealed that the positions of certain motifs—namely, of peonies, phoenixes, and *xiezhi*—in Boston's Andean tapestry match those of corresponding motifs in MMA I and the Saikōji piece.[54]

Many of these shared motifs appear to have been culturally recast in the Peruvian textile. A few examples show ways in which ancient Chinese emblems were adapted to a New World situation. The Peruvian birds (Figure 29) that Cammann identified as peacocks prove to be modified phoenixes when compared with their counterparts in the embroideries of the Metropolitan Museum (see Figure 20) and the Japan group. And the flamelike shapes signifying mystical power that flare out a short distance from the body of the *xiezhi* in the Chinese-made textiles (Figure 30 [x]), are totally transformed in the Peruvian tapestry, where they resemble pectoral wings or even antlers (Figure 31 [y]). As noted by Cammann, the crowned Andean lion (Figure 32) is distinctly European in character, while the lions in the Metropolitan Museum's pieces and in the Japan group are typically Chinese (Figure 33). The *qilin* (Figure 34) and other auspicious Chinese creatures in the Metropolitan and the Japan group textiles are accompanied in the Andean tapestry by indigenous animals that Camman identifies as llamas or vicuñas (Figure 35) .

The Peruvian tapestry provides evidence in support of the idea that the Spanish took Chinese design sketches and/or textiles to their colonies in the Andes and commissioned artisans there to use them as models for tapestries. Although Spain did not have a commercial base in China, from its colony in Manila it was able to engage in trade with Chinese merchants operating off China's coast and also to do business at trading points in Southeast Asia. Goods thus acquired were transported on Spanish ships, known as Manila galleons, from the Philippines across the Pacific to Lima and Acapulco.

MMA I AND II: New York via Japan

Traveling the trade routes, Chinese flower, bird, and animal embroideries of the types in the Metropolitan Museum and the Japan group were eventually widely dispersed in Asia, India, Europe, and South America. Where might Mrs. Havemeyer and her husband, Henry O. Havemeyer, have acquired theirs?

As we have seen, numerous embroideries dating from the same period and with essentially the same design as MMA I and MMA II are preserved in Japan. The Havemeyers had strong connections among Asian art dealers; the couple collected Japanese textiles between 1876, when they made their first such acquisitions at the Centennial International Exhibition in Philadelphia,[55] and 1924.[56] This period of time overlaps Japan's Meiji era (1868–1912), when a reshuffling of society and the opening of the country to trade with the West resulted in the introduction of traditional Japanese goods to the international marketplace. Those goods would have included embroideries. There are many examples of textiles that were sold after being passed down for generations in Japanese households. In the Meiji era in particular such heirlooms tended to end up abroad.

Although it cannot be ruled out that the Havemeyer embroideries were imported to Europe directly from China, the evidence presented above suggests that they were shipped initially to Japan and remained there for more than two centuries before coming into the possession of the American collectors. In other words, MMA I and MMA II, like the embroideries procured by Fujihiro and Korenori,

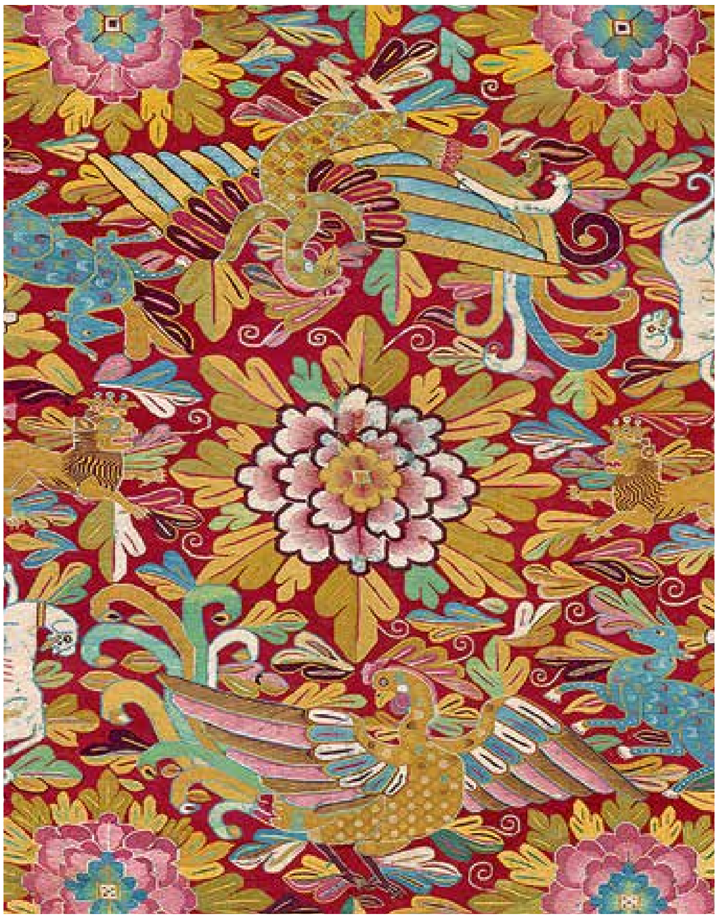

24. Chrysanthemums in the Saikyōji embroidery (Figure 7)


25. Tulips in the European embroidery (Figure 23)


26. Monkey with belt and ornament in the European embroidery (Figure 23)


27. Detail of monkey in a flower, bird, and animal design embroidery. China, Longqing (1567–72)—Wanli (1573–1619) period. Silk, embroidered with silk and gilt-paper-wrapped threads, 43⅜ x 70½ in. (110 x 179 cm). Sesshōsekizan float, Shiga Prefecture, Japan

28. Tapestry. Peru, colonial period, late 17th– early 18th century. Tapestry weave, wool, silk, cotton, and linen. Museum of Fine Arts, Boston (11.1264). Photograph: ©Museum of Fine Arts, Boston



29. Pair of phoenixes in the Peruvian tapestry (Figure 28)

may well have traveled the Asian trade routes to Japan, where they would reside for many generations before continuing on to their final destinations.

As for MMA III, almost everything remains to be discovered about its journey from China to New York. The search is a fascinating one, since the significance of the Metropolitan's embroideries lies not only in what they tell us about China during the late Ming and the first half of the Qing dynasty, but also in what they add to our knowledge of the cultural relations among China, Japan, Europe, South America, and North America during that time.

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30. *Xiezhi* in the Saikyōji embroidery (Figure 7)

31. *Xiezhi* in the Peruvian tapestry (Figure 28)

32. Lion in the Peruvian tapestry (Figure 28)

33. Lion in MMA I (Figure 1)

34. *Qilin* in MMA III (Figure 3)

35. Llama or vicuña in the Peruvian tapestry (Figure 28)

1. Embroideries with gold backgrounds and four-directional compositions are preserved in Japan at the following places, listed from north to south:

   Engakuji in Kanagawa; Hōjōji in Shizuoka; Rinzaiji in Shizuoka; Ryūmontakiyama in Shiga (two works); Saikyōji in Shiga; Sesshōsekizan in Shiga; Honkokuji in Kyoto; Kankoboko in Kyoto (two works); Shōkokuji in Kyoto; Marubeni Company in Osaka; Kurokawa Institute of Ancient Cultures (Kurokawa Kobunka Kenkyūjo) in Hyogo; Yōmeiji in Shimane; and Kyūshū National Museum in Fukuoka (two works).
2. Reference material related to the Japan group includes: Mikami and Yamanobe 1969, p. 86; Nishimura 1973, pl. 62; Hibino 1982, p. 218; Osaka Shiritsu Hakubutsukan 1988, p. 30; Otsu Rekishi Hakubutsukan 1996, p. 49; Tokugawa Bijutsukan 1998, pl. 125; Yoshida 1998; Yoshida 2007, pp. 110–11; Kokuritsu Rekishi Minzoku Hakubutsukan 2008, pp. 48–49, pl. 20; Yoshida 2011.
3. See note 1 above for locations.
4. There are other embroideries of this type in Europe. Donatella Failla (1987, p. 120), mentions one example at El Escorial and another at a church (unnamed) in Seville. It has not yet been determined whether these examples are of Chinese origin. For further information on the Chiavari piece, see Failla 1982; Algeri 1985; Algeri 1986, pp. 64–67; Failla 1987; Failla 1994; Algeri 2003, pp. 98–99.
5. Failla 1982, p. 96.
6. Failla 1987, pp. 120–21.
7. The motifs in the Chiavari embroidery bear close comparison to rank insignias illustrated in *Daming huidian* (Great Ming dynasty legal code) (1587) and *Sancai tuhui* (Pictorial encyclopedia of the heaven, earth, and man) (1609). Failla 1982, p. 97.
8. Failla 1987, p. 119.
9. Yoshida 2008.
10. Cited in Yoshida 2007, pp. 104–8.
11. This early (Qing dynasty) Guangzhou embroidery, formerly in the Palace Museum in Beijing, is now in the Guangzhou Museum.
12. *Rongmao zhen* is a variation of satin stitch employed to simulate the texture of animal hair.
13. *Yao zhen* is a variation of satin stitch used for outlining plumage and fur.
14. Q*ilin yaocai* is an embroidery technique combining satin stitch with couching. It is used to depict dragon scales and small, scale-like feathers.
15. Peacock feather threads are not present in these works. Outlining threads resembling horsehair are present, but the Textile Conservation Department has determined that these are composed of cellulose rather than protein fiber.
16. As provisionally reconstructed by the Department of Textile Conservation, the full dimensions of MMA I (see Appendix Figure 1) would be approximately 102⅜ by 74⅞ inches (260 by 190 cm). MMA II is not included in this comparison because of its incomplete state.
17. It has been pointed out that combining flowers, birds, and animals was a distinct tradition in the eastern part of Central Asia, where an embroidery of this description is known to have been produced sometime between the eleventh and thirteenth centuries. The disposition of four animals, one on each side of the embroidery, stems from Chinese tradition. See Watt and Wardwell 1997, pp. 172–75, fig. 50.
18. A rank badge embroidered with phoenixes and peonies is illustrated in Huang 1987, p. 52, fig. 47.
19. Portugal was the first European power to enter China. Portuguese ships sailed into Guangzhou in 1513, but China's rulers put a stop to foreign trade a few years later. From the 1520s until 1554, Chinese merchants did business with Portuguese smugglers along China's south coast. In 1554 the Portuguese successfully negotiated an agreement to conduct trade in Guangdong. Three years later, Portugal leased Macau and was allowed to establish a settlement there. In 1578, Portuguese ships were authorized to sail in and out of Guangdong harbor. In light of this timeline, it seems probable that European export goods began to be produced in Guangzhou after the Portuguese secured permission to trade in Guangdong in 1554.
20. The Saikyōji (Type 2) and Chiavari (Type 3) embroideries are thought to have originated in the Wanli era.
21. The compositions of MMA I and the Shōkokuji embroidery differ only slightly. In the place of the lion in MMA I, the Shōkokuji embroidery has a goat.
22. For Hasegawa Fujihiro, see Miyake 1956.
23. Studies tracing the trade routes include: Okamoto 1936; Boxer 1948; Boxer 1959; Boxer 1969; Arano 1992; Murai 1997.
24. Linschoten (1663) 1968, p. 241.
25. Starting with the fourth generation, Kamei family graves were sited at Yōmeiji, in Shimane prefecture. Yōmeiji has a four-directional flower, bird, and animal embroidery, but it is unclear with which family member it is associated. For this reason, the datable Jōdenji embroidery, which has a vertical composition, is discussed here.
26. Yoshida 2011, pp. 7–10.
27. Sūden (1608) 1989, p. 196. The destination of the first voyage is given as Saiyō, a name that can designate either Macau (see Iwao 1958) or all of southern China (see Nagazumi 2001, pp. 50–51). The present author interprets the name, as used in the Korenori documents, to designate the broad area of southern China.
28. Sūden (1608) 1989, p. 203.
29. Koizumi 1906, p. 388.
30. The exception, preserved at Rinnōji, has colorful flower, bird, and animal motifs embroidered on a plain white background. Stylistic and material considerations suggest that this piece was produced later than the Honkokuji, Rinzaiji, and Saikyōji embroideries.
31. Vertical as well as four-directional compositions are included among the twenty-six flower, bird, and animal embroideries preserved in Japan.
32. *Nuihaku* is the name for textiles covered with gold leaf and then embroidered; the term also designates the garments fashioned from this textile. For sumptuously embroidered Noh costumes of the Momoyama period (1573–1615), see Kokuritsu Nōgakudō 1986, p. 38, fig. 27 (a jacket of phoenix, willow, and cherry blossom pattern embroidery on gold-foil ground; Itsukushima Shrine, Momoyama period); and Tokugawa Bijutsukan 1998, p. 159, pl. 68 (a robe made of paulownia, bamboo, phoenix, and flower curved-line pattern embroidery on gold-foil ground; Kasuga Shrine, Momoyama period), and p. 160, fig. 76 (a robe of reed and bird pattern embroidery on gold-foil ground; Hayashibara Bijutsukan, Momoyama period).
33. Sudō 1998.
34. Since the dimensions of the embroideries in the Japan group do not correspond to the lifestyle of sixteenth-century Japan, it is doubtful that any of them were originally produced for the Japanese. Embroideries of similar size and shape, and with central round medallions, were made in India about this time as bedcovers for the Portuguese. Four such works, all from the seventeenth

century, are in the collection of the Museu Nacional de Arte Antiga, Lisbon: inv. 2281, 129 x 105 1/8 in. (328 x 267 cm); inv. 2164, 102 3/8 x 82 1/4 in. (260 x 209 cm); inv. 112, 109 1/2 x 78 3/4 in. (278 x 200 cm); inv. 113, 88 1/8 x 67 3/4 in. (224 x 172 cm). See Passos Leite 1981, pp. 33, 34, 35, 39.

35. The embroideries at Honkokuji, Rinzaiji, Shōkokuji, and Saikyōji were used in these ways.
36. The four textiles were replaced several years ago by reproductions. The originals are now stored in the districts of Kankoboko, Mōsōyama, and Ashikariyama.
37. Failla 1982, p. 96.
38. The *fenghuang* is a legendary bird that appears when a ruler governs virtuously. See Hua 1993, p. 1133, and Xu Huadang 2000, p. 21. In the Yuan dynasty (1271–1368) pairs of flying *fenghuang* with different tail shapes emerged as a common motif; see Watt and Wardwell 1997, pp. 196–99, no. 60. The *Feng xi mudan* was used over a long period.
39. Xu Zhongjie 1985, pp. 138–39.
40. See Han 1995, pp. 35–36; Chen 1992, pp. 52–53.
41. See Hua 1993, p. 1538; Chen 1992, p. 53; Zuo 2001, p. 123.
42. See Han 1995, pp. 13–14.
43. See ibid., pp. 22–23; Chen 1992, p. 51.
44. See Han 1995, p. 28.
45. See Cammann 1944, p. 108; Hua 1993, p. 1136; and Joyce Denney, "Rank Insignia," in Phipps, Hecht, and Martín 2004, pp. 254–55, no. 77.
46. See Han 1995, pp. 9–11.
47. Irwin and Hall 1973, vol. 2, pl. 20, no. 41.
48. Failla 1982.
49. The principal distinction between the Indian and Chinese phoenixes is in the construction of the birds' tails. The elongated tail of the Indian phoenix is composed of small triangles linked together, giving it a jagged, spikey appearance, whereas the tails of Chinese phoenixes usually branch out in gentle, continuous curves.
50. Cooper Hewitt, Smithsonian Design Museum, New York (1953-123-2); Royal Ontario Museum, Toronto (978.339).
51. Yoshida n.d. (forthcoming).
52. Cammann 1964, p. 23, fig. 3.
53. Failla 1987.
54. Yoshida 2007, pp. 111–13.
55. Meech 1993, pp. 129–30.
56. Del Collo 2013, p. 4.

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The Metropolitan Museum's three Havemeyer embroideries reassembled to approximate their original configurations

Diagram 1. MMA I (Figure 1, 29.100.154) shown with its proper border (a) restored from MMA 29.100.156

Diagram 2. MMA II (Figure 2, 29.100.155) shown with two of its fragments (d and e) restored from MMA 29.100.156

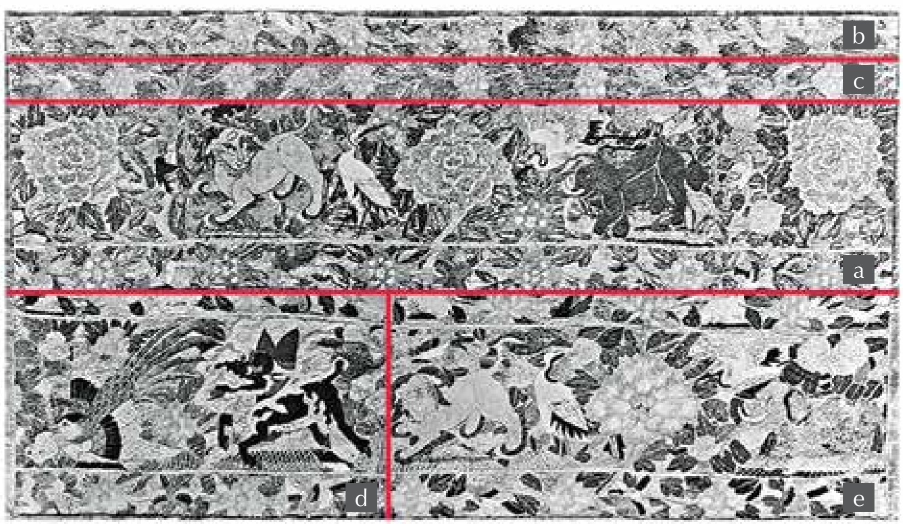

Diagram 3. MMA 29.100.156. Lines indicate the location of seams joining the embroidery's five separate elements

TABLE 1. MATERIALS AND TECHNIQUES USED IN THE SAIKYŌJI EMBROIDERY AND IN MMA I, II, AND III

	Saikyōji	MMA I	MMA II	MMA IV
Foundation fabric: silk plain weave	√	√	√	√
Warp: no twist (density)	(28/cm)	(30/cm)	(30/cm)	(30/cm)
Weft: no twist (density)	(24/cm)	(30/cm)	(30/cm)	(30/cm)
Embroidery thread				
Untwisted thread	√	√	√	√
Twisted thread (twist and ply)	(S-2Z)	(S-2Z, S-3Z)	(S-2Z)	(S-2Z)
Two-color plied thread (twist and ply)	(S-2Z)	(S-2Z)	(S-2Z)	(S-2Z)
Metallic thread: silk S-2Z twist core thread wrapped in Z direction with gold-leaf strips on a paper substrate with a lacquer adhesive	√	√	√	√
Thick thread: a core fiber wrapped with floss silk	√	√	√	√
Main embroidery stitches: satin stitch, long and short stitch, couching stitch, knotting stitch, backstitch	√	√	√	√

TABLE 2. DIMENSIONS OF THE METROPOLITAN MUSEUM'S EMBROIDERIES AND OF THE MAIN COMPARISON PIECES DISCUSSED IN THIS ARTICLE

Location	Accession No.	City, Country	Condition	Height (cm)	Width (cm)
MMA	29.100.154	New York, United States	incomplete	208	190
MMA	29.100.155	New York, United States	incomplete	152	100
MMA	29.100.156	New York, United States	fragments	99	175
MMA	48.187.614	New York, United States	complete	254	203
Honkokuji		Kyoto, Japan	complete	197	165
Rinzaiji		Shizuoka, Japan	complete	245	211
Shōkokuji		Kyoto, Japan	complete	270	215
Saikyōji		Shiga, Japan	complete	255	195
Kyūshū National Museum		Fukuoka, Japan	complete	251	220
Museo Diocesano		Chiavari, Italy	complete	263	208

Appendix Figure 1. Metallic threads from the Saikyōji embroidery (Figure 7): paper strips gilded with the use of lacquer adhesive wound in a Z direction around silk S-2Z core threads. Photograph: Masako Yoshida

Appendix Figure 2. Metallic threads from the FRESS embroidery (Figure 23): strips of metal sheet wound in an S direction around silk Z core threads. Photograph: Masako Yoshida

Diagrams of flower, bird, and animal design embroideries of Types 1, 2, and 3. Numbers identify distribution of motifs; letters represent structural components of the composition.

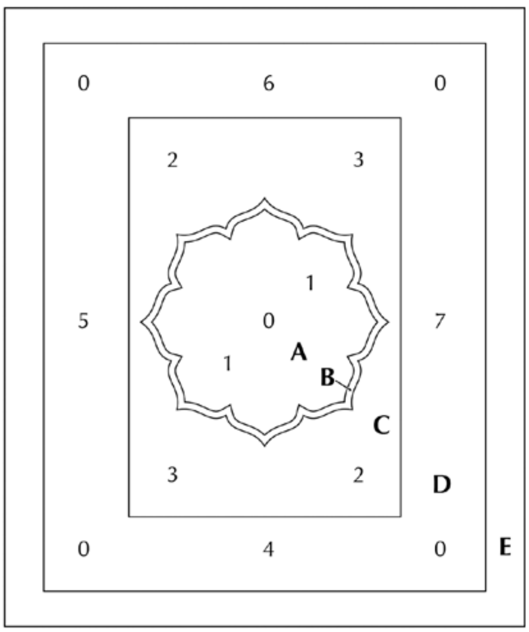

Diagram 4. Type 1, represented by the Honkokuji embroidery. Key: O peony, 1 phoenix (*fenghuang*), 2 peacock, 3 golden pheasant, 4 tiger, 5 *qilin*, 6 deer, 7 *xiezhi*. Diagrams 4–6: Anandaroop Roy

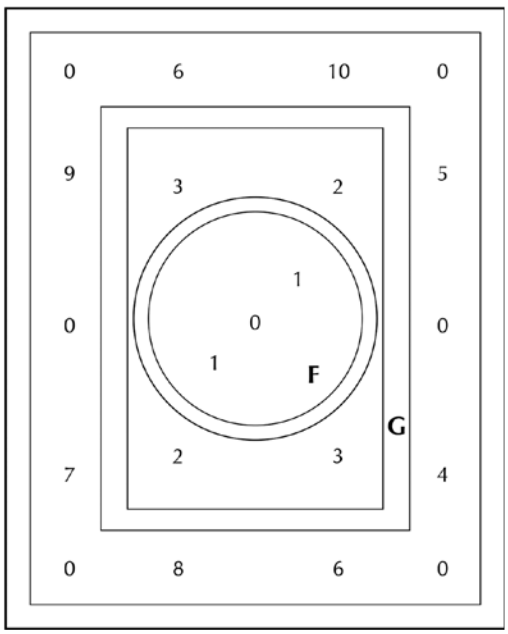

Diagram 5. Type 2, represented by the Saikyōji embroidery (Figure 7). Key: O and 1–7 are the same as in Diagram 4; 8 goat, 9 lioness or lion cub, 10 rabbit

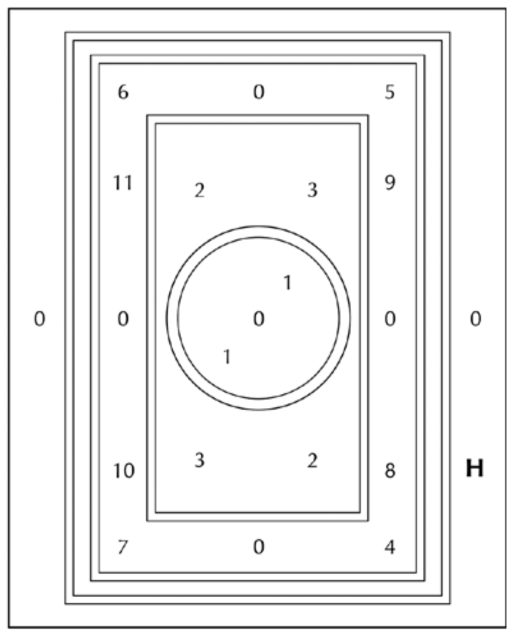

Diagram 6. Type 3, represented by the Chiavari embroidery (Figure 9). Key: O and 1–9 are the same as in Diagram 5; 10 lion, 11 horse

A Greek Inscription in a Portrait by Salvator Rosa

MICHAEL ZELLMANN-ROHRER
University of California, Berkeley

In the collection of The Metropolitan Museum of Art is a painting most often identified as a self-portrait by Salvator Rosa (1615–1673), depicting a man holding a human skull (Figure 1). The identity of the sitter has been disputed,[1] though the work can be securely set in the context of the friendship between Rosa and Giovanni Battista Ricciardi (1623–1686), owing to an inscription.[2] In fact, three inscriptions appear in the composition, and one of them, composed in classical Greek, has previously been misinterpreted.

Born in Arenella, near Naples, Rosa traveled to Rome as a young man. There, in addition to painting, from 1638 he received training in poetry and satire from the court poet Antonio Abate (d. 1697), becoming an adept himself.[3] A few years later, while in Florence, Rosa first encountered Ricciardi, a future professor of philosophy, who would guide Rosa in that discipline, particularly its source texts from classical Greece and Rome, over the course of a long friendship.[4] Ricciardi was a bibliophile, known for his ability to locate and acquire copies of classical and other texts of interest to the literary elite of Tuscany, and Rosa occasionally served as his agent in this enterprise. In 1651, Rosa acquired for Ricciardi in Rome three Greek texts: the *Adversus mathematicos* by Sextus Empiricus, the *Bibliotheca* by Photius, and the commentary on Homer by Eustathius of Thessalonike.[5]

In Florence, Ricciardi participated in the Accademia dei Percossi, which Rosa founded with Lorenzo Lippi (1606–1665) about 1643.[6] The group included, among other intellectuals, the philologists and classical scholars Carlo Roberto Dati (1619–1676), Andrea Cavalcanti (1610–1672), and Valerio Chimentelli (1620–1668), who had contacts with major centers for the study of antiquity in Rome and at the University of Pisa.[7]

This milieu would certainly have provided a suitable setting for Rosa to become conversant in Greek and Roman literature and culture. Indeed, there is noticeable self-identification with classical antiquity among the Percossi, as Rosa describes the villa of his friend Giulio Maffei (d. 1656) at Monterufoli as "the Garden of Hesperides" and a "little Parnassus," and casts himself and his colleagues as Greek philosophers.[8] Their banquets often concluded with orations, including one titled "Encomium of the Golden Age" by Evangelista Torricelli (1608–1647), a noted physicist and mathematician, which borrowed heavily from classical texts,[9] and a poetic composition by Niccolò Simonelli (d. 1671), an important early patron of Rosa's work, which praises Rosa as the "Demosthenes of painting."[10]

Rosa's own literary production, situated in this context, bears out his familiarity with classical works. His satires bristle with classical allusions from a wide range of genres, some rather obscure, including direct citations in the original Latin[11] and broader textual reminiscences.[12] These also appear in the letters Rosa wrote to Ricciardi,[13] in which Rosa quotes Ovid in the original[14] and Aristotle in a Latin translation.[15] In a continuation of the pattern of classicizing self-identification, Rosa calls Ricciardi "Horace" (after the Roman poet)[16] and later "my wise and refined Metrodorus" (after the Greek philosopher Metrodorus of Lampsacus, one of the founders of Epicureanism),[17] while casting himself as Boethius (after the late ancient philosopher).[18] On the topic of a set of engravings, including a depiction of Diogenes the Cynic, Rosa exclaims, "Oh, how much in debt we are to the Stoic School," and mentions Latin dedicatory inscriptions for the engravings.[19] Rosa discusses classical texts that inspired his paintings, referring to Plutarch as the source for the subjects of Pan and Pindar, Aethra and Theseus, and Pythagoras on the seashore liberating a net full of fish.[20] He writes about a depiction of the Catilinarian Conspiracy, executed in close accord with the description of the Roman historian Sallust,[21] and refers to a painting of his on the "calling of Protagoras to philosophy," taken from the work of the Roman author Aulus Gellius.[22] Ricciardi in turn offered recommendations for suitable classical subjects, which Rosa welcomed.[23]

Rosa's paintings and drawings provide further testament to his interest in and acquaintance with classical languages.

Metropolitan Museum Journal 49
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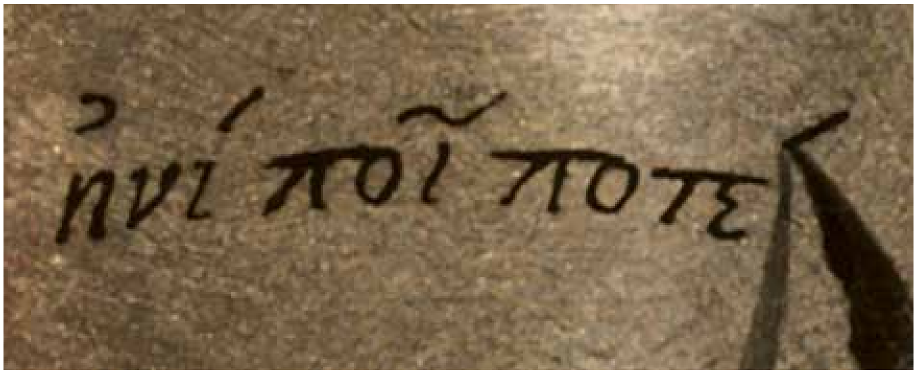
1. Salvator Rosa (Italian, 1615–1673). *Self-Portrait*, ca. 1647. Oil on canvas, 39 x 31¼ in. (99.1 x 79.4 cm). The Metropolitan Museum of Art, Bequest of Mary L. Harrison, 1921 (21.105). Photograph: Juan Trujillo, The Photograph Studio, MMA



2. Detail of Figure 1, image rotated

Aside from his predilection for subjects drawn from classical literature, Rosa quotes the original texts themselves as inscriptions. A drawing by Rosa from his time in Florence, now in a private collection in Karlsruhe, depicts a young man inscribing a rock in Latin with a line adapted from the Roman poet Statius. On the back of the drawing is a letter likely written by Ricciardi to a mutual friend, Ascanio della Penna, quoting the same passage.[24] Also worth mentioning is a painting of Rosa's now in the National Gallery in London, in which a man holds a tablet inscribed "Aut tace aut loquere meliora silentio" (Either keep quiet or say something better than silence), a line reminiscent of two Greek aphorisms collected by the anthologist Stobaeus.[25]

It is an arresting feature of the painting at the Metropolitan that the sitter not only holds and contemplates the skull but also writes upon it with pen and ink,[26] and not in the vernacular of the gift inscription but in classical Greek. Rosa captures the sitter in the act of inscribing, with pen in mid-stroke, adding an accent to the last of the three Greek words, which appear as: ἠνί ποῖ ποτέ (Figure 2).

Numerous discussions of the painting have mentioned this inscription and offered a transcription and translation.[27] They universally construe the text as three syntactically independent words, the first as an interjection and the second and third as interrogative adverbs, rendered in English along the lines of, "Behold. Whither? When?"[28] While these translations capture the semantic value of the first and second words correctly, that of the third has been misunderstood. The key lies in the accent written on its final letter—indeed, the stroke with which the sitter is eternally occupied in Rosa's depiction.

Classical Greek is generally agreed to have had a pitch accent, relating to the pitch of the voice used to pronounce the accented syllable, in contrast to its descendant, modern Greek, and many other Indo-European languages, which employ a stress accent. A system for marking these accents in writing was not developed until after the classical period and only came into full use in manuscripts produced by the Byzantines, later spreading to the Greek-literate scholars of the Italian Renaissance and beyond, to become modern scholarly practice.

An important practical implication of the accent system is its ability to distinguish between homographs, among them the class of adverbs that can function as either interrogatives or indefinites, with the same base semantic value, depending on their accentuation. Both the second and third words of this inscription belong to this class. ποῖ, an adverb denoting place, specifically as an end or goal of motion, has interrogative force if written with an accent (orthotone), but an indefinite force if written without an accent (enclitic): hence ποῖ means "whither?" while ποι means "somewhither." Rosa has clearly written the orthotone form, ποῖ, which previous translations have rendered correctly. With the third word, the circumstances are otherwise. The base adverb ποτε denotes time. When written orthotone, the accent falls as an acute on the first syllable, πότε, and the word has interrogative force (when?), which is how Rosa's inscription previously has been interpreted. As accented by Rosa, however, this cannot be correct: his adverb has the enclitic form, ποτέ, and is therefore indefinite, meaning "sometime."[29]

The inscription should not be read as two independent interrogatives (whither? when?) but as an interrogative followed by an indefinite (whither, sometime). Interrogatives in classical Greek, as in English, can introduce not only direct questions but also so-called indirect questions, when governed by a verb denoting questioning or, more broadly, any informative or thinking process whose object could be a question. The latter situation pertains to the Greek inscription in the painting. The interjection ἠνί, which connotes both literal sight and metaphorical contemplation, should not be read in isolation from the interrogative but rather as governing it. What is missing is a finite verb for the resulting indirect question clause, but it can be easily supplied from the context. A useful parallel is a formulaic question put to travelers met in transit in the classical world, ποῖ καὶ πόθεν,[30] literally "Whither and whence?" but clearly with some form of a verb of motion implied: "Whither (are you going) and whence (are you coming)?" Just such a verb can readily be supplied here, with the passage of time suggested by the skull, the object of the sitter's contemplation, and inscription: "Behold, whither (I, we, you, mankind, etc., is going) at some point in time." Or more concisely, "Behold whither, eventually." Death, figured by the skull, is the universal endpoint; only the time of arrival is uncertain.

A source for the Greek inscription in Rosa's painting in a classical or later Greek text has not been located, but it is entirely possible that it was produced in the circle of Rosa and Ricciardi.[31] The Greek is neat in its pithiness, but it would not necessarily demand mastery of the classical idiom to produce. Given the importance of classical culture and literature to the group, the motive was certainly present.

NOTES

1. See, for example, Roworth 1988, pp. 103–4, and Scott 1995, which refers specifically to the Greek inscription to argue for identifying Rosa's friend Ricciardi as the sitter as opposed to Rosa (p. 70).
2. *Salvatore Rosa dipinse nell'Eremo / e dono a Gio. Batt. Ricciardi / suo Amico* (Salvatore Rosa painted [this] in the solitude of the wilderness and gave [it] to Giovanni Battista Ricciardi, his friend).
3. See Perelli 2006, p. 39. The inscription is painted on the crumpled sheet of paper depicted on the lower left.
4. On Ricciardi and his close connection with Rosa, see Volpi and Paliaga 2012, esp. pp. 23–63.
5. Ibid., p. 27. At Pisa, Ricciardi also introduced Rosa to Paganino Gaudenzio (1595–1649), who knew Greek well, and from whose writings Rosa borrowed in his painting; see Langdon 2010, p. 28.
6. Perelli 2006, pp. 49–50.
7. Langdon 2010, p. 24.
8. Hoare 2010, p. 38.
9. The manuscript text is preserved in the Biblioteca Nazionale, Florence; see Scott 1995, p. 57n5.
10. Hoare 2010, p. 36.
11. "Mentre il *iam satis* ritrovar vorresti, / vedi per tutto il *quidlibet audendi* [italics in this edition]" (When you want to find "enough already," you see everywhere "[capacity for] daring anything at all"). Rosa, *La poesia* 500–501 (see Romei 1995), quoting Horace, *Carmina* 1.2.1 and *Ars poetica* 10, respectively (see Shackleton Bailey 2001).
12. For example, "E per farla cantar si suda e stenta, / ma, s'incomincia, poi mai la finisce" (And to make it sing he sweats and struggles, but, if it starts, then he never gets it to stop). Rosa, *La musica*, lines 272–73 (see Romei 1995); cf. Horace, *Sermones* 1.3.1–8 (see Shackleton Bailey 2001). Also "Sotto ogni ciel padre commune è 'l sole" (Under every sky the sun is the common father). Rosa, *La pittura,* line 129 (see Romei 1995); cf. Petronius *Satyricon* 100.1 (see Mueller 1995). For more, see Rosa, *La poesia,* line 304, cf. Horace, *Sermones* 1.8.2; and Rosa, *La poesia,* line 405, cf. Catullus, *Carmina* 43.8 (see Mynors 1958). See the various commentaries in Romei 1995.
13. Rosa apologizes for a brief letter (August 27, 1652; Festa and Borrelli 2003, p. 161, no. 144), because his head is, so to speak, full of "slaughter and rumor," such that he resembles the mythological Fury Allecto: "Però, amico, vi prego a compatirmi se fra questo mentre sarò breve nello scrivervi, attesoché ho la capa così piena di straggi e rumori che sembro sia Alletto, giuro a Bacco!" In a letter of January 26, 1670 (ibid., p. 393, no. 375), Rosa complains of the cold, such that he could not warm himself by "the torch of Cupid, or even the embraces of Phryne," a notorious courtesan in classical Greece mentioned by Diogenes Laertius, among others ("Eppure non posso riscaldarmi, né mi riscalderiano né le faci di Cupido né gl'abracciamenti di Frine!").
14. Letter of December 19, 1651 (ibid., p. 126, no. 114), and Ovid, *Ars amatoria* 1.349–50 (see Kenney 1995).
15. Letter of September 9, 1656 (Festa and Borrelli 2003, p. 224, no. 201), and Aristotle, *Eudemian Ethics* 1245b. The translation, the work of an anonymous translator, is printed in Academia Regia Borussica 1831, p. 623.
16. Letter of January 5, 1650 (Festa and Borrelli 2003, p. 45, no. 46).
17. Letter of July 6, 1652 (ibid., p. 153, no. 137).
18. Letter of March 27, 1654 (ibid., p. 196, no. 176).
19. "Oh quanto siamo tenuti alla scuola degli Stoici, i quali ci hanno insegnata un'efficace medicina per alcune humane difficultà!

    "Le dedicatorie, o latine o volgari, ci deveno importar poco; con tutto ciò procurerò di sodisfarvi" (Oh, how much in debt we are to the Stoic School, which has taught us an effective medicine for any human difficulty! The dedications, Latin or vernacular, should matter little to us; with all this I will try to satisfy you). Letter of October 21, 1663 (ibid., p. 316, no. 296). Rosa also praises the surpassing wisdom of the Greek dialogues of Lucian, *Juppiter confutatus* and *Juppiter tragoedus*, in a letter of June 19, 1656 (ibid., pp. 220–21, no. 198): "Per Dio Ricciardi che giornalmente conosco che Luciano l'ha intesa meglio d'ogn'altro, e ch'el suo Cinisco dichi molto bene il fatto suo con Iupiter, e col medesimo Timocles." (By God, Ricciardi, every day I'm coming to know that Lucian understood it better than anyone else, and that his Cyniscus remonstrates very well with Jupiter, as does Timocles with the same.)
20. The subjects of two paintings were drawn from two works of Plutarch, the *Life of Numa* and *Life of Theseus*, respectively: "In una tela grande ho dipinto il dio Pane in atto di discorrere con Pindaro poeta e di compiacersi delle sue poesie conforme accenna Plutarco nella Vita di Numa" (On a large canvas I painted the god Pan in the act of speaking with the poet Pindar and taking delight in his poetry, as Plutarch intimates in the Life of Numa); and "Quando Ethra mostra a Teseo suo figliolo il sasso ove erano nascoste le scarpe e la spada di Egeo suo genitore, conforme il medesimo Plutarco narra nel principio della sua vita" (When Aethra shows to her son Theseus the stone where the shoes and the sword of his father Aegeus were hidden, as the same Plutarch recounts at the beginning of his *Life*). Letter of October 9, 1666 (ibid., p. 349, no. 328). Rosa derived the subject of a painting of Pythagoras from Plutarch ("Motivo tolto da un'opuscolo di Plutarco"); see letter of July 29, 1662 (ibid., p. 294, no. 272).
21. "Dell'Istoria della Conciura di Catelina, espressa per l'appunto conforme la descrive Salustio" (Of the story of the conspiracy of Catiline, expressed exactly as Sallust describes it); see letter of September 8, 1663 (ibid., p. 311, no. 291).
22. "Uno [quadro] di palmi 10 e largo sette, con dentro la Vocazione di Protagora alla filosofia (la quale non raconto, potendola voi vedere in Aulo Gelio)" (A [painting] 10 palms [high] and seven wide, containing the Calling of Protagoras to philosophy, which I do not recount, since you can look in Aulus Gellius). Letter of November 9, 1664 (ibid., p. 326, no. 305).

23. Rosa had recently read the *Life of Apollonius* by Philostratus, which Ricciardi recommended, and enjoyed it, but had not found suitable subjects for painting as he had hoped, and so asks for another recommendation, for more "unusual" subject matter. Letter of September 16, 1662 (ibid., p. 298, no. 277).

24. See Statius, *Silvae* 4.2.13 (see Courtney 1992). A reproduction of the drawing and the text of the letter are given in Ozzola 1909. See, further, Langdon 2010, p. 29nn135–37; and Paliaga 2009, p. 159. In both drawing and letter the Latin reads: "Hic aeui mihi prima dies" (Here [i.e., in this idyllic scene] is the first day of my life), not as Langdon translates, "This day is my first." As has not yet been emphasized, the line of Statius in fact runs, "Haec aeui mihi prima dies" (This is the first day of my life). In context, the poet counts as "barren" all days leading up to the present one, on which he has received an invitation to a state banquet from the emperor Domitian, to which he responds in the present poem. Rosa and Ricciardi deliberately altered the Latin to fit the intended context.

25. National Gallery, London (NG4680). Scott identifies "an aphorism translated from the Greek philosopher, Pythagoras," which is of course attractive, given Rosa's interest in philosophy; see Scott 1995, p. 61. The relevant entry in Stobaeus (3.34.7), under Pythagoras's name, is χρὴ σιγᾶν ἢ κρείσσονα σιγῆς λέγειν, "One should be silent or say something better than silence." But the phrase could also have been suggested by another aphorism in the same section of Stobaeus's work, attributed to the tragedian Dionysius, ἢ λέγε τι σιγῆς κρεῖττον ἢ σιγὴν ἔχε, "Either say something better than silence or keep silent." Stobaeus 3.34.1 (Dionysius frag. 6); see Snell, Kannicht, and Radt 1986–2004, vol. 1, p. 244. A blending of the two also seems possible. It may be more than a coincidence that Rosa, along with Cosimo Brunetti, searched in Rome on Ricciardi's behalf for the works of the Swiss philologist Konrad Gesner, who published a Latin translation of Stobaeus's anthology. The search is mentioned in a letter from Rosa and Brunetti to Ricciardi; see letter of January 14, 1652 (Festa and Borrelli 2003, pp. 133–34, no. 119). Gesner's translation of the relevant passages, "Aut oportet silere aut afferre meliora silentio" (One should either keep silent or contribute something better than silence) and "Aut dic aliquid silentio melius, aut sile" (Either say something better than silence, or keep silent), are close enough to Rosa's inscription that they could plausibly have served as an aid in its composition ("Aut tace aut loquere meliora silentio"); see Gesner 1557, vol. 1, pp. 457–58.

26. A related drawing is discussed by Michael Mahoney (1977, vol. 1, p. 474, no. 49.4, which he labels *Study for a Self-portrait*). This drawing does not detail the text itself, however.

27. Not always correctly: for example, ἠνί ποί [*sic*] ποτέ (Brigitte Daprà in *Salvator Rosa: Tra mito e magia* 2008, p. 104, no. 5).

28. The MMA digital catalogue record suggests that this translation appeared as early as 1935: "Eleanor C. Marquand. *Letter to Margaret D. Sloane*. January 26, 1935, notes that the Greek scholar Adolph Cotton translates the words on the skull as 'Behold, whither, when,' but cannot identify a source for them" (www.metmuseum.org/Collections/search-the-collections/437508?rpp=20&pg=1&ao=on&ft=salvator+rosa&pos=1). This may well be the same Adolph Cotton who received a Master's degree in archaeology from Princeton University in 1934 and served as assistant curator at the British Museum before his presumed death at sea in 1935. See "Former Student Disappears at Sea," *Papers of Princeton*, February 13, 1935, vol. 1, no. 17, p. 1. Among subsequent translators, Helen Langdon, while missing the precise sense of the Greek (she gives "Behold, whither, when"), comes the closest to the correct interpretation in her commentary: "It exhorts the viewer to behold this symbol of death, to which we journey, though we know not when." Langdon 2010, p. 114.

29. When an enclitic follows an orthotone word, the two are pronounced essentially as a single word, and a complex set of rules determines the placement of an accent on one or both. As happens here, an enclitic under some circumstances may be written with an accent, but with a different one than it would have had in its orthotone form, with the semantic force unaffected. In this particular case, modern scholarly convention would prefer the writing ποῖ ποτε, where the enclitic lacks a written accent. From a theoretical perspective, however, the writing ποῖ ποτέ is more correct, and considerable variation on points such as this appears in medieval manuscripts and early printed editions. The fundamental rule of accent placement is that the "contonation unit" (acute accent as rise in pitch followed by an unmarked fall in pitch on the next syllable, or the circumflex accent as rise and fall in pitch combined in a single syllable) may not fall more than one mora (a syllable containing a short vowel; a syllable containing a long vowel or diphthong counts as two morae) from the end of the word. The notional "word" envisaged here, consisting of orthotone plus enclitic, ποῖποτε, would thus violate that rule (the contonation unit falls two morae from the end of the word); hence an additional accent, the acute, is placed on the final syllable. At any rate, ποτέ is also the conventional form for the enclitic written in isolation (the lexical form), and we could make the case for the painter, or a classicist friend who advised him on the text, having simply located the word in a lexicon and copied it down without applying the rules for accent.

30. For example, Plato, *Phaedrus* 227a 1; Diogenes Laertius, *Vitae philosophorum* 6.59; and a Latin equivalent in the *Satires* of Horace 2.4.1, "Unde et quo Catius" (Whence and whither [goes] Catius?).

31. The first word of the Greek inscription, ἠνί, represents a rare alternate form, or alternate spelling, of ἦν, itself not particularly common. It may have arisen through misreading of earlier texts by scholars in late antiquity and Byzantium. It was, however, taken up as a word in its own right by at least one later author. *The Frogs* of Aristophanes has ἦν ἰδού (1390), but a late ancient commentary ad loc. points to an underlying ἠνὶ ἰδού, elided to ἦν' ἰδού (see Dübner 1877). Modern editors consistently print ἦν ἰδού, and none entertains the alternative. Similarly, in the *Greek Anthology* 6.236.3 (see Beckby 1965–), modern editors print ἠνίδε (a compound of ἦν and ἴδε, the latter related to ἰδού), but the medieval *Suda*, quoting this line in the entry cited in the following paragraph, divides it into ἠνὶ δέ.

The far more common means of expressing the same thought ("behold") would have been with ἰδού. The *Suda*, a postclassical Greek work combining encyclopedia and lexicon, specifically lists ἠνί as a dialect variant for ἰδού: Ἠνί: ἀντὶ τοῦ ἰδού. Δωρικῶς, "Ἠνι (is used) instead of ἰδού in the Doric dialect." *Suda*, η, no. 385 (see Adler 1928–35). It is possible to imagine that whoever composed the present text consulted this or some similar work, perhaps in an effort to find a more exotic expression. Significantly, ἠνί is used twice in the epigrams of Janos Ryndakenos Laskaris (1445–1535), active as a scholar and teacher of Greek in Italy and France. See *Epigrammata* 4.3 and 45.3 (Meschini 1976); on Laskaris's career, see Wilson 1992, pp. 98–100. The absence of published evidence from the intervening period renders as pure conjecture hypotheses about the text's subsequent use, but it seems worth noting that Laskaris would have been well placed to introduce this rare form from the Byzantine into the Italian intellectual milieu, such that it could be available for use in this inscription.

Academia Regia Borussica
1831 *Aristoteles latine interpretibus variis.* Vol. 3 of Aristotelis opera. Berlin: Apud Georgium Reimerum.

Adler, Ada, ed.
1928–35 *Suidae lexicon.* Lexicographi Graeci recogniti et appartu critico instructi 1. Leipzig: B. G. Teubneri.

Beckby, Hermann, ed.
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Honoré de Balzac and Natoire's *The Expulsion from Paradise*

CAROL SANTOLERI

Research Assistant, Department of European Paintings, The Metropolitan Museum of Art

The nineteenth-century French novelist Honoré de Balzac (1799–1850) has a well-documented reputation for drawing on the conventions of art to add depth and nuance to his literary work. Intrigued by a wide range of biblical, mythological, and genre subjects, he peppered his novels with references to scores of paintings that would have been familiar to his audience.[1] He was also a passionate collector, who, like a character in one of his novels, frequented the establishments of art dealers in an effort to fill his home with paintings, drawings, and decorative arts.[2] Yet, notwithstanding his evident appreciation of art and his ability to conjure up the rich iconography of well-known painters, he seems not to have been a sophisticated collector. Toward the end of his life, he noted in a letter to art critic Théophile Thoré that, although he enjoyed hunting for additions to his "petit musée," he was not particularly knowledgeable on the subject of paintings.[3] While he professed to own pictures by or attributed to such artists as Holbein, Domenichino, and Rubens,[4] no work by or even after these artists has ever been associated with his collection. To date, only two pieces have been identified: *Bacchante in a Landscape* by Jean-Baptiste Mallet, now in the Louvre, Paris, and *The Expulsion from Paradise* by Charles Joseph Natoire (1700–1777), belonging to the Metropolitan Museum (Figure 1).[5]

Research indicates that Balzac purchased the Natoire in 1846 with his future wife, Eve Hanska (1804–1882), and that it remained in their collection for thirty-six years.[6] The history of Balzac's engagement with the painting can be traced through the letters he wrote over a period of almost seventeen years to Hanska—a noblewoman of Polish descent who had married Wenceslas Hanski (1782–1841) in 1819 and lived in western Ukraine at Wierzchownia, then part of the Russian Empire.[7] The two began corresponding in February 1832, when Hanska sent Balzac an admiring yet critical fan letter, referring to herself simply as "L'Étrangère" (the foreigner).[8] After an epistolary courtship interspersed with extended periods of shared travel and stopovers in Wierzchownia, the two were married on March 14, 1850. Tragically, Balzac died of ill health on August 18, only five months later.

Balzac and Hanska first saw the Natoire on a trip across Italy, Switzerland, and Germany in 1846.[9] On March 16 of that year, the writer boarded a mail coach in Paris for Rome, where he met up with Hanska. In mid-April, the two set sail for Genoa, continuing by way of Lake Orta and the Simplon Pass to Switzerland. On May 16, a few days before the writer's forty-seventh birthday, they arrived in Basel, where they stayed at the luxurious Hôtel des Trois Rois to celebrate the feast day of Saint Honoré.[10] At Miville-Krug, a local dealer in antiquities, they saw a number of items of interest, including *The Expulsion from Paradise*, which depicts the liminal moment when Adam and Eve come to terms with the severity of their situation, as an angry God emphatically casts them out of the Garden of Eden. Balzac, describing the work in an 1846 letter to Hanska, recognized its pathos: "Among the serious paintings in my cabinet, the Natoire makes a pitiful sight."[11]

At the time, Natoire's legacy was not without controversy in France. On the one hand, he was known as an accomplished painter and teacher, serving as a professor at the Académie Royale de Peinture et de Sculpture and director of the French Academy in Rome, a post he held for nearly twenty-five years. Some of his most esteemed paintings decorated the Château de Versailles, Hôtel de Soubise, and Chapelle des Enfants-Trouvés in Paris, while the Louvre was said to hold three of his mythological compositions: *Juno*, *The Three Graces*, and *Venus Demanding Arms from Vulcan for Aeneas*.[12] On the other hand, the preservationist Alexandre Lenoir revived, in 1837, the longstanding debate on the relative values of Rococo and Neoclassical art, arguing that Natoire and his contemporaries François Boucher,

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1. Charles Joseph Natoire (French, 1700–1777). *The Expulsion from Paradise*, 1740. Oil on copper, 26¾ x 19¾ in. (67.9 x 50.2 cm). Signed and dated at lower left: *C. Natoire / 1740*. The Metropolitan Museum of Art, Purchase, Mr. and Mrs. Frank E. Richardson III, George T. Delacorte Jr., and Mr. and Mrs. Henry J. Heinz II Gifts; Victor Wilbour Memorial, Marquand, and The Alfred N. Punnett Endowment Funds; and The Edward Joseph Gallagher III Memorial Collection, Edward J. Gallagher Jr. Bequest, 1987 (1987.279)

Jean François de Troy, and Carle Vanloo had contributed to a decline in painting.[13] Balzac, a keen observer of French society who kept abreast of contemporary issues, chose to engage in the dispute. In his 1837 novel *La Maison Nucingen*, he compared Natoire to Raphael, an artist whose work he held in the highest esteem, and whose renowned fresco of Adam and Eve (Raphael Rooms, Vatican Museums, Vatican City) may well have influenced Natoire's work. Alluding, perhaps, to the similarities between the two painters as well as to their differences, Balzac wrote: "While serving time in the ministry, where I was squeezed for eight hours a day among twenty-two-carat simpletons, I saw some characters who convinced me that shade has its asperities and that there are angles in the greatest platitude! Yes, my dear, such a bourgeois is to another as Raphael is to Natoire."[14]

Throughout the *Comédie humaine*, begun long before he first saw Natoire's *The Expulsion from Paradise*, Balzac frequently alluded to religious works of art. Yves Gagneux found that, of the one hundred masterpieces mentioned by Balzac in his novels, forty are biblical paintings created by such artists as Raphael, Titian, and Murillo.[15] Addressing a fascination with the liminal realm between mortality and immortality, Balzac conjured up works of art that illuminate the human spirit as it undergoes a transformation. He described, for example, the apotheosis of the eponymous figure in Domenichino's *Communion of Saint Jerome* (Vatican Museums), the mystical glow surrounding Christ as he ascends into the paradisiacal realm of Raphael's *Transfiguration* (Vatican Museums),[16] and the youthful splendor of the Virgin Mary as she receives the gift of eternal life in Titian's *Assumption of the Virgin* (Santa Maria Gloriosa dei Frari, Venice).[17]

The story of Adam and Eve's spiritual transformations played a role in at least two of Balzac's works. In the early 1830s, he built the novel *Le Chef-d'oeuvre inconnu* around three painters: Nicolas Poussin, Frans Pourbus the Younger, and Frenhofer, a fictional acclaimed artist.[18] Their reactions to a painting of Adam and Eve by the Netherlandish artist Jan Gossart (called Mabuse)[19] set the tone for a story about a painter who was struggling to achieve immortality through the power of his art. In the novel, Balzac's characters are led to believe that the portrait on which Frenhofer has been furtively working for such a long period of time will prove to be a masterpiece. When they discover that the painting is a tour de force only in the eyes of its author, each character experiences a loss of innocence as he faces the prospect of artistic failure and confronts his own mortality.

Balzac turned again to the story of Adam and Eve while compiling *Les Cent Contes drolatiques* (1832–37). In a vignette called "Naïfveté" (Naivety), he presented a child's perspective on religious imagery in the tale of a young prince and princess who are taken to see a painting by Titian of the biblical couple:

> "You wished to see Adam and Eve, who were our first parents; there they are," [their mother] said./ Then she left them in great astonishment before Titian's picture, and seated herself by the bedside of the king, who delighted to watch the children./ "Which of the two is Adam?" said Francis, nudging his sister Margot's elbow./"You silly!" replied she, "to know that, they would have to be dressed!"[20]

Balzac's interest in biblical themes was fostered by his relationship with Eve Hanska. She was born on December 24,[21] a date celebrated by Roman Catholics as the feast day of Adam and Eve. Notwithstanding the variations on her given name,[22] Roger Pierrot argues that Hanska was deliberately called "Eve" in concurrence with the feast day, as was her brother, Adam, born on the same day a year later. Balzac's letters support Pierrot's theory. Tellingly, on June 10, 1846, he wrote to Hanska: "Miville is sending me the Natoire. . . . You will have your pretty patroness."[23] Although patron saints were disappearing from the French national discourse as a consequence of the Revolution, the reduced calendar of feast days heightened the interest in the celebrations that survived. Consequently, many Catholics maintained a rapport with their patron saints. Hanska, a devout Catholic, would have been keenly aware of the many traditions associated with the saints. Balzac himself had been named for Saint Honoré, the patron saint of bakers, whose feast day was celebrated just four days before his birthday. In several of his novels, he explored the culture of patron saints, leaving no doubt that he was intrigued by the attendant contradictions inherent in contemporary religious practices.[24]

In his letters, Balzac drew parallels between Eve Hanska and the biblical Eve. On January 20, 1838, he responded to Hanska's query: "You have asked me how, knowing everything, knowing everyone, observing and fathoming all, I can be duped and misled? . . . Ultimately, dear and pious Catholic, God knew in advance that Eve would succumb, and he allowed it to happen."[25] On November 20, 1843, he wooed Hanska with a dramatic portrayal of Eve, citing what he described as a Hebrew word: "*Lididda* which encompasses notions of paternity—maternity, filial piety, love, divine sweetness, paradise—etc. and celestial voluptuousness. . . . It's the only legacy from terrestrial paradise [left] to the children of Adam: Eve retained it. I am the only one who has had this idea. . . . Thus for us, we have the name of the first woman . . . which is indescribable in the modern languages."[26] And on August 12, 1847, he assured her of his devotion: "No, you see, time alone will tell you of the affection of this poor Adam, chased from paradise by circumstances, without Eve."[27]

2. Jean Gigoux (French, 1806–1894). *The Salon of Madame de Balzac*, ca. 1862. Oil on canvas, 46½ x 72½ in. (118 x 184 cm). Maison de Balzac/Musée de la Ville de Paris (BAL 88-0018). Photograph: © Maison de Balzac/Roger-Viollet

Therefore, it is not surprising that Balzac and Hanska were charmed by Natoire's rendering of Adam and Eve. When the writer returned to Paris in late May 1846 after traveling with Hanska, he immediately commenced negotiations to buy *The Expulsion from Paradise* from Miville-Krug. In a letter to Hanska dated May 30, he voiced his intentions: "You will have [the] Adam and Eve; it will not be said that my desires alone will be fulfilled."[28] By June 10, he had settled on a price, and five days later the painting was delivered.[29] From the moment it arrived in Paris, *The Expulsion from Paradise* attracted attention. On June 20, Balzac reported optimistically to Hanska, "Chenavard[30] found the Natoire [to be] an excellent piece and Cailleux[31] said it had value, that such things are coming back into fashion."[32] A month later, on July 19, he was euphoric: "You cannot imagine what a big deal the Natoire is!"[33]

In late May 1846, Balzac learned that Hanska was pregnant,[34] and he redoubled his efforts to find a home for them in Paris. On September 28, he bought a house at 14, rue Fortunée (rue Balzac after 1850), near the Arc de Triomphe. Even before closing on the property, he began to envision how his collection would be distributed throughout the rooms, and the Natoire was a priority. In a letter dated September 19, 1846, he told Hanska that it would hang in her sitting room: "This small green salon will be your boudoir, your room for work, for writing, etc. There, all will be marquetry, Louis XV, and Rococo. There, you will have your Adam and Eve, the Greuze, and other paintings from the era of Madame de Pompadour; there, I want you to have two Watteau[s]."[35] A few months later he added, "[The] Adam and Eve will be over your desk."[36] In July 1848, he wrote to say that he had found some decorative brackets to flank the painting: "Yesterday Fabre brought four small Venetian consoles, two to hold, on each side of the painting of Adam and Eve, the two lovely compositions of Old Age and Childhood that you know and that make a delightful effect."[37]

In September 1848, Balzac left Paris to join Hanska at her home in Wierzchownia, where they remained until after they were married. Before leaving Paris, he compiled a lengthy inventory of the rue Fortunée house, detailing the work that was to be completed in his absence.[38] As if setting the scene for a novel, he meticulously sketched his vision for each successive room, describing not only the array of finishes and fabrics, but also the furniture, objects, and other works of art to be installed there. Under the heading "Salon du 1er étage," he described the *salon vert*:

> This room . . . is hung . . . with apple green wool velvet. . . . On each side of the entrance door [are] two beautiful armoires. . . . To the right of the door a desk. . . . On top, a Venetian cabinet. . . . Above the small cabinet from Venice a painting by Natoire representing Adam and Eve in a Louis XV frame very richly carved and gilded. . . . On this side of the room [there are] two corner pieces . . . supporting two grand candelabra . . . [each] topped with a bouquet of fleurs-de-lis with six candles.[39]

Balzac's vivid description corresponds closely to a painting by Jean Gigoux, *The Salon of Madame de Balzac*, executed about 1862 (Figure 2).[40] Here we find Balzac's widow with her handiwork seated by the fire in a pale green room, the *salon vert*. The painting reveals that little in the interior had changed. Hanging on the wall above the desk to the right is undoubtedly *The Expulsion from Paradise*. Although a plume of dried flowers blocks part of the picture, the areas of light and shadow in Gigoux's rendering of Adam and Eve correspond to those in the original composition. After Balzac died, Eve de Balzac never remarried; instead, she spent the remaining thirty-two years of her life in the house that the writer had designed for her, surrounded by his belongings. While she entertained most of her visitors on the ground floor,[41] Gigoux, her family portraitist and close friend after Balzac's death,[42] portrays her in the sitting room upstairs. His painting indicates that the widow kept the Natoire close by until her death on April 11, 1882. Two weeks later, on April 25, it was auctioned off in an anonymous sale in Brussels at the Hôtel des Ventes.[43] Subsequently, the painting changed hands on a number of occasions without reference to either Balzac or Hanska, arriving at the Metropolitan Museum with a void in its provenance that has only recently been filled.

NOTES

1. Boyer and Boyer-Peigné 1999; Gagneux 2012.
2. See, for example, Balzac's novels *La Peau de chagrin* and *Cousin Pons*.
3. In a letter to Théophile Thoré, director of L'Alliance des Arts, Paris, dated December 13, 1846, Balzac wrote: "J'aime à aller [*sic*] à la chasse des tableaux et des objets d'art, et à faire patiemment et péniblement un petit musée. Mais, malheureusement, je ne me connais pas en tableaux." See Balzac 1882, pp. 555–56.
4. Of the twenty-six works of art that hung in his gallery, Balzac claimed to have held paintings by Domenichino, Sebastiano del Piombo, Guido Reni, Jan Davidsz. de Heem, Anthony van Dyck, and Adriaen Brouwer; portraits by Bronzino, Hans Holbein the Younger, Palma il Vecchio, and Michiel Jansz. van Mierevelt; and other works attributed to Giorgione, Peter Paul Rubens, and Paul Brill. See "Inventaire dressé par Balzac du mobilier de son hôtel de la rue Fortunée," from about 1848, in Balzac 1990, vol. 2, pp. 1048–49.
5. Inventory numbers RF 3843 and 1987.279, respectively. Roger Pierrot summarizes the results of an exhaustive investigation of Balzac's personal collection in his preface to Boyer and Boyer-Peigné 1999, pp. 13–14.
6. Danielle Oger lays out the evidence in her catalogue entry for Natoire's *Adam and Eve* in ibid., pp. 205–6, in which she credits Marie-Martine Dubreuil of the Musée du Louvre for drawing attention to the connection between Balzac and the Natoire. See also Caviglia-Brunel 2012, pp. 57, 300. The complete provenance can be found at www.metmuseum.org.
7. Born Eve Constance Victoire Rzewuska, Hanska grew up in western Ukraine in Pohrebyshche (Vinnytsia region), a village situated southwest of Kiev. Upon marrying Hanski, she moved to his estate nearby at Wierzchownia (Verkhivnya, Zhytomyr region). After she and Balzac were married in 1850 at the Church of Saint Barbara at Berdychiv (Zhytomyr region), she moved to the writer's home on the rue Fortunée in Paris. Her only surviving child, Anna (1828–1915), was married in 1846 to comte Georges de Mniszech (1823–1881). See Pierrot 1999.
8. Ibid., p. 63.
9. Ibid., pp. 193–206.
10. Balzac 1990, vol. 2, p. 189n3.
11. Ibid., p. 211, June 15, 1846: "Au milieu des solides peintures qui sont dans mon cabinet, le Natoire fait une piteuse figure."
12. [Jacques] Vincens Saint-Laurent, "Natoire," in *Biographie universelle, ancienne et moderne* 1843–65, vol. 30, pp. 233–34.
13. See "Mémoire de M. le chevalier Alexandre Lenoir sur cette question: Faire l'analyse des productions des peintres les plus célèbres de l'antiquité, du moyen-âge et des temps modernes; examiner quelles furent les causes de la décadence de l'art à la suite du règne de Louis XIV," in *Congrès historique* 1839, p. 438, October 17, 1838.
14. Balzac 1844, pp. 36–37: "Durant mon temps de galère ministérielle, où j'étais serré pendant huit heures de jour entre des niais à vingt-deux carats, j'ai vu des originaux qui m'ont convaincu que l'ombre a des aspérités, et que dans la plus grande platitude on peut rencontrer des angles! Oui, mon cher, tel bourgeois est à tel autre ce que Raphaël est à Natoire."
15. The forty biblical works include eight by Raphael; five by Titian; four by Bartolomé Estebán Murillo; three by Giovanni Bellini; two each by Francesco Albani, Correggio, Anne Louis Girodet-Trioson, and Domenichino; and one each by Cristofano Allori, Philippe de Champaigne, Andrea di Cione (Orcagna), Jacques Louis David, Jan Gossart (called Mabuse), Bernadino Luini, Fra Bartolomeo, Domenico Piola, Nicolas Poussin, Rembrandt, Andrea del Sarto, and Leonardo da Vinci. See Gagneux 2012, pp. 280–86.
16. Vatican Museums 40384 and 40333, respectively. See Gagneaux 2012, pp. 188–89 and 40–41.

17. Ibid., pp. 136–37.
18. Balzac 1845.
19. Gossart painted several versions of the biblical couple: *Adam and Eve*, ca. 1510 (Museo Thyssen-Bornemisza, Madrid [1930.26]); *Adam and Eve*, ca. 1520 (National Gallery, London, on loan from the Royal Collection Trust [L14]); and *Adam and Eve*, ca. 1525–30 (Staatliche Museen zu Berlin, Gemäldegalerie [661]). See Ainsworth 2010, pp. 114–22.
20. The text was written by Balzac (1837, pp. 310–11) in a pastiche of inauthentic Rabelaisian French: "Vous avez voulu veoir Adam et Eve, qui sont nos premiers parents; les vecy, fiet-elle./Adonques elle les lairra en grant estomirement devant le tableau du sieur Titian, et s'assit au chevet du roy, lequel print plaizir à resguarder les enfans./Lequel des deux est Adam, fiet Françoys en poulsant le coude à sa sœur Marguerite./Ignard, respartit la fille, pour le scavoir, faudroyt que ils feussent vestus." It was translated as "Innocence" in Balzac 1907, p. 467. Balzac would have been referring to Titian's *Adam and Eve*, ca. 1550 (Museo Nacional del Prado, Madrid [P00429]).
21. Although Eve Rzewuska's baptismal certificate has never been found, Pierrot concludes that she was born on December 24, 1803, in the Julian calendar (followed by her family for religious reasons), equivalent to January 5, 1804, in today's Gregorian calendar. See Pierrot 1999, pp. 12–16.
22. These include Ewelina and Eveline as well as Eve. Balzac (1990, vol. 2, p. 201, June 2, 1846) contributed to the confusion, calling her: "l'Ève, l'Évelin, l'Évelette, l'Éveline, ou le min[ette], l'ange, la fleur, le trésor ou le l[ouplou]p, le bonheur, la force et l'amour."
23. Ibid., pp. 203–4, June 10, 1846: "Miville m'envoie le Natoire. . . . Tu auras ta jolie patronne."
24. See, for example, Balzac's *La Peau de chagrin*, *Le Député d'Arcis*, *Ursule Mirouët*, and *Un Début dans la vie*.
25. Balzac 1990, vol. 1, p. 432, January 20, 1838: "Vous m'avez demandé comment, sachant tout, connaissant tout, observant et pénétrant tout, je sois dupé et trompé? . . . Enfin, chère et pieuse catholique, Dieu savait d'avance que Ève succomberait, et il l'a laissée faire."
26. Ibid., p. 732, November 20, 1843: "*Lididda* qui enferme les idées de paternité,—de maternité, de filialité, d'amour, de suavité divine, de paradis—etc. de volupté céleste. . . . C'est le seul legs du Paradis terrestre aux enfants d'Adam: Ève l'a retenu. Je suis [le] seul qui ait eu cette idée. . . . Ainsi à nous deux, nous avons le nom de la 1re femme . . . qui est inénarrable dans les langages modernes."
27. Ibid., vol. 2, p. 670, August 12, 1847: "Non, voyez-vous, le temps seul vous dira l'affection de ce pauvre Adam chassé du paradis par les circonstances, sans Ève."
28. Ibid., p. 191, May 30, 1846: "Tu auras Adam et Ève; il ne sera pas dit que mes fantaisies seront seules accomplies."
29. Ibid., pp. 203–4, June 10, 1846: "Miville m'envoie le Natoire et le Holbein pour 350 fr[ancs]."; ibid., p. 211, June 15, 1846: "A 9 h. ½ les rouliers ont apporté *Adam et Ève*. . . . Je n'avais, pour payer, qu'un billet de 500 et on a trouvé difficilement la monnaie."
30. Paul-Marc-Joseph Chenavard (1807–1895) was a painter who studied under Louis Hersent, Jean Auguste Dominique Ingres, and Eugène Delacroix before turning to the German School to nurture his growing philosophical interests.
31. Alphonse de Cailleux (1788–1876) held the position of Directeur général des musées de France from 1841 to 1848.
32. Balzac 1990, vol. 2, p. 218, June 20, 1846: "Chenavard a trouvé le *Natoire* une excellente chose et Cailleux a dit qu'il avait une valeur, que cela redevenait de mode."
33. Ibid., p. 267, July 19, 1846: "La peinture italienne, c'est l'âme, la Hollande et les Flamands, c'est la nature, la France, c'est l'esprit. En ce moment, l'esprit revient à la mode, et l'on s'occupe de peintres français immenses qui ont été dédaignés. Tu ne te figures pas quelle belle affaire est le *Natoire*!" (Italian painting is the soul; Dutch and Flemish, nature; French, the mind. These days, the mind is back in fashion, and people are paying attention to great French painters who were once disdained. You cannot imagine what a big deal the Natoire is!)
34. See "Victor-Honoré," in ibid., Index, p. 1178. She miscarried before December 1, 1846; ibid., p. 436n2.
35. Ibid., p. 323, September 19, 1846: "Ce petit salon vert sera ton boudoir, ta chambre de travail, d'écriture, etc. Tout y sera marqueterie, Louis XV et rococo. Tu y auras ton *Adam et Ève*, le Greuze et d'autres tableaux du siècle de Mme de Pompadour, je t'y voudrais 2 Watteau [*sic*]."
36. Ibid., p. 533, January 24, 1847: "*Adam et Ève* sera au-dessus de ton bureau."
37. Ibid., p. 938, July 29, 1848: "Hier Fabre a apporté 4 petites consoles vénitiennes, 2 pour mettre de chaque côté du tableau d'*Adam et Ève*, les 2 jolies compositions de *La Vieillesse* et de *L'Enfance* que vous connaissez et qui font un effet délicieux." Fabre was a Parisian artisan who specialized in frame making and marquetry inlay; ibid., p. 549n6.
38. "Inventaire," in ibid., pp. 1019–51; Jarry 1924, p. 23.
39. "Inventaire," in Balzac 1990, vol. 2, pp. 1035–37: "Cette pièce . . . est tendue . . . de Velours de laine couleur vert-pomme. . . . De chaque côté de la porte d'entrée deux belles *armoires*. . . . A droite de la porte un *bureau*. . . . Dessus: Un *cabinet vénitien*. . . . Au-dessus du petit cabinet de Venise un *tableau* de Natoire représentant *Adam et Ève* dans un cadre Louis XV très richement sculpté et doré. . . . Dans . . . la pièce de ce côté deux *encoignures* . . . supportant toutes les deux grands *candélabres* . . . terminés par un bouquet de fleurs de lys à six bougies."
40. The Maison de Balzac bought Gigoux's painting at auction on April 15, 1988, from the family of a private collector. *Dessins, aquarelles, bronzes, tableaux modernes*, sale cat., Hôtel Drouot, Paris, April 15, 1988, lot 14. (I am grateful to Yves Gagneux for providing this information in an email dated May 7, 2013.) Alexandre Estignard (1895, p. 71) dated the painting to about 1862, noting that it was owned by Paul Lapret. Lapret (born Paris, 1839) was a portrait painter who studied under Gigoux and published his monograph in 1902. Pierrot (1999, p. 371) refers to a sales catalogue, "Nombreuses Peintures par J. Gigoux*,"* Hôtel Drouot, Paris, June 14, 1950, which lists four paintings of Eve de Balzac (lots 10, 49, 50, and 51). I have been unable to trace this catalogue.
41. Jarry 1924, pp. 62–64; Pierrot 1999, pp. 421–24.
42. Gigoux exhibited five portraits of Eve de Balzac and her family at the Paris Salons: Salon of 1852, no. 541, "Portrait de Mme de . . . ; pastel"; Salon of 1853, no. 534, "Portrait de Mme la C[omte]sse Georges Mniszech; pastel"; Salon of 1857, no. 1170, "Portrait en pied de Mme la comtesse Georges de Mniszech"; Salon of 1861, no. 1264, "Portrait de M. le comte Georges de Michech [*sic*]"; see Sanchez and Seydoux 2002–4. Four of these works are at the Maison de Balzac, Paris; the 1852 portrait of Madame de Balzac is at the Musée-Hôtel Bertrand, Châteauroux. For more on her relationship with Gigoux, see Pierrot 1999, pp. 365–71.
43. As: "Charles Natoire, 1740, *Adam et Ève après le péché*, cuivre, H. 0.67– L. 0.47." In *Catalogue de tableaux et objets d'art, anciens et modernes,* sale cat., Hôtel des Ventes de Bruxelles, Brussels, April 25–26, 1882, lot 13.

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Another Brother for Goya's "Red Boy": Agustín Esteve's Portrait of Francisco Xavier Osorio, Conde de Trastámara

XAVIER F. SALOMON
Peter Jay Sharp Chief Curator, The Frick Collection, New York

The exhibition "Goya and the Altamira Family," held at The Metropolitan Museum of Art from April 22 to August 3, 2014, brought together for the first time four portraits by Francisco de Goya y Lucientes painted about 1787–88. For the occasion, the celebrated "Red Boy" in the Museum's collection was displayed together with likenesses of his parents and two of his siblings in a gallery of the European Paintings Department.

Goya's portrait of the head of the family, Vicente Joaquín Osorio de Moscoso y Guzmán, conde de Altamira (Figure 1), was paid for on January 29, 1787, and was the first of the artist's Altamira paintings.[1] Commissioned by the Banco de San Carlos (renamed Banco de España after 1829), of which Altamira was a director, the portrait is still in the bank's collection. In the succeeding two years, the count commissioned Goya to paint three portraits for the family's palace on the calle de la Flor Alta in Madrid: the Metropolitan Museum's full-length portrait of Altamira's first wife, María Ignacia Álvarez de Toledo, with their infant daughter María Agustina (Figure 2), and their sons Vicente Isabel, conde de Trastámara (Figure 3), and Manuel, señor de Ginés (Figure 4), the "Red Boy."

Inventories of the Altamira collection reveal that family portraits by other artists hung in the palace as well. The postmortem inventory of the conde de Altamira, compiled between January 7 and February 8, 1817, lists a series of portraits of the count and his family, including an image of the count on horseback by Antonio Carnicero (1748–1814) and, in one room, "eight portraits of the family of the Count of Altamira."[2] A subsequent inventory, compiled on March 13–14, 1864, after the death of Vicente Pío Osorio de Moscoso y Ponce de León (the grandson of the conde de Altamira in Goya's portrait [Figure 1]), lists in detail Goya's portraits of the Altamira family along with those by a number of other painters.[3] The equestrian portrait of the count by Carnicero was still in the palace, as was another portrait of him attributed in the inventory to Luis Egidio Meléndez (1716–1780).[4] Two of the three Goya portraits—those of the countess with her daughter María Agustina (Figure 2) and the "Red Boy" (Figure 4)—are also listed, while for some unknown reason, the portrait of Vicente, conde de Trastámara (Figure 3), is not mentioned in the document.[5] Another portrait by Goya, that of the architect Ventura Rodríguez, now in the Nationalmuseum in Stockholm, was also acquired by the Altamira family before 1864.[6]

The Altamiras owned a substantial group of family portraits by the Valencian painter Agustín Esteve y Marques (1753–ca. 1820), who in the 1780s and 1790s collaborated with Goya, especially on portraits, and became a well-known portraitist himself. According to early sources, he produced fourteen portraits for the family of the duke of Osuna and others for the dukes of Alba.[7] Esteve must also have painted a significant number of portraits for the Altamira family. The Altamira inventory of 1864 documents several of them, including a set of portraits of the count and countess, and another single image of the count.[8] It is unclear if one of these portraits of the conde de Altamira could be a version of the one signed by Esteve that is at present in the Universidad de Granada (Figure 5), or if the portrait of the countess can be identified with the one that was in the collection of José Calvo in Madrid in 1957.[9] Five additional paintings of children by Esteve are listed in the 1864 Altamira family inventory. One of these portraits was oval in format and represented the daughter of the duque de Montemar with a small dog.[10] Another portrayed a "girl with a tambourine in her hand, seated on a cushion."[11] Three of the canvases clearly represented four of the Altamira children. The first included a double portrait of Vicente, conde de Trastámara, and his sister María Agustina (both children were also portrayed by Goya: see Figures 3 and 2).[12] The second and third were images of Francisco Xavier and Juan María, brothers of Vicente, Manuel (the "Red Boy"), and María Agustina.[13]

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1. Goya (Francisco de Goya y Lucientes; Spanish, 1746–1828). *Vicente Joaquín Osorio de Moscoso y Guzmán, Conde de Altamira*, 1787. Oil on canvas, 69⅝ x 42½ in. (177 x 108 cm). Banco de España, Madrid. Photograph: Album / Art Resource, NY

2. Goya. *María Ignacia Álvarez de Toledo, Condesa de Altamira, and Her Daughter María Agustina*, 1787–88. Oil on canvas, 76¾ x 45¼ in. (195 x 115 cm). The Metropolitan Museum of Art, Robert Lehman Collection, 1975 (1975.1.148). Photograph: Juan Trujillo, The Photograph Studio, MMA

Esteve's portrait of Juan María is the only portrait in the artist's Altamira group that is known to have survived (Figure 6). The canvas was acquired in 1946 by the Cleveland Museum of Art, which bought it as a Goya from Joseph Duveen. It is much damaged and over-restored, and its attribution to Goya was doubted early on.

Recently, scholars have connected the painting to Esteve's work. The inscription at the bottom of the canvas clearly identifies the sitter as Juan María, Altamira's son who was born on August 28, 1780, and who died on October 18, 1785, at the age of five.[14] The information provided by the inscription on the portrait in Cleveland and by the matching ones on three of Goya's portraits (Figures 2, 3, and 4) allows us to reconstruct the life dates of the Altamira children. Vicente, conde de Trastámara, is thought to have been the eldest. He was born on November 19, 1777, and after his father's death on August 26, 1816, he became the next conde de Altamira, dying on August 31, 1837. The next in line was Juan María, who was three years younger. Manuel, the "Red Boy," was born in April 1784 and died on June 12, 1792, and María Agustina was born on February 21, 1787, almost ten years after her eldest brother. Documents mention three other children: two boys, Francisco Xavier and Josef Fernando, and a girl, María de la Encarnación, but their dates are unknown.

The mention in the 1864 inventory of Esteve's portrait of Francisco Xavier Osorio, "Conde de Trastamara," is puzzling. The title of Trastámara was habitually given to the eldest son of the conde de Altamira, and since Vicente was the heir, I proposed in the publication that accompanied the exhibition in 2014 that the compiler of the inventory might have confused Vicente (conde de Trastámara) with his younger brother Francisco Xavier.[15] Only a few weeks after the opening of the exhibition "Goya and the Altamira Family," Esteve's portrait of Francisco Xavier Osorio came to light. The previously unpublished canvas allows us to add a further piece to the puzzle of the Altamira family. As the companion to the Cleveland painting, it proves beyond a doubt that the latter work is indeed by Esteve, and it also allows us to revise some of the information about the Altamira children.

The canvas (Figure 7) was acquired by its present owner in Madrid from heirs of the Altamira family and, being unlined, it is in exceptionally good condition. The painting's dimensions are very close to those of the Cleveland portrait, and the sitters in both works are shown standing on an identical tiled floor. That the painting is indeed the one mentioned in the 1864 Altamira inventory is proved by the number 507 painted in white in the bottom right corner, the same number as the one in the document. Francisco Xavier, unlike his brothers, is shown in profile, holding a hat in his left hand and elegantly resting his right hand on a stick. His outfit is similar in design to those of Juan María and Manuel, but different in color; it features a combination of green and pink instead of the blue and pink and the red and white of his brothers' clothing. In style and color Francisco Xavier's costume is almost identical to those of Francisco de Borja and Pedro de Alcántara, the young sons of the dukes of Osuna, in Goya's family portrait of 1788 in the Museo del Prado.

The inscription at the bottom of the painting provides Francisco Xavier's basic biographical data, previously unknown to scholars. He was born on December 3, 1776, and died in November 1785, just short of his ninth birthday. He was, therefore, the eldest of the Altamira children, a year older than Vicente. His name probably derived from the happenstance of his birth on December 3, the feast day of Saint Francis Xavier. The compiler of the 1864 inventory

3. Goya. *Vicente Osorio de Moscoso, Conde de Trastámara*, 1787–88. Oil on canvas, 53 1/8 x 43 1/4 in. (135 x 110 cm). Private collection

4. Goya. *Manuel Osorio Manrique de Zuñiga*, 1787–88. Oil on canvas, 50 x 40 in. (127 x 101.6 cm). The Metropolitan Museum of Art, The Jules Bache Collection, 1949 (49.7.41)

5. Agustín Esteve y Marques (Spanish, 1753–ca. 1820). *Vicente Joaquín Osorio de Moscoso y Guzmán, Conde de Altamira*, ca. 1790–95. Oil on canvas. Universidad de Granada

6. Esteve. *Juan María Osorio*, ca. 1785. Oil on canvas, $47\frac{1}{4}$ x $33\frac{1}{8}$ in. (120 x 84.1 cm). The Cleveland Museum of Art; Gift of the Hanna Fund (1946.431). Photograph: © The Cleveland Museum of Art

was therefore correct in identifying Francisco Xavier as the "Conde de Trastamara," and the inscription on the portrait confirms the fact. As the eldest son, he was the heir to the title; Vicente acquired it only after his brother's death in 1785, a couple of years before Goya painted his portrait.

Juan María and Francisco Xavier died a month apart from each other in October and November 1785, a fact suggesting that they may have been the victims of a contagious illness. The two portraits must therefore predate the sitters' demise. Judging from the children's appearances, the works were painted soon before their deaths at the ages of five and eight, respectively. By the time Goya portrayed Vicente and Manuel about 1787–88, the boys in Esteve's portraits were dead, and it is likely that his paintings of Vicente and the "Red Boy" were conceived to match the preexisting ones by Esteve. The inscriptions on the paintings were probably all added at the same time, between 1785 (Francisco Xavier and Juan María are recorded in the inscriptions as having died in that year) and 1792, when Manuel died (he is recorded as alive in the inscription).

This newly identified portrait by Esteve is an important addition to the painter's oeuvre and enhances our developing knowledge of the Altamira family as art patrons. In its pristine condition it also provides an important example of Esteve's work from about 1785 and gives a good sense of what the portrait of Juan María Osorio in Cleveland would have looked like before its substantial restoration campaigns under Duveen. While the "Red Boy," his mother and sister, and his brothers Vicente and Juan María have all "emigrated" to the United States, where they were reunited in the spring of 2014 at the Metropolitan Museum, Francisco Xavier is the only member of the Altamira family, together with Goya's portrait of the count, to have remained in Spain. Even though he was left out of the family gathering in New York, he is here reunited in print with his parents and siblings.

7. Esteve. *Francisco Xavier Osorio, Conde de Trastámara*, ca. 1785. Oil on canvas, 50 x 37½ in. (127 x 95 cm). Private collection, Madrid

NOTES

1. For a full account of the relationship between Goya and the Altamira family, see Salomon 2014.
2. The Astorga, c^{a} 1817 inventory is in the Archivo Histórico Nacional, Toledo, Sección Nobleza, 2 d. 2, and is transcribed in Pérez Preciado 2008, doc. 18, pp. 916–26. In particular, see p. 918: "Un retrato de tamaño natural q^{e} rep^{ta} el s^{r} D. Vicente Joaquin Osorio, Conde de Altamira, Marq^{s} de Astorga & a caballo (denominado el vidriero) su tamaño quatro var^{s} casi quadrado, pintado p^{r} Antonio Carnicero"; and p. 920: "Ocho retretratos de familia del S^{r} Conde de Altamira."
3. For the 1864 inventory, Archivo Histórico Nacional, Toledo, Sección Nobleza, Baena, 291, see the transcription in Pérez Preciado 2008, doc. 20, pp. 929–49.
4. 1864 inventory, no. 25: "El Exmo D. Vicente Osorio de Moscoso Marques de Astorga Conde de Altamira, Duque de Seea y Baena, Gentilhombre de cámara de S. Ml Caballero gran cruz de la Real y distinguida orden de Carlos 3^{o} & El caballo es el llamado Viderico celebrado de los facultativos por su buena estampa, nobleza, gallardia, buenos movimientos y demas circunstancias. Es de la pieza que S. E. tiene en la villa de Baena, Reyno de Cordoba con esta marca Lo pintó por el mismo natural y con la posible exactitud Antonio Carnicero año de 1783 Alto 10-8 Ancho 10-5½ Marco dorado" (Pérez Preciado 2008, p. 930), and no. 296: "Retrato del Exmo Marques de Astorga Conde de Altamira. Año de 1775 Original al parecer de Luis Menendez Alto 4-1½ Ancho 3-1 Marco dorado" (ibid., p. 940).
5. 1864 inventory, no. 31: "La Excma Sra D^{a} Maria Ignacio Alvarez de Toledo Marquesa de Astorga Condesa de Altamira y la Sra D^{a} Maria Agustina Osorio Alvarez de Toledo su hija nacio en 21 de febrero de 1787. Original de D. Francisco Goya de su primera epoca. Alto 7 pies Ancho 4½ Marco dorado" (ibid., p. 930), and no. 547: "El E. Sr. D. Manuel Osorio Manrique de Zúñiga Señor de Gines. Original y firmado de Francisco Goya. Alto 4-6½ Ancho 3-4½ Marco dorado" (ibid., p. 948).
6. Nationalmuseum, Stockholm, inv. NM4574. 1864 inventory, no. 15 415: "Retrato d D. Ventura Rodríguez medio cuerpo tamaño natural firmado en un targeton de F^{co} de Goya Alto 3-8 Ancho 2-9½ Marco Dorado" (ibid., p. 929).
7. For Esteve, see Soria 1943 and 1957.
8. 1864 inventory, no. 438: "Retrato del E. Sr. Marques de Astorga. Conde de Altamira. Duque de Sessa y de Maqueda. Consejo de Estado y caballerizo mayor de S. M. & original de Agustín Esteve. Alto–9 Ancho 1-11½ Marco dorado" (Pérez Preciado 2008, p. 944), and its pendant, no. 439: "Retato de la E. Sra D^{a} María Ygnacia Alvarez de Toledo, Gonzaga Marquesa de Astorga condesa de Altamira. Original de Agustín Esteve. Comp^{o} al anterior" (ibid.). No. 544: "El Exmo. Marques de Astorga conde de Altamira, Duque de Sessa y de Maqueda Consejero de Estado y Caballerizo mayor honorario de S. M. Parece de Esteve. Alto 3-11 Ancho 3-5. Marco dorado" (ibid., p. 948).
9. For these two portraits, see Soria 1957, pp. 99–100, nos. 40, 42.
10. 1864 inventory, no. 33 675: "Una niña con corpiño encarnado con la mano derecha acaricia a su perrito y en la izquierda tiene una rosquilla; hija del Sr. Duque de Montemar. Original de Esteve. Alto 2-11½ Anco 2-3 Marco Dorado ovalo" (Pérez Preciado 2008, p. 930).
11. 1864 inventory, no. 530: "Retrato de una niña con una pandereta en la mano sentadita en un almohadón. Original de Esteve Alto 2-7 Ancho 1-11½" (ibid., p. 948).
12. 1864 inventory, no. 492: "El E. Sr. Conde de Trastamara y la E. Sra D. Maria Agustina hija del E. Sr. Marques de Astorga. Original de esteve. Alto 2-9 Ancho 1-11 Marco dorado" (ibid., p. 946).
13. 1864 inventory, no. 507: "El E. Sr. D. Francisco Javier Osorio Alvarez de Toledo, Conde de Trastamara, Original de Esteve. Alto 4-6 Ancho 3-5 Marco dorado" (ibid., p. 947), and no. 548: "El E. Sr. D. Juan Maria Osorio Alvarez de Toledo: de Esteve. Alto 4-6 ancho 3-5 Marco dorado" (ibid., p. 948).
14. For the death date of Juan María, see an unpublished letter from Mary Crawford Volk, July 23, 1992, to Alan Chong in the curatorial files of the Cleveland Museum of Art.
15. Salomon 2014, p. 43.

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Nature as Ideal: Drawings by Joseph Anton Koch and Johann Christian Reinhart

CORNELIA REITER
Interim Director, Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna

Over the last ten years, The Metropolitan Museum of Art has acquired a substantial and representative collection of works by the circle of German and Austrian artists living in Rome about 1800, most notably Joseph Anton Koch (1768–1839) and Johann Christian Reinhart (1761–1847). Both artists devoted themselves to landscapes in a Neoclassical style that picture an idealized nature as a reflection of a higher spirituality. They held a key position in the revival of landscape painting and drawing about 1800—not only in the rich painted and graphic oeuvre they left behind but also in their personal influence as critical guides to the events in the art world unfolding around them. They functioned as promoters of the next generation of artists, for whom the ideal classicism of Koch and Reinhart served as a starting point for the development of a genuine Romantic conception of landscape.

The graphic work of the Tirol native Joseph Anton Koch from different periods and in various genres is particularly well represented in the Museum's collection. He was unquestionably one of the most important practitioners of Neoclassical landscape painting and drawing. The son of a landless laborer in the Lechtal in Tirol (Austria), Koch received decisive assistance from the bishop of Augsburg, who, after being apprised of the boy's early demonstration of a talent for drawing, made it possible for him to receive proper artistic training. During his years at the Hohe Karlsschule in Stuttgart from 1785 to 1791, Koch was stirred by the ideas of the French Revolution. Rejecting the restrictive and outmoded teaching methods, he left the school in 1791 for Strasbourg. There he first moved in Jacobin circles but soon distanced himself from them and set out on travels through Switzerland, where, over several years, he produced a large number of landscape studies from nature that served as a reservoir of motifs for his later works. After going to Italy and briefly staying in Naples, he settled in Rome in 1795, where he received his mail at the Antico Caffè Greco in the Strada Condotti. There he joined the circle around Johann Christian Reinhart, the Danish-German painter Asmus Jakob Carstens (1754–1788), and the Danish sculptor Bertel Thorvaldsen (1770–1844). He spent the greater part of his life in Rome, where, with his pronounced, outgoing personality, he became the center of the German artists' colony. Something of that personality is expressed in an outstanding portrait of Koch by the Swiss artist and sometime coworker in Koch's atelier Hieronymus Hess (1799–1850),[1] which is now also in the Metropolitan Museum (Figure 1).[2] Koch, born in 1768—as is noted on the drawing—belonged to a generation that chose to ennoble the empirical image of nature with idealized compositions and the incorporation of narratives, generally drawn from classical mythology.

The first of his works to be discussed here is a gouache of a southern coastal landscape that is impressive for its large size and ambitious staffage (Figure 2).[3] The landscape represents—in idealized form—the town of Vietri sul Mare, on the Gulf of Salerno, south of Naples.[4] This sheet clearly reproduces the view, executed from nature, that is now in the Kupferstichkabinett of the Akademie der Bildenden Künste Wien in Vienna (Figure 3).[5] The Viennese drawing made on site and the idealized New York view are immediate reflections of Koch's response to the magnificent coastal landscape south of Naples. Its lush vegetation and classic blocklike architecture already presented a consummate harmony that was suited to Koch's purposes. He rightly saw this stretch of coastline as the perfect incarnation of Nicolas Poussin's (1594–1665) artistic ideal, one to which he subscribed and hoped to revive informed by his own vision.

In its essentials the drawing in the Metropolitan follows the composition of the 1795 study: the trees as a *repoussoir* on the left; on the right, a towering mountain peak; and particularly the idealized, geometric southern architecture in the middle ground. The sheet is inscribed in pen and brown ink at the bottom left of the mount—doubtless with an eye to a

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1. Hieronymus Hess (Swiss, 1799–1850). *Portrait of Joseph Anton Koch*, ca. 1823. Graphite on paper, sheet 7⅜ x 6⅛ in. (18.9 x 15.4 cm). Signed in graphite, bottom right: *H. Hess*. Inscribed in graphite, bottom center: *Joseph Anton Koch. Maler gegenwärtig in Rom. / geboren in Obergieblen in Tyrol den 27. July 1768*. The Metropolitan Museum of Art, Purchase, Guy Wildenstein Gift, 2010 (2010.387)

French and international tourist public as potential buyers: *fait d'aprés* [*sic*] *la Nature par J. Koch a* [*sic*] *Rome 1800*.

In its imposing format and detailed execution, the New York sheet must surely be considered a final work. It captivates the viewer with its effective coloring, in part a pastose application of watercolor, especially evident in the atmospheric light of the sunset. The unpeopled landscape in Vienna has here been enlivened with a richly evocative staffage that primarily occupies the foreground. On the left three women dancing the tarantella are caught in graceful movements—an obvious allusion to the classical motif of the Three Graces. They are flanked by shepherds in contemplative poses who are following their performance. The group of musicians behind them appears considerably smaller and plays only a subordinate role. The bacchanalian *vita activa* of the southern natives is juxtaposed to the *vita contemplativa* represented by the pair of monks walking on a stone road on the right. The radiant youth of the dancing figures contrasts on numerous levels with the advanced age of the reflective monks. With these figural additions Koch elevated this stretch of coastline to an ideal, symbolic plane, forming in the interplay of human figures, inventively designed architecture, and natural spaces an almost cosmic-seeming image of earthly life.

Koch—along with Reinhart and Jacob Wilhelm Mechau (1745–1808)—is rightly considered one of the discoverers of the untouched villages outside Rome in the Sabine and Alban Hills, which he explored from the beginning of the century together with his artist colleagues on numerous art treks. The harmonious hill formations in Rome's environs were for Koch, who was concerned most of all with creating a clearly structured landscape space in his pictures, a virtually ideal source of motifs.

These hills, the central feature of Koch's landscape art, can also be seen in an outstanding work owned by the Metropolitan Museum. This pen drawing was once thought to be a view of the hill town Paliano, south of Olevano, but has now been identified, based on the unique silhouette of the tower that surmounts the hill, as Civitella (present-day Bellegra) (Figure 4).[6] As is so often the case in Koch's work, there exists a number of other versions of the motif: three oil paintings—one in Erfurt,[7] one in Vienna's Belvedere (Figure 5),[8] and a third in a Vorarlberg private collection[9]—as well as several drawings,[10] including the preliminary drawing for the oil paintings, already squared off, in the Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna.[11] According to Christian von Holst, the New York drawing is probably identical to the sheet mentioned in Otto R. von Lutterotti's monograph on the artist as *Landscape between the Volscian and Alban Hills*.[12] This drawing might be a more finished repetition of the composition after at least one of the paintings was completed. It is remarkable for the freedom of its pen lines, which again and again achieve a great density in the internal forms, mainly through hatching. The drawing's elements of close hatchings recall those found in Koch's series of twenty etchings, *Vedute Romane*, published in 1810 (see Figure 7).[13] The considerable vitality of the drawing, which spreads across the surface of the paper like a pattern, identifies this sheet as a fully finished work of art destined for sale.

Yet another sheet in the Metropolitan is also directly related—this time in terms of motif—to Koch's etchings of Roman views. The detailed drawing of the ruins of the emperors' palaces on the Palatine Hill in Rome (Figure 6),[14] squared in graphite for transfer to another format, essentially corresponds to the motifs depicted in number 18 of the series (Figure 7). There, by showing the ruins of the imperial palaces, Koch devoted himself to an emblem of ancient Rome.[15] The New York drawing agrees in detailed motifs to the etching of the same name, but in a considerably larger format.[16] Possibly Koch captured all the particulars of the view in this enlarged version so as then to be able to transfer them—with the aid of the grid of squares—to the smaller etching.[17] In any case, the drawing's perfection is striking, especially in its massive substructures that seem almost geometrical in their regularity.[18] Koch included an imposing view of the Baths of Maxentius, the Baths of Severus, and, in the distance in the middle, the Torre della Milizie standing in front of the Forum of Trajan. On the right, one recognizes the tall campanile of

2. Joseph Anton Koch (Austrian, 1768–1839). *Vietri on the Gulf of Salerno*, 1800. Pen and dark gray and black ink, black crayon, colored in watercolor and gouache on paper, sheet 24⅜ x 37⅜ in. (61.7 x 95 cm). Inscribed in pen and brown ink, bottom left of mount: *fait d'aprés* [*sic*] *la Nature par J. Koch a* [*sic*] *Rome 1800*. The Metropolitan Museum of Art, Purchase, The Elisha Whittelsey Collection, The Elisha Whittelsey Fund, Van Day Truex and Harry G. Sperling Funds, David T. Schiff and Mr. and Mrs. Mark Fisch Gifts, and funds from various donors, 2010 (2010.39). Photographs of Figures 2, 4, 10, 21: Mark Morosse, The Photograph Studio, MMA

3. Joseph Anton Koch. *Vietri on the Gulf of Salerno*, 1795. Watercolor and gouache over graphite on gray-blue laid paper, 18⅛ x 28 in. (46.1 x 71.2 cm); verso: graphite study of an overgrown gate with two women carrying jars on their heads. Inscribed in graphite: *Koch pittore tedesco, per recapito al Caffé Greco Strada Condotti, incontro della Barcaccia./a Roma*. Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna (6577). Photographs of Figures 3, 7, 9, 14, 16: Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna

4. Joseph Anton Koch. *View of Civitella*, early 19th century. Pen and black ink, border in black ink, preliminary drawing in black crayon, squaring in black crayon on paper, sheet 14 x 19½ in. (35.6 x 49.6 cm). Inscribed in pen and brown ink, lower left: *Koch. Rom*; in graphite, beneath the border: *9*. The Metropolitan Museum of Art, Purchase, David T. Schiff Gift, 2009 (2009.29)

Santa Francesca Romana. In front of it are the four arches of the Aqua Claudia,[19] and, behind them, very small, the Arch of Constantine. The Capitol is visible in the background on the left. The detailed staffage in the foreground of the New York drawing features idyllic, carefree rural life—a wayfarer with a dog, a woman with a child, and, on the right, a group of musicians and a woman dancing.

The *Vedute Romane* were produced mainly for financial reasons. Prints were, on the one hand, a medium in which an artist might formulate his ideas independent of commissions, and, on the other—thanks to the ease with which they could be reproduced—offered the potential for highly lucrative sales of large editions.[20]

Koch must have considered the series a success, since again and again he referred back to its landscape prospects, especially in later paintings. This was typical of him, for he frequently resorted to compositions that he had once worked out to his satisfaction and employed them in new contexts.[21] Koch also used the motif of print number 18 in his series *Vedute Romane* (Figure 7) in a watercolor in Dessau, *View from Santa Balbina of the Ruins of the Palaces of the Caesars in Rome*,[22] a pendant to the watercolor in Frankfurt-am-Main, *View from the Monastery San Isidoro of Saint Peter's in Rome*.[23]

5. Joseph Anton Koch. *View of Civitella*. Oil on canvas, 13¾ x 19¾ in. (35 x 50 cm). Belvedere, Wien (2328). Photograph: Belvedere Wien

A fourth drawing by Koch in the Metropolitan Museum is related to an extensive decorative commission. *The March of Silenus* (Figure 8) can clearly be associated with Koch's designs for the Roman House in Leipzig of the publisher Hermann Härtel. Härtel sojourned in Rome from 1829 to 1831 and, impressed by the Nazarene frescoes in the Casa Bartholdi and the Casino Massimo, planned to have his new garden pavilion, erected in the years 1832 to 1834, decorated with wall paintings by German artists. In late 1832 the commission was awarded to three artists of similar sensibilities: Bonaventura Genelli (1798–1868), Friedrich Preller (1804–1878), and Koch. Koch and Genelli knew each other during the time Genelli was in Rome, from 1822 to 1832. Koch was obliged to deliver only preliminary drawings for his contributions; it was planned that Preller would execute them.

From surviving correspondence between Koch and Genelli in which the subjects were coordinated,[24] we learn that Koch was highly delighted with the commission. The last stage in his preparations were seven watercolors of historical-mythological landscapes that have been lost since World War II.[25] Koch had followed the advice of his friend Genelli in his selection of subjects: Apollo among the Shepherds, the Abduction of Hylas, Diana and Actaeon, Silenus and His Followers, the Death of Orpheus, Nessus's Rape of Deianira, and Chiron Teaching Achilles to Play the Lyre. They were largely themes from Greek mythology in which landscape played a considerable role.

The March of Silenus closely resembles a drawing of the same subject in Vienna (Figure 9) and probably represents a later repetition of it.[26] Both drawings most likely repeat the watercolor made in 1832–33 for Härtel's Roman House.[27] The Vienna drawing is sketchier, especially in the graphite underdrawing that is still working out the composition, whereas the New York sheet can essentially be seen as a fair drawing. In Greek and Roman mythology, sileni, frequently surrounded by maenads, were hybrid creatures, half man and half horse, that were members of the retinue of Dionysus. They stand for unbridled lust and are often pictured, as here, as old men in a state of intoxication. Koch, himself already an old man, reverted to existing compositions,[28] above all in the figural staffage as well as in the landscape surroundings that characterize the compositions. His designs, like Genelli's, were never realized as wall paintings.[29]

Finally, there is one work in the Metropolitan Museum's collection that has nothing to do with Koch's familiar graphic oeuvre with its emphasis on landscape. It is a calendar (Figure 10) that was probably executed as an occasional piece, possibly a present to an artist colleague.[30] The signature on the right side, *I.K.:/inv:/1822*, clearly dates the sheet to 1822. Also inscribed on the sheet in the small circular fields are the numbers *28*, *30*, and *31*, and, in an

6. Joseph Anton Koch. *Ruins of the Imperial Palaces in Rome*. Pen and black ink, squared in graphite with the squares numbered, border in black ink on paper, sheet 15 x 19⅜ in. (38 x 49.2 cm). Inscribed in brown ink, top left: *N. 3*. The Metropolitan Museum of Art, Purchase, David T. Schiff Gift, 2005 (2005.179)

7. Joseph Anton Koch. *Ruins of the Imperial Palaces in Rome*, 1810. Etching no. 18 in *Vedute Romane*, image 6¾ x 9 in. (17.2 x 22.9 cm). Signed bottom right: *Koch fece*; inscribed in plate, bottom center: *Ruine del Palazzo de' Cesari in Roma*. Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna (3915)

8. Joseph Anton Koch. *The March of Silenus*, 1833–34. Pen and brown ink, border in brown ink on paper, sheet 11 x 7⅛ in. (28 x 18 cm). The Metropolitan Museum of Art, Mary Oenslager Fund, 2006 (2006.335)

9. Joseph Anton Koch. *The March of Silenus*, after 1832. Pen and brown ink over graphite on paper, 11⅞ x 7¾ in. (30.1 x 19.7 cm). Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna (6323)

elongated oval at the bottom edge, the initials of the German names for the days of the week.[31] Beneath these is a silk ribbon threaded through the sheet from the back with the numbers *1* to *31*; the ribbon can be shifted so that the numbers accord with their appropriate weekday.[32] The somewhat schematic quality of the figural depictions is probably a reflection of Koch's inexperience with such subjects and genres. The interest of this calendar sheet lies mostly in its complex and highly associative iconography, which can be briefly sketched as follows. In the center, the mythical figure of Cybele, wearing a crown representing a city wall, is seated on a lion throne.[33] A universal female deity like the late Egyptian Isis, Cybele ruled as mistress of the four elements, who are depicted beneath her.[34] The female figure in the light blue garment on the left and holding a jar represents Water. Next to her kneels a figure in green with a bared bosom, representing Earth. To the right of Earth an allegory of Fire dressed in red points upward. Closing the composition on the right side, a draped Hermes figure hovers as an allegory of Air. The figure of Air follows earlier depictions of Hermes, for example, the sculpture by Giambologna (1529–1608) now in the Louvre, whereas the remaining allegories are free variations on traditional iconography. Arching over this allegorical scene is a cosmic rainbow, in the spandrels of which crouch angelic figures of Day and Night.

The Four Seasons are pictured in the corners, beginning in the lower left with Spring dancing with a floral garland, followed counterclockwise on the lower right by Summer, with reference to its harvest of grain. Fall is pictured in the upper right with baskets overflowing with fruits, and in the upper left is a personification of Winter leaning against an anchor in an antique pose. Once again Koch was borrowing from traditional, easily understood pictorial images in many cases drawn from prints; here, stylistic features suggest his sources were prints from the sixteenth century.[35] In the lozenges bordering the central panel, three on each side, are the months with their specific activities.[36] The ornament that separates the lozenges could be interpreted as a power symbol like a bundle of lightning bolts. Number symbolism appears to play an important role. Particularly in the frame, the numbers three and four predominate; the latter reflects the cosmic principle, whereas the triad symbolizes the Trinity. The principle of the divine is also addressed in the lunette at the top, in which the kneeling angels adore a burst of light, a design that shows Koch to have been influenced by Philipp Otto Runge's (1777–1810) series of the Seasons.[37] The highly allusive iconography was doubtless meant to underscore the notion of cyclical return, and in its mythical-religious allusions it represents a perpetual calendar with any number of references and associations condensed within it.

In 2008 the Metropolitan Museum acquired one of Koch's major paintings, *Heroic Landscape with Rainbow* (Figure 11). It occupies a key position in his oeuvre and is a composition that he executed in several versions; the Museum's painting is the fourth. According to a handwritten label glued on the back, it was purchased directly from the artist by Gustav Parthey in December 1824, the year it was painted.[38] The monumental version of this picture, developed over a long period and finalized only in 1815, is owned by the Neue Pinakothek in Munich.[39] The original version from 1805, sketchier, more pastose, is preserved in the Kunsthalle in Karlsruhe.[40] A simplified replica is in a German private collection.[41]

The impressive subject, one of the artist's most original compositions, ultimately looks back to the view of Vietri sul Mare in Vienna (Figure 3) and the large drawing in New York (Figure 2). The view of Vietri is rightly considered to be the origin of his "heroic" landscape. In a letter to Robert von Langer, professor at the academy in Munich, the artist said as much: "It is a region that appears the way one imagines Greece to be. I took the motif from the beautiful region near Salerno on the way to Paestum, with ancient cities on hills in the remarkable light. One also sees the sea with shadowy blue mountains in the distance."[42]

It is possible, even with the naked eye, to see detailed underdrawing in spots, the extent and significance of which are fully revealed only by infrared reflectography (see Figure 12).[43] Such images have for the first time shown how carefully Koch prepared all the details of a composition, even in later versions of an already established pictorial conception. As yet his practice of producing such careful drawings directly on the picture support has not been extensively studied.[44] In the detail of its preliminary drawing, the Metropolitan Museum's painting is apparently unusual, for infrared photos of the Karlsruhe and Munich versions do not reveal anything like the same preparation.[45] The New York underdrawing lends support to the widely accepted appraisal of Koch as first and foremost a draftsman, one whose greatest achievements were in the medium of drawing. This is also indicated by the preponderance of drawings in his total output.[46] The style of the New York underdrawing and its use of both chalk and wash exhibit Koch's typical and essentially consistent way of drawing. In other words, through his draftsmanship, Koch had the ability simultaneously to elevate and ennoble the direct impression of nature. In its character and specific execution, it is especially close to the studies in Koch's sketchbooks, in which he captured landscapes, figures, plants, animals, and so forth directly from nature.

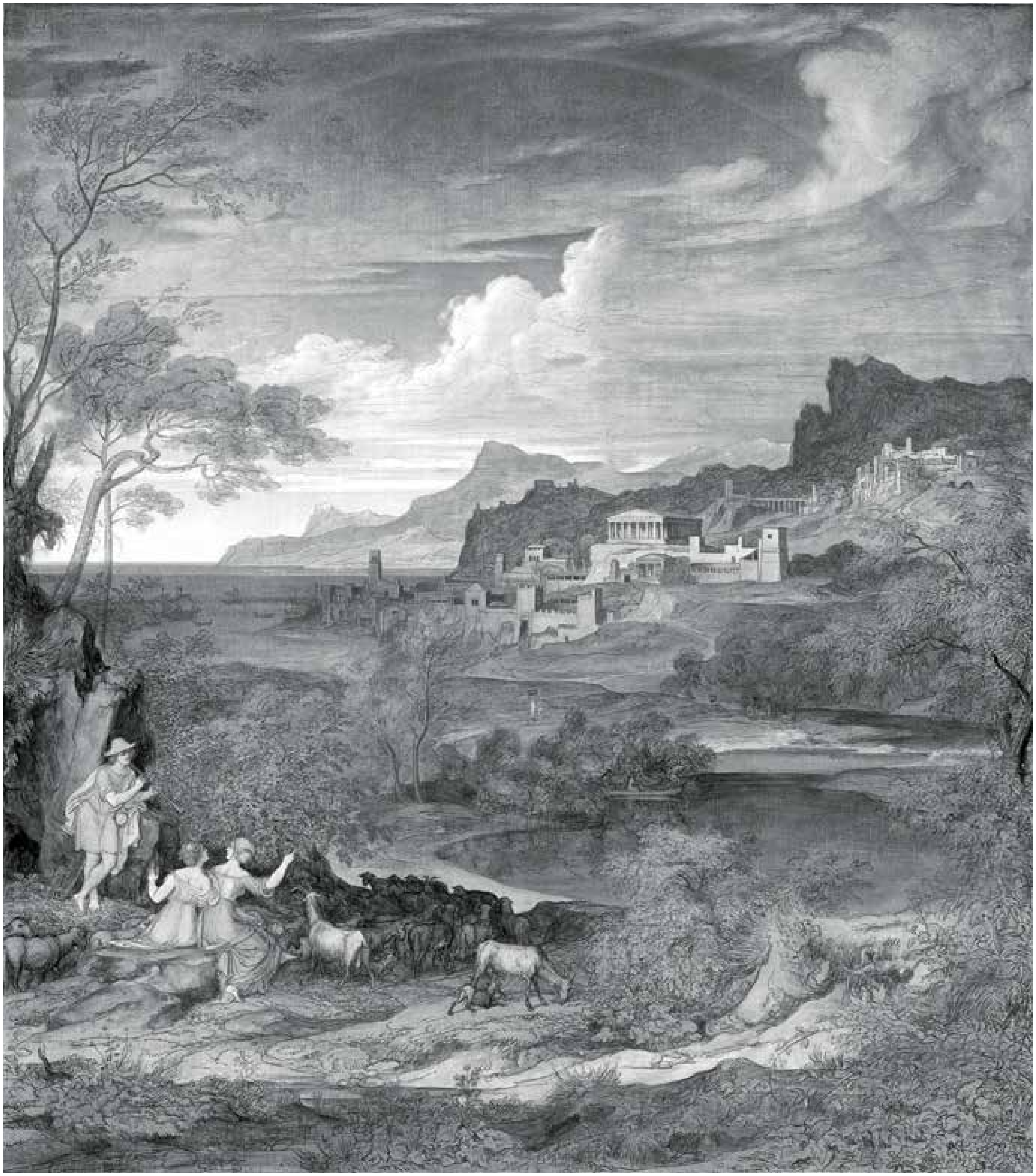
The underdrawing establishes both the overall composition of the painting and all its details. The painting diverges from it only slightly; for example, not all of the sailboats in the left background were taken over into the painting. Beginning in the top left corner, numbers are written along the edges of the canvas, which doubtless stood in for the squaring; that is missing on the underdrawing.[47] The horizontal edges are numbered from left to right, the vertical ones from top to bottom. In the rational construction of Koch's composition, we can see even more clearly than in the finished painting the degree of calculation that went into his pictorial inventions. The suggestion of segments of a circle in the bottom corners is like a distant echo of the arc of the rainbow mirrored in the water in the right middle ground. It is above all the artist's painstaking consideration of form and proportion that gives his picture a distinct aura of the sublime. Evidence of this is visible along the right edge, where small strokes mark the relative proportions of the elongated leaves grouped into individual decorative palmette formations.

10. Joseph Anton Koch. Calendar with Allegories of the Elements, 1822. Pen and black ink, watercolor on paper, approx. 16⅞ x 13¾ in. (43 x 35 cm). Signed in black ink, bottom right: *I.K: / inv: / 1822*. The Metropolitan Museum of Art, Karen B. Cohen Fund, 2008 (2008.474)

11. Joseph Anton Koch. *Heroic Landscape with Rainbow*, 1824. Oil on canvas, 42¾ x 37¾ in. (108.6 x 95.9 cm). Signed and dated on rock at left: *J. Koch / 1824*. The Metropolitan Museum of Art, Purchase, Anne Cox Chambers Gift, Gift of Alfred and Katrin Romney, by exchange, and Nineteenth-Century, Modern, and Contemporary Art Funds, 2008 (2008.420)

The plants in the foreground are described in detail, each leaf precisely rendered (Figure 13), and recall the painstaking plant studies in Koch's sketchbooks (Figure 14), the most direct evidence of his great skill in drawing and composition allied to his unique design sense.[48] In the sketchbooks there are also studies of animals and figures, many of which he transferred directly into his large-format compositions (see Figures 15, 16).[49]

In many of the sketchbook studies, colors and even the names of species are carefully noted.[50] Like the oil painting's underdrawing, Koch's sketchbooks document the artist's characteristic additive concept of art, one that led him to combine with great deliberation separate elements of landscape, mainly based on direct observation, in such a way as to create a vision of a higher order. Microcosm and macrocosm are blended into an idealized image of

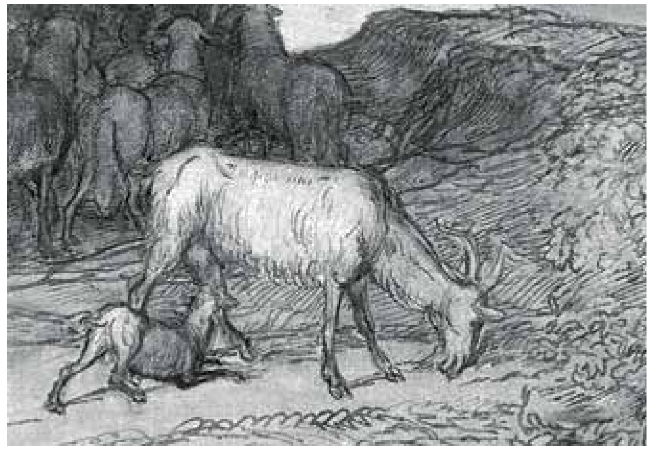


12. Infrared reflectogram of Figure 11. Imaging of Figures 12, 13, 15: Charlotte Hale

humankind in harmony with nature, in the painting bracketed and underscored by the double rainbow that arcs across the entire composition. Again and again one sees in the sketchbooks close-up studies of rock formations, some of which appear in the foreground of this painting, evidence of Koch's considerable interest in geology, even geognosy. He was particularly attuned to the morphology of a given landscape, concerned to discover the forces that shaped it and the composition of its underlying strata.[51] Thanks to techniques that now allow us to discover underdrawing and analyze it in great detail, such drawings as those in Koch's sketchbooks can significantly expand a museum's graphic holdings.

The Metropolitan Museum also has some works by Koch's close friend and colleague Johann Christian Reinhart that illustrate various facets of his art. Reinhart, about seven

13. Infrared reflectogram of detail of Figure 11



15. Infrared reflectogram of detail of Figure 11

14. Joseph Anton Koch. Plant studies with color notations in a sketchbook with studies of Olevano and the Serpentara, 1816–20. Inscribed in graphite: *fioretti gialli, sotto verde bianchastro sopra / verde turchinetto, Scizzi, bordura, giuncastra*; in another hand: *gelb in der Mitte* / [illegible]. Graphite, 7⅜ x 9¼ in. (18.6 x 23.6 cm). Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna (8402, sheet 28)

years older than Koch, also belonged to the artistic and social hub of the German artists' colony resident in Rome. Born in Hof, in Bavaria, as the second son of a Protestant minister, Reinhart, after initial studies in theology in Leipzig, received his artistic training with Friedrich Oeser (1751–1792), an exponent of early academic classicism. In 1785 he met Friedrich Schiller, which led to a lively exchange of ideas, especially beginning in 1801 until Schiller's early death in 1805. Already in 1789 Rinehart was settled in Rome, where he lived until his death and where he produced a considerable number of landscape paintings and, especially, etchings.

Perhaps most significant is an imposing drawing of an Arcadian landscape with three figures next to a pond (Figure 17), a composition that to my mind is directly related to Koch's gouache *Vietri on the Gulf of Salerno* (Figure 2). Both have the same unusually large format, indicating that Reinhart, too, considered this a finished work of art. In addition, their wood frames are identical, with gilded rosettes in the corners.[52] That the sheets are related is further confirmed by their provenance; both come from a private Scandinavian collection.[53] It is tempting to think that the two works were acquired directly from their respective artists at the beginning of the nineteenth century and framed as pendants by the collector.

Reinhart's drawing, which is dated 1792 by the artist, is an ideally composed wooded landscape with a pond in the center foreground, beside which are three women in classical dress. Two stand next to an altarlike structure, one of them motioning with an outstretched hand to the third, seated in the left foreground. The arrangement of this staffage and the basic composition of the landscape agree with those of a painting by Reinhart from 1796 that is now in the Museum Georg Schäfer in Schweinfurt.[54] Considering the numerous differences in the topography, however, the New York drawing cannot be thought of as a preliminary study for the painting; it was an independent work, probably destined for sale. Both works can be considered to be in the tradition of Claude Lorrain (1604/5?–1682), Poussin, and Gaspard Dughet (1615–1675), which Reinhart—like Koch—hoped to revive in his art.[55]

The New York crayon drawing is carefully executed on brown paper in Reinhart's typical style, which is characterized by a pervasive linear structure; here he also left the warm brown paper bare or allowed it to show through. He added virtuoso white highlights to the swift-moving cloud formations, to the foreground figural staffage, and to the edge of the pond. In the foreground corners one finds minutely rendered plants like the detail studies Reinhart drew from nature on single sheets, mostly in chalk, which were highly prized by collectors.[56] Such details are nonetheless subordinated to the restrained Arcadian mood, which is intensified by the warm harmony between the brown paper and the black crayon.

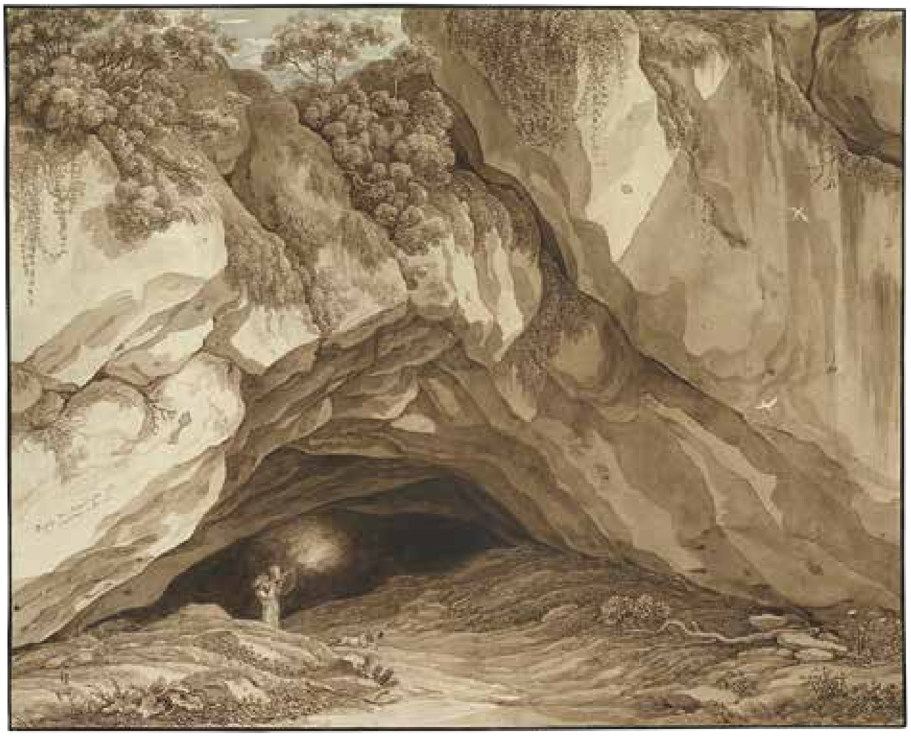
The other drawings by Reinhart in the Museum's collection illustrate various modes of his draftsmanship. The earliest is a spontaneous study of an old man wearing a tricorne hat, inscribed in the artist's hand at the top *hei-nisch*, which might be someone's name (Figure 18).[57] Inge Feuchtmayr dates this drawing to about 1782, based on its similarity to figure studies in an album of fifty-four drawings preserved in Weimar.[58] Those studies also exhibit a hint of caricature typical of Reinhart's work, which can be seen in the New York drawing's depiction of a specific pose and physiognomy. The texture of the coat, the moneybag in the man's hand, the tricorne, the facial features, and the suggestion of a shadow on the ground are captured in swift, sure strokes.

The detailed and elegantly washed drawing of the entrance to a cave in Figure 19 is dated 1786. According to the inscription, it is the Muggendorf Cave near Streitberg, in the part of Bavaria called Saxon Switzerland, so called because of the resemblance of the landforms to those of Switzerland.[59] The notation *fec. 1786./a Leipsic* indicates that the drawing was apparently not executed from nature but later, doubtless

16. Joseph Anton Koch. Studies of goats, sheep, and dogs with identifications from a sketchbook with drawings of Rome, the Sabine and Alban Hills, and Umbria, 1816–20. Inscribed in graphite: *yberozza*, *serpentella*, *castellona*, *majolo*, *Berilozza*, *Argentine*, *Piccolina / Piccolina*. Graphite, 8 x 11 3/4 in. (20.4 x 29.7 cm). Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna (8217v)

17. Johann Christian Reinhart (German, 1761–1847). *Wooded Landscape with Pond*, 1792. Black crayon, heightened in white gouache on brown paper, 23 x 33 7/8 in. (58.4 x 86 cm) (two sheets). Signed in brown ink along left edge: *C. Reinhart fec. 1792*. The Metropolitan Museum of Art, Rogers Fund, 2007 (2007.264)

18. Johann Christian Reinhart. *Standing Man*, ca. 1782. Black crayon on laid paper, 6¼ x 3¾ in. (15.9 x 9.5 cm). Inscribed in black crayon, top: *hei-nisch*. The Metropolitan Museum of Art, Harry G. Sperling Fund, 2007 (2007.424)



19. Johann Christian Reinhart. *Entrance to the Muggendorf Cave near Streitberg*, 1786. Pen and brown ink, brown and gray wash, border in black ink on paper, sheet 15 x 18¾ in. (38.2 x 47.6 cm). Signed in brown ink along left edge: *Reinhart fec. 1786. / a Leipsic*; inscribed, bottom left: *Eingang der Muggendorfer Höle* [*sic*] / *bei Streitberg in Bareuthe*. The Metropolitan Museum of Art, Gift of Katrin Henkel, 2003 (2003.405)

based on studies. The pastor Johann Friedrich Esper, superintendent in Wunsiedel, near Bayreuth, since 1779, publicized its caves and the fossils found in them.[60] The spot had been attracting geologically minded tourists from all over Europe since the 1760s.[61] A very similar drawing by Reinhart, documenting the popularity of such subjects, is in Leipzig's Museum der Bildenden Künste.[62]

With a virtuoso handling of washes, Reinhart rendered sunlit portions of the massive rock wall above the cave by leaving the paper blank. The structure and composition of the stone are minutely registered. All his life the artist was fascinated by rock formations and caves and repeatedly captured them in detailed studies. In this he reveals—much like Koch—a well-developed interest in geology. In the left foreground two hunters accompanied by a dog are shooting at two birds. They represent one of the artist's passions, which he indulged in his free time. Hunters appear in his landscapes as staffage in the most varied contexts.[63] The massive rock formations, compared with the diminutive figures, emphasize nature's superiority over human existence. Only in the detailed descriptions of the plants in the foreground and in the vegetation on the upper rocks does Reinhart insert more human-scale forms of nature, which he repeatedly captured as well in his numerous botanical studies. Like Koch, Reinhart studied the details of the plants, animals, and figures. He used these studies, which almost resemble examples from pattern books, in his large-format compositions.[64]

A study of a massive rock wall, dated to 1786–89 (Figure 20), is sketchily rendered in a combination of drawing in graphite and sparingly applied brown washes. The similarity of the drawing technique to that of Reinhart's study of the Monk and Nun cliff near Eisenach, in Thuringia, now in Berlin's Kupferstichkabinett,[65] suggests that the present sheet pictures the same motif and was executed at very close to the same time. The graphic pattern of the rough rock wall extends almost to the upper edge of the sheet, where a few trees and bushes are indicated. The study again documents Reinhart's keen interest in geological forms and at the same time exudes an almost impressionistic charm in the spontaneity of its execution.

A crayon drawing of a rocky landscape with a recumbent stag from 1824 exhibits a wholly different stylistic approach (Figure 21).[66] Very regular, short strokes that form a dense network of lines render the landscape in great detail, including the almost ornamental foliage of the sturdy trees and the stag that is resting majestically in the foreground. As it happens, the animal had been trained by a Viennese equerry and taken to Rome by a company of trick riders in 1823. Reinhart wrote about it in a letter to the painter and engraver Adolf von Heydeck (1787–1856) dated July 10, 1824: "Last

20. Johann Christian Reinhart. *Rocky Cliff* (*Monk and Nun near Eisenach in Thuringia*), 1786–89. Graphite, brown wash on paper, sheet 12⅞ x 11⅛ in. (32.7 x 28.3 cm). Verso inscribed in graphite: *44 Batkauzen* [?] *1892*; at right: *Joh. Chr. Reinhardt / S=4*. The Metropolitan Museum of Art, Gift of Bruce and Angelika Livie, 2005 (2005.181)

21. Johann Christian Reinhart. *Rocky Landscape with Stag*, 1824. Black crayon on paper, sheet 17⅝ x 15½ in. (44.9 x 39.5 cm). Signed in black ink on rock at lower left: *J. C. Reinhart, Roma 1824*. The Metropolitan Museum of Art, Gift of Thomas and Gianna le Claire, 2006 (2006.219.2)

year the equerry de Bach from Vienna was here with a company with horses and a stag that jumped over them. I have done several studies of this stag and drawn him leaping over fallen trees, chased by a dog, and up close in a landscape composed for the purpose. I have already repeated this drawing for England 3 times, the first one [the Prussian diplomat Jakob Salomon] Bartholdy bought, and now I am painting it for the wealthy Israelite [perhaps Carl Mayer] Rothschild in Naples."[67]

These drawings were largely made directly from nature and document Reinhart's intensive study of various terrestrial forms. His interest in geology or geomorpology, like Koch's, is perfectly apparent. The position of the tree stump in the right foreground is extremely effective; it functions as a *repoussoir* motif on the one hand, and, on the other, its jagged fractures introduce an interesting graphic element into the foreground.

Two more drawings in the Museum's collection should be briefly mentioned. In terms of motifs as well as of style they exhibit a direct connection with the work of Koch and Reinhart as presented here. One is a drawing by Thorvaldsen, a close friend of Koch's, showing the seventeenth circle of Hell from Dante's *Divine Comedy*.[68] The other is a drawing by another close friend of Koch's, the Dutch-born Hendrik Voogd (1766–1839). A view of the so-called Villa Maecenas in Tivoli, near Rome, its idealized approach is close to the style practiced by Koch.[69]

The works by Koch and Reinhart discussed here—especially in reference to the underdrawing of Koch's *Heroic Landscape with Rainbow*—provide a representative sampling of the range of the artists in terms of both media and subject matter. This topic is even more worthy of study, as both artists held key positions in the development of landscape about 1800, which was for the next generation of artists a central point of departure for the genesis of the Romantic conception of the genre. It becomes evident once more that Rome, with its international artists' colony, achieved a primary place as the artistic center of the world even beyond the antique.

ACKNOWLEDGMENTS

I was able to study this segment of the Metropolitan Museum's collection intensively during a two-month fellowship at the Museum in April and May 2012. I am grateful to Stijn Alsteens, curator, Department of Drawings and Prints, who made many important suggestions and encouraged me to write this article. He also generously made available to me the materials he had already gathered in connection with the works presented here.

NOTES

1. Hess first completed an apprenticeship as a painter-decorator and received instruction in the workshop of the painter Maximilian Neustück (1756–1834). He attended public drawing school until 1816 and continued his training in the workshop of Peter Birmann (1758–1844). Through Birmann he became acquainted with the art dealer C. T. Müller, who in 1819 took him to Naples, where by the end of 1820 he had produced a series of etchings of Neapolitan folk scenes. With the aid of a scholarship he journeyed to Rome, where he stayed from the spring of 1821 to the summer of 1823. He was on friendly terms with Koch, working for a time as an assistant in his studio as well as with Bertel Thorvaldsen and the Nazarenes. For more on Hess, see *Hieronymus Hess* 1999–2000.
2. The provenance of the portrait of Koch, before becoming part of the Metropolitan Museum's collection, is as follows: Richard von Kühlmann (1873–1948), Ohlstadt; (sale, Galerie Bassenge, Berlin, June 4, 2010, lot 6367 [as by Heinrich Maria von Hess]); [Kunsthandel Katrin Bellinger, Munich]. An almost identical version of this portrait is in the Kupferstichkabinett, Staatliche Museen zu Berlin, inv. Hess SZ 1. Stijn Alsteens suggested that the sheet could be a tracing of the one in New York. Or, of course, both versions could be copies of a common original.
3. The provenance of the large gouache is as follows: private collection, Göteborg; (sale, Auktionskammare, Uppsala, June 2, 2009, lot 58); [Kunsthandel Katrin Bellinger, Munich].
4. In the spring of 1795, while staying with his English patron George Frederic Nott, Koch visited the small, picturesquely situated coastal village of Vietri sul Mare. See Holst 2010, pp. 236–38.
5. The Kupferstichkabinett in the Akademie der Bildenden Künste Wien, Vienna, has one of the largest holdings of drawings by Koch, which with few exceptions entered the collection in 1865 as a complete portfolio from the artist's estate by way of his son-in-law Johann Michael Wittmer (1801–1880). See Reiter 2011, especially no. 7.
6. *View of Civitella* is presumed to have belonged originally to the Cichorius collection. The provenance before coming to the Metropolitan Museum is: (sale, C. G. Boerner, Leipzig, May 1908, lot 341); private collection, Munich, ca. 1950; (sale, Bassenge, Berlin, November 30, 2007, lot 6656); [Kunsthandel Kathrin Bellinger, Munich]. At a symposium held at the Istituto Storico Austriaco in Rome in May 2011, Jytte W. Keldborg (author of *Gli artisti danesi ad Olevano Romano e dintorni* [2011]) recognized the motif as Civitella (present-day Bellegra). This observation was confirmed by Serfino Mampieri, an expert on the topography of the environs of Rome and chairman of the Friends of the Olevano Museum.
7. Museen der Stadt, Angermuseum, Erfurt, inv. 1527; Lutterotti 1985, no. G 65.
8. Belvedere Wien, Vienna, inv. 2328; Lutterotti 1985, no. G 66.
9. The version not listed in Lutterotti is in a Vorarlberg private collection (art market, Innsbruck, 1978). For a thorough discussion, see Holst 2010, pp. 260–64.
10. See also the fully executed pen drawing based on this study with the inscription *Pagliano v. d. Campagna zwischen Volsker- und Albanergebirge* (Museum of Art, Rhode Island School of Design, Providence, inv. 53.314; Lutterotti 1985, no. Z 951, fig. 209), and the drawing *Italienische Landschaft mit Staffage* (without indication of place, formerly private collection, Munich; Lutterotti 1985, no. Z 1124), which in the detail reproduced corresponds to the left third of this sheet. The identification as Pagliano in the inscription on the sheet in Providence would thus be erroneous.
11. Pen and gray ink over graphite, squared in graphite, on light brownish paper, 8½ x 12¼ in. (21.5 x 33.1 cm), inv. 6336; see Reiter 2011, no. 725 (there still identified as Paliano).
12. Lutterotti 1985, no. Z 1008.
13. The motifs of the *Vedute Romane* follow detailed studies from nature, most of which are found in a sketchbook Koch used about 1805, now unbound, in the Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna. In the etchings Koch kept very close to the compositions of the drawings, merely adding staffage, generally highly evocative, in the foreground of each print.
14. The provenance of *Ruins of the Imperial Palaces in Rome* before becoming part of the Metropolitan Museum's collection is as follows: Ottaviano Koch (1853–1939), Rome; Stiftung Wolfgang Ratjen, Vaduz; David Lachenmann; [Kunsthandel Katrin Bellinger, Munich]. See also Lutterotti 1985, p. 593.
15. Koch had already pictured these ruins in number 8 of the etching series, though from a different angle and with staffage emphasizing the Christian life.
16. See Riccardi 2000, no. 18.
17. A small-format preliminary drawing for this etching, still without staffage, is in the Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna, inv. 6361; see Reiter 2011, no. 150.
18. A drawing of this subject, also squared, is in the Kupferstichkabinett, Staatliche Museen, Berlin, inv. SZ 38; and a sepia drawing of the ruins of the emperors' palaces is preserved in the Staatsgalerie zu Stuttgart, inv. 4171.
19. These arches appear in closely related form in etching number 10, *Aqueduct under Santa Bonaventura*. See Riccardi 2000, no. 10.
20. For Koch it was doubtless the second motivation that was crucial. Constantly burdened by financial problems, he hoped for income from selling views of Rome to the international tourists who streamed into the Eternal City. He sought commissions in Vienna from 1813 to 1815. Disappointed, he returned to Rome.
21. He also produced copies of individual paintings separately from the original commissions for financial reasons.
22. Staatliche Galerie, Dessau, inv. 295, 12¾ x 18⅝ in. (32.3 x 47.2 cm); Lutterotti 1985, no. Z 154.
23. Städel Museum, Frankfurt-am-Main; Lutterotti 1985, no. Z 111. See also the drawing in the Kunstmuseum Mannheim of this motif from about 1810 with a procession of monks in the foreground (inv. G 1160); Schulte-Arndt 1997, no. 167.
24. For an example of the correspondence between Koch and Genelli, see Lutterotti 1985, p. 127. The provenance of *The March of Silenus* (Figure 8) before becoming part of the Metropolitan Museum's collection is as follows: (sale, Karl & Faber, Munich, November 29, 2005, lot 260); [Kunsthandel Katrin Bellinger, Munich].
25. The publisher Heinrich Brockhaus, who saw Koch's watercolors at Härtel's, noted appreciatively in his diary on August 25, 1833: "These drawings provided me with the greatest delight; I have not seen anything more beautiful in a long time, nothing more ingenious, nothing fresher; and Koch is well into his sixties! This is the way nature should be perceived and portrayed. Not only prospects, it has penetrated deeply into the spirit and captured it. The staffage was also very significant here and perfectly charming." (Diese Zeichnungen versetzten mich in das lebhafteste Entzücken; ich habe lange nichts Schöneres gesehen, nichts Geistreicheres, nichts Frischeres; und Koch ist hoch in die Sechzig! So muß die Natur aufgefasst und wiedergegeben werden. Nicht nur Prospecte, es ist tief in den Geist eingedrungen und dieser erfasst. Die Staffage war auch

hier sehr bedeutend und allerliebst.) Quoted in Lutterotti 1985, p. 128.

26. See Reiter 2011, no. 42.
27. The composition corresponds to that of the watercolor of about 1832–33 (lost in World War II, formerly Berlin; see Lutterotti 1985, fig. 219), which was produced as a design for Härtel's Roman House in Leipzig.
28. See also the slightly differing versions in the Kupferstichkabinett, Kunstmuseum, Basel, inv. 186.50.18; Lutterotti 1985, no. Z 40; and *Triumph of Bacchus*, private collection, Munich, Lutterotti 1985, no. Z 1072.
29. Only the room designed by Preller was executed.
30. The provenance of Koch's calendar before coming to the Metropolitan Museum is: Collection of Wilhelm Ettl, Frankfurt, 1956; (sale, Karl and Faber, Munich, May 14–16, 1961, lot 681); (sale, Karl and Faber, Munich, May 28–29, 1976, lot 447); Armin Pertsch, Mannheim; (sale, Pforzheimer Kunst- und Auktionshaus, Pforzheim, October 6, 2007, lot 1185); [Kunsthandel Kathrin Bellinger, Munich]; see also Lutterotti 1985, no. Z 1069.
31. S[onntag], M[ontag], D[ienstag], M[ittwoch], D[onnerstag], F[reitag], and S[amstag].
32. In addition, on the back there are two or possibly three red wax seals that cannot be further identified, as well as the following inscriptions, doubtless not from the artist's hand: *681* (in graphite, center), *230* (ballpoint, lower center), *3627/III*[?] (pen, bottom right).
33. The type of the central Cybele, who was venerated mainly in Late Antiquity, corresponds to the Tyche of Antioch, who also wore a crown of city walls and was worshiped as a mother goddess (Magna Mater).
34. The literary source for the goddess Tellus/Cybele/Mater Magna Deum seated on a lion throne could be Titus Lucretius Carus *De rerum natura* 2. 600–609. There, after a gap in the manuscript, it is said that the goddess seated in her car goads two lions into the air. It is especially worth noting that her walled crown is described in lines 606–7, indicating that the earth is the support of cities. For this suggestion I am indebted to Wolfgang Speyer of the Institut für Klassische Archäologie und Wirkungsgeschichte der Antike, University of Salzburg.
35. As yet, no specific patterns have been discovered.
36. This calendar follows the chronograph of A.D. 354 (the original has not come down to us; one of the copies is preserved in the Bibliotheca Apostolica Vaticana, Vatican City). In it the twelve months are pictured on facing pages. As on the New York sheet, each month is represented by a single figure engaged in its characteristic activity and with its typical attributes; see Salzman 2001, especially pp. 1183–84.
37. The cycle of the Seasons by Philipp Otto Runge was widely circulated in the form of etchings, which could well have been in Koch's collection. Nearly all artists owned prints by other artists and had them readily available as sources of ideas.
38. From Parthey's collection, *Heroic Landscape with Rainbow* was owned by his descendants until 1991; on loan to the Märkisches Museum, Berlin, 1951–91; (sale, Christie's, London, June 21, 1991, lot 52); private collection; (sale, Sotheby's, London, May 30, 2008, lot 10, to Konrad Bernheimer, Colnaghi's, London). See Rewald 2010, p. 51. I am grateful to Sabine Rewald, Jacques and Natasha Gelman Curator for Modern Art, Department of Modern and Contemporary Art, MMA, for providing me with the documentation relating to this picture.

    For a detailed discussion of this version, see Lutterotti 1985, no. G 59. A precise preliminary drawing for this painting is in Karlsruhe; see Lutterotti 1985, no. Z 144.
39. Oil on canvas, 74 1/8 x 67 in. (188.4 x 170.1 cm), inv. WAF 447; see Lutterotti 1985, no. G 30, and Vignau-Wilberg 2003, pp. 275–77.
40. Oil on burlap, 45 7/8 x 44 1/4 in. (116.5 x 112.5 cm), Staatliche Kunsthalle, Karlsruhe, inv. 789; for this version, see Lutterotti 1985, no. G 10, and Holst 1989, no. 75.
41. Oil on canvas, 28 3/4 x 23 5/8 in. (73 x 60 cm); see Lutterotti 1985, no. G 10a, and Holst 1989, no. 77.
42. "Es ist eine Gegend, so wie man sich Großgriechenland denkt. Das Motiv habe ich aus der schönen Gegend bei Salerno auf dem Weg nach Paestum, mit antiken Städten auf Gebirgen in frappantem Licht. Auch sieht man das Meer mit blauen schattichtem Gebirge in der Fern." Koch to Heinrich von Langer, March 17, 1814; Lutterotti 1940, p. 165.
43. For the infrared imaging I thank Charlotte Hale, conservator, Department of Paintings Conservation, MMA. The overall, zoomable infrared image can be found on the Museum's website: www.metmuseum.org/collection/the-collection-online.
44. I am grateful to Sabine Grabner, curator of nineteenth-century art at the Belvedere Wien, Vienna, who examined the paintings in her collection for underdrawings and definitely detected them. With the naked eye they are visible only in spots, to be sure, but they are very clearly there. Their visibility without technical equipment depends on the thickness of the pigment applied over them.
45. My thanks in this regard to Alexander Eiling (Kunsthalle, Karlsruhe) and Herbert Rott (Bayerische Staatsgemäldesammlungen, Neue Pinakothek, Munich), who ordered these photographs for the purposes of my research. According to a written communication from Eiling, in the Karlsruhe version it is possible to make out underdrawing in the area of the building complex in the middle ground, which is already visible to the naked eye. The infrared photograph of the Munich version reveals only partial preliminary drawing and by no means a detailed, final one.
46. Lutterotti (1985) catalogues more than 1,000 drawings as opposed to only about 120 paintings.
47. Once again, I am grateful to Charlotte Hale, who examined the picture for the purposes of my study.
48. In 1865 the Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna, acquired from the estate of Koch's son-in-law Johann Michael Wittmer six sketchbooks—including Koch's last one, the second half of which was further used by Wittmer, as well as two unbound sketchbooks now mounted as single sheets. The institution fully researched and annotated these sketchbooks in the 2011 catalogue of its Joseph Anton Koch holdings, which includes more than 860 items; see Reiter 2011. The significance of this project is all the greater since the sketchbooks were intensively used by Koch's pupils as study material.
49. Like the figural staffage in Koch's landscape paintings, the depictions of animals were also based on close study of individual breeds, their specific movements, behavior, and appearance. See Reiter 2011, pp. 39–62, nos. 594–602.
50. The precision of Koch's renderings of specific species in his plant studies is an indication of the extent of his botanical knowledge. In addition to a sketchbook in the Kupferstichkabinett, Akademie der Bildenden Künste Wien, Vienna, noted for its plant studies from Olevano and the oak grove known as the Serpentara from the years 1816–20 (inv. 8402; see Figure 14 and Reiter 2011, pp. 191–208, nos. 648–713), the Morgan Library and Museum in New York has a Koch sketchbook in which plant studies are richly represented (1984.37).
51. It must be noted that, at the time, geology was an especially popular scientific discipline even among landscape painters. Their renderings of the typical structure of various types of rock presupposed

a knowledge of geological theories, which Koch is known to have possessed—in part thanks to his personal acquaintance with the naturalist Alexander von Humboldt. For example, he claimed that Anton Friedrich Büsching's *Neue Erdbeschreibung*, a standard eighteenth-century work of geography, was his most important reading after the Bible. The Austrian painter Michael Wutky (1738–1822), whom Koch knew personally, probably from his Roman sojourn, owned a mineral collection that was important enough to be mentioned in city guides to Vienna.

52. A very similar frame was used in the so-called Green Salon of Duchess Anna Amalia in the Wittums Palace in Weimar. See Schröder 2007, p. 15, fig. 1. I am grateful to Stijn Alsteens for this suggestion.
53. The Reinhart drawing (Figure 17) was sold through Thomas le Claire Kunsthandel.
54. Oil on canvas, 56¾ x 66⅞ in. (144 x 170 cm), inv. MGS 1916 (there listed as *Ideale Baumlandschaft* [*Ideal Landscape with Trees*]). See Feuchtmayr 1975, no. G 5 (considered a questionable work). On this painting, see most recently (with reference to the New York drawing) Rott et al. 2012, p. 282, no. 191. Rott acknowledges the work as Reinhart's.
55. A drawing by Reinhart that is comparable in its rendering of a wooded landscape with Arcadian staffage in the same size is in Klassik Stiftung Weimar, Museen, Graphische Sammlungen, inv. KK 259. The sheet is executed in the same technique—black crayon with heightening in white gouache—and is of a similar format: 20½ x 33⅜ in. (52.2 x 84.7 cm); see Rott et al. 2012, p. 284, no. 190. An almost identical repetition of the right side of the composition with the characteristic tombstone in the background, though executed in pen and ink, is preserved in a German private collection (reference from Thomas le Claire Kunsthandel).
56. The art theorist and Romanist Carl Ludwig Fernow (1763–1808) wrote incisively about Reinhart's studies after nature: "No one surpassed [Reinhart] in the thorough study [of nature], perhaps no one would surpass him. All objects in the landscape, especially trees, cliffs, ruins, the plants in the foreground, and so forth, are in his paintings so characteristically presented, with such masterly confidence and exactitude that one can recognize in them each kind of tree, each plant, each rock and kind of cliff as well as in nature itself." (Im gründlichen Studium übertrifft ihn keiner, hat ihn vielleicht nie einer übertroffen. Alle Gegenstände der landschaftlichen Natur, vornehmlich Bäume, Felsen, Ruinen, die Pflanzen der Vordergründe etc. sind in seinen Gemälden so charakteristisch, mit so meisterhafter Sicherheit und Bestimmtheit ausgedrückt, daß man jede Baumart, jedes Gewächs, jede Stein- und Felsart in ihnen, so gut wie in der Natur selbst, wieder erkennt.) Fernow 1802, p. 260.
57. See Feuchtmayr 1975, no. Z 358. The work's provenance is as follows: (sale, Gallery Gerd Rosen, Berlin, November 25–26, 1952, lot 1721); Edwin Redslob, Berlin; (sale, Bassenge, Berlin, May 15, 1976); (sale, Karl and Faber, Munich, December 7, 2006, lot 587); [Kunsthandel Katrin Bellinger, Munich].
58. The last drawing in this album (Kunstsammlungen zu Weimar, inv. 2192-2244) is inscribed: *ad nat.[uram], 9. Nov. 1782, Reinhart*. See Feuchtmayr 1975, no. Z 257, and Rott et al. 2012, pp. 166–67, nos. 55–58.
59. The locale is clearly identified by the inscription at lower left: *Eingang der Muggendorfer Höle* [*sic*] / *bei Streitberg in Bareuthe* (*Entrance to the Muggendorf Cave / near Streitberg in Bayreuth*). The drawing was previously in a private collection, Constance; Katrin Henkel, Munich. See also Schmid 2012, p. 12, fig. 2.
60. Esper published a treatise, illustrated with colorplates, which established him as the founder of paleontological cave research. See Esper 1774.
61. See Schmid 2012, p. 12.
62. See Rott et al. 2012, no. 52.
63. See also Schmid 1995, pp. 51–58.
64. For reproductions of Reinhart's nature studies of leaves and other vegetation, see Rott et al. 2012, pp. 194–211.
65. Kupferstichkabinett, Staatliche Museen zu Berlin, inv. SZ Reinhart 28. See Rott et al. 2012, p. 157, no. 46.
66. The work was formerly in a private collection, Hof; [Thomas le Claire Kunsthandel, Hamburg].
67. "Im vorigen Jahr war der Stallmeister de Bach von Wien mit einer Gesellschaft hier, mit Pferden und einem Hirsch, der über die Pferde setzt. Von diesem Hirsch habe ich mir einige Studien gemacht und ihn im Setzten über umgefallene Bäume, von einem Hund verfolgt, in einer dazu komponierten Landschaft groß gezeichnet. Diese Zeichnung habe ich für England schon 3 Mal wiederholt, die erste kaufte Bartholdy, und jetzt male ich ihn für den reichen Israelit Rothschild in Neapel." Quoted in Feuchtmayr 1975, p. 318. Additional drawings of this stag are in the Thorvaldsen Museum, Copenhagen (see Feuchtmayr 1975, no. Z 185), and on the art market (sale, Karl and Faber, Munich, June 1, 1995, lot 269; and sale, Reiss and Sohn, Königstein im Taunus, November 23, 2001, lot 97). The related painted version from 1824 is preserved in the Städtische Galerie, Wiesbaden; Feuchtmayr 1975, no. G 17.
68. Bertel Thorvaldsen, *Dante and Virgil on Geryon*. Black and white crayon on brown paper, 13⅛ x 10¾ in. (33.5 x 27.3 cm). The Metropolitan Museum of Art, Purchase, The Isaacson-Draper Foundation Gift, 2008 (2008.205). The drawing was formerly in the collection of Baron Niels Rosenkrantz, Hesselager (Fyn, Denmark), Schloss Ryegaard; [le Claire Kunst, Hamburg]. See Holst 1980 p. 90, no. 25, fig. 72, which shows the drawing in its unrestored state.
69. Hendrik Voogd, *View of the Villa of Maecenas at Tivoli*, 1793. Pen and brush in sepia on heavy laid paper, sheet 10¼ x 15⅞ in. (26 x 40.3 cm). Signed on verso in brown ink: *La Villa Mecenate a Tivoli Roma 1793. H. Voogd fecit*. The Metropolitan Museum of Art, Harry G. Sperling Fund, 1989 (1989.125.1).

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A Buddhist Source for a Stoneware "Basket" Designed by Georges Hoentschel

DENISE PATRY LEIDY

Curator, Department of Asian Art, The Metropolitan Museum of Art

Among the ceramics produced under the direction of the famed French designer Georges Hoentschel (1855–1915),[1] an unusual piece (Figure 1), sometimes classified as a "basket," raises intriguing questions regarding the range of sources that inspired French and other European ceramists in the late nineteenth and early twentieth centuries. Made of stoneware, this extraordinary vessel was hand-built in the studio established by Jean-Joseph Carriès (1855–1894) in Burgundy in 1888. After Carriès's death, Hoentschel worked there with Carriès's affiliates to produce ceramics that followed the style of certain types of Japanese stoneware then being exhibited and extolled in Europe. The decision to make the basket of stoneware rather than porcelain reflects the contemporaneous Western perception that stoneware (and the anonymous artists who crafted it) embodied an aesthetic that was more immediate, intimate, and expressive than the perfected and highly decorated products of large porcelain manufactories. The matted glaze also reflects an appreciation for Japanese traditions.

This uncommon vessel sits on a base whose bulbous shape is accentuated by four thick vertical bands appliquéd along the sides. Four curved prongs, joined together at the top of the basket, spring from the base. These prongs were shaved to create the appearance of metal and are connected to one another on the interior by strips of clay. Additional clay plaques decorated with stylized vegetal patterns fill the interstices between the prongs where they emerge from the base, and clay was also used to define a cylindrical opening (Figure 2) in the center of the vessel, which helps to explain its designation as a "basket."

While the embellishment of a surface with additional elements is characteristic of Art Nouveau (1890–1910) ceramics, the shape of the basket suggests an unexpected prototype, a Buddhist ritual implement (Figure 3) known in Sanskrit as a *vajra*.[2] The overall shape of the Hoentschel-designed basket is remarkably similar to that of one half of a *vajra*. Although the number of prongs can differ, they invariably converge at their tips, as do those found on the ceramic designed by Hoentschel. Moreover, the articulation and decoration of the lower half of the Hoentschel piece show parallels to the shaping and decoration of the bead-like forms at the center of a *vajra*.

Symbolic of both the power of a thunderbolt and the adamantine qualities of a diamond, the *vajra* signifies indestructibility in the pursuit of enlightenment. Although they have a long history in Indian culture, such objects first became prominent in Buddhist rites between the seventh and ninth centuries, owing to the development of new practices during that time.[3] By the twelfth century, these expanded traditions had spread, and ritual implements, particularly the *vajra* and the bell, were produced in large numbers throughout Asia. Ironically, at about the same time, Buddhism essentially disappeared from India.[4] While *vajra*s are seen in the hands of deities represented in Indian Buddhist art, no examples of Indian *vajra*s have been preserved. By the late nineteenth century, when Hoentschel designed his basket, the type of Buddhism that involved the use of *vajra*s was practiced principally in Tibet, Mongolia, and China, and to a lesser extent in Japan.[5]

Ritual implements were neither trade goods nor objects that were exhibited at world's fairs or other international displays. One wonders, therefore, where and how Hoentschel, one of his collaborators, or, possibly, a patron would have seen or acquired a *vajra*. Representations, sometimes fanciful, of these implements appear in Chinese decorative arts such as porcelain or cloisonné (Figure 4), and it is possible that such a motif might have spread to Europe through trade in such luxuries. However, the three-dimensional understanding of the object's shape seen in the basket produced under Hoentschel's supervision suggests that an

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1. Georges Hoentschel (French, 1855–1915), designer. "Basket," ca. 1900. Glazed stoneware, H. 19½ in. (49.5 cm). The Metropolitan Museum of Art, Robert A. Ellison Jr. Collection, Purchase, Acquisitions Fund; Louis V. Bell, Harris Brisbane Dick, Fletcher, and Rogers Funds and Joseph Pulitzer Bequest; and 2011 Benefit Fund, 2013 (2013.491). Photographs of Figures 1, 2: Joseph Coscia Jr., The Photograph Studio, MMA

2. View of Figure 1 from above

3. Ritual implement *vajra*. China, Tang dynasty (618–907), 9th–10th century. Gilt bronze, L. 8⅜ in. (21.3 cm). The Metropolitan Museum of Art, Charlotte C. and John C. Weber Collection, Gift of Charlotte C. and John C. Weber, 1994 (1994.605.43) . Photograph: Oi-Cheong Lee, The Photograph Studio, MMA

actual *vajra* rather than a two-dimensional image served as the prototype.

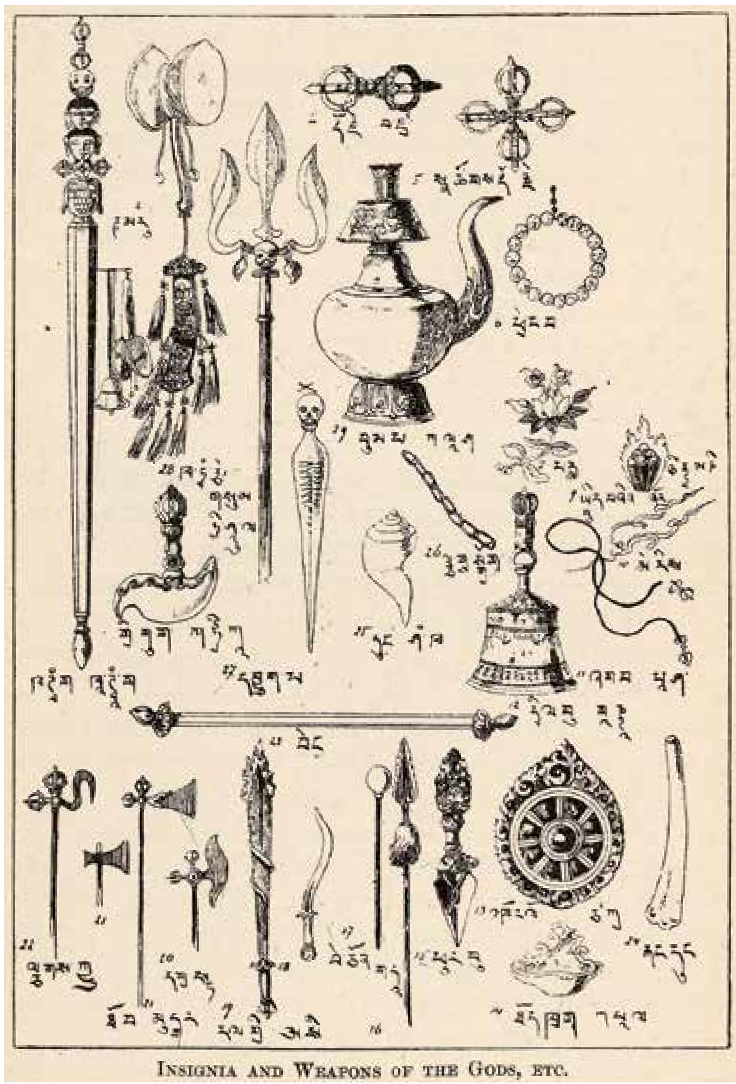
Hoentschel and his patrons were part of a multinational, peripatetic circle, and such an implement could have been acquired, possibly as a souvenir, during travel in Asia. Hoentschel, a collector of Japanese art, worked on the interior design of the Akasaka Palace, built for the Crown Prince in Tokyo between 1899 and 1909, a time when Buddhist art was often available for purchase. Between 1872 and 1874, the Meiji government (1868–1912) actively discouraged the practice of Buddhism by enforcing a policy known as *haibutsu kishaku*, which led to the defrocking of monks and the destruction and/or closing of nearly 40,000 temples. The subsequent dispersal of icons and other temple goods is reflected in the late nineteenth-century burgeoning of Japanese Buddhist art collections in the West.[6]

It is also possible that Hoentschel's introduction to the *vajra* can be linked to the study of Buddhism and, in particular, to the Western fascination with Tibetan Buddhism (also known as Lamaism[7]) in the second half of the nineteenth century. As a primary source for practices no longer preserved in India, Tibet was important to both Western and Asian scholars.[8] Western studies of Tibetan Buddhist belief practices and imagery were published in 1863 and 1895.[9] The latter, a significant early analysis of this particular Buddhist practice, includes a chart of ritual implements showing both a two-pronged and a four-pronged *vajra* (Figure 5). While there is no known documentation attesting to the presence of a *vajra* in late nineteenth-century France, the 1883 guidebook to the collection of the Musée Guimet, the Asian art branch of the Louvre in Paris, describes Tibetan Buddhist sculptures then on view as figures holding such implements.[10]

Given Hoentschel's prominence in cultural and artistic circles and his ties to Asia, it seems reasonable to suggest that he had not only seen a *vajra* but also knew what it meant and how it was used. Moreover, the choice of this rather obscure implement as a prototype for a ceramic piece fits within the parameters of the cultural concerns of the day, particularly in France, where an emphasis on the fin de siecle as a period of both decline and renewal was reflected in the development of a range of philosophical and artistic schools. Chief among them, the late nineteenth-century Symbolist movement in painting, spurred by an earlier flowering in literature, focused on the use of art to reveal the spiritual and the unseen. Symbolism was closely aligned with Art Nouveau,[11] noted for its eclectic use of earlier and imported imagery:[12] the *vajra*, an unusual shape with esoteric associations, would have appealed to artists working in these idioms.

The concerns about stagnation, corruption, social change, and industrialization that inspired artistic movements such

4. Box with design of crossed *vajras*. China, Ming dynasty (1368–1644), late 16th century. Cloisonné, Diam. 8½ in. (21.6 cm). The Metropolitan Museum of Art, Gift of Edward G. Kennedy, 1929 (29.110.90a, b)



5. Illustrations showing *vajras* and other ritual implements. From Waddell 1895, p. 341

as Symbolism and Art Nouveau also spurred the rise of myriad spiritual/occult movements throughout Europe and in the United States in the mid-to-late nineteenth century. It may be worth noting that one such movement, Theosophy, which was established by Helena Blavatsky (1831–1891) and others in London and New York, began about 1879 to focus on Tibet as the source of true or pure knowledge that was purportedly preserved by great souls known as mahatmas and accessible only to initiates.

Although it cannot be proved, it is tempting to speculate that the peculiar "basket" designed by Hoentschel was produced for, or commissioned by, a client interested either in emerging artistic currents such as Symbolism and Art Nouveau, or in obscure spiritual practices.[13] The work might also have been made for an individual engaged in both of these late nineteenth- to early twentieth-century phenomena.

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NOTES

1. For a recent study of the artist, see Kisluk-Grosheide et al. 2013.
2. The *vajra* is known as a *jingang* in Chinese, a *kongoshō* in Japanese, and a *dorje* in Tibetan.
3. Davidson 2003.
4. Buddhism endured in isolated pockets of India's southern and northeastern regions.
5. The types of Buddhism practiced in Sri Lanka, Thailand, and elsewhere in mainland Southeast Asia do not include the use of the *vajra*.
6. One of the best-known examples of this phenomenon is found in the work of the American scholar Ernest Francisco Fenollosa (1853–1908), who played a seminal role in fostering the study of Japanese Buddhist art. Fenollosa's collection was eventually acquired by the Museum of Fine Arts in Boston, where from 1890 to 1896 he served as the first curator of a newly established department of Asiatic Art. See Chisolm 1963.
7. As mentioned earlier, this type of Buddhism, in particular the Gelugpa tradition, was also practiced in Mongolia and China. For reasons of simplicity, Tibetan Buddhism is cited here.
8. Tibet and its religious traditions were simultaneously revered and reviled in Western scholarship and popular culture. See Lopez 1998.
9. Schlagintweit 1863 and Waddell 1895.
10. De Milloué 1883, pp. 69, 71, 74.
11. See Greenhalgh 2000.
12. Japanese woodblock prints, valued for their bold, two-dimensional compositions and strong colors, were among the most influential works of art imported into France at the time and played a significant role in the development of *japonisme.* It is interesting to note that such prints (which never include images of a *vajra*) often illustrated the life of the "floating world," or entertainment districts of Tokyo and Kyoto, areas that were probably similar in outlook and interest to those of the demimonde sometimes featured in Art Nouveau.
13. There may have been a group of potential buyers rather than a single individual who served as prospective patrons for the creation of such an unusual vessel.

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