

LEONARDO DA VINCI

*“La Bella Principessa”*

THE PROFILE PORTRAIT OF A  
MILANESE WOMAN

MARTIN KEMP AND PASCAL COTTE  
with contributions by  
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## 8. *Fingerprint Examination*

PETER PAUL BIRO

As has been shown in the preceding chapters, Lumière Technology's multispectral imaging system is shedding new light on many aspects of art works we would normally not see. My own laboratory in Canada is equipped with an equally groundbreaking imaging system, which provides images also at unprecedented resolution. But why do we need all this new technology? Why build new cameras that can examine pigments, even at a molecular level, and see things the human eye would not experience without them?

Few today have not watched popular detective dramas on television or in the cinema and marvelled at what intrepid forensic specialists can do with their sophisticated equipment. Alas, much of what we see is pure fancy and make-believe, skewing the viewer's perception of what forensic science really is. If only things were so simple in real life... Nevertheless, the forensic sciences and technology have begun to make a positive contribution to the study of works of art, complementing the art-historical analysis of the image.

The word "forensic" in the strictest sense refers to the application of scientific methods to questions arising from crime and litigation. For some two decades now, I have been applying forensic methods to matters of attribution of works

of art—not who committed the crime but who committed the painting or drawing! My background is primarily in art conservation, microscopy, digital imaging and image processing, disciplines that are essential if one is to examine works of art or tackle questions of authorship from a forensic viewpoint.

Traditionally, art has been authenticated by provenance and/or connoisseurship. Provenance, simply put, is the historical paper trail of the work's travels from the artist's hand to its present owners. Even major works preserved in museums are often missing important parts of their pedigree, and some lesser works lack provenance altogether. Connoisseurship relies on an expert's close comparisons of a given work with closely related examples in order to discern where it "belongs" in terms of place, date and maker. By applying forensic methods, the process of attribution takes a novel and remarkable turn: it can use the evidence of fingerprints to trace a work of art back *literally* to the artist's hand. In effect, when the paper trail is missing or broken, forensics can at times fill in the gap.

The presence of fingerprints on paintings is more common than previously recognized, possibly because they are hard to spot due to their size or faintness. Even when they are visible, few in the art world have known how to utilize them, lacking exemplars for comparison. This is now changing rapidly. In my own work over the past two decades, I have been building the beginnings of a database of artists' fingerprints.

## **Introduction**

Before discussing the prints found on the new portrait, it is useful to provide a very basic, but brief introduction to fingerprints and the process of acquiring and comparing them.

Fingerprints are the contact marks or impressions left by the “ridge skin”, in other words, the ridges on our fingers and hands. If a substance such as ink or paint coats the finger, it makes what is generally referred to as a “stamped impression”. When a finger exerts pressure on a soft, pliable surface (e.g. putty or wet paint), it leaves a “plastic impression”. Both types of ridge skin mark can, of course, occur on the same object.

In general, fingerprint examination is the observation and comparison of visual information left by the ridge skin. When comparing fingerprints, the examiner looks for common features such as ridge endings, divisions, crossings, etc. The utility of the process is based on the fingerprint community’s assertion that the probability of two individuals having the same fingerprints is nil. In fact, in the century or so that fingerprinting has been used by our courts of law internationally no such coincidence has ever been demonstrated.

For two fingerprints to “match”, they must be compared in accordance with basic principles, such as being reproduced to the same scale and presented in the same orientation. Once that is achieved, three levels of possible correspondence are examined. Level 1 is described as the general flow of ridges. If, for example, one print displays a delta and the other shows a series of parallel ridges, a “no match” is declared. Loop, arch, whorl and delta (the roughly triangular configuration of ridges that can arise between series of curves) are terms used to describe Level 1 patterns. The purpose of a Level 1 comparison is to eliminate unlikely contributors and to narrow down the possible ones. Level 1 detail is not sufficient to individualize by itself. Twins, for example, often have highly similar prints, but when examined in finer detail they do not match.

If two prints correspond in Level 1 detail, then the examiner proceeds to look for Level 2 detail. Level 2 details are the bifurcations, crossovers, ridge endings, etc. “Characteristics” are essentially deviations in a ridge’s path. The most basic ridge is the “dot”, also called an “island”. If the dot is elongated sufficiently, it becomes a “short ridge” with two “ridge endings”. When a ridge’s path divides into two branches, it is called a “bifurcation”. When two bifurcations appear on the skin overlaying each other, they are called a “trifurcation”.<sup>114</sup> If there is sufficient Level 2 agreement—where the same characteristics are found in the same relative position—the examiner can determine that to be a match.

Lastly, Level 3 detail is considered to be the minutest aspect of ridge impressions, such as the outline of the ridges and placement of sweat pores. If the examiner determines that either print being compared lacks sufficient detail, he or she can deem the comparison attempt to be “inconclusive”. The number of corresponding features necessary for a match is not uniform from country to country and is generally left to the examiner’s discretion and expertise.

### **Fingerprints on works of art**

In the context of artistic creation, there is now a growing body of evidence of the use of fingertips to complement the brush. An example is my ongoing study of the works of J.M.W. Turner in the Turner Bequest at Tate Britain, comprising some 30,000 pages of notes, sketches and watercolours. The examination of around 3,500 pieces to date has yielded about 1,000 images of fingerprints, often recording multiple prints. My current estimation is that the database contains some 3,000

distinct fingerprints, occurring on roughly 10% of Turner's output on paper. These prints fall into two main classes: accidental and intentional, both important.

Those like myself who are searching for and examining fingerprints on works of art face challenges that are not experienced by fingerprint examiners in the world of law enforcement. With art works, for instance, it is not possible to use the myriad destructive detection processes employed in crime labs, such as staining, fuming and dusting, which often sacrifice the object for the evidence. Moreover, we are not looking for latent prints on works of art—the kind we leave on a drinking glass or whatever object we touch. Latents are left with the secretions of our sweat glands and they break down fairly rapidly. Although some methods of staining can develop latents as old as 20 years, they involve destructive processes that cannot be applied to a work of art.

Besides knowledge of fingerprint examination techniques, the forensic art specialist must thus also have an explicit understanding of:

- The media and techniques of the creative process;
- The conservation history of the art work;
- The context of the print and its relationship to the work;
- The material composition of the fingerprint impression;
- The intended function of the fingerprint.

Generally speaking, the approaches available to the forensic art specialist are good lighting, imaging, digital image processing, and visual and instrumental examination. Each one of these can be highly complex as well as experimental. They need to be implemented with the object's conservation needs in mind, such as the light levels received during examination

and imaging, the ultraviolet content of the illumination, the temperature, and its physical handling, to mention just a few. Often prints are discovered on images that were taken with another purpose in mind, resulting in less than ideal resolution and lighting. The presence of fingerprints found in layers below the visible surface of a painting presents further challenges, solved by mapping the entire surface in infrared or with radiography and producing images of sufficient resolution.

When working with fingerprints on paintings, the crucial question is: whose print is it? The artist? An assistant? A restorer? Obviously, it is important to recognize and differentiate between the original pictorial layer and later retouching. The prints that interest us are clearly those left by the artist during the creation of the painting or drawing (i.e. those preserved in the original media). Such evidence has temporal ramifications—the print having been sealed in time, a veritable time capsule from when the picture was executed.

Over the centuries, however, a painting may suffer greatly from wear and tear, from cleaning and restoration, and from chemical and physical damage (e.g. environmental pollution and radiation). Fingerprints on them can suffer in the same way, placing specific demands on imaging and processing in an attempt to recover them. In these situations, digital image processing may be the only means to develop the print to a level of usability for comparison. Multispectral imaging, in particular, opens up possibilities for digital enhancement of barely visible and invisible prints, otherwise not possible. It enables the isolated amplification of the fingerprint information against its background, eliminating other interference such as “noise” created by the imaging device.

## Fingerprints in the work of Leonardo

It is now well known that Leonardo, in his painting and drawing, not only employed the brush but also his fingers and hands.<sup>115</sup> His unfinished *St Jerome* in the Vatican provides an early example of this, with over two dozen fingertip impressions left in the wet pigment, clearly used to shape the underpainting for the background of sky, water and rocks.<sup>116</sup> For the present essay, I have looked at these in detail and revisited previous cases of potential Leonardo attributions I have investigated. I have also examined the numerous images received from Pascal Cotte/Lumière Technology and Martin Kemp, including high-resolution multispectral images of the *Cecilia Gallerani*, the *Mona Lisa*, “*La Bella Principessa*” and the *Madonna and Child with a Vase of Flowers* in the Alte Pinakothek, Munich.<sup>117</sup> All of these works display both finger- and hand-prints, some accidental and some intentional. There are numerous prints that preserve ridge impression with a level of clarity that make potential comparisons possible.

### THE *ST JEROME* PRINTS

Leonardo’s *St Jerome* is generally thought to have been painted *c.* 1480–85, a dating of particular interest for the present study. Parts of it were executed by the fingertip(s) to a quantitatively identifiable extent. In the detail of the background reproduced here (fig. 100), there are 19 touches clearly visible, not counting the longer, stretched out strokes of the fingertip. Pietro Marani ascribed these fingerprints to Leonardo without hesitation.<sup>118</sup> In forensics this is not how a *de facto* identification is carried out. Yet, given the circumstances, few would dispute that these fingerprints were left as part of the creative paint-

ing process and that the painter was Leonardo. In the general sense, then, it is this very high degree of probability that connects the hand to the name.<sup>119</sup> At this early stage in his career, Leonardo was not known to have employed assistant painters; it is realistic to assume that he did have some pupils who helped with menial tasks, though improbable that any would have been allowed to participate so extensively in the making of such an underpainting.<sup>120</sup> With this postulation, I treat the

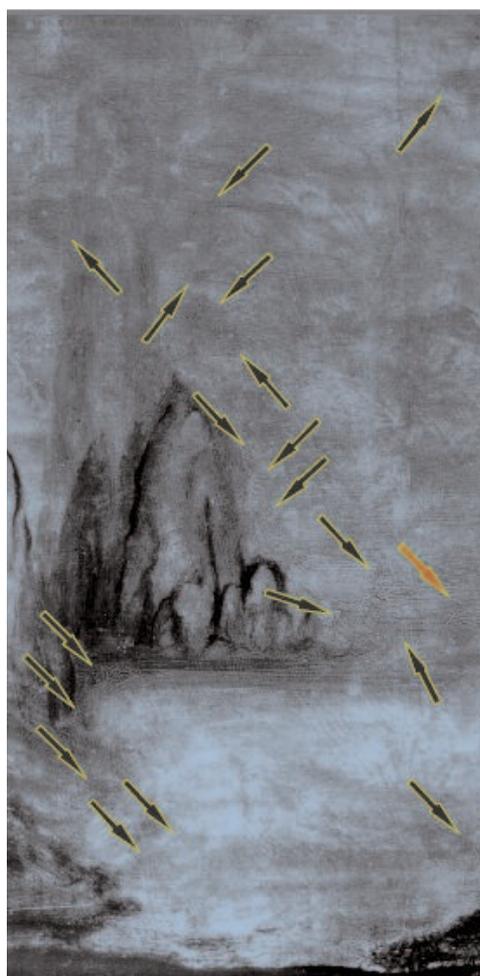
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*Figure 100*

LEONARDO DA  
VINCI

Detail of  
background of  
*St Jerome*, with  
numerous  
fingerprint  
impressions  
(the largest and  
clearest of which  
is shown by red  
arrow)

Rome, Pinacoteca  
Vaticana



clearest *St Jerome* prints as references—“exemplars” as the fingerprint examiner would call them.

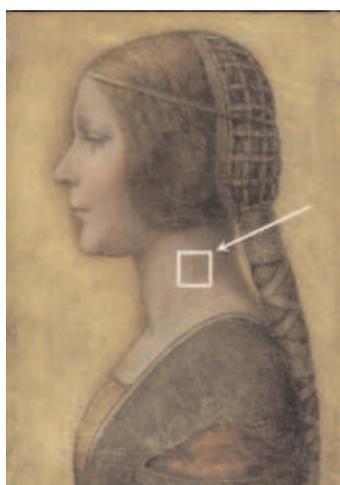
The prints in the *St Jerome* are in various states of distortion due to the movement or direct interaction of the finger with the wet paint: in other words, they are plastic (three-dimensional) and not stamped impressions (which would have left one color over another). In some instances, such as the area to the right of the rocks, the touch shows where the fingertip was removed from contact with the wet pigment with a straight vertical lift, as if to represent the foam and froth of waves spreading vapour into the air. Some are deliberate smears, such as the long parallel lines that form the water’s surface in front of the distant rocks. Then there are some that are a combination of both types, where part of an impression is clear and part of it is smeared in the direction of the finger’s movement. Leonardo’s brilliant and effective use of the ridges on his fingers and hands clearly contributed to the subtle and sublime effects he created here and in so many of his works. It reveals the imaginative and ever-exploring creative mind for which he is so revered. The presence of such fingerprints also contributes to the process of attribution by opening up a new potential for discovery through forensic connections.

#### THE PRINTS ON “*LA BELLA PRINCIPESSA*”

Lumière Technology’s multispectral images revealed two specific impressions on the drawing. One is a “stamped impression” in ink of a finger near the upper left edge of the vellum (see fig. 109). Pascal Cotte’s spectral analyses indicate that the print’s material composition is consistent with the medium of the drawing (see fig. 94). The other print is a “plastic impres-

sion” in the sitter’s neck (fig. 101), which appears to be from the outer edge (hypotener area) of the artist’s hand.

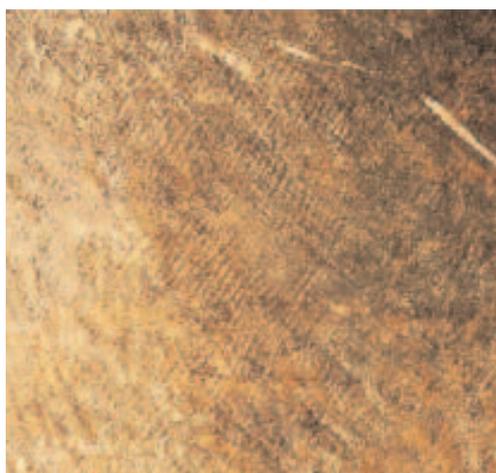
In the original discovery image of the hand print (fig. 102), lines running parallel to each other can be observed. The distance between them (0.5 mm) corresponds to the average distance between ridges generally encountered.<sup>121</sup> Through digital processing (fig. 103), the ridge pattern can be isolated from



*Figure 101*  
Position of  
the palm-print  
on “*La Bella*  
*Principessa*”



*Figure 102*  
Discovery  
image of the  
palmprint on  
“*La Bella*”



*Figure 103*  
Palmprint on  
“*La Bella*”  
after digital  
processing

its background. Once isolated, the ridges can be amplified separately without amplifying the background.

Unfortunately, the lack of consistent definition of ridge impression does not permit a ridge count. Ridge counting is basic in fingerprint comparison work. If, for example, we are comparing two sets of two bifurcations between an evidence print and an exemplar and in one there are nine ridges between the characteristics and ten in the other, the two prints cannot possibly come from the same finger. At present I am not in possession of an exemplar that could be potentially compared to the palmprint in “*La Bella*”. Nevertheless, the palmprint—regardless of its forensic utility—can be usefully considered in the context of Leonardo’s working methods.

To explore how and why it was created, one need only look at Leonardo’s apparently unprecedented degree of exploitation of this technique—an excellent example of which is the *Cecilia Gallerani*. As we know from Lumière Technology’s digitized images, the sitter’s chest is literally covered with the patterns of multiple, edge-of-hand prints (fig. 104), as are signifi-

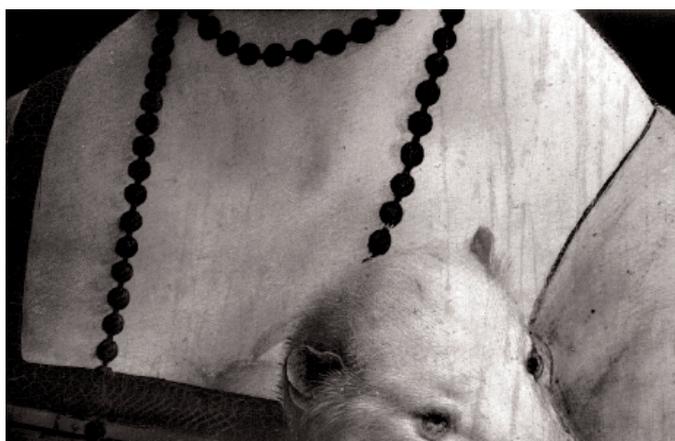


Figure 104

Digitally enhanced detail of *Cecilia Gallerani*, showing chest area covered with ridge impressions running at *c.* 30° angle

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*Figure 105*

Detail of face of *Cecilia Gallerani*, with rectangular area digitally enhanced to reveal ridge impressions



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*Figure 106*

More highly amplified detail of neck of *Cecilia Gallerani*, showing consistent application of edge-of-hand impressions



cant portions of the face. The effect is vaguely similar to fine hatching (fig. 105). The touches blend pigments, smooth out brushstrokes, add or remove pigment and create delicate passages of shading (fig. 106).

The examination of the palmprint in “*La Bella*” reveals the removal of chalk from the surface. It may have been intentional, as in *Cecilia*. However, we cannot eliminate the possibility that it may have been unintentional, the result of the artist having rested the edge of his hand on the surface for a certain period of time while in the process of drawing the portrait. This is the only print in the neck and chest area, whereas in the case of the *Cecilia* there are many prints, often overlapping each other and definitely resulting from deliberate and calculated acts on the part of the artist. The isolated incidence of the print in “*La Bella*” might point to its accidental nature, or simply reflect the loss of other prints during the course of restoration or mounting onto its present wooden panel.

The fingerprint on the left edge of “*La Bella*” appears to correspond to the area towards the tip of finger, most likely the index or middle finger. It lacks the core; there is no delta. All that is available in the discovery image (fig. 107) is the curvature of the Level 1 ridge pattern, suggesting the finger’s orientation. Nevertheless, this print offers possibilities through digital image processing (figs. 108 and 110A). Being near the edge of the vellum (fig. 109), it appears to have come from handling the sheet and not from deliberate artistic manipulation of the surface in creating the portrait’s background.

The print has an irregular shape rather than being oval. It is juxtaposed to another smaller fragmentary print slightly above it. The usual expectation—especially from law enforcement examiners unaccustomed to the artistic process—is that since a fingertip is oval in shape, it will produce an oval print on objects. But a fingertip, by and large, acts like an elastic stamp; it picks up the shape and distribution of whatever



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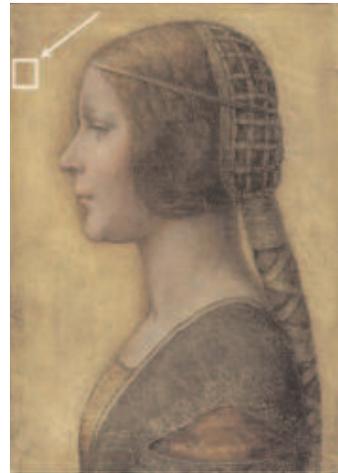
*Figure 107*

The discovery image of the fingerprint on “*La Bella Principessa*”

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*Figure 109*

The location of the fingerprint on “*La Bella Principessa*”



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*Figure 108*

Intermediate step in the digital enhancement of the discovery image of the fingerprint

medium it comes in contact with. If the fingertip is in contact with a regular, even surface (e.g. an inkpad), it will create a regular, oval print. If the finger touches a surface where a specifically shaped area provides the medium, it will transfer that shape and that medium. This is the most frequent occurrence with works of art, where for the most part only oddly outlined prints are found.

#### COMPARISON OF THE FINGERPRINTS ON “*LA BELLA PRINCIPESSA*” AND THE *ST JEROME*

Although small and faint on the discovery image, digital image processing of the fingerprint on “*La Bella*” (fig. 110A) helped recover ridge path detail at a resolution approaching that needed for fingerprint examination: it reveals a number of recognizable characteristics that can be compared with those of a digitally enhanced fingerprint on the *St Jerome* (fig. 110B).

The comparison centers on the technical issues of substrate, matrix, distortion and ridge path deviation—that is, the surface on which the print is deposited (vellum vs. wet pigment), the material with which the print is formed (ink vs. bare finger), the deformation of the fleshy pad of the finger under pressure, and the distinctive bends in the patterns of ridges.

There is no discernable distortion in the ink fingerprint on “*La Bella Principessa*” due to pressure or motion. Since it was most likely the result of handling the light-weight object, no significant pressure distortion would be expected. The fingerprint on the *St Jerome* was deposited with numerous others in the still wet paint surface. It has no discernible matrix—the impression is the same color as the substrate. The result of the creative use of the fingertips for painting, the print reveals

slippage on the right side of the print in a clockwise direction while the left side preserves ridge impressions from a simple vertical touch. Such a print is the result of a touch, the finger is then turned slightly to the right and then moved sideways in the same direction. (This preserves the left side of the print as a clear impression and right part of it as a smear.)

I have singled out eight characteristics discernible on both prints. There is, most notably, a short ridge or “island” whose two end points are marked “2” and “6” (fig. 110). This island has a decisive value in this comparison, for it has a highly indi-

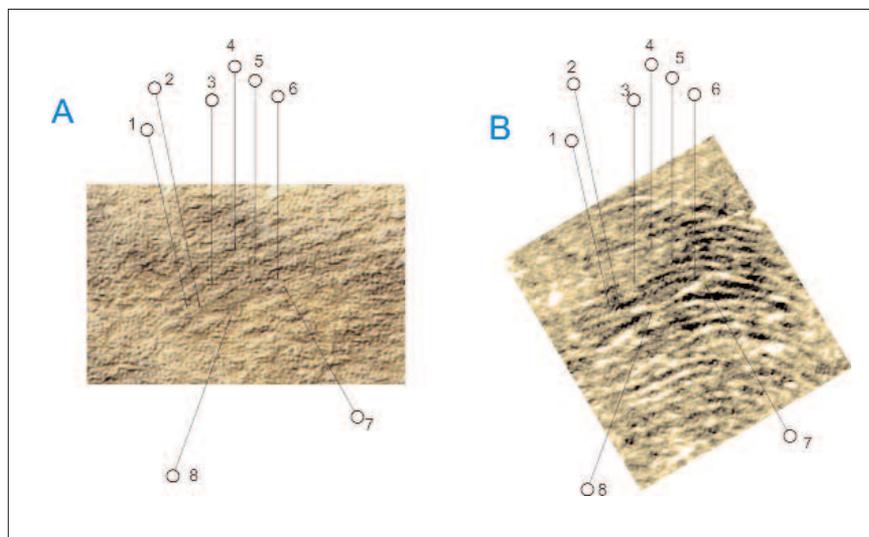


Figure 110

Digitally  
enhanced details  
of fingerprints  
on “*La Bella  
Principessa*” (A)  
and the *St  
Jerome* (B)

vidual shape, its endpoints are obvious and its outline is clear (fig. 111). Finding such a characteristic is significant as it presents crucial identification criteria, referred to as distinctiveness for individualization. (I recall having worked with this feature some years ago in another case, discussing it with a veteran fingerprint examiner, who considered the outline of the large island significant enough that a positive identification could be argued on the basis of that one characteristic alone.<sup>122</sup>) If one traces the contour of the large island in one print and superposes it in the same position in the other, we find that its outline and dimensions match exactly, even without embarking on lengthy analyses of the radii of the curvature of the contours.

In both prints, the large island is surrounded by characteristics in the same relative position. To verify this, the eight positions of the arrowheads in figure 110 were superposed and marked (fig. 112). It is important to keep in mind that the ridge-to-ridge distance in these illustrations represents no more than about 0.3 to 0.5 mm. The small difference in the position of the arrowheads when superposed is well within an acceptable range of tolerance and correspond to a small fraction of the overall width of a ridge. In fact, the two pairs overlap very closely.

### **Conclusion**

The correspondence between the fingerprints on Leonardo's *St Jerome* and "*La Bella*" provides a highly valuable piece of evidence among the numerous other analyses presented in this book. It has been demonstrated that both finger and palmprints are part and parcel of the original drawing. Although it is not expected that the fingerprint comparison alone would

Figure 111

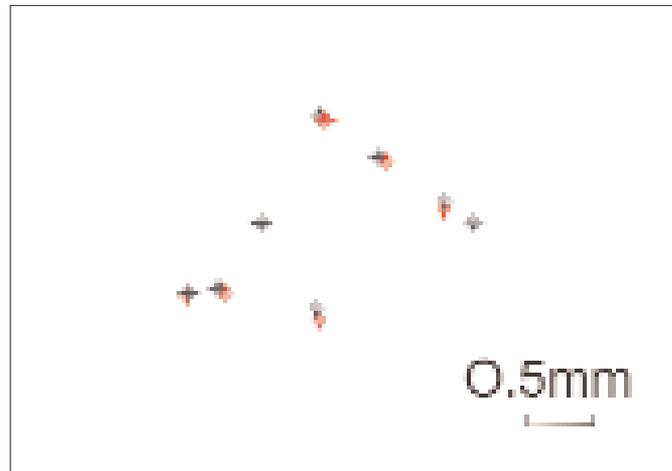
Digitally enhanced details of fingerprints in figure 110 with contours of the uniquely shaped island marked



Figure 112

Relative positions of the eight fingerprint characteristics identified in figure 110 superimposed (red for “*La Bella*” and black for *St Jerome*)

[Or vice versa for colour codes?]



be sufficient to establish innocence or culpability—were this a legal case—the coincidence of the eight marked characteristics is strongly supportive of Leonardo’s authorship of “*La Bella Principessa*”. Moreover, in the last days of finalizing this study, I gained access to a good-quality photograph of an x-ray of Leonardo’s *Ginevra de’ Benci* (c. 1478; Washington, DC, National Gallery of Art).<sup>123</sup> This reveals a fingerprint that is, not surprisingly, analogous—including the presence of the uniquely shaped large island—to those discussed above.

LA BELLE FERONIERE

LEONARDO DA VINCI

