Magic Eye

Professor Rick Johnson taps his engineering acumen—and a longtime passion for Dutch art—to explore the materials used by Van Gogh, Rembrandt, Vermeer, and more

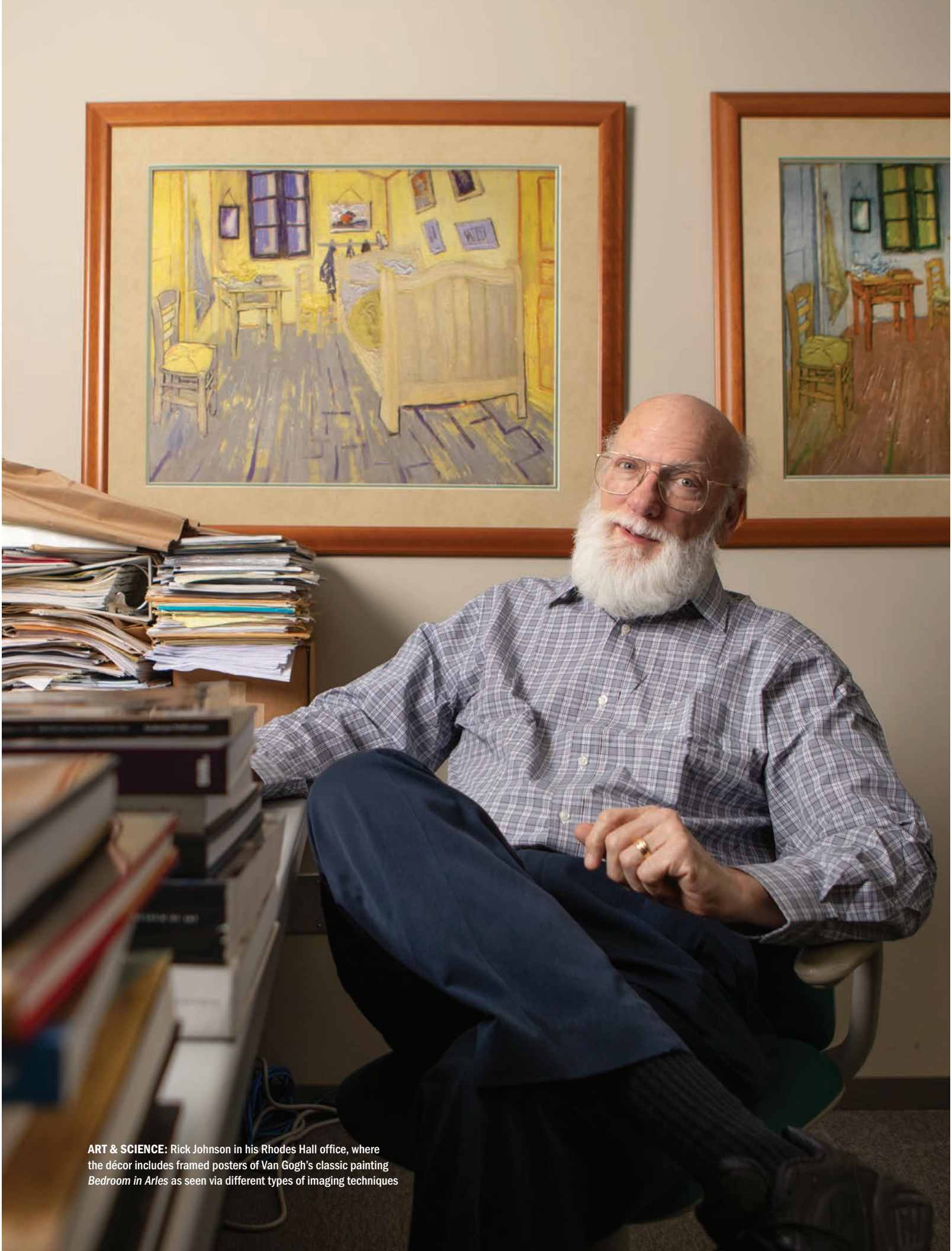
By Beth Saulnier

PHOTOS BY ROBERT BARKER

Lisa Pincus calls it "the ugly Vermeer." Entitled *Young Woman Seated at a Virginal*, it depicts a rosy-cheeked lady with light brown curls, wearing a yellow shawl and gazing vaguely in the direction of the viewer as she fingers the keys of the title instrument, a type of harpsichord. The painting, an oil on canvas currently held by the Leiden Collection in New York, is believed to date from the early 1670s, a few years before Johannes Vermeer's death in 1675. But to Pincus—a Cornell art history professor who specializes in seventeenth-century Dutch art—it's arguably the weakest entry in the artist's distinguished oeuvre. "I think it's a really wooden depiction," she says. "We have a pretty set idea, 'This is what Vermeer does; this is how his paintings look.' It doesn't have the subtlety, the nuance, the kind of light we expect of Vermeer."

As Pincus explains, there's a long history of Vermeer forgeries. (Most notably: during the German occupation of the Netherlands, Nazi leader Hermann Göring was fooled into buying a fake painted by a skilled Dutch forger, who was hailed as a folk hero after the ruse became public.) For years, the authenticity of *Young Woman Seated at a Virginal* was in doubt, given its perceived artistic shortcomings. "I still would like to disown it," Pincus says. "The only reason I don't is because Rick has made it clear that it is by Vermeer."

"Rick" is C. Richard Johnson Jr., an engineering professor on the Hill—and, at the risk of a mixed metaphor, something of a Renaissance man. At Cornell since 1981, Johnson has spent decades teaching and doing research in electrical engineering, particularly in the fields of control systems and signal processing. But over the past twelve years, his interests have entailed as much art as science. A pioneer in the field of computational art history, Johnson leverages both his engineering acumen and his abiding passion for art to study the physical materials with which works are made. "Rick is fabulous—omnivorous, open, enthusiastic, and caring," says Pincus. "He has boundless energy, curiosity, generosity, and a brilliant mind. He can come up with more ideas in five minutes than I can in five months." ›

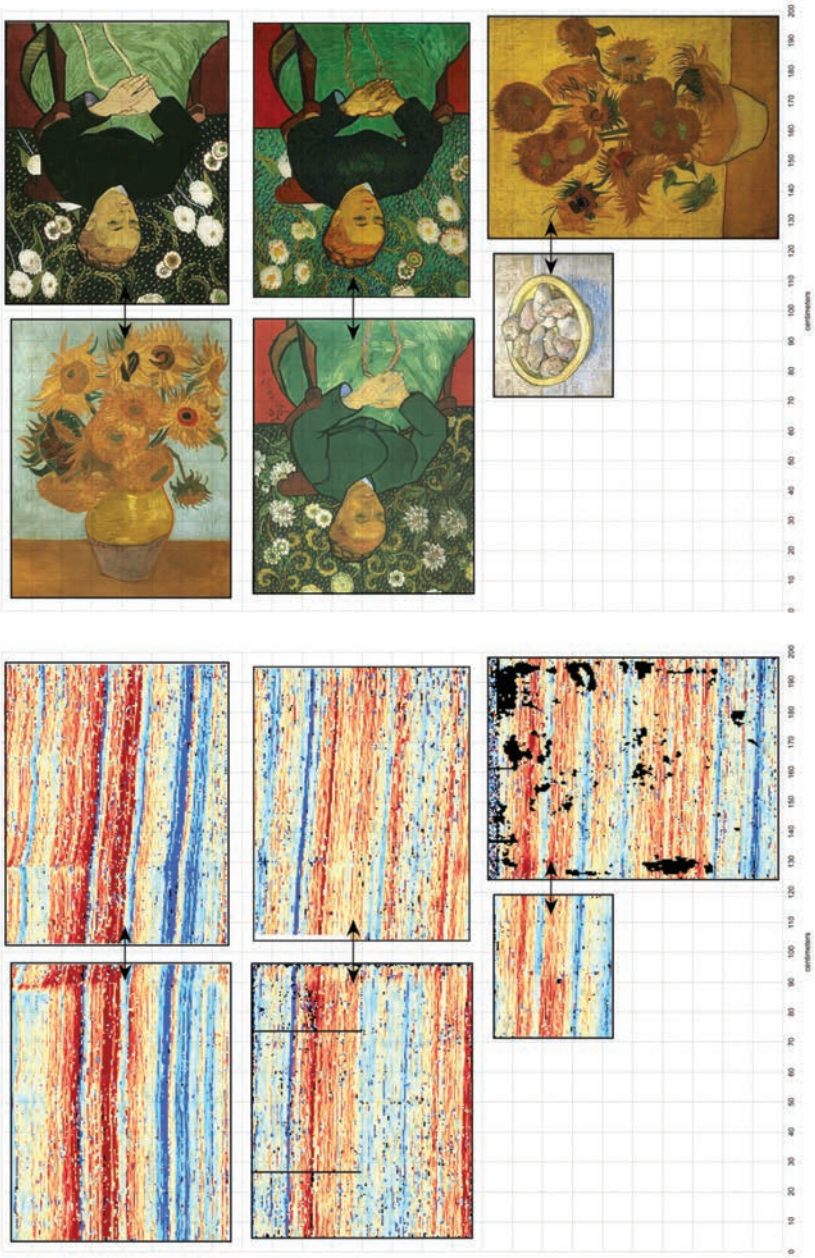


ART & SCIENCE: Rick Johnson in his Rhodes Hall office, where the décor includes framed posters of Van Gogh's classic painting *Bedroom in Arles* as seen via different types of imaging techniques

In 2007, at the start of a five-year stint as an adjunct research fellow at the Van Gogh Museum, Johnson launched the Thread Count Automation Project (TCAP), which informs the study of works on canvas by mapping the thread density of the fabric on which they're painted. By comparing the "weave maps" of various paintings, researchers can establish that they came from the same roll of cloth—and, therefore, that the artworks were likely produced in the studio of the same artist around the same time. (The concept is bolstered by the fact that canvas of that era was woven by hand, making each bolt distinctive, and that it was a pricey commodity for cash-strapped artists who weren't likely to leave it unused.) That's how Pincus was convinced of the authenticity of *Young Woman Seated at a Virginal*, whose weave map matched that of one of the most beloved of Vermeer's works: *The Lacemaker*, housed in the Louvre in Paris.

In a December lecture in the A.D. White House as part of the Milstein Program in Technology and Humanity, Johnson put up a slide showing the two paintings: *Young Woman* was on the left, *The Lacemaker* on the right, and their respective (and visibly matching) weave maps beneath them. "If you doubted the painting on the left, how could they be on the same canvas?" he asked the audience. "Somebody's answer would be, 'His cousin painted it; he showed him how and gave him the canvas; it's not a Vermeer.' So [the match] doesn't cure everything, but it's another piece of forensic evidence that stacks up to make the case."

In other words—as Johnson frequently stresses—weave matches are a powerful tool, but they don't themselves constitute proof of authorship; that has to come through additional means, such as understanding of an artist's technique and studio practices. For Pincus, it's that very knowledge that makes this match probative. "We know very little about Vermeer, but we're pretty sure he didn't have studiomates, and he didn't have students," she says. "He wasn't rich. He died bankrupt. I don't think he'd be cutting off pieces of canvas [and giving them away]. I've reconciled myself that this is a late edition to the corpus."



MATCH MAKER: Weave maps (seen in the two bottom rows) connect three sets of paintings by Van Gogh, showing that each pair came from the same roll of canvas.

As Johnson Museum of Art curator Andy Weislogel, PhD '00, puts it, Rick Johnson is "no slouch"; his art-and-science bona fides are impeccable. On the Hill, he holds an endowed position as the Geoffrey S.M. Hedrick Senior Professor of Engineering; on the other side of the Atlantic, he has a research appointment at the Rijksmuseum in Amsterdam and has served as an adviser to the Netherlands Institute for Art History in The Hague, where he was the first-ever fellow in computational art history. His many admirers on campus and beyond include Cornell's own Frank Robinson, director emeritus of the Johnson Museum and himself an expert on seventeenth-century Dutch prints. "A work of art is the meeting place of many different disciplines; that's what's so interesting about studying this stuff," observes Robinson, who invited Johnson to present his research to museum staff during his time as director. "The scientific aspect of it is absolutely vital—and in that respect, Rick is top of the line."

But as Johnson cheerfully admits, he'd never even been to an art museum until he was in his early twenties. He grew up in the Deep South, and was "the first male in my lineage to finish college" when he

WEAVEMAPS, ARTWORKS, AND WATERMARKS THROUGHOUT: PROVIDED

earned a bachelor's in electrical engineering from Georgia Tech. "Dad worked for the power company, and he wanted me to be an engineer," Johnson explains, "because the engineers were the ones who came to work with clean shirts, and they went home with clean shirts." As an undergrad studying abroad in Germany, his host family told him he absolutely had to go to a museum—and he did, in Berlin. At the end of the term, he spent two months traveling around Europe on a rail pass, "sleeping every third night on the train," and the many museums he visited instilled a lifelong love for the Dutch masters.

While earning his PhD in electrical engineering at Stanford, he talked his way into a graduate seminar on Rembrandt. "I was like the village idiot," he recalls, "in the sense that I'd say, 'You just said you see so and so; I'm looking at the same thing, and I have no idea what you're talking about.' I ended up asking all these stupid questions. But the professor told me later that it was great, because it made the rest of them articulate what they normally would take for granted." The following semester, Johnson impressed a visiting art historian by pointing out that a slide of a Frans Hals painting had been projected backward. (His clue: in Hals's work the light always comes from the same direction.) She invited him to join a Vermeer research project, and he went on to earn a PhD minor in art history—the first Stanford had ever granted.

In the mid-Aughts, planning his fourth sabbatic leave, Johnson resolved to integrate his engineering research with his passion for art; he landed a meeting at the Van Gogh Museum, where he ultimately spent a semester. He initially got involved with work to identify fakes through x-ray analysis of brushstrokes and other features—the subject of a May 2007 interview he did on NPR's "Science Friday"—but ultimately focused on thread counting as a method with the potential for broad applications. As Johnson explains, the practice then entailed the use of magnifying glasses and the painstaking, manual counting of small sections of x-radiographs (which reveal weave patterns because the lead-white paint used to prepare canvases is denser between the threads than atop them). Not only was it tedious, but counting an entire canvas—rather than a number of sample sections—was wildly impractical. "Let's say you have a painting that's forty-five by fifty centimeters, and you're going to count the threads in every little half-centimeter," he says. "You end up with something like 9,000 places to count. Nobody's going to do it."

THE 'UGLY VERMEER': *Young Woman Seated at a Virginal* (top left) and *The Lacemaker* (top right), each oriented to correspond with their respective weave maps (bottom row)

'We can actually put the rolls back together, pretty much,' Johnson says of Van Gogh's canvases, 'and that will date his paintings to within a three-week period.'

But Johnson immediately realized that counting threads was an example of a basic engineering concept: frequency, or the number of times that a particular thing occurs within a set interval. He attacked the problem by writing a basic algorithm called a Fourier transform—something Cornell engineering students study sophomore year—which is essentially an equation for reverse-engineering information into its constituent parts. "It worked, and I took it back the next day and said, 'We'll count every painting in the museum!' " he recalls with a chuckle. "And they said, 'Please, try not to be so American.' "

In the intervening years, Johnson and his colleagues have refined their computational methods and mapped much of Van Gogh's oeuvre, matching his works to nearly four dozen rolls of canvas. Together with existing documentation—such as the artist's correspondence with his brother Theo—the weave maps offer valuable insights into Van Gogh's career, which lasted a mere ten years. "We can actually put the rolls back together, pretty much," Johnson says, "and that will date his paintings to within a three-week period." Among their revelations: that the seventh in Van Gogh's *Sunflowers* series—bought for nearly $40 million in 1987 by a Japanese insurance magnate despite being long considered a potential forgery—was ›

PAPER CHASE: Andy Weislogel, PhD '00 (at left in photo at top), with Johnson in a print storage room at the Johnson Museum. Left: A Rembrandt self-portrait illuminated to show a variant of the "Basilisk" watermark.

likely genuine, given that it matched other works on a twenty-meter roll of jute canvas supplied by Paul Gauguin. "It didn't look like Van Gogh's brushwork, but it was a coarse fabric, and he was struggling with it," Johnson explains, noting that the artist complained about the difficulty of painting on jute in a note to Theo. "[The previous experts] didn't take that into account."

Aside from Van Gogh, the most frequent subject of Johnson's TCAP analysis has been Vermeer. In addition to helping establish the authenticity of *Young Woman Seated at a Virginal*, the method has informed understanding of numerous works in Vermeer's oeuvre. For instance, it has helped reveal that certain paintings were likely intended as "pendant pairs"—works of roughly the same size intended to be hung together. "About 40 percent of Vermeer's paintings come with a partner on the same canvas," Johnson observes. "So this practice must have been part of his studio."

TCAP has contributed to the study of other artists' works as well. At the talk in the A.D. White House, Johnson put up slides of three of Claude Monet's famed *Haystacks* paintings and punctured the enduring romantic notion that he returned to the same farm field throughout the year to capture the seasonal nuances. "He did them all in his studio," he said. "They're all from the same roll of canvas." The method also helped art historians identify the subject of a Velázquez portrait—a dwarf in the Spanish royal court—by demonstrating that the work was painted around the same time as the artist's portrait of King Philip IV in the mid-1640s.

In one of the talk's most intriguing anecdotes, Johnson described the analysis of three seventeenth-century French paintings: *The Triumph of Pan*, *The Triumph of Bacchus*, and *The Triumph of Silenus*. While it's known that Cardinal Richelieu commissioned the series from artist Nicolas Poussin for his chateau, only the first (in London's National Gallery) has always been considered a true Poussin. As Johnson and colleagues explained in the *Journal of the American Institute for Conservation* in May 2013: "The success of this commission led to demand for the production of copies close in date to the originals, some of which are represented in major collections." For that reason, the authenticity of *Bacchus* (housed in Kansas City's Nelson-Atkins Museum of Art) has been questioned over the years, though it's now generally accepted as original and the museum labels it as such. And as for *Silenus*? As Johnson told the audience: "It's in the basement in the National Gallery in London and is considered to be a fake [from] 100 years later, and nobody needs to see it." But as weave mapping revealed: all three came from the same roll of canvas.

When Louisa Smieska, PhD '15, was a grad student in chemistry, she took a course at the Johnson Museum on the intersections of art and science that Johnson co-teaches; among other activities, she got to try manual thread counting using a scrap of canvas and a microscope. She went on to postdocs at the Cornell High-Energy Synchrotron Source (CHESS)—where she used x-ray fluorescence (XRF) to analyze the pigments in illuminated manuscripts from Kroch Library—and at New York's Metropolitan Museum of Art, where she employed similar techniques to study items ranging from ancient Egyptian jewelry to nineteenth-century American furniture. Now a CHESS staffer, Smieska is continuing to leverage cutting-edge

science to analyze artistic materials, including using XRF to reveal a hidden work beneath a painting by nineteenth-century French artist Honoré Daumier. "Even though our research hasn't overlapped that much, Rick has been an amazing mentor figure to me," Smieska says. "He wants to see people succeed in this strange, interdisciplinary field."

Working with colleagues in the U.S. and abroad, Johnson is turning his computational eye on a variety of other artistic media, including photographic paper, parchment, and the silk used in ancient Chinese paintings. But his most active and prominent project involves analysis of the handmade paper used in centuries-old prints. In 2015, Johnson and Weislogel launched the Watermark Identification in Rembrandt's Etchings (WIRE) project, which aims to date the Dutch master's works through analysis of the distinctive markings on the paper on which he (and, after his death, others) printed them. "How do you know if this piece of paper you're holding is a lifetime impression or a posthumous impression?" Robinson muses. "Whether it's 1635 from the original edition, or 1640 but pulled from the plate by Rembrandt, with all of his special inking and wiping of the plate and the little additions that he sometimes makes? Or is it posthumous, from an eighteenth- or nineteenth-century edition when the plate was exhausted? One of the best ways is to look at the paper. If the paper was made in 1635, probably that's one of the early ones. If it was made in 1720, it surely is not a lifetime impression." Such questions, Robinson says, have financial implications for dealers, collectors, and museums. "But leaving the market aspect aside," he says, "what's really important is the artistic vision of Rembrandt."

Similar to the weave-mapping work, WIRE leverages the financial and logistical realities of seventeenth-century print-making. "The research is based on the assumption that paper was expensive in Rembrandt's time, and he was not always a wealthy person," says Weislogel. "So when he wanted to make prints, he went into the market to buy paper. He would have bought a small batch, and he would have gone back to his press and used it up quickly so he could sell the prints and recoup his investment. And he did this with over 200 known batches of paper during his thirty-plus years of making prints."

The batches themselves can be identified through watermarks—the distinctive logos embedded in each sheet. But it's hardly a straightforward process. "In the abstract, a watermark would indicate a particular papermaker or region where paper is made," Weislogel says. "However, it all goes completely crazy, because as soon as a particular papermaker became popular, all the imitators would jump in and copy the watermark." Take the "Strasbourg Lily" watermark, comprising a coat of arms with a *fleur-de-lis*, it originated in that city in northeast France, but knockoffs were later made elsewhere in the country. Says Weislogel: "There was a lot of copycatting."

So watermark identification often comes down to minute details—differences between very similar marks, owing to the fact that the designs were made by hand. In addition to the watermark itself, researchers consider the relative location of "chain lines"—the thin stripes that run down each sheet. (The first step in papermaking is to dip a mold, consisting of a ›

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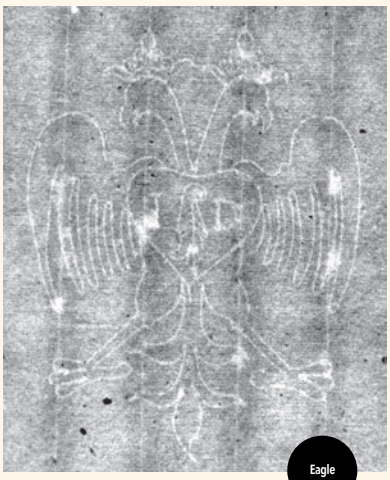
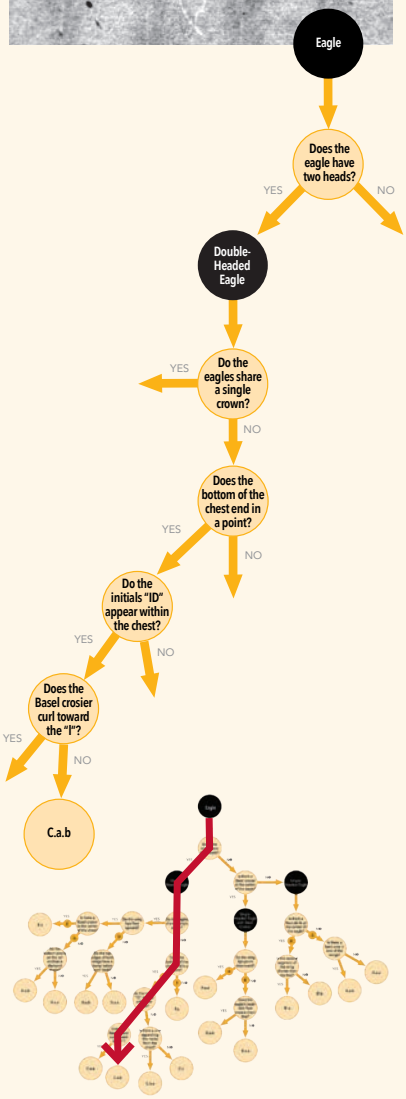
MAKER'S MARK: A curatorial assistant at the Johnson Museum (above) uses a flashlight to display the watermark in a print of Rembrandt's *The Flight into Egypt*. Left: Two variants of "Strasbourg Lily" illustrate the challenge of discerning small differences among similar watermarks.

Hitting the Mark

To identify watermarks, WIRE has created binary decision trees—a series of yes/no questions that leads users to the answer. Here, the "Eagle" tree (at bottom, with the correct path in red) leads to the "Double-Headed Eagle" watermark's "C.a.b" variant (below, with a detail of its "branch").





screen inside a frame, into a vat of pulp; chain lines are marks left by the wires that affix the screen to the frame.) Then there's the issue of "twins": for efficiency's sake, papermakers would use two matching molds during production of each batch, with watermarks as close to identical as possible. To facilitate identification, the researchers have created binary decision trees, which narrow down the possible watermarks based on a series of yes/no questions. Identifying a mark called "Foolscap with Five-Pointed Collar," for example, can involve such questions as "Is there a C or D shape on the cross, with chain line down center of face?" and "Is the collar shoulder below the face straight, or does it have a bent corner?"

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It's a painstaking process—one that the researchers are streamlining by creating an online tool that will let anyone upload images and identify watermarks by answering yes/no questions generated according to a user's previous answers; the website is aimed to go live in 2020. The work, conducted under an NEH grant, is the focus of a semester-long course that allows undergrads to participate in WIRE for academic credit. As Johnson stresses, part of his motivation in founding TCAP and WIRE was to create research projects to which undergrads could meaningfully contribute. And both he and Weislogel point out that such efforts are a natural fit for academia. "University museums don't have the fancy high-end collections; Rembrandt prints are probably the nicest things that most university museums have in terms of high-quality art," says Johnson. "But they have two things that major museums don't have: they've got all the experts on the same campus, and they have a technical labor pool in terms of students."

The WIRE project is an outgrowth of the work of Dutch scholar Erik Hinterding, who published a catalogue of Rembrandt watermarks in 2006; in it, he identified fifty-four main types of watermarks in the master's prints, and broke those down into hundreds of variants and subvariants. WIRE ultimately aims to create decision trees for all the main types (with "branches" leading off into the many subvariants). The researchers have already found some previously uncatalogued variations as well as prints never before observed on a certain paper, evidence that the artist had gone back to earlier plates and reprinted them. "We're total geeks about watermarks now," Weislogel says with a laugh. "When you discover something you think hasn't been seen before, or constitutes a new variation that helps you solve the puzzle of reassembling a particular batch of paper, it's immensely rewarding and good fun."

In fall 2017, the WIRE research and related artwork were the subject of an exhibit at the Johnson Museum entitled "Lines of Inquiry." The project was also the focus of a day-long symposium that drew more than 100 scholars to campus; featuring Hinterding as the keynote speaker, it included talks by Johnson, Weislogel, Pincus, and students on the WIRE research team. "Since I've been working on this project, I've come to think about prints and their production in such a different way," Weislogel admits. "I won't go so far as to say I ignore the wonderful work of art that's printed on the surface and concern myself only with the watermark. But you think about works of art as three-dimensional, living, breathing objects in a very different way after you've spent such a long time and great effort studying the supports on which they're printed, and thinking about where they came from and how the paper went through the market even before Rembrandt got his hands on it." The project, he says, "has underscored the crucial importance of blending traditional art historical knowledge and connoisseurship with an openness to what science and technology can bring to the equation." ■

DECISION TREE: SARA GORSKE '20