Small bronzes of the Italian Renaissance were in general deliberately patinated, but the actual nature of these patinas has been given surprisingly little attention. This scholarly neglect must be attributed to the silence of the literary sources. Except for a bare handful of citations such as those of the Paduan Pomponius Gauricus in De sculptura of 1504 and a single sentence in Giorgio Vasari’s Vite of 1550, contemporary documents yield no information as to how organic patinas—frequently called “lacquers” or “varnishes”—were actually created. And although virtually every modern discussion of small Renaissance bronzes sooner or later makes reference to patinas, especially in the contexts of condition and attribution, the actual composition or production of these varnishes is seldom mentioned. This omission is not surprising, given that the patinas are notoriously difficult to describe in words and that even high-quality color photographs can sometimes be very deceptive.

Other issues have posed obstacles to research. First, there is the unavoidable fact that one can seldom be absolutely sure that the patina seen on a bronze is in its original condition. Small bronzes have frequently been considered little more than household furniture and have been routinely waxed and polished like bric-a-brac or even repatinated if they appeared worn or shabby. Other examples leave little doubt that bronzes were systematically repatinated to suit a collector’s tastes. There is also the possibility of deliberate deception.

Studies of patination inevitably lead to the problems posed by repatination. Any serious connoisseur of bronzes comes to know what the surfaces of a familiar sculptor’s bronzes look like, but an unexpected patina can raise many questions. A careful examination of a bronze’s surface, aided by magnification and a truly strong light, when possible, yields important evidence. When bronzes were repatinated, the old patinas were seldom entirely stripped off; many genuine organic patinas are, as will be discussed below, amazingly tough and insoluble. Thus it is often but not always possible to see telltale dark patches of an older patina lurking beneath a newer, more translucent one. These patches generally indicate only that the present patina is not original, and thus have no bearing on a proposed attribution.

The patinas to be discussed in this article, based on research conducted in 1990 and in subsequent years, are entirely organic in nature—that is, composed of natural oils and resins. Most, if not all, Renaissance patinas are organic. In 1990, along with Norman Indictor and Raymond White, both organic chemists, I published a purely technical article on a select group of sixteen small bronzes of the Italian Renaissance in The Metropolitan Museum of Art. We chose bronzes whose patinas—the “lacquers” or “varnishes” so frequently mentioned in the literature—were probably organic, in our judgment, and had a reasonable chance of being original.

The chemical analysis of organic patinas is quite demanding and poses certain difficulties. In order to preserve the integrity of the bronze, samples taken must be minute—micrograms—and merely physically manipulating and storing such samples without loss or contamination requires extreme care. All too frequently, these organic coatings are so oxidized and insoluble that any attempt at chemical manipulation required for their study destroys them. Consequently, the intractable nature of these patinas means that any single analysis may or may not yield useful results. This frequently leads the researcher to pool analytical results from a group of bronzes that appear to have identical
patinas and are all believed to be by the same hand. The hope is that what eludes detection in one example will be found in another, although this goal is not always realized.\(^6\)

The most common color for Italian Renaissance patinas is probably black or near-black. Both the 2001 exhibition *Donatello e il suo tempo* in Padua and the 2008–9 exhibition *Andrea Riccio: Renaissance Master of Bronze* at the Frick Collection demonstrated just how fond the sculptors of the Paduan school were of opaque black patinas (as were, apparently, most sculptors of sixteenth-century Italy north of the Apennines, especially the Venetians).\(^7\) This is not to say that all black patinas were necessarily produced in the same way or that all northern Italian patinas were black.

Both Vasari and Gauricus specifically mention black patinas. The sculptor Severo Calzetta da Ravenna, who worked in Padua and apparently knew Gauricus, also chose black. Upon visual examination, Severo’s *Saint Christopher* (Figure 1) in the Metropolitan Museum shows the remains of a rather glossy black original patina. It is quite thin, not very durable when handled, and consequently has only survived in the deeper recesses of the modeling. This unassuming patina seems to be the rule for Severo’s bronzes and is apparently just a simple drying oil or varnish pigmented with carbon black.\(^8\) Another northern Italian example, also in the Metropolitan Museum, is the *Hercules Shooting the Stymphalian Birds* (Figure 2), frequently attributed to the Venetian sculptor Camelio (Vittore Gambello). It has a similar but more attractive surface. Here we detected a varnish medium composed of walnut oil and a conifer resin.\(^9\) The most common and presumably the least expensive varnish of the Renaissance, referred to as *vernice commune*, seems to have been a drying oil, most likely linseed,\(^10\) which was cooked down with a conifer pitch, probably pine, the most readily available.\(^11\) This addition of pine pitch improved
the gloss, but at the expense of durability. Presumably, the typical black patina of the Veneto consisted of some similar mixture, with the addition of a black pigment, probably mostly lampblack, which has very little bulk and consequently great tintorial strength. The patina of the Severo Saint Christopher may very well be such an inexpensive mixture, although it has not been analyzed.

Severo has an exceptional place in the history of Renaissance bronzes, since he was, along with Antico (Pier Jacopo Alari Bonacolsi, ca. 1460–1528), one of the first sculptors who unquestionably practiced indirect casting and produced replicas of their own models. These replicas provide the opportunity to compare a large group of essentially identical bronzes with one another. At first glance, both Severo and Antico seem to have played similar pioneering roles in the history of patination, since both clearly patinated their statues and in a systematic manner. This data may be misleading, however, since these sculptors’ preferred styles of patination are more readily apparent because of the multiple replicas of their work. There were, no doubt, earlier organic patinas on indoor bronzes (which would include the small bronzes under discussion here), as the documents hint, but virtually none have been systematically investigated.

The black paint patina, frequently rather heavily applied, remained the Veneto-Paduan standard. The Metropolitan Museum’s Madonna and Child by Niccolò Roccacatiliani (Figures 3, 4) is more or less representative of the group. The surface appears somewhat crusty and without any appearance of transparency. Closer examination reveals typical paint film defects such as incipient cleavage and apparently retouched flaking. There is a palpable sense that the patina is an applied layer of fairly irregular thickness that is physically separable from the surface of the metal. Hence, the patina looks just like what it is: a coat of paint. The finish might be appropriate to a larger-scale work, but here, instead of enhancing the piece, it just hides the raw bronze surface, flaws and all, under an opaque film.

This rather indifferent effect was not the case with all black paint patinas, however. The Metropolitan Museum’s glorious Saint Sebastian (Figure 5) by the Venetian Alessandro Vittoria also has a northern Italian–style black patina, but one that is rich and glossy with hints of transparency that enhance the modeling. The coating seems inseparable from the surface of the bronze, like a taut, elastic skin. Vittoria’s manner of patination, if not the color, is certainly parallel to the exquisite patinas of Giambologna (1529–1608) and his school and was probably directly influenced by them. The Giambologna patina was the finish that served as a paradigm for Florentine and much other bronze sculpture well into the eighteenth century.

In our 1990 study we were highly fortunate that the bronzes with the finest, often richly colored patinas—the well-documented bronzes of Giambologna and his circle—yielded the most interesting and revealing data. These included three small bronzes: Saint John the Evangelist, The Risen Christ, and Saint Matthew (Figure 6). All were from a Carthusian monastery south of Florence, the Certosa del Galluzzo, and were firmly documented as being by the hand of Antonio Susini and dating to 1596.

The analytic methods used for detecting the organic components of patinas have distinct limitations. If a specific organic substance is detected, it is almost certainly present, but the converse is not true. If a substance is not detected, it can nevertheless be present. One case in point, among many, is the patina on the handsome bust of Francesco I de’ Medici (Figure 7) in the Metropolitan Museum, which was modeled by Giambologna and probably cast by Pietro Tacca (1577–1640). It has a magnificent organic patina of a striking color like that of a very old Burgundy wine, but chemical analysis only detected “traces of an uncharacterized drying oil.” Resins must be present, and quite possibly an organic colorant (given the patina’s unusual color), but none of these were found by the analytical instrumentation. Again, more recent analyses have demonstrated that what we considered pine resin in 1990 could be at least two different resins: one true pine (the genus Pinus), and the other Burgundy pitch. Burgundy pitch comes not from a pine but a spruce, in this case Picea abies, the so-called Norway spruce. (This distinction proved to be of major significance with translucent patinas, as will be discussed below.) Mastic resin—so frequently mentioned in Renaissance sources—continues to be very difficult to detect, especially if previously heated, and larch resin (so-called Venice turpentine from Larix decidua) is even more so. Although we found larch resin in the patina of the Susini Risen Christ in 1990, the resin was not identified as such in any of the recent analyses of a much larger group of bronzes.

One insistently puzzling fact is that sources of the period frequently do not mention by name varnish ingredients one certainly might expect that they knew. For example, in his Vocabulario toscano dell’arte del disegno, written in 1681, Filippo Baldinucci is explicit in his definition of pitch: “Pitch . . . pine resin drawn from its wood by fire, a black and tenacious substance. . . . There is however another sort that is called Greek pitch, and is straw colored.” Baldinucci unequivocally states that pitch is black pine resin, and pece greca merely the paler, higher-quality variety of it. His definition of the abeti (fir trees) says nothing about their producing any resin, but he does make an interesting observation about the trees themselves: “They may be found in great abundance at Falterona in the Apennines, and on other mountains in Tuscany.” One of the more common trees in the very area he names is the silver fir (Abies alba),

4. Detail of Figure 3

which is the source of the frequently mentioned resin olio di abezzo. With regard to larch, which Baldinucci likewise includes among the abeti, he again says nothing about its resin but does make the teasing observation that the larch is considered miraculously flammable simply because “this tree is bituminous and ignites quite readily.”

If Baldinucci was ignorant—or indifferent—to the use of larch turpentine and even Tuscan olio di abezzo (today called Strasbourg turpentine) in the arts, others were not. For example, the anonymous author of the Marciana manuscript of the first half of the sixteenth century gives a recipe for “a varnish of ‘olio di abezzo’ which dries both in the sun and the shade” and even warns that the material is subject to adulteration, a sure sign that it was valued.

Numerous analyses suggest that—with the exception of the rare chemical patinas—mineral pigments such as ochers or umbers were not present in significant amounts, if at all, in the patinas of the Italian Renaissance. Since the 1990 study, this author has further analyzed numerous Renaissance bronzes using X-ray fluorescence (XRF). While XRF performs only elemental analysis, it does so quite reliably. No more than trace amounts of iron and manganese were ever detected, even in quite darkly colored patinas. Since the two most common transparent earth pigments—burnt sienna and burnt umber—contain iron, and iron plus manganese, respectively, the XRF findings seem to indicate that deeply colored patinas were produced without these pigments.
For further confirmation of this hypothesis, microsamples of typical brown translucent patina were carefully removed from an individual bronze from the Giambologna studio, the Metropolitan Museum's *Hercules and the Erymanthian Boar* (Figure 8), for analysis by energy-dispersive spectroscopy in the Museum's scanning electron microscope. Only minute quantities of iron and no manganese whatsoever were detected.  

Put simply, there seem to be no mineral pigments present in sufficient amount to provide any more than a faint modifying tint, at most, on all the bronzes in the circle of Giambologna, and apparently on Italian bronzes in general. This paucity of mineral pigments leads to a major question: how, in fact, were the warm, dark, but translucent patinas of the Renaissance actually produced?

Vasari's one sentence on patination in the *Vite* is curious, especially regarding "black" patinas: "Some make it black with oil; others with vinegar make it green, and others give it a black color with varnish." Why is black the only color mentioned besides green? Since Vasari, writing in 1550, probably had monumental, frequently-exposed sculpture foremost in mind, one cannot help but think that he meant *osco* (dark) rather than *nero* (black). For example, Italians still frequently speak of wine as being *nero*, not red but black. One thing is certain. Vasari refers to oil and varnish, but like Gauricus, he does not mention *colori* (paints), an omission that tallies well with the hypothesis that inorganic mineral pigments were not used in Italian bronzes in general. Contemporary sources may yield only limited evidence, but recent investigations by this author suggest a very plausible explanation of how a variety of lustrous, dark, translucent patinas ranging from rich warm browns to almost black were produced, at least in the late sixteenth-century circle of Giambologna and his followers in Florence.

The Metropolitan Museum is fortunate in having a number of well-documented bronzes from the Giambologna circle with well-preserved original patinas, all of which are a rich, translucent brown. The most artistically outstanding of these are the three above-mentioned Certosa del Galluzzo bronzes (see Figure 6). As noted, they are from the hand of Antonio Susini, who by 1580 was a major assistant to Giambologna and, by 1600, a sculptor with a studio of his own. Susini was arguably the most skillful bronze chaser and finisher of the Italian Renaissance. *Saint John the Evangelist, The Risen Christ*, and *Saint Matthew*, all of 1596, remained in the Certosa del Galluzzo until the end of the eighteenth century. Their documentation has never been questioned, and all are in excellent condition. Even under careful microscopic inspection, I could not find the slightest evidence of subsequent intervention or any more than a moderate degree of wear. For striking proof of just how pristine these patinas are, one may look at the underside of Saint Matthew's *book—usually hidden by the angel supporting it—and discover what house painters call a "holiday," a spot missed when the patinating varnish was applied (Figure 9). The bare metal is untouched and only slightly tarnished. A fourth bronze designed by Giambologna was also examined: an exceedingly fine *Pacing Horse* (Figure 10). Its patina, while somewhat more worn than the previous three examples, is otherwise unaltered and absolutely typical.

It was already apparent in the 1990 analyses that all the bronzes studied must contain a drying oil, which was positively detected as linseed. The patinas also contained resins. Mastic resin, an exudate from a tree closely related to the pistachio, was detected in the *Pacing Horse*. The horse's patina also contained conifer pitch, then identified as pine, as did *The Risen Christ*, along with the rarely detected larch resin, so-called Venice turpentine. Maddeningly, nothing at all could be found in the patina of the *Saint Matthew*. Despite this apparent heterogeneity, it is clear that all the bronzes have some sort of oil-and-resin varnish—that is, a
varnish made from a resin that had been heated in oil until it dissolved. When traditionally prepared, such a varnish is typically quite dark—sometimes virtually black—and very viscous. Yet if thinned with spirits of turpentine (aqua di ragia), or simply more oil, the varnish can be painted onto a surface in a thin layer that is surprisingly pale—no darker than light amber—and nothing like a dark brown Renaissance patina.

How might the color have turned from light amber to dark brown? As paintings conservators know, thin, pale oil-and-resin films, when sufficiently aged over many decades
or even centuries, may turn quite dark. Thus, it might be thought that patinas, like picture varnishes, were very much lighter when first applied than they are now. This is exceedingly improbable. When Vasari says that the patinas were made to be “black,” surely he does not mean that it would take centuries for them to darken to that color. By the time Giambologna and his circle were fully active in Florence in the late sixteenth century, methods of patination were certainly being consciously chosen not only for their color but also for their translucency and for their uniform appearance throughout whole suites of bronzes. The Certosa del Galluzzo bronzes are all identical in color, deep chestnut brown in the wear-protected areas, while the Facing Horse is only slightly darker in shade. Brown is probably the most common choice for Giambologna school patinas, but there are certainly others: a richer golden brown, a strikingly original clear red, and even a more or less “neutral” amber, among others. The colors, while varied, are not haphazard. Standard formulas and application procedure were obviously used, since strikingly similar patinas could be achieved whenever desired. It is extremely likely, for instance, that the Certosa del Galluzzo bronzes, all from the same commission and of identical color, were all patinated in the same way.

We generally regard patinas as more or less decorative afterthoughts, sometimes chosen with artistic care but otherwise merely a necessity to hide the inevitable patches and repairs subsequent to casting. On at least one occasion, however, the tables were turned, and it was the method of patination that encouraged a major innovation in the mechanical finishing of the cast bronze surface. Patinas, if sufficiently translucent, have not only an aesthetic advantage but an important drawback: especially when new, they can hide little. Consequently, the finish on the underlying bronze surface must be virtually perfect if the final bronze is to appear truly flawless. The use of these translucent patinas in the Giambologna circle eventually led to such innovations as the use of precision screw plugs in the finishing of bronzes, allowing repairs that were essentially invisible even prior to patination. Although the principle of the screw was known from antiquity, no use of screws is known in even prior to patination.

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Many of our original patina analyses of 1990 were too ambiguous, and the number of patina samples tested too small, to do more than suggest how these translucent patinas were produced. Consequently, I resorted to a simple empirical program of experimentation, using materials that we detected in the patinas we analyzed or those that were known by documentary evidence to have been available in sixteenth-century Italy. Some of the materials found by analysis were probably not of the period, such as shellac—still the favorite touch-up medium for bronzes but seemingly not in use until after the sixteenth century. Others, like beeswax and nondrying fats, were definitely in use at the time but only as superficial polishes, since their direct addition to a varnish would only severely impair its quality.

Numerous recipes for historical varnishes are known today, and many more probably lurk in such sources as the exceedingly popular sixteenth-century (and later) books of collected recipes for everything from curing plague to removing grease spots. Even serious collections of recipes, however, such as the early seventeenth-century de Mayerne manuscript on the materials of painting, are far more striking for their repetition than their variety. In any one epoch only a small number of varnish materials are mentioned with regularity. Drying oils (such as linseed and walnut), resins such as mastic, juniper (sandaraca) and other conifer resins and pitches, as well as mineral bitumen (pece di giudea), are some of the materials that appear most often; others are only occasionally mentioned or are obviously fanciful and inappropriate to varnish making. This limited range of oils and resins suggests that the translucent patinas of Giambologna are more likely to have been achieved through the ingenious manipulation of familiar materials than through the use of any unique ingredients.

As important as the ingredients of a varnish is its method of application. It is well known that heat speeds the drying of a varnish film. (In fact, during the Renaissance varnished paintings were routinely exposed to sun to speed their drying.) This simple principle was eventually exploited commercially to create what are now called stoving varnishes for metal objects. The piece was given a coat of an oil-and-
resin varnish, fairly similar to those discussed above, and then baked in an oven. The varnish cured rapidly to give a hard, tough, and very adherent film. Since rapid, high-temperature curing severely darkened the films, these varnishes were usually pigmented to hide that fact.

Although the process was well known by the nineteenth century, this author has not, so far, been able to find a sixteenth-century reference that explicitly describes patinating bronzes by stoving them. Nevertheless, there are some early precedents. Theophilus Presbyter, writing about 1100, describes the sgrafitto decoration of copper blackened by a burnt-on coating of oil. Later in the Middle Ages, linseed or walnut oil was applied to gold surfaces and heated under milder conditions to form thin, russet-colored films that permitted delicate sgrafitto decoration—a technique known as brun émail. Much later, Pomponius Gauricus describes a black patina made by applying a varnish of liquid pitch to the bronze and then exposing it to the smoke of burning lamp straw. This certainly could produce a black, but not very durable, coating. The recipe is nevertheless pertinent because it involves the heating of a bronze surface previously coated with an organic material in order to darken it.

The above-mentioned Marciana manuscript provides an interesting recipe for the application of a varnish to metal subsequently heated to darken and harden it. The varnish recipe, while specifically recommended for protecting ferrous metals (that is, those subject to rust)—namely “arquebuses, crossbows and iron armor”—could just as well been applied to bronze. The varnish is made from a mixture of linseed oil, vernice in grana (juniper resin, the so-called sandaraca), and “clear Greek pitch” all cooked together. The piece is first scraped and polished, and then heated “in a hot oven since that is a better place to heat it than anywhere else.” The varnish is subsequently spread with a piece of wood on the hot metal, until the coating adheres well and gives the piece a “beautiful variegated color.” Since the Marciana author also warns against heating the metal too hot and “frying” the varnish, the temperature need not have been any hotter than the use of a baker’s oven suggests, about 200° C. The author also notes that if you replace the Greek pitch with “naval” pitch, pece navale—no doubt the pece nere of Baldinucci, the byproduct of the production of charcoal from a coniferous wood—he believes it would make the work black (nero). As in the reference in Vasari’s Vite, no pigment is mentioned, and it seems likely that by nero the author only means dark, since even the most “cooked” samples of oil-and-resin varnishes produce only a dark and not a true black color, unless actually carbonized by heat as described by Theophilus. Another intriguing, if somewhat later, source refers to a very similar varnishing procedure. In 1645, Abraham Bosse (1602–1676), the prolific and well-known engraver, published the Traité des manières de graver en taille douce, the first book on the art of etching. The etching ground he recommends consists of heating either linseed or walnut oil with various resins until the mixture forms what he describes as transparent reddish syrup. This varnish, which thickens when cooled, must consequently be spread hot—with the palm of one’s hand, no less—onto a copper etching plate. The horizontally supported plate is then further heated by carefully surrounding it with burning coals until the varnish is hard. This is clearly a recipe for a stoving varnish, if on copper rather than bronze.

There was thus sufficient historical evidence, even if indirect, to justify my empirical trials. These included many false starts and blind alleys, as well as the more fruitful and informative experiments that will be described here. I experimented with baking varnishes of known composition onto thinly rolled, rectangular test pieces, so-called coupons, most of which were a genuine 8% tin bronze. The baked varnish samples were shared with Václav Pitthard, conservation scientist at the Kunsthistorisches Museum, Vienna, who conducted analyses of them. The information from this investigation increased our knowledge to the point of warranting publication: a joint study of these patinas of known composition is currently in press.

In one instance I prepared a varnish by cooking together equal weights of linseed oil and mastic resin until the resin totally dissolved. I then diluted it with spirits of turpentine and applied it to a coupon of tin bronze. After it was allowed to dry to tackiness (to prevent it from running or frilling when subsequently heated), the sample was placed in an oven at 130˚ C (266˚ F) for three hours. The resultant stoved varnish film was a clear pale amber (rather than dark in color) that was hard, tough, and adherent. It was also resistant to solvents, swelling but not dissolving when soaked in commercial paint stripper, and even the solvent-swollen varnish film could only be removed by rather vigorous scraping. The sheer physical durability of these stoved varnishes is certainly one of the reasons for their use as bronze patinas. The next varnish trial was similar to the first but with the addition of a conifer resin, in this case Burgundy pitch, chosen in the hope of producing a darker color. After a number of trials with the Burgundy pitch it became apparent that the best color was developed after six hours at about 150˚ C (302˚ F). In tone and luster the resulting patina was strikingly similar to the handsome translucent brown ones of the Giambologna circle discussed above, especially if a little lampblack was added (Figure 11). It should be pointed out that whereas Burgundy pitch worked well, trials with various other resins, especially ordinary pine resin, did not yield colors resembling Giambologna’s patinas or, indeed, those of any Renaissance bronzes.
Other trials with this varnish combination of mastic and Burgundy pitch revealed that more pitch and high temperatures favor darker colors, but too much pitch gives a brittle film of inferior quality and a tendency to frill and run during stoving. Linseed and walnut oil seem to work equally well, and the larch resin (Venice turpentine) detected in the Certosa del Galluzzo Risen Christ can at least partially replace mastic, though to no striking advantage. The possibility of an addition of bitumen is somewhat more problematic. Bitumen, also called asphaltum, is a natural petroleum mineral, brownish black to black in color and with a glassy fracture.\textsuperscript{54} It was well known in the Renaissance as pece di giudea, Judean pitch, so called because lumps of it were found floating in the Dead Sea. It was routinely confused, and is sometimes still, with pece greca, “Greek” pitch, a very different resinous material extracted from various species of pine. Bitumen can be obtained from a great variety of sources and with differing qualities, but only a few types are now available commercially in small quantities. Of these, the easiest to obtain today is the mineral pitch called Gilsonite\textsuperscript{55}, which comes from Utah and was hardly accessible in Renaissance Italy. I did, however, try making a varnish of it with oil, mastic, and pine pitch. The results were unsatisfactory. The Gilsonite, though fairly soluble when hot, rapidly came out of solution as the varnish cooled. Seeking to find a sample of bitumen more geographically appropriate, I managed to track down a sample of genuine Dead Sea pitch, the true pece di giudea.\textsuperscript{55} The results were scarcely more successful. Bitumen appears in a large number of old recipe collections as both a varnish and a colorant. If dissolved in spirits of turpentine, it gives a dark but perfectly transparent brown lacquer of an attractive shade. Unfortunately, although bitumen appears to be a glassy solid, it actually behaves more like an exceedingly viscous liquid and flows slowly, even in the cold. This cold flow produces traction fissures in the varnish film with frequently disastrous results. Although we found bitumen associated with varnish films, I suspect that some of it was applied later, and if any patinas did originally contain substantial amounts of bitumen, they simply have not survived. Adding just a small amount of it to the basic resin mixture, however, even to the simple oil-mastic varnish, produces an interesting range of warm brown colors after stoving, without seeming to impair the quality of the film (Figure 12).

Two other conspicuous patination types are found among later Florentine bronzes: clear red and golden brown. Unfortunately the Metropolitan Museum does not own typical examples of either, so no samples were analyzed in 1990, but more recently I conducted trials to reproduce both colors. A translucent red patina, which first appears in the Giambologna shop, could only have been produced by an organic colorant that was either soluble in the varnish or introduced as a transparent lake, since there were no inorganic pigments available with both the right color and sufficient transparency. In the old sources, two organic materials are routinely cited as producing clear deep-red varnishes. One is “dragon’s blood,” which despite its fanciful name is merely a wine-red resin obtained from a species of palm, Calamus draco, and the other is alkanet, a root extract from a common herbaceous plant, Alkanna tinctoria. In my trials both dissolved in the pale mastic varnish but almost immediately faded on stoving. Since both materials are known to fade rapidly when exposed to light, even at room temperature, they were hardly serious candidates to begin with.

The color of the Florentine red patina most strongly suggests the presence of the dyestuff madder, Rubia tinctoria, which, after indigo blue, was the most light-stable organic colorant known in the Renaissance.\textsuperscript{56} Madder is also very stable when heated. Although the synthetic equivalent of the major component of madder is still widely available as alizarin crimson, I prepared a genuine madder lake from dried madder roots and alum, and then ground the lake in pale mastic and oil varnish. The dry alumina lake proved extremely difficult to disperse in varnish, but after low-temperature stoving, the color was surprisingly convincing, if slightly too bright. Using modern alizarin lake, I obtained an even better match, possibly because the less light-stable component of madder, purpurin, has faded away since the Renaissance.\textsuperscript{57} Even more likely, the difference in color change was owing to a deliberate addition of a black pigment as one modern trial using madder and a little lampblack suggests. Figure 13 shows four samples of red patinas,
all prepared with the mastic varnish and stoved at 130° C. The sample on the far left is the pure madder lake I prepared, applied somewhat too thickly. The next is the same madder lake more thinly applied with a bit of lampblack added, while the third is synthetic alizarin crimson tinted with lampblack. Even minimal amounts of essentially transparent pigments such as lampblack could make noticeable differences in tonality while barely affecting clarity. Speculating that the secret of the rich patina of the Giambologna Medici bust discussed earlier (see Figure 7) might similarly be the addition of Burgundy pitch to a madder varnish that was subsequently stoved at higher temperatures, thus making the color darker and browner, I used this protocol to make a sample that was surprisingly convincing (see Figure 13, coupon on far right). Unfortunately, madder has persistently escaped detection in chemical analysis of all red patinas, even in the samples that I prepared myself from genuine madder root.58

The golden brown patina, as seen on the signed David with the Head of Goliath by Giovanni Francesco Susini in Vienna (Figure 14), to give but one example, has so far eluded my attempts to reproduce it. Stable yellows, especially transparent ones, were notoriously deficient in the Renaissance palette, and the few transparent yellows that were available, such as aloe59 or even gamboge, proved useless in the trials. The golden brown patina otherwise may be a varnish tinted with a small amount of some variety of bitumen, but only further analysis will tell.

Varnishes applied cold to paintings definitely darken with time, frequently severely; why not those on bronzes?

Indeed, patinas on bronzes do apparently darken, but seldom very severely. My research leads me to propose an explanation. Consider a small group of Giambologna bronzes that do not have any of the typical Giambologna patina colors—namely, those in Dresden. One is the Mercury (Figure 15), well documented as having been sent by Francesco I, grand duke of Tuscany, to the Dresden court in 1586.60 The patina is in superb condition, as one might expect of a bronze that has been in the same collection for more than four hundred years. It certainly appears to be original. Furthermore, the color seems to be deliberate; other Giambolognas in Dresden have the same hue. The color of this patina is not brown—neither chestnut nor
golden—nor is it red, but a clear, now darkish amber. I suspect—granted, without chemical analysis—that it is a stoved varnish of the typical type but prepared without the addition of either a labile conifer resin such as Burgundy pitch or an organic colorant such as carbon black or madder. It appears quite similar to the clear varnish I prepared using only linseed oil and mastic resin, which when stoved produced a pale amber shade. If my speculation is correct, the patina has darkened somewhat on aging but certainly not dramatically. A similar varnish applied cold would have darkened far more: apparently, the heating of a fresh varnish film during stoving speeds up the oxidation and polymerization of the film so much that very little unreacted material is left to darken with time.

The pale amber patina of the Mercury, like those on the other Giambologna bronzes in Dresden, seems to have been intended as a relatively colorless, protective varnish designed to display the luxuriously chased metal surface underneath it to the greatest effect. In bronzes with such a patina, the
need for near-invisible screw plugs is evident. If baking bronzes to patinate them seems a little far-fetched, there is convincing analytical proof of stoving. Mastic, a very common and versatile resin, is usually easy to detect in aged oil paint films and picture varnishes, all of which were obviously applied cold. It does not appear to be readily detected in organic patinas on bronzes, however, even on the bronze coupons that I prepared and stoved with a varnish containing at least 25 percent mastic resin. Since mastic resin can be detected readily in unstoved picture varnishes while the heated mastic in stoved patinas only can be detected with difficulty, if at all, it is reasonable to assume that many organic patinas on bronzes were indeed stoved. The discovery that many of the conifer resins previously thought to be pine might equally well have been Burgundy pitch similarly argues for stoving. In some of the stoved samples that I sent to Vienna for analysis, Burgundy pitch could be distinguished from mere pine resin, but as discussed above, this is not invariably the case. Apparently the major detectable components in both pine resin and Burgundy pitch are quite similar, and it is only the accessory components that distinguish them. If for some reason only traces of unaltered resin are left on a bronze, it may be impossible to detect those accessory compounds, so that the Burgundy pitch remains analytically invisible. Burgundy pitch may well be undetectable for the same reason that mastic is: stoving at high temperatures.

Nevertheless, Burgundy pitch can unquestionably be detected in the dark brown patinas of at least five of the Giambologna and Susini bronzes in the Kunsthistorisches Museum in Vienna. These include such Giambologna masterpieces as Hercules and the Erymanthian Boar and Hercules and Antaeus (Figures 16, 17). Thus whether or not Italians verbally distinguished between pine resin and Burgundy pitch Giambologna and his circle clearly used the latter in their brown patinas. While we cannot detect Burgundy pitch in all of them, this may be simply due to the limits of the analytical methods employed.
Apart from the question of how the typical Giambologna brown patina was actually produced, one may ask why Renaissance sculptors evolved a special technology for patinating their bronzes. They could easily have used the same paints that contemporary artists were using and produced the same range of color and translucency. The simplest answer is that they did use paint, in most cases. There is absolutely no evidence that large indoor sculpture was given anything more than what was essentially a coat of paint. Furthermore, it is highly unlikely that most of the small bronzes with opaque black patinas ever saw the inside of an oven, to judge from their usual condition. Why, then, were the complex stoved-varnish patinas necessary at all?

For the answer, one may look to the fact that small bronzes were intended to be touched and handled as part of the experience of collecting them, viewed within the context of the aspirations of the Medici. Ordinary oil-based films take a certain time to dry to the touch, but they can require months to harden sufficiently to resist the constant handling that Renaissance bronzes received. Before the routine use of modern drying agents—siccatives such as manganese and cobalt—thorough drying (even of relatively thin films) inevitably took much longer. Stoving allowed a bronze to be patinated and leave the studio as soon as a day after it was cast and chased. Perhaps this is how stoving originated—simply as a method of speeding the drying of an oil or varnish film on a metallic surface. It may have been realized only later that, with the appropriate choice of varnish resins, temperatures, and accessory colorants, one could produce a range of especially attractive and extremely durable patinas.

Some tentative general conclusions can be drawn from the research presented here. The majority of Italian small bronzes had patinas based on oil-and-resin varnishes or simply a drying oil, possibly with some varnish added. On those of northern Italy the varnish was apparently applied cold and commonly pigmented to the point of opacity with carbon black. These patinas are frequently not very durable, since they are essentially only paints. Colored translucent patinas were apparently developed and certainly more favored in central Italy, especially in the Florence of Giambologna. These too were oil-and-resin varnishes but were heated after application. This heat treatment greatly improves the durability of patinas. They may gradually wear, but generally do not chip or flake. Furthermore, by selecting the proper resins one could obtain patinas ranging from a relatively uncolored transparent film to richly translucent browns, without the use of any mineral pigments. Carbon black could be added in relatively small amounts to adjust the shade, and also a red transparent pigment, very likely madder lake. Otherwise, the usual painter’s palette was ignored.

In contrast to Florentine practice, the materials used for the opaque black patinas of northern Italy did not have to be chosen with much discrimination, nor, in fact, were they. As seen in the bronzes by Roccagagliata and Vittoria (see Figures 3, 5), the results in the north were highly variable. Translucent Florentine-style patinas were much more demanding because specific resins were needed. It remains a puzzle how Burgundy pitch was distinguished from pine pitch, since the materials are close in appearance and little if any verbal distinction seems to have been made between them in the Italian literature; in fact, they both may have been considered pece greca. It is worth noting that whereas Baldinucci, writing as late as 1681, makes no mention of any resin being extracted from the abeti, Bosse in 1645 mentions poix de Bourgogné as a possible substitute for Greek pitch. The fact that Burgundy pitch was unquestionably known and used in France but apparently not even mentioned by Baldinucci more than thirty-five years later suggests that Giambologna may have learned of Burgundy pitch and its properties either when he was still in France or while being trained in Antwerp, years before his Florentine career.

Although the scientific tools now at our disposal are at least occasionally able to reveal that the Florentines used Burgundy pitch, in most cases it remains impossible to distinguish Burgundy pitch from other conifer resins. The most plausible assumption is that all of the translucent chestnut browns of the Giambologna circle, with their striking consistency of color, were patinated in the same way using Burgundy pitch, but this question will only be firmly resolved when scientific methods are found to detect this resin infallibly.

Most sculptors, at least those satisfied with black, essentially opaque patinas, probably used whatever resin was at hand, even if only out of ignorance of precisely what was being sold to them. After all, virtually any sort of paint vehicle would do, even a simple drying oil. It was quite a different matter if one was aiming for translucent patinas of a specific, reproducible color. Then, apparently, the resin used mattered very much, and likewise the specific means of color development through stoving. I believe I produced a convincing imitation of an unpigmented chestnut brown patina in the Florentine manner by using a specific resin, Burgundy pitch, in a varnish that was applied and then stoved. Although I tried a great many other resins, oils, and heating schedules, I certainly did not try them all, nor could I; there are simply too many possible combinations. Other methods may very well exist, but it is unlikely that they will be found without further analytical advances. Considering the present analytical situation, where Burgundy pitch and mastic can only be fitfully detected and larch resin hardly ever, further progress remains unlikely without an analytic breakthrough.
Nevertheless, the research described here has shown that major thought and experiment were devoted to patinating bronzes in a rich variety of colors. While such a patina may simply have been an aesthetic choice, it certainly also added to the effect of the bronze as a precious object, as if to make it especially worthy of princes. It is not surprising that ever-ambitious Medicean Florence was the home of these truly deluxe bronzes, distinguished not only by their inherent sculptural qualities but also by their flawless yet durable patinas, which enhanced their beauty and social prestige. Although time has dimmed some of their luminosity, the patinas of Giambologna’s most exquisite works still frequently display some of the brilliance of gold glimpsed through richly colored enamel. This visual parallel with goldsmith’s work is unlikely to be accidental. Frequently intended as gifts to other princely collectors, bronzes were conceived as tangible representatives of Medicean courtly ideals, taste, luxury, and royal largesse. A Giambologna bronze was exquisitely finished to meet the demands of Medici ambitions, and because of the fortunate durability of their patinas, some of these sculptures remain well preserved today as lasting reminders of the court’s splendor and munificence.

NOTES

1. Bronze is not used here solely in its strictest sense as an alloy of copper and tin; instead, for convenience and by longstanding convention, it denotes all of the alloys containing varying mixtures of copper with tin, zinc, and lead that were used for sculpture in the Renaissance. As far as I have observed, the actual composition of a “bronze” appears to have little influence on the formation of organic patinas, either in their intrinsic color or in their ease of application. Of course, since the color of the substrate metal varies considerably, from ruddy bronze to brassy yellow, it certainly can influence the overall color of the bronzetto. Nevertheless, this influence is usually not very dramatic unless the patina was pale and translucent to begin with or, much more commonly, if the patina has worn away.


3. For example, as the opaque black patina wears away on a bronze, the metal is gradually exposed and subsequently tarnishes. This tarnishing, plus the accumulated debris of centuries of handling, produces the dark brown color frequently referred to as a “natural” patina. Obviously, there is never any substitute for direct inspection.

4. A small but significant group of bronzes was chemically patinated, namely those of Antico (Pier Jacopo Alari Bonacolsi of Mantua, ca. 1460–1528) and his circle. The author hopes to write about these chemical patinas in the near future.


8. “Carbon black” here simply means any traditional pigment whose major colorant is carbon—in most cases either lampblack (the soot from burning oil or resin) or so-called “ivory black” (well-charred bones, ground fine). Modern carbon black is actually thermally decomposed natural gas.


10. Usually either linseed or walnut oil was used, but the more expensive walnut oil seems to have been considered superior because it yellowed less, or at least so Vasari said (“il noce è meglio, perché ingiallo meno”). Vasari (1550) 1966–76, vol. 1 (text), p. 103. Of course, yellowing would have been an irrelevant problem in a black varnish.

11. The Marciana manuscript describes a “common” varnish of clear Greek pitch and linseed oil cooked with alum as being the best (vernice ottima commune) and clearly implies it is being made specifically for sale, since instructions are given for cheapening it (per vendere con più guadagno). Furthermore, if made with black pitch—no doubt cheaper still—it would be good for “sword pommels, spurs and such” (pomi di spade et speron e similai)—i.e., metals, especially ferrous. See Merrifield 1967, vol. 2, p. 637, no. 405. The significant Marciana manuscript was originally published by Mary Philadelphia Merrifield, in 1849, but she only included the recipes pertaining to painting and varnishes. As Merrifield notes (1967, vol. 2, pp. 603–6), the manuscript was written in Tuscan dialect by an author familiar with artists active in Florence and also in Rome at least until the sack of 1527.


14. The bronze commission was actually given to Giambologna, but with the stipulation that Susini was to do the actual work.

15. All of the chemical analyses mentioned in this article were done by gas chromatography/mass spectrometry (GC/MS) and/or pyrolytic GC/MS.


17. We originally proposed in 1990 that the red was the result of an inorganic colorant, but now I am not nearly so sure. It is quite difficult to imagine any inorganic colorant then available that could have produced that shade and also be translucent. In any case the color can be quite closely matched by adding madder lake to standard Burgundy pitch, mastic and drying oil varnish before applying it to a bronze coupon and baking it. (see Figure 12, first coupon from right).


19. The common Italian name for this species is abete rosso thus misleadingly suggesting that it belongs among the firs.

20. The terms resin, turpentine, and pitch are used rather loosely. A “turpentine,” as in the Venice or Strasbourg varieties, is more properly an oleoresin, a semifluid exudate containing both a volatile fluid component and a solid resin. Thus, pine oleoresin is usually referred to simply as “turpentine,” the volatile component as “spirits of turpentine” (Italian aqua di ragia), and the resinous portion as “rosin.” (In popular usage, however, spirits of turpentine—until recently a common paint thinner—i.e., confusingly referred to merely as “turpentine.”) Pine pitch is a tarry substance obtained by strongly heating pine wood and is dark in color, the so-called pece nera or navale, while pece greca seems, in general, to have been simple pine oleoresin—turpentine in the strict sense—or even solid pine resin.

21. Pitthard et al. n.d. (forthcoming). This publication also describes many more technical details of how I prepared the varnish coupons otherwise irrelevant to my present argument.
22. Baldinucci 1681, p. 119: “Pece...Ragia di pino tratta da...Legname col fuoco e...Eccene d'una...che si chiama pegreca, è di colori capellino.”

23. Ibid., pp. 1–2: “Se ne trovano in gran copia della Falterona negli Appenini, e in altre montagne di Toscana.”

24. See, for example, Merrifield 1967, vol. 2, p. 635, no. 45. Merrifield gives all of the recipes relating to painting and varnishes in the Marciana manuscript, both in the original Italian and in English.

25. It is actually related to cypress. Larch apparently does not grow in the Apennines but in the Italian Alps—hence the term Venice turpentine, presumably because that city is the natural outlet for such Alpine products.


28. Not only is this bronze, formerly in the Linsky Collection, a fine example of the subject, but it has an especially well preserved patina without any signs of subsequent intervention. Mark Wyppyski of the MMA’s Department of Scientific Research has analyzed the two samples. His internal report states: “The first one, from the left index finger, contains large amounts of copper, sulfur and chlorine, presumably from corrosion products, as well as small amounts of magnesium, aluminum, silicon, potassium, calcium and iron. The second sample, from the hog’s bristles, contained much less copper, sulfur and chlorine, and appears to be mainly organic material (carbon and oxygen).” I did also see some magnesium, aluminum, silicon, potassium, calcium and iron in this sample, but I do not think these are present in large enough concentrations to qualify as an intentional additive to the patina. I also checked for the presence of manganese [in the patina] but did not detect it in either sample.”

29. This cannot be true of every Renaissance bronze, since there must be at least some original mineral-pigmented organic patinas among the multitude of bronzes I have not examined, even after excluding all the ones that have clearly been repatinated. But it certainly seems to be a reliable generalization.


31. It should be pointed out that the Giambologna Hercule and the Erymanthian Boar mentioned above has an identical sort of “holiday” directly behind the head of Hercules. If, as will be discussed, Giambologna’s patinas were essentially colorless varnishes when applied, these lapses in patination would not have been obvious. Even now, when covered with dust and tarnish, these patches of bare metal surface hidden in obscure corners are easy to miss.


33. For early precision-cut screws, see Vincent 1989.

34. For instance, we originally identified virtually all conifer resins as pine—there was a single occurrence of larch—but now Burgundy pitch can sometimes be distinguished, as will be discussed below. See Pitthard et al. n.d. (forthcoming)

35. Probably the best known of these is the Segreti of “Alessio Piemontese” (apparently the pseudonym of the humanist Girolamo Ruscelli), first published in 1555 and in sixteen further editions by 1599. For these, see Eamon 1994, pp. 134–51. There are no doubt pertinent recipes to be found in this vast accumulation of heterogeneous material, but its bulk and inaccessibility (no modern reprints exist of the original texts) have prevented investigation.

36. Théodore Turquet de Mayerne (1573–1655), “Pictoria Sculptoria et quae Subalteream artem, 1620,” British Library, MS Sloane 2052, reproduced in its entirety by Ernst Berger (de Mayerne 1901, pp. 92–365). De Mayerne was a highly distinguished physician who, among others, served the Stuart kings and was a friend of Rubens.

37. Certain varnishes are specifically mentioned as being capable of drying in the shade. All of these appear to be so-called spirit varnishes, solutions of a resin in a volatile solvent (such as gum benzoin in alcohol) that dried simply by evaporation. Merrifield 1967, vol. 2, pp. 628–29, no. 394.


39. The recipe comes from Pliny, but was apparently somewhat misunderstood; Gaucinus confuses pine pitch with Pliny’s bitumen. See Gaucinus (1504) 1969, p. 228n38.

40. Nineteenth-century sources describe other methods of patinating bronzes by smoking them. In fact, one method is even described as “the true Florentine patination” (“il veritable bronze florentin”); Garnier and Chouraqt 1978. The bronze is exposed to the fumes of horn filings. The authors specify stag horn, but I tried this method using ox horn, heated to smoking. It indeed produces a lustrous, adherent, varnishlike layer of a very dark brown to black color. The colored layer turns out to be a copper sulfide, the mineral chalcocite, as identified by X-ray diffraction. Totally opaque yet exceedingly thin, the patina is quite unlike any actual Renaissance patina I have ever seen. Various other methods are described in the nineteenth century as being specifically “Florentine.” The most common involves painting the bronze with a suspension of an iron oxide such as ochre—frequently mixed with graphite—and then heated to about 150° C. Presumably this method produces a layer of metallic oxides that remains thin and thus adherent. See, for instance, Hiorns 1920, pp. 99–104. Conceivably any of these processes—exposure to smoldering straw or sawdust, sulfiting with the smoke from horn (or leather, which works just as well), controlled heating under a layer of ocher—might have been known in the sixteenth century, since they are all within the range of Renaissance technology. Examples may yet be identified, perhaps previously mistaken for “natural” patinas.

41. Among the artists named by the author of the Marciana manuscript as sources for various recipes, the latest in date is Jacopo Sansovino.


43. Ibid.: “olio di seme di lino libre 2. vernice in grana libre 1, pece grecha chiara oz 2” (“Two pounds of linseed oil, one pound of varnish in grain [juniper], two ounces of clear Greek pitch”) Even assuming a twelve-ounce pound, there would still be only one part of “clear Greek pitch” to six of juniper resin, a rather small amount.

44. Ibid.: “un forno caldo perche fa meglio che scaldarlo altrove.”

45. Ibid.: “un bello colore cangiante.” Cangiante is here perhaps best translated as “variegated” or even “mottled,” considering that the varnish is applied with a stick.

46. I heated a heavy layer of varnish made of linseed oil, Burgundy pitch, and mastic for more than three hours at 200° C and produced a very deep, clear, ruddy color, quite handsome but certainly not black. Of course, if heated to virtually the point of combustion, it would have charred to black, but probably no one today would describe the results as a “patina.”

47. For the original Bosse text of 1645, with considerable added comments and annotations, see Bosse 1758.

48. Ibid., p. 3. It should be noted that in the recipe Bosse writes that poix de Bourgogné (Burgundy pitch) may be substituted for poix greque (Greek pitch).


50. Ibid., pp. 17–18. Bosse was describing what he called vernis dur, a hardened oil-resin ground presumably long in use for executing
etchings in the manner of burin engraving. Modern “hard ground” etching resist is a softer wax-resin mixture frequently attributed to Rembrandt or Callot, each of whom certainly used but did not invent it.

51. Pitthard et al. n.d. (forthcoming). I must especially thank Claudia Kryza-Gersch of the Kunsthistorisches Museum for first suggesting, and then arranging, this collaboration.

52. Lampblack is pure carbon with an exceedingly small particle size that renders it quite transparent at low concentrations and difficult to detect by technical means.

53. I could scarcely try every possible combination. Besides the sheer number of trials necessary, I was deterred by the fact that trustworthy samples of many of the natural resins are no longer commercially available. After finding genuine Judean pitch and reliable juniper resin, I was stymied by olio di abezzo (Strasbourg turpentine). The difficulty of finding unadulterated genuine materials is not a new one: many of the old recipes warn of the problem.

54. It is not to be confused with coal tar or even the petroleum pitch produced artificially as a residue from the distillation of crude oil.

55. I thank Dr. Jacques Connan of Elf Exploration Production, France, who years ago supplied me, a total stranger, with genuine Dead Sea pitch merely on the basis of an e-mail request.

56. There are actually two colorants in madder: alizarin and purpurin. Alizarin is the more light-stable and is available as “alizarin crimson,” a synthetic but otherwise chemically identical dye precipitated with alumina hydrate to form a so-called “lake.” Natural madder lake can usually be distinguished from alizarin crimson since purpurin, only present in madder, fluoresces a bright orange under ultraviolet light. Curiously, the natural madder lake—prepared by the author from genuine madder roots and alum—fluoresced typically, but when dispersed in mastic-and-oil varnish and stoved, it did not.

57. See note 56 above.

58. Pitthard et al. n.d. (forthcoming)
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