Conservation

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The Getty Conservation Institute (GCI) works internationally to advance the field of conservation through scientific research, field projects, education and training, and the dissemination of information in various media. In its programs, the GCI focuses on the creation and delivery of knowledge that will benefit the professionals and organizations responsible for the conservation of the visual arts.

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Front cover: Constanza Miliani, a researcher at the Istituto di Scienze e Tecnologie Molecolari CNR in Perugia, taking in situ measurements of the infrared reflectance spectrum of fifteenth-century wall paintings by Filippo Lippi, as part of the Organic Materials in Wall Paintings project, which is being conducted by the GCI and a number of other scientific laboratories. Using the noninvasive technique of reflectance Fourier transform infrared spectroscopy with fiber optics, she is able to classify the organic materials present on the surface of these paintings, which are located in Saint Stephen's Cathedral in Prato, Italy. *Photo:* Francesca Piqué.

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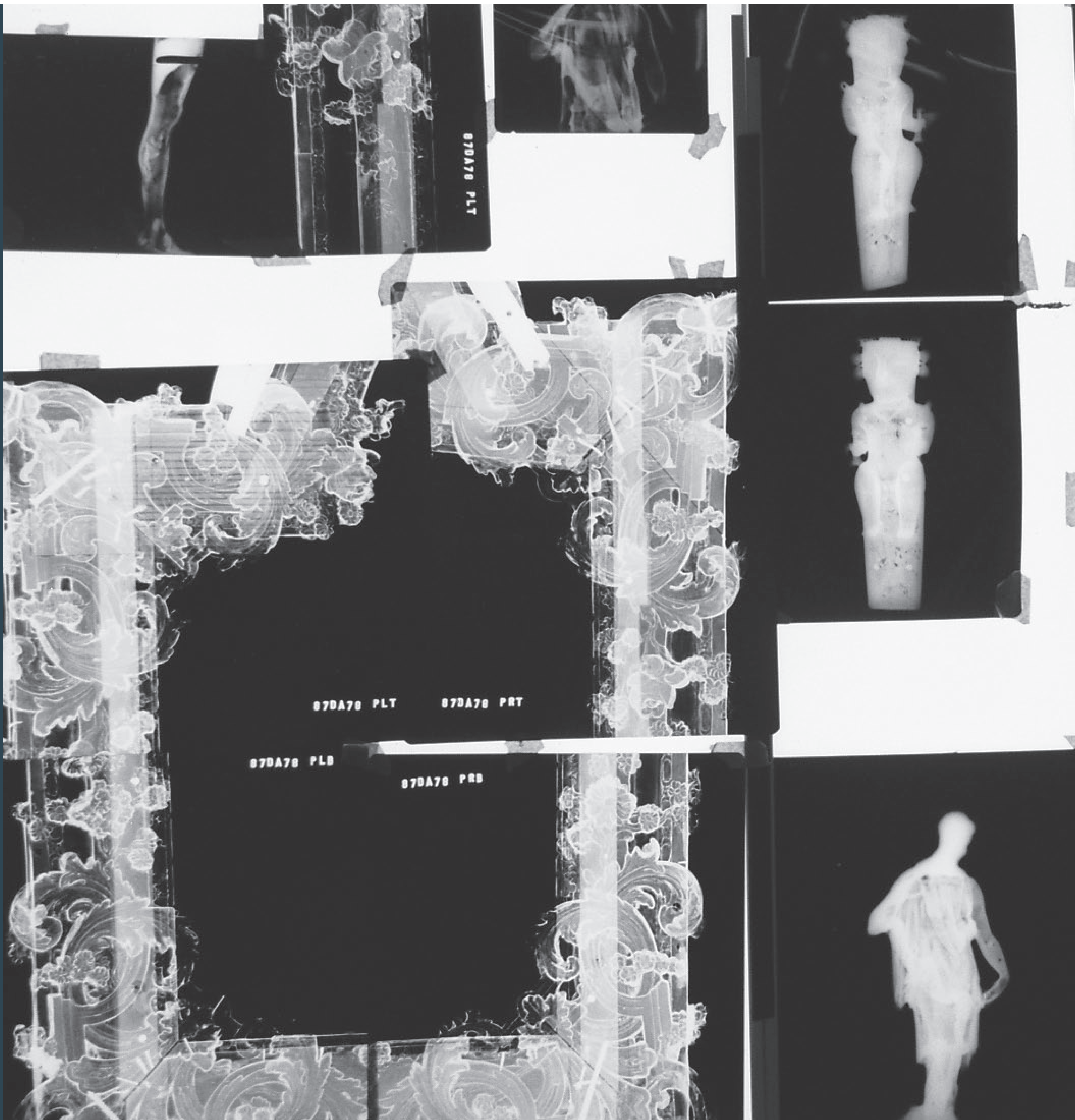
By Giacomo Chiari and Marco Leona



X-rays of art objects. The number of techniques available to conservation scientists for the examination of art objects has increased dramatically since the first half of the twentieth century, when X-rays were first used to analyze works of art. *Photo:* Dennis Keeley.

# of Conservation Science

Conservation science is the commonly used term for a number of related disciplines relevant to scientific research in the study and conservation of cultural heritage. Generally speaking, work in this field falls into three major areas, which interact with one another so extensively that it is often difficult to distinguish them from one another.

The first area includes *archaeometry* and *technical art history* (debatable terms, perhaps, but well-established ones), which involve the study of cultural heritage with the goal of knowing what the heritage is made of, when it was made, where it was made, and how it was made. In archaeometry, archaeologists and archaeological scientists generally study sets of excavated objects and their context, while in technical art history, art historians and museum scientists tend to focus on individual objects removed from their context.

The second area of research encompasses study of the changes occurring in objects and the causes of degradation, with the goal of reducing deterioration, if not stopping it forever (a difficult thing to do, as this runs counter to the second principle of thermodynamics). This area involves the study and development of methods for mitigating deterioration.

Finally, there is a third area, sometimes called *technology transfer.* Whether they are engaged in archaeometry or in conservation, conservation scientists often create or modify instrumentation to facilitate their work, since the conservation field represents too small a market to provide sufficient incentive for manufacturers to produce instruments specific to conservation science. The creation of new tools, or the upgrading of old ones, is necessary for increasingly better analyses of a greater number of materials, using smaller samples or no samples at all. These goals are achieved either by adapting instrumentation from other branches of science or by the ad hoc design and optimization of new instruments. As Irwin Scollar, formerly of the Rheinisches Landesmuseum in Bonn, is reported to have said, “We’re fighting a guerilla war with available weapons, or probably those captured from the enemy.”

Conservation scientists often act as interpreters for professionals with different backgrounds. The conservation scientist becomes the link between scientific theory and cultural heritage application, or between cultural theory and scientific application (for example, exploring the geochemical literature to identify techniques for determining the provenance of rocks used to produce Neolithic tools, and finding a laboratory with experience in those techniques and a willingness to do the research).

With regard to the ways in which conservation science work is carried out, an important distinction should be drawn between research conducted in academia and research institutions, on the one hand, and research conducted in museums and field projects (i.e., archaeological sites, monuments, etc.), on the other. Non-conservation academic research allows scientists to explore in detail a specific problem or an area of interest. In general, one can focus on a single topic and establish the goal of the research, the research strategy, and possibly the final outcome.

For conservation scientists working in a museum full of objects (often lacking a well-documented provenance) or working at an archaeological site or historic building, the challenge is very different. Rather than a specific research topic, a material object or structure is typically at the center of the conservation scientist’s focus. The problems faced are not chosen by the scientist nor are the means of solving them necessarily available.

No single practitioner can be expected to possess all the expertise needed to deal with the various aspects of cultural heritage. Nevertheless, the economics of cultural institutions are such that even the few museums and sites that are fortunate to have scientific laboratories can hardly support more than one to three scientists on their regular staffs. Therefore, cultural institutions must cooperate among themselves, as well as with academic laboratories, in order to effectively conduct advanced research.

Scientists David Carson (sitting) and Eric Doehne (standing) using the GCI's environmental scanning electron microscope (ESEM). In combination with optical microscopy, the noninvasive ESEM provides scientists with fast and reliable answers to technological questions on a variety of materials. *Photo:* Dennis Keeley.

Joy Keeney in the GCI's organic materials laboratory preparing paint samples for analysis using gas chromatography–mass spectrometry (GC-MS). The GC-MS process helps to identify organic components in the samples. *Photo:* Dennis Keeley.

An Evolving Field

Conservation science is coming of age in its development. Any new scientific field has an experimental, or embryonic, stage in which scientists from other fields sporadically venture into its new activities, bringing with them expertise but only a modest understanding of the needs of the discipline—sometimes with questionable results. Then a small number of scientists begin to join forces, committing their careers to the new field, gaining over time a fuller understanding of it and a systematic approach to it.

This is how conservation science was born. In its earliest days, it was not considered by the scientific community to be hard science. In recent years, funding from governments and private institutions has attracted more scientists, and the number of researchers in the field is now large enough that international meetings are regularly convened for participants to share ideas and results. Peer-reviewed journals allow for the circulation of related work and (no less important) create a sense of identity for conservation scientists. Greater visibility and a greater commitment to research in conservation can attract talented young people who a few years ago would have selected one of the more traditional branches of science.

As in other branches of science, the tremendous progress in technology—including the advent and use of personal computers—has significantly altered the field. In conservation science, new analytical techniques have made possible microinvasive or noninvasive approaches. For example, binding media analysis has always been difficult. Today, however, one can detect, after centuries of aging, minimal amounts of organic materials using refined versions of gas chromatography–mass spectrometry. Drawing from techniques developed in biology and biotechnology, it is now possible for conservation scientists to use antibodies to identify parts per million of proteins, allowing them to distinguish rabbit glue from fish glue or cowhide glue, or parchment made of sheepskin rather than goatskin. This information is fundamental to the art historian for identification and attribution and fundamental to the conservator for treatments.

Now available are new techniques such as environmental scanning electron microscopy, portable X-ray fluorescence, and Raman spectrometry, which are totally noninvasive—i.e., they do not require samples from an object or involve the risk of damaging it with dangerous radiation analysis. Both the purchase cost and the difficulty of operation of this equipment have dramatically decreased. For most techniques, there is now a portable version of the instrumentation, making it possible to take the analysis to the object rather than bringing the object to the laboratory. These portable instruments have made advanced instrumentation increasingly available to conservation research laboratories and increasingly useful for fast, noninvasive or microinvasive materials analysis.

In addition, the number of techniques that allow conservation scientists to examine the surface of an object, to even see under the surface (e.g., infrared reflectography) or through an object (e.g., radiography), or to reconstruct the object three-dimensionally (e.g., CT scan) has increased exponentially. Further progress in diverse techniques, such as hyperspectral imaging, confocal microscopy, and the scanning probe microscopies, is also expected.

In short, conservation scientists today can do things more rapidly, more precisely, and in a less damaging way then previously. They also can do things that just a few decades ago would have been impossible. The impact of this science applied to culture is tremendous and allows many historians—art and otherwise—to make great progress in their disciplines as well.

An Applied Science

When dealing with valuable cultural heritage, researchers have constraints in the size and amounts of samples that can be taken. For instance, the modus operandi of a geologist studying marble from a quarry and of a conservation scientist studying the same marble as used in a statue by Michelangelo are obviously different. The science is similar, but the goals and techniques are different. Moreover, most of the time, conservation scientists are dealing with unique assemblages of objects and their evolution over time, often under unknown conditions. In paleontology, the possibility of verifing a hypothesis by devising an experiment and reproducing the event in the laboratory is often precluded.

Conservation science is sometimes compared to forensic activities, since the goal is to reconstruct the action behind the production of the object by studying a few material traces. Greater interest in the material aspects of a work of art broadens the focus from the aesthetic or documentary value of the object to include a larger view of a human society, both in terms of the skills it perfected and of its relations with the environment and with other societies. The interdisciplinary aspect of such a search is obvious.

The scope of conservation science, though, is to determine not only how the object was made but also how it was modified by the passage of time, and what the mechanisms were that altered its original condition. If these deterioration mechanisms are still active (and therefore dangerous to the conservation of the object), it is the responsibility of the conservation scientist to help the conservator find methods to slow these mechanisms to the degree possible. This goal can be accomplished in various ways—one being to modify the surface of the object to make it more resistant to external attack. Much has been done in this direction, but efforts have not always been successful. Typically, the cause of these failures is a lack of understanding of the nature of the object or of the consolidant used, or of the combination of the two. The composite material that is created may be disastrous for the object when the two interacting substances are not compatible. It is the responsibility of the conservation scientist to ensure that these errors are not repeated.

Another way of ensuring a longer life for cultural heritage is preventive conservation. Once the basic mechanisms of deterioration are understood for individual objects and the impact of the environment on the objects is evaluated, one can try to mitigate these effects—not by changing the object's surface composition but by modifying the environmental impact using various kinds of protection (e.g., shelters, anoxia boxes, climate control devices, etc.). This approach to conservation relies heavily on a detailed knowledge of the nature of the objects, the environmental conditions and their interaction, and the ability to communicate with building engineers and facilities maintenance specialists.

Enhancing Understanding of Heritage

Art historians, archaeologists, museum curators, conservators, and architects generally recognize that understanding the material aspect of an object is necessary to comprehend it and its original context fully. Art is often solely understood as an inspired act of creation by an individual artist. While the artist's concept is certainly a component of the art object, the technique and the materials used are equally important. On the purely aesthetic side, they ultimately determine the final visual effect, and they have been chosen and manipulated by the artist with this in mind. On a broader scale, materials and techniques are an expression of the society in which the artist lived, and they reflect the role of the artist as a technologist. When the hidden technological information (the availability and choices of materials, studio practices, etc.) is revealed, a window is opened onto the economics of the period in which the object was created. The conservation scientist—by focusing on the material aspects of the work and by illuminating the link between the hand and the society that created it—plays a major role in this effort to contextualize the artwork.

Materials and techniques are also fundamental to understanding how an art object interacts with its environment. The chances of survival of the work of art over time are, in fact, a function of the object's constitution and of its environment. If Leonardo da Vinci had been able to consult a conservation scientist before painting *The Battle of Anghiari,* that now-vanished masterpiece might still be with us.

Since archaeology discovered modern instrumental analysis methods, the field has changed radically. The ratio of trace elements in obsidian flints can now precisely identify their quarry of origin, a fact that enables reconstruction in detail of the trade system in the prehistoric Mediterranean basin. The lead isotope ratio allows the same for coins and glass. Now there are ways of determining the temperature at which a ceramic was fired, of ascertaining the age of a wooden log within one year by examining the thickness of the rings, and of dating a soil layer more than 10,000 years old by looking at the shape of the pollen contained within it.

But to be able to obtain results in principle is not enough. Reference databases are essential. To see that two grains of pollen are different in two soil layers, or that an instrumental pattern is characteristically found in a particular sample and not in another, is only the first level of investigation and discovery. A more complete characterization of samples and objects requires that analytical patterns (pollen shapes and sizes, peak positions and intensities in a Raman spectrum) be unequivocally matched to those of known reference materials studied under reproducible conditions and catalogued in a reference library. The development of databases, including databases of aged substances, requires substantial commitment of both staff time and instrument use and is only possible when a large number of researchers are dedicated to the task. It is a sign of conservation science's maturity that it has reached this stage, as evidenced by the significant databases compiled by the Infrared and Raman Users Group (IRUG) and by mass spectrometry users.

Scientist Giacomo Chiari collecting samples of hematite from a wall painting at the Moche site of Huaca de la Luna, Peru. When the paint was originally applied, the iron oxide pigment particles oriented themselves toward the magnetic North Pole. Because the pole changes position over time, the orientation of the particles can be used to determine the date of the paintings. *Photo:* Ricardo Morales.

Impact on Conservation

Modern art theory notwithstanding, we do not like modification in the appearance of our masterpieces. Even in cases where the artist's intent seems to include deterioration, museums (and perhaps human nature, in general) are ill disposed to accept it. A notable work of art constitutes significant capital, and ultimately, a museum's collection is its main asset. Substantial resources are spent by museums to conserve works that the artists may have never intended to be permanent.

Slowing down deterioration, stabilizing objects, and assuring that display and storage conditions are of the best quality to preserve and maintain works of art for the longest possible time are among the main mandates of the conservation scientist. If archaeometry has often been compared with forensic sciences, so has conservation been compared with medicine—besides the diagnosis, one needs the cure.

Maintaining an object unchanged forever is generally acknowledged to be an impossible goal. Yet conservation scientists are often requested to suggest or devise techniques and materials that strive to do precisely this. It is accepted conservation practice that the visual aspect of the object should not be altered by a treatment. But the understanding of the complexities of objects and of the information that can be obtained from them has now grown to include their broad chemical-physical properties. These properties should not be modified, for such changes might hinder or prevent future studies or treatments. Since damage to objects can often be attributed to past improper treatments, reversibility—the ability to undo any intervention performed on an object—has become a desired component of conservation treatments. Of course, no human activity is fully reversible: if stopping deterioration runs counter the second principle of thermodynamics, then reversibility truly violates Heisenberg's uncertainty principle. However, modern conservation and conservation science can evaluate the risks of new treatment, and of any intervention in general, with the tools of risk management and the concept of retreatability rather than reversibility. Treatments or interventions (such as sampling) are never good or bad. They may be more or less invasive, more or less needed, more or less urgent, and more or less feasible.

John Donohoe, head of engineering and maintenance at the Getty Center, and Cecily Grzywacz, a GCI scientist, placing samplers in the J. Paul Getty Museum's fan system in order to determine the levels of nitrogen oxides and volatile organic compounds in the air delivered to the galleries. By developing ways to mitigate the impact of the environment on objects in collections, conservation science seeks to reduce the potential for damage to these objects. *Photo:* Dennis Keeley.

Conservation science has contributed enormously over the past thirty years to the ways in which cultural heritage is preserved, displayed, and utilized. New conservation materials, such as varnishing resins specially developed in collaboration between museum scientists and industrial researchers, are now commonplace in the paintings conservation laboratory. Today, cleaning of works of art can be done in very specific and controlled ways through laser cleaning, first developed for outdoor sculpture but now increasingly used for other substrates (from graffiti-defaced rock art to amalgam gilt bronze). These instances are examples of close collaboration between industrial and academic researchers and museum conservators and scientists.

Conservation science is also making contributions to the prevention or limitation of further damage to collections through greater understanding of display and storage environments. The ability to monitor color change in light-sensitive objects and the understanding of fading caused by light has increased greatly as a result of the concerted efforts of several laboratories around the world. The possibility of monitoring the light exposure of watercolors or photographs while they travel for exhibitions is now a reality, accomplished with a tool as simple as a highly light-sensitive dye-coated paper strip. Likewise, it is now possible to predict an object's propensity to fade by using a simple microfading test. From the adoption of a common accelerated corrosion test used in metallurgy to evaluate which materials can be used in display and storage cases, to the development of diffusion tube and ion chromatography techniques to quantify corrosion-inducing airborne pollutants, preventive conservation has become a science with dozens of practitioners in a number of museums.

Conserving single objects is only a small part of the more general duty of conserving cultural heritage for future generations. Major risks now include not only unavoidable natural catastrophes (the Bam earthquake in Iran is a recent example) but also large-scale damage due to war, looting, theft, and illegal excavations. Equally powerful destruction agents are the consequence of normal human activities, often praised as economic development—for example, the demolishment of old buildings. The detrimental effect that industrial society generally has on the environment certainly can disrupt the material stability of cultural heritage objects.

Although these are enormous problems for which complete and lasting solutions may never be found, science can significantly contribute to mitigating their negative effects. Seismic damage mitigation devices are already installed in many museums and historic buildings. Specially sealed cases can protect delicate objects from aggressive environments. Satellite images can show the presence of archaeological sites before potential excavation, thus forcing authorities to limit new construction.

Further development of the profession requires greater educational programs and opportunities, including university curricula at all levels and in the various branches of research, coupled with more internships in museums and in the field. Growth in the number of available jobs and the hiring of appropriately trained professionals should be supported simultaneously, in order to allow for balanced development. To some degree, this process is at work in several countries, but much more remains to be done.

The field of conservation science is in expansion, and more and more innovative approaches are likely to be developed in the years to come. This optimistic assessment is mitigated only by the fact that the challenges confronting the field will, inevitably, increase in complexity and size, with the passage of time and the growth of human society.

Giacomo Chiari is chief scientist at the Getty Conservation Institute. Marco Leona is David H. Koch scientist in charge of the Department for Scientific Research at the Metropolitan Museum of Art, New York.

Dialogue

A Diverse Discipline

A Discussion about Conservation Science

What is the character of conservation science? What has been its impact on conservation practice? And what is the best way to bring new scientists into the field? Conservation *put these questions and others to three distinguished conservation scientists with extensive experience working at the nexus of science and art.*

Aviva Burnstock is a reader and acting director of the Department of Conservation and Technology at the Courtauld Institute of Art, where she took a postgraduate diploma in the conservation of easel paintings (1984) and a Ph.D. (1991). From 1986 to 1992, she worked in the Scientific Department of the National Gallery, London, after a year as a paintings conservator in Australia. Her first degree is in neurobiology. She was awarded the first Joop Los Fellowship at the Institute for Molecular Physics (AMOLF/FOM), Amsterdam, in 2003.

Chris McGlinchey has worked as a conservation scientist at the Museum of Modern Art, New York (MoMA), since 1999 and has also served as adjunct professor of conservation science at New York University since 1986. Prior to working at MoMA, he was a scientist in the Paintings Conservation Department at the Metropolitan Museum of Art in New York (1984–1999) and helped with the development of a stable varnish for old master paintings. He has a master's degree in polymer science and engineering from Polytechnic University, Brooklyn.

Narayan Khandekar received a Ph.D. from the Department of Organic Chemistry, University of Melbourne, and a postgraduate diploma in the conservation of easel paintings from the Courtauld Institute of Art. He has worked at the Hamilton Kerr Institute, the Melbourne University Gallery, and the Museum Research Laboratory of the Getty Conservation Institute. He is currently senior conservation scientist in the Straus Center for Conservation, Harvard University Art Museums, and senior lecturer in the History of Art and Architecture, Harvard University.

They spoke with Giacomo Chiari, chief scientist at the GCI, and Jeffrey Levin, editor of Conservation, The GCI Newsletter.

Jeffrey Levin: *How would each of you define conservation science?*

Aviva Burnstock: I would say it is research applied to the study of works of art and their physical preservation that includes the component of scientific methodology or analysis.

Chris McGlinchey: It's a general term that describes the work of any scientist who conducts research to assist with the study, examination, and preservation of museum objects.

Burnstock: What about the use of scientific methodology or analysis—because that's normally what a scientist does. There are methodologies that you can apply that deal with conducting experiments, the reproducibility of results, constructing hypotheses, and testing them. Wouldn't you say that is what makes it a hard science?

McGlinchey: The term, by necessity, must be imprecise, so that it reflects the breadth of scientific talents the profession requires. The nature of the inquiry will determine what technical resources, among the many available, will be tapped.

Burnstock: But isn't conservation science necessarily a hybrid? In order to pose questions, it requires not simply the ability to do analysis of a particular type but also an overview of how experiments can be carried out to examine complex problems. That's what makes it special.

Narayan Khandekar: There are other areas of science that are like that, such as marine science, which deals with the same types of issues with many different methods of analysis. I also think it might be good to broaden the definition from museum objects to cultural heritage. There are scientists involved in the conservation of sites, outdoor monuments, and all sorts of things that are not museum objects. I think of myself as a museum scientist, but there are others who deal with difficult nonmuseum things—repairing prehistoric footprints, sheltering sites to protect them, repairing archaeological monuments, and so on.

Burnstock: Is that conservation science?

"When we're talking about the big advances in conservation science, they clearly fall into two camps: materials research and objects."
—Narayan Khandekar

Photo: Dusan Stulik

Khandekar: I think it is. You need to understand what the treatment is and the impact that treatment may have on the object, which includes the site and the environment.

Levin: *I think we would all agree that conservation science is a hybrid. But is it now recognized as a separate discipline? Has it achieved its own distinct identity?*

Khandekar: I think it's recognized. The National Science Foundation has been giving grants to the field. That's recognition by a U.S. government organization that conservation science is a scientific discipline.

McGlinchey: It's a great start. But I don't think there's a cultural identification of conservation science as a separate discipline, as there is with environmental or marine science. We're further along than we were fifteen years ago, but I don't think we're close.

Burnstock: I'm not sure that useful conservation science can be separated from input from art historians and individuals who define our cultural heritage, informed by pure science and conservation practice. The most useful projects may not be categorized strictly as conservation science, whatever that is. They're always hybrid projects.

Giacomo Chiari: *Is the conservation scientist recognized at the same level as a chemist or a physicist or a biologist? Is conservation science a science?*

Burnstock: It's not traditional in the way that chemistry and physics are traditional, long-standing disciplines, taught systematically with underlying principles. But that shouldn't limit the funding that goes to a project, which, if well defined, can be very useful in preserving cultural heritage.

Levin: *Over the last fifteen or twenty years, in what areas has conservation science had the greatest impact on the practice of conservation?*

Khandekar: There are certain individuals who have contributed greatly to the advancement of different aspects of conservation using science as a basis—people like Richard Wolbers with gel cleaning and René de la Rie with his work on stable varnishes and retouching media. At the moment, there are people who work on model systems, like Christina Young, who works with Aviva. And there are people like Michael Schilling and Tom Learner who have developed new analytical methodologies.

Burnstock: I thought the question was more about the areas where conservation science has contributed, rather than individuals—for example, the recognition of the importance of passive conservation control of the environment, and the improvements in the way that art objects are transported in meeting the world demand for blockbuster exhibitions. Those are areas in which conservation science has contributed a lot.

Levin: *The individuals that Narayan mentioned have generally done research on ways to improve analysis and treatment of specific objects. The things that you're describing, Aviva, are more about the care of collections.*

Burnstock: There are huge areas of conservation—quite specific and very important—where enormous advances have been made. For example, the study of the stability of materials. The general principle that conservation materials should be stable and reversible has been a big step forward. There are a number of individuals whose research has contributed to that. Equally, the study of the materials and techniques of works of art and their deterioration is a major area of advance. All of those things help us to preserve our cultural heritage better than we could before.

McGlinchey: I concur. For example, introducing scientific rigor to the concept of reversibility has allowed for the efficient evaluation of materials of potential value to the conservation community.

Khandekar: When we're talking about the big advances in conservation science, they clearly fall into two camps: materials research and objects. Everything that we've discussed can fall into one of those two groups.

Photo: Courtesy Aviva Burnstock

"Science might bring new ways of examining or testing, but it's important that the questions are focused and defined by a conservator who knows what the pressing issues are."
—Aviva Burnstock

Levin: *In what way has the relationship among conservation scientists, conservators, and curators changed in recent years?*

Burnstock: There's a dialogue. Some institutions, like the Courtauld, where I work, are keen on improving relationships among curators and conservators and others, who want to study works of art in different ways. Dialogue is encouraged, so that you now have museums where curators are involved in the conservation of works of art, and you have academics in universities who are interested in material studies of paintings and, by implication, in their conservation.

Khandekar: I also think that it's improved. One of the things that we do at Harvard, which has a long-term effect, is running undergraduate and postgraduate courses through the History of Art and Architecture Department that look at the materials and techniques of art and artists, and at scientific analysis. People taking those courses have become museum directors and curators, and they have developed a stronger appreciation for the physical objects, which is critical.

Burnstock: We have similar courses for undergraduate art historians, some of whom subsequently apply to the conservation of paintings program. They obviously see the relationship between technical studies of objects and their preservation. That's certainly a way that we can train conservators, but generally speaking, we don't attract scientists in that way. That's a problem.

McGlinchey: There is good collegial interaction between the Institute of Fine Art [IFA] and the Conservation Center at New York University. In terms of bringing science into the IFA program, demand for it has increased over the last fifteen years because new techniques have created information that tells us a great deal about, for example, painting techniques and metallurgy. Those students who ultimately become curators and museum directors do have an awareness of how science can assist them.

Levin: *I'd like to return to this question of looking at the particular problems of objects and materials, and looking at the overarching problems of collection care, site preservation, and preventive conservation. How evenly divided is work in each of these broad areas? Do you see conservation science moving toward one or the other?*

McGlinchey: My sense is that they're expanding concurrently. There's a need to advance what one might call routine technical examination issues, as well as the long-term, big-picture research projects. The big-picture issues are derived from the collection that scientists are associated with—and if there is something about that collection that can define a research project that potentially could benefit segments of other collections.

Burnstock: Conservation science is still small enough to be driven by the needs of the profession. I see several areas where that might change. Certainly issues related to tourism and the transport and display of paintings will be a focus for conservation scientists—how we preserve our works under conditions driven by cultural needs. But there are other areas, too. For example, there's proliferation in contemporary art of different materials and all kinds of combinations of media that are going to demand different sorts of conservation.

McGlinchey: Since Aviva brought up the issue of contemporary art, one thing that hasn't been mentioned, which is important, is that change tends to be most dramatic for things that are young. This is not just common to modern materials but also to encaustic, oil, and tempera techniques as well, and it relates to how we look at old master paintings. We can begin to ask ourselves questions about why something looks the way it does and how rapidly those changes occurred. For example, did Rembrandt himself witness changes to his work? It's not just about the materiality of the collection—it's the age of the collection. With contemporary art, we're dealing with things that for all intents and purposes have zero hours of aging. How we exhibit and store these collections has tremendous bearing on how long they will last.

Khandekar: One of the things that I have found very useful is having postdoctoral scientists in my lab who come not from conservation but from a pure science background. They bring a wealth of information and interests that don't necessarily occur to those of us who work in museums. They're given the freedom during their fellowships to explore their own research, and so far it's proven very successful in bringing new scientists into the field.

Burnstock: Do you find that people from a hard science background without experience in conservation can quickly pick up conservation issues? Or do they need to work with conservators and consult with them in order to focus their questions and approach?

Khandekar: They do need that guidance, and that's why they're in the museum environment. The conservators and curators are all part of the program, and they help guide the research and the questions.

Burnstock: That collaboration is very important, isn't it? Hard science might bring new ways of examining or testing, but it's important that the questions are focused and defined by a conservator who knows what the pressing issues are.

Levin: ***Should conservation scientists be able to pursue advanced degrees while on the job, in order to encourage people with a variety of backgrounds to enter the field? Or is it better for scientists to get a Ph.D. in one of the more recognized scientific disciplines first?***

Burnstock: People trained in a conservation specialty are well placed to focus their questions. They're typically quite passionate, but they hardly ever have the resources to investigate those questions in detail, whether it's via a limited project or pursuit of a Ph.D. There are many people trained in paintings conservation who would like to do a Ph.D. because they find a gap in knowledge that they feel they can address. But there's little support for people at that level, certainly in the U.K.

McGlinchey: I don't think there's a single solution. My personal feeling is that predoctoral candidates have the greatest potential to ultimately advance this field. The operative word is *potential*. If people whose undergraduate degrees are in chemistry, physics, or biology discover conservation before they go on to graduate school, and they have an opportunity to do a predoctoral internship to learn conservation issues and the limitations of techniques presently used in conservation laboratories, then when they go to graduate school and get exposed to cutting edge technology, they see immediately what techniques may have most potential. It gives them the vision of the direction a particular science is headed in, and how it can be applied to conservation. In addition, they're talking to other students and research advisors about conservation. They're potentially inspiring other people to look into the possibilities that conservation has for a particular science.

Burnstock: It's equally useful for people who have been in the profession for some time. Those people often make significant contributions to conservation science because they're focused on the problems growing out of their own experience.

McGlinchey: The reason I said that we should not limit ourselves to exclusively nurturing postdocs is that it's a little bit like an unhealthy forest. For a healthy forest, it's not enough to have a diversity of trees—it's important to have each species of trees represented at various stages of growth. We run the risk of being top-heavy by emphasizing the postdoc route.

Khandekar: I think that the single most important factor in scientists coming into the field is their interest in art. Once they have found a way to combine their interest in art and science, then the level of their education isn't the most critical factor. I don't think it needs to be defined as an undergraduate or postgraduate or postdoctoral way of entering the field. Individuals will find their own way.

Burnstock: Don't you think, though, that conservators need to drive the questions? Can scientists drive the questions in conservation science entirely?

Khandekar: Conservators don't need to drive the questions. There are projects I have worked on that are more science and art-history based than conservation based. Comparing diary notes with what materials an artist used to paint is something that doesn't have anything to do with conservation, but it still falls under conservation science.

Burnstock: I would argue that it's implicit in conservation to understand the materials and their deterioration.

Photo: Jeffrey Levin

"In an environment where resources are so limited, we need ways to prioritize the research that goes on in this field."
—*Chris McGlinchey*

Levin: *Chris, where would you come down on this notion that the conservation scientist can sometimes drive research?*

McGlinchey: Quite honestly, I feel split. It's a gamble to have the scientist drive the questions, but it is essential they have an interest in art and cultural heritage for them to have a long-term commitment. In an environment where resources are so limited, we need ways to prioritize the research that goes on in this field. If scientists are conducting research that hasn't received buy-in from conservators, it's going to be difficult for conservators to see the value a scientist can bring them.

Levin: *Why, as yet, isn't there any kind of formal association of scientists working in this field?*

Khandekar: There's the Institute of Conservation Science, which is based in England.

Levin: *But that's strictly a U.K. organization. Why isn't there such an association in the United States, or an international organization of that kind?*

Burnstock: Perhaps because scientists working on works of art may have disparate areas of specialization, which leads to polarization of interests. For example, there are analytical scientists who specialize in one piece of equipment or in the analysis of inorganic or organic materials, and there are those fewer people who have more holistic views of conservation science.

McGlinchey: What is happening on an international level is the loose formation of users groups, such as the Infrared and Raman Users Group and the nascent gas chromatography users group. A great way to advance those areas is to have scientists with common interests join together. I'd like to see that develop further.

Burnstock: They're very useful, I agree. But unless you're a specialist in those fields, you don't belong to those groups. They're not really conservation scientist associations with holistic visions.

Khandekar: There are subgroups in the larger conservation organizations that help scientists deal with this lack of an international body—the Research and Technical Studies specialty group in AIC and the scientific subgroup in ICOM. There isn't a massive demand for such an organization because it's a small field.

Levin: *To what degree are new kinds of collaborations occurring between conservation institutions and nonconservation scientific organizations?*

Chiari: *In Italy, for five years, there was the Progetto Finalizzato Beni Culturali of the Italian National Research Council, which funded scientific and technological research into cultural heritage. That had a tremendous impact.*

Burnstock: There's also the MOLAB/EUArteck European organization, which gives institutions that don't have analytical equipment the opportunity to look at new methods for noninvasive study of works of art. These sorts of relationships are potentially very useful. We don't have a laboratory at our institute, but through my liaison with AMOLF [the Dutch Institute for Atomic and Molecular Physics] and the institute's relationship with ICN [the Netherlands Institute for Cultural Heritage], we've provided students with an opportunity to do excellent work using up-to-date analytical equipment and access to experts in both analysis and conservation science in a range of disciplines. Of course, these places are far away from where we are.

Khandekar: A couple of examples come to mind from the Getty. With the gel cleaning project, Dusan Stulik set up a successful collaboration with California State University, Northridge, and used their radioactive lab for conducting a number of experiments. Another example was the exterior mosaic of St. Vitus Cathedral in Prague. The coatings for the mosaic were developed with labs at UCLA.

McGlinchey: Shortly after arriving at MOMA, I interviewed the senior conservation staff to get a sense of some of the intractable problems they were confronting. It became evident that there was a need for a conservation-quality adhesive that would work for low-surface-energy polymers—nonpolar polymers like polyethylene. I contacted researchers at the Polymer Research Institute of Polytechnic University in Brooklyn, and that began collaborative research on a specific class of adhesives that are ideal for that group of polymers. We've made a lot of progress, and it's been a fruitful collaboration.

Burnstock: How many questions that you engage with as conservation scientists are driven by curatorial questions or art-historical questions?

Khandekar: We have a curatorial staff at Harvard that is very interested in the work that we do. We have regular, almost daily, interaction with the curators. It is a very supportive environment.

McGlinchey: For me, direct contact with the curators happens when they're concerned about issues of stability—for example, they want to know if a particular light level is safe or will cause fading. It's that kind of instance where I get contacted directly.

Burnstock: Do people from outside your institution come to you because you're the expert conservation scientist in that sort of modern collection?

McGlinchey: Yes. But at MOMA the collection is so broad and complex that I can spend all of my working hours answering questions directly related to our museum collection. When I do get outside calls, if I can't answer them in a brief phone conversation or with a quick follow-up call, I try to direct them elsewhere.

Burnstock: Because we have concerns that deal with other cultural heritage—the National Trust, English Heritage, and other collections in the U.K. that are in uncontrolled conditions—our interactions involve more than the Courtauld Institute Gallery's collection, for which we're responsible. In education, one is required to deal with a range of issues wider than those limited to museums.

Khandekar: Part of my work is doing fee-for-service analyses for regional museums and private collectors. Much of it is routine analysis, which we're trying to reduce, but we still take on projects that have an interesting research component. It's very important because it gives these people access to something that they normally don't have in a smaller museum.

Burnstock: The UKIC [United Kingdom Institute for Conservation], which is probably going to turn into the Institute of Conservation, was proposing that educators and people who work in museums act as mentors for people who've got questions about conservation science and preservation of cultural heritage. Do you have something like that in the United States?

Khandekar: I can't think of anything. I do take in people who are looking to enter conservation school or to get into the field, and give them lab projects so they get some experience to help them with their applications. And we have high school students occasionally, as well. I find it very rewarding working with people, showing them the work that I do, and giving them an opportunity to see if this is something that they want to pursue.

McGlinchey: The MOMA education department has great high school summer and after-school programs. In addition, if the applicants have any potential interest in conservation issues, they're directed to the conservation department. We've had a lot of successful, great students come out of that.

Burnstock: Giacomo and I had a discussion earlier about consciousness-raising for professionals who are involved in the preservation of cultural heritage—the people we need to persuade to do scientific studies as part of conservation. It's those people who can and should be made aware that conservation science is an important part of preserving cultural heritage. That's lacking.

Levin: *It's been noted that there is an insufficient number of conservation scientists, as well as an insufficient set of opportunities for conservation scientists. How do we increase both of these areas simultaneously?*

Khandekar: Angelica Rudenstine of the Mellon Foundation is helping to address these issues. She has created a number of endowed positions and a number of training opportunities, and in a relatively short amount of time, she has given us the opportunity to increase the population of conservation scientists and provide them with jobs when they finish their training.

McGlinchey: The Mellon Foundation has been fantastic, but I would hope to see additional granting foundations follow. It's great when outside organizations recognize the need. But it's absolutely critical that the need be recognized internally within the institution.

Khandekar: This ties in with what we were saying earlier about having directors and curators who are well versed in the benefits of conservation science. They're the people making the decisions about their museums. If you have directors who are supportive, then they can talk to the trustees. It may also be useful to have scientists as trustees. That's how you start changing the environment and making the scientists an integral part of museum work. That is when you start getting more funding and equipment. It comes from educating people early on.

Levin: *What will this field look like fifteen years from now?*

Burnstock: It's a resources issue. Institutions that have centralized resources are beginning to open up and facilitate research in collaboration with others. If that continues, or if there is direct funding for improving facilities in areas that require extra support for doing conservation science, one could expect a developing profession.

McGlinchey: I can only hope that we'll see progress. There are a number of scientific groups conducting research that have only recently been established. The ultimate benefits of their research remain to be seen.

Khandekar: Fifteen years ago we couldn't have anticipated what would happen now. Equally, I don't think that we can anticipate what will happen in the future. I know that the field will improve, but it is difficult to know in which ways.

Burnstock: Collaborations with other centralized institutions can and will benefit us if they continue in pursuit of excellent conservation science, focused by conservators. If these institutions change their policies about collaboration, then we're in great difficulty. It all depends on the goodwill and the opportunities to collaborate with other institutions.

McGlinchey: I talked a little bit about curators' concerns about fading. That's an example of their interest in preventing the collection from, to use an economic term, depreciating. But to flip that around, how can a scientist make the collection appreciate in value? Beyond addressing the kind of technical questions we've alluded to already, what kind of information can we provide that not only improves our understanding of works of art, but causes us to appreciate them more? That's an abstraction that I was thinking of when you asked how this field is going to be different fifteen years from now.

Khandekar: A collection appreciates in value when you understand it better. The work we do allows us to understand the collection better, so at a fundamental level, everything that we do helps us appreciate the collection.

McGlinchey: But does the curator recognize that?

Khandekar: We can talk to curators and help them understand that, and then we can also publish in journals that curators read—*Burlington Magazine, Apollo, October,* or *Artforum*. Exposure and understanding of what we do is crucial.

Burnstock: It's entirely necessary to communicate with both curators and people who understand the works that we are dealing with—their preservation and their historical context. That leads to an appreciation of collections and cultural heritage in general. And, of course, it contextualizes what we do.

Khandekar: There are museums like the National Gallery in London that have taken amazing steps toward that with their Art in the Making exhibitions and small specialized shows that combine art history, conservation, and conservation science, looking either at specific paintings or a small group of paintings. It doesn't just help the professionals—the public also finds these exhibitions very engaging. In England there's a great sense of ownership of the public collections. People enjoy learning more about what they perceive as their own.

Chiari: *We should make an effort to digest and present our results to the general public and to try to make our presence more visible. That may mean concentrating less on presenting to the public the scientific details of our professional work—leaving that to the specialized journals—and concentrating more on how that work really enriches our understanding of the objects.*

Burnstock: That sort of accessibility comes via collaboration with people who look at works of art, including the public, curators in museums, academics who study paintings, and conservators who look at their material nature and their preservation. And that, as Narayan has pointed out, includes compelling exhibitions and publications that result from those exhibitions that have been popular with the public. Making scientific knowledge accessible implies contextualization of the information and building a picture of the point of the scientific work—not just the pure analysis, which few will understand.

Training and Education in Conservation Science

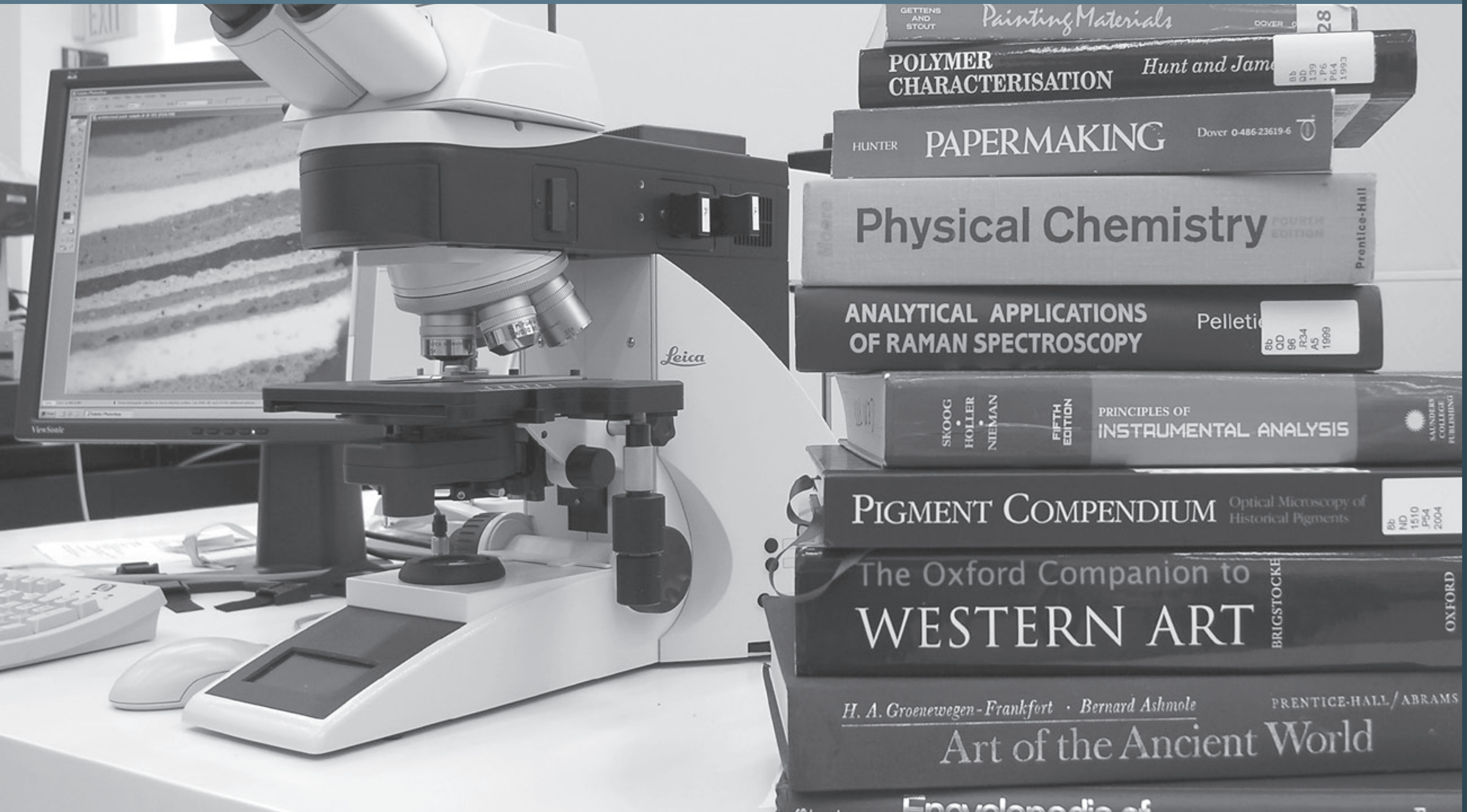
By Karen Trentelman

Conservation science draws from a variety of scientific disciplines, as well as arts and humanities disciplines, such as art conservation, archaeology, and art history. *Photo:* Jeffrey Levin.

"How did you get into conservation science?" is probably one of the most frequently asked questions of scientists working in the area of cultural heritage. And the answers to that question are as varied as the field itself. The tremendous diversity of materials to be studied and issues to be resolved in conservation science draws people from a wide variety of scientific backgrounds, including physics, chemistry, materials science, geology, and biology. Indeed, as increasing numbers of people enter the field, the various routes into conservation science—and the amount of education and training that should be required for people entering the field—have become subjects of discussion and debate. But regardless of the route an individual has taken, the impetus is typically the same: a passion to understand and preserve our cultural heritage.

Conservation science is not a well-established field in the same manner as traditional scientific disciplines such as physics, chemistry, or materials science. Neither can it be classified as a subdiscipline of one of these fields, such as condensed matter physics, organometallic chemistry, or nanomaterials. In some ways, conservation science is more difficult to define.

In general, the work of conservation scientists includes authentication, art-historical research, and conservation-related research. Although authentication may be the easiest to understand because it supports purchases and the assignment of value to objects (or perhaps because of the success of the *Antiques Roadshow* television program), it is not the primary focus of most conservation science studies. More frequently, studies of the materials and methods used to create works of art are carried out with the goal of contributing to the understanding of artists' work and its significance within an art-historical or cultural context. Conservation-related



GCI scientist Eric Hansen discussing a GCI project on lime-based mortars and plasters with Getty graduate intern Ann Bourges (now a GCI research lab associate). The GCI offers scientists a number of training opportunities in conservation science, including graduate internships and postdoctoral fellowships. *Photo:* Dennis Keeley.

research includes studies in the behavior and stability (or lack thereof) of the materials that compose works of art, and the development of materials and methodologies to counteract, or at least to mitigate, deterioration. This last activity might best earn the name conservation science, although any activity that advances the understanding of a work of art can be considered to aid in its subsequent preservation.

Because of this breadth of activity, conservation science draws from nearly all areas of physical science, as well as arts and humanities disciplines, such as art conservation, archaeology, and art history. It demands that its practitioners be familiar with the materials and methods used to create works of art in nearly every culture and time period throughout history, understand the properties and behavior of those materials as they age, and develop strategies to prevent or slow their deterioration.

Entering the Field

Perhaps the most common route into conservation science has been to obtain an advanced degree in one of the established scientific disciplines and then to apply that training to the study of works of art. Although most science programs do not specifically teach conservation science applications, they do promote critical thinking and creative problem solving—essential tools for any good scientist. Graduate-level research, in particular, teaches and encourages independent thinking, the application of the scientific method, the development of research strategies, the ability to critically interpret the significance of results, and the skills to effectively communicate findings. Given the broad scope of questions asked of most conservation scientists, these adaptive skills may be more important than proficiency with a particular technique or methodology.

Some argue that training in just one of the traditional scientific disciplines may not be sufficient for the highly specialized and diverse application of conservation science. However, most scientists do not end up working in the area of specialization they chose in school but, rather, adapt the skills they learned during their studies and develop new skills for whatever the application and their employment demand. Conservation science and the study of materials important to works of artistic and cultural significance may similarly be viewed as another area to which science is applied. There is a long history of this approach, as exemplified by the series of seminars entitled Application of Science in Examination of Works of Art, begun in 1958 at the Museum of Fine Arts, Boston. Adaptation of new scientific methodologies to the study of works of art is still a very important aspect of the field, as evidenced by the recent advances made in instrumentation which either enable the examination of works of art noninvasively (as with Raman microscopy) or provide a means of getting better information out of smaller samples, as with newly developed pyrolysis gas chromotography–mass spectrometry (GC-MS) techniques.

It is generally accepted that some degree of formal scientific training is a necessary prerequisite for entry into the field. But there is considerable debate as to how much education should be required. A Ph.D. is becoming an increasingly common requirement for conservation science positions, even for entry-level positions. Determining whether or not this is appropriate depends, in part, on how success in the field is measured.

Measuring Success

One of the difficulties of measuring success in conservation science is that it is a hybrid field—a blend of "pure" research traditionally associated with university-based laboratories and "applied" research typically conducted in industrial-based laboratories. Although the division between these traditional approaches to research is becoming blurred—as funding agencies such as the National Science Foundation increasingly support the development of joint academic-industrial research centers and require that research programs not only have intellectual merit but a broader impact as well—the measures of success for scientists working in either academia or industry are still clearly defined. However, most conservation scientists do not work in either a purely academic or purely industrial environment. They may be based in museums, research institutions, or even private laboratories. As such, the criteria for measuring success in conservation science have not yet been clearly defined for the field as a whole.

In academia, success is measured by the number of publications produced and the ability to generate external funding. In order to be successful in these endeavors, a Ph.D.—and an association with a recognized research institution—are generally necessary. Reviewers of publications and grant applications need to evaluate the qualifications of the applicant quickly. If they are not familiar with the field (and most scientists in traditional disciplines are not aware of conservation science) then a doctorate in a recognized discipline provides them with a benchmark by which to assess the applicant. Publication in mainstream scientific journals tends to be dominated by academic researchers, as is success in competing for grants from national agencies. However, it is not an exclusive club. Scientific journals such as *Analytical Chemistry* and *Analytica Chimica Acta* frequently publish articles relating to conservation science. In addition, the National Science Foundation—in particular its Division of Materials Research—has recently funded grants supporting the acquisition and development of instrumentation to be used for conservation science projects.

In industrial-based research laboratories, such as those in pharmaceutical, defense, or chemical development companies, success is generally based on results and the ability of the research to improve the company's bottom line. There is more room for individuals with varying levels of education in an industrial or corporate setting than there is in academia, although promotion and the ability to direct research rather than simply to execute it generally correlate with the level of education. Furthermore, corporations will frequently assist their employees in obtaining more education to further their careers within the company.

One of the difficulties in conservation science is that, as a blended field, it measures success following both of the above models. The discovery of new phenomena and dissemination to the broader field are as valued as studies of individual works of art that may impact their preservation, exhibition, or (in extreme cases) value. However, a conservation scientist's success may also be measured by his or her ability to interact successfully with conservators, curators, and art historians and to contribute to the understanding and interpretation of works of art. This attribute, which perhaps is one of the more challenging aspects of conservation science, is also the one that is least likely to be learned through a traditional scientific education program.

Jens Stenger—an Andew W. Mellon postdoctoral fellow in conservation science at Harvard University Art Museums—taking samples from *Saint Roch* by Giovanni Canavesio. Stenger is working on a collaborative project to better understand the unusual painting technique of distemper on canvas. Postdoctoral fellowships are a traditional route for scientists to receive additional specialized training in conservation science. *Photo:* Narayan Khandekar.

Options for Training

The traditional route for scientists to gain experience in areas outside their field of graduate study is through postdoctoral fellowships. There are a few postgraduate programs through which scientists may receive additional, specialized training in conservation science, including long-standing programs such as the Charles Culpepper Fellowships offered through the National Gallery of Art in Washington, D.C., and individual advanced training fellowships awarded to museums and cultural institutions through agencies such as the Kress Foundation and the National Endowment for the Arts. It is encouraging that additional ongoing programs have recently been established, including the conservation science postdoctoral programs at the Harvard University Art Museums and the Getty Conservation Institute, although more such programs are certainly needed.

Over the last decade, there has been a dramatic increase in the number of available conservation science positions, due to attrition as well as to the creation of new positions. The Andrew W. Mellon Foundation, in particular, through the efforts of its program officer Angelica Zander Rudenstine, has been pivotal in increasing support for conservation science and in the creation of several new conservation science positions at museums and cultural institutions in the United States. Whereas perhaps there used to be only one conservation scientist at an institution, there now may be several. Consequently, institutions are faced with the task of standardizing educational and experience requirements for hiring and promotion.

As mentioned earlier, a doctoral degree is increasingly becoming a requirement for entry into the field. Without question, the field can only benefit from having well-trained scientists among its ranks. While a Ph.D. program does not guarantee the ability to think critically and creatively, it does provide some measure for judging otherwise unknown applicants. Furthermore, having more Ph.D.-level scientists may enable the field as a whole to compete more successfully with academic scientists to publish in mainstream journals and, more important, to obtain external funding.

However, some of today's foremost conservation scientists do not hold Ph.D.s but have developed their skills on the job. Not surprisingly, many believe that it would be a mistake to insist on hiring only Ph.D.s, thereby closing the avenues that have been used by many skilled conservation scientists in the past. In order for the field to benefit from the contributions of such individuals in the future, it has been suggested that the industrial model be followed more closely—to bring in individuals with various levels of education and to encourage those who show promise, in part by supporting them with additional formal training as appropriate.

Is it possible, or even reasonable, to establish a single set of professional standards for a field as complex and diverse as conservation science? There is, of course, no simple answer to this question. Conservation science needs creative scientists from a variety of backgrounds. But we must be careful not to create a set of prerequisites that constrains the field to growth in only one direction. By keeping in mind the particular needs of this special field and by taking what is most appropriate from the academic, industrial, and museum models, we may create our own definition of success and, in doing so, ensure a field that is creative, vigorous, forward looking, and respected. We must attract talented, well-trained scientists to join the field, while maintaining a mechanism for mentoring promising young scientists developing within the field. We must establish collaborations with mainstream science and encourage technology transfer, while simultaneously keeping a vigorous connection with the disciplines conservation science supports and relies on, such as art history, archaeology, and, of course, conservation itself. We must engage the support of other areas of science by disseminating our research to wider audiences through publication and presentations, while remaining mindful of the needs of our ultimate commitment—the cultural heritage itself.

Karen Trentelman is a senior scientist with the Getty Conservation Institute.

Science for the Conservation of Wall Paintings

By Francesca Piqué

Lorinda Wong of the GCI using multispectral imaging to study the seventeenth-century wall paintings cycle by Andrea Pozzo at the Mission of Mondovì in Italy. *Photo:* Francesca Piqué.

Historically, there has been a widespread misconception among art historians and restorers that most wall paintings are frescoes. The term *fresco* has a specific and precisely defined meaning: pigment particles (substances that add color) mixed in water and bound to the surface of the wall by the carbonation of fresh lime plaster. This durable painting technique enjoyed brief periods of popularity among the ancient Romans and Italians, but in its purest form it was generally rejected by artists as too limiting. Instead, painters from all periods, across the globe, have relied on a wide range of organic materials (e.g., egg, glue, resins) as binders (materials that hold pigments together and bond paint to a surface) for works of art on walls. This lack of understanding of the nature and presence of the organic materials used in wall paintings has resulted in considerable damage from misguided restoration interventions.

While identifying inorganic components in wall paintings today is a relatively straightforward process, doing the same for organic materials remains a challenge. The challenge arises principally from four factors: low binder-to-pigment ratio (as low as one-tenth of a percent of binder); the unstable chemico-physical nature of organic materials, which may result in rapid and dramatic decay; the large, often vast, heterogeneous, open and porous wall painting systems, which are highly susceptible to degradation and contamination; and the complex interactions among the painting materials (typically pigments and binders but also other materials as well), which can limit and alter the capability of scientific instruments to identify materials.

Appropriate conservation treatment should be minimal, compatible with the original material, and stable in the long term. To achieve this, interventions—both preventive and remedial—must be developed according to a methodology that begins with the characterization and identification of the problems through rigorous diagnostic investigations. Conservation science, by virtue of its multidisciplinary nature, has a crucial role in this process. Environmental science, analytical chemistry, and materials science, among the many disciplines that make up conservation science, are key to answering specific questions regarding the causes and mechanisms of deterioration in works of art. Conservation science may also provide effective solutions to remedy the situation.

Members of the OMWP project sampling Tintori wall painting replicas for the evaluation of invasive techniques. From left to right: Austin Nevin, the Courtauld Institute of Art; Fabio Morresi, the Scientific Laboratories of the Vatican Museums; Cristina Grandin, the Laboratorio per l'Affresco di Vainella; Elisa Campani, University of Parma; Gwänelle Gautier, University of Pisa; Monica Favaro, Istituto di Chimica Inorganica e delle Superfici; and Giancarlo Lanterna, Opificio delle Pietre Dure. *Photo:* Francesca Piqué.

Examples of Tintori wall painting replicas at the Laboratorio per l'Affresco di Vainella. These are similar to the replicas used by the OMWP project to evaluate investigative techniques. *Photo:* Francesca Piqué.

To enhance the way that conservation science supports the conservation of wall paintings, the Getty Conservation Institute has partnered with a number of scientific laboratories to create the Organic Materials in Wall Painting (OMWP) project. The goal of the project is to develop a set of guidelines to facilitate the study of organic materials in wall paintings. The project has two parts: first, to evaluate various investigation techniques and to develop a series of guidelines for organic materials identification; second, to apply these guidelines to wall painting conservation case studies to illustrate the guidelines and their practical benefits.

Developing a Methodology

There is not a single area of expertise or a single investigative technique that can be used to efficiently detect organic materials in wall paintings. Different types of investigations and techniques must be used and integrated to obtain significant results. Characterizing organic materials through scientific investigation in a way that is both resource effective and that minimizes the amount of sampling required is a principal aim of the OMWP project.

The methodology advocated by the project is based on a sequence of investigations and, during the case study phase, on the role of the conservator in the formulation of questions and in the interpretation of results. The investigations include:

Noninvasive investigations (no sampling required)

- *Imaging and surface mapping techniques*—providing topographic information on areas of the paintings
- *Point analysis*—explores a tiny area on the surface of a painting

Invasive investigations (sampling required)

- *Nondestructive*—carried out directly on an unmounted sample without altering it
- *Paradestructive*—carried out on a prepared sample (e.g., mounted as a cross section or thin section showing the painting stratigraphy). Preparation procedures may induce physical and chemical alterations and prohibit the recovery of the sample in its original form; however, the same sample may be used for other analytical procedures, such as:
  - *Imaging and surface mapping*—providing topographic information on an area of the prepared sample (cross section)
  - *Noninvasive point analysis*—explores a point-like surface of the prepared sample
- *Destructive*—completely consumes the sample analyzed

Proper sampling procedures are crucial for invasive techniques. To ensure representative results, sampling locations should be carefully selected based on the results of noninvasive investigations. It is important to select a representative area of the phenomenon under study and to ensure that sampling is minimal and confined. Samples are then studied, with preference given to nondestructive investigations that do not preclude further testing; destructive methods are left for last.

The process is iterative—each new result is interpreted and its significance is reviewed in relation to previous results; it will either serve to confirm or reject previously held hypotheses. Even after an exhaustive study of a sample, it is not uncommon for questions to remain or for new questions to arise, requiring additional sampling.

Evaluating Investigative Techniques

The OMWP project's first phase evaluated a number of techniques by examining a group of lime-based wall painting replica samples of known composition made by Leonetto Tintori between 1993 and 2000 and provided to the project by the Laboratorio per Affresco Elena e Leonetto Tintori in Italy (see *Conservation,* vol. 18, no. 3). These reference standards are characterized by the use of different types of binders and pigments and by the timing of the application according to the level of carbonation of the plaster—fresh, partially carbonated, or fully carbonated (i.e., plaster that is wet, partially dry, or fully dry).

Each of the partner laboratories investigated the analytical potential of one or more techniques on the Tintori samples. For newly developed techniques, testing these samples has been useful not only for evaluating each technique but also for creating a database of reference information on the particular pigment and binder combinations studied.

Imaging technologies commonly identify surface behavior associated with different material compositions—for example, UV-visible fluorescence associated with the presence of fluorescing organic materials. Maps of UV-visible fluorescence on a painting's surface, integrated with visual examination by conservators, permit the identification of areas and points of a wall painting's surface likely to be rich in organic materials. Point analysis is then used to further characterize the visible emission fluorescence of these materials. The research conducted by the OMWP project shows that the fluorescence emission of the organic material is strongly affected by the type of pigments used, as well as by the timing of the application (i.e., to fresh, partially carbonated, or fully carbonated plaster). Some pigments, such as red and yellow ocher, quench the fluorescence of organic materials. Therefore, in the presence of these pigments, lack of fluorescence does not imply the absence of organic materials.

Noninvasive techniques have an intrinsic limitation: they provide information about a painting's surface but not about its stratigraphy. However, the value of noninvasive imaging and point analysis resides in the techniques' mapping capacity. With large painted surfaces, this is a significant advantage because it allows characterization and mapping of similar surface behavior. As a consequence, only limited sampling is required to answer specific questions associated with the behavior observed; in fact, the most appropriate sample location can be selected from the information provided by the noninvasive investigations and by the conservator. Appropriate sample handling and preparation are also extremely important in order to prevent sample contamination, and for reliable identification of the limited amounts of organic materials in the samples.

The evaluation of the investigative techniques is ongoing and is based on various factors: the type of information provided by a specific technique, the sensitivity of the technique, the amount of sample required, the cost of the analysis, the length of time required, and the general availability and difficulty of the technique.

The development of a set of methodological guidelines will provide a useful tool in streamlining the identification of organic materials in wall paintings through both simple in situ examination and more sophisticated analytical procedures. It is important to illustrate the effectiveness of this methodology with case studies and to highlight the importance of planning diagnostic investigations based on information previously collected and on a conservator's observations prior to the conservation intervention. This is the aim of the second phase of the project.

Case Studies

Applying the methodology to wall paintings requiring conservation will provide an opportunity to verify and illustrate the validity of the methodology and its direct implications for wall paintings conservation. The case studies will focus primarily on lime-based wall paintings. Noninvasive research work began this spring on the wall paintings cycle of the lives of Saint John and Saint Stephen painted in the fifteenth century by Filippo Lippi in Saint Stephen's Cathedral in Prato, in conjunction with a conservation project being carried out under the supervision of the Italian Ministry of Cultural Heritage. The conservation work—under the direction of Mark Gittins of the firm Conservazione Beni Culturali—has been ongoing since spring 2001. These paintings have a complicated conservation history—the current conservation effort is the third in the past century. The Opificio delle Pietre Dure in Florence, an OMWP partner, has been responsible for the project's diagnostic investigations. The OMWP project team's work on the Lippi cycle complements research already conducted at the site during conservation. The scientific work at this site, along with the conservation work, will be completed by the end of 2005.

The OMWP project team is currently researching other case studies where the OMWP guidelines can be applied from the beginning of a conservation program, to support conservation treatment planning. The OMWP research work will include the integration of the various techniques that can address questions from conservators and questions that require knowledge of the organic materials present in the wall. It is hoped that this work will provide an opportunity for better understanding of the original binding materials used in the paintings. This information is important not only to enrich the field's scarce knowledge about the use of organic materials in wall paintings but also to provide support information for future studies of paintings by the same artist or of paintings from a similar period.

Conservator Mark Gittins of Conservazione Beni Culturali and conservation scientist Giancarlo Lanterna from the Opificio delle Pietre Dure (OPD) examining and evaluating the results of on site invasive investigations. The OPD is responsible for the project's diagnostic investigations, which have included the characterization of synthetic resins used during previous conservation interventions. *Photo:* Francesca Piqué.

Catia Clementi and Ilaria Motta from the University of Perugia taking in situ measurements of the UV-visible fluorescence emission of organic materials in the Filippo Lippi wall paintings in Saint Stephen's Cathedral in Prato, Italy. *Photo:* Francesca Piqué.

Not all of the investigative techniques tested in the first phase will be applied to the case studies; only those deemed appropriate, based on ongoing study and the needs of the wall paintings, will be employed. The case studies aim to demonstrate the iterative nature of scientific investigation and the essential role the conservator plays in the practical application of conservation science.

The work completed so far—the first phase of the project—has shown the advantages and the limitations of currently used investigative techniques. Evaluation of these techniques on wall paintings samples of known composition has proven very useful in illustrating the type of results that the various binder and pigment combinations provide. Research has shown that information about the inorganic materials present in the paintings is important in order to aid interpretation of the findings regarding organic materials. These results, to be compiled by the OMWP project, will be available as a reference for further wall painting studies.

Technologies are constantly improving and—significant for the study of wall paintings—laboratory instruments are becoming portable, making information about the nature of the materials in paintings accessible in situ without the gathering of samples and facilitating direct dialogue with the conservator. A good example is the in situ use of reflectance Fourier transform infrared spectroscopy (FTIR) with fiber optics. Following the identification of areas with different fluorescence emission, noninvasive FTIR has proven helpful in characterizing these differences by enabling classification into organic materials groups, such as proteins and lipids, without requiring samples.

On the one hand, the continuous advancement and availability of techniques are beneficial, as they provides conservation science with more tools to examine heritage. On the other hand, research that utilizes different techniques may produce an accumulation of data and may use significant resources without contributing substantially to the work of conservators. It is essential that scientific research focus on actual conservation problems, that it be conducted with the most efficient techniques, and that its results be interpreted and evaluated in order to provide the information needed by a wall paintings conservation program.

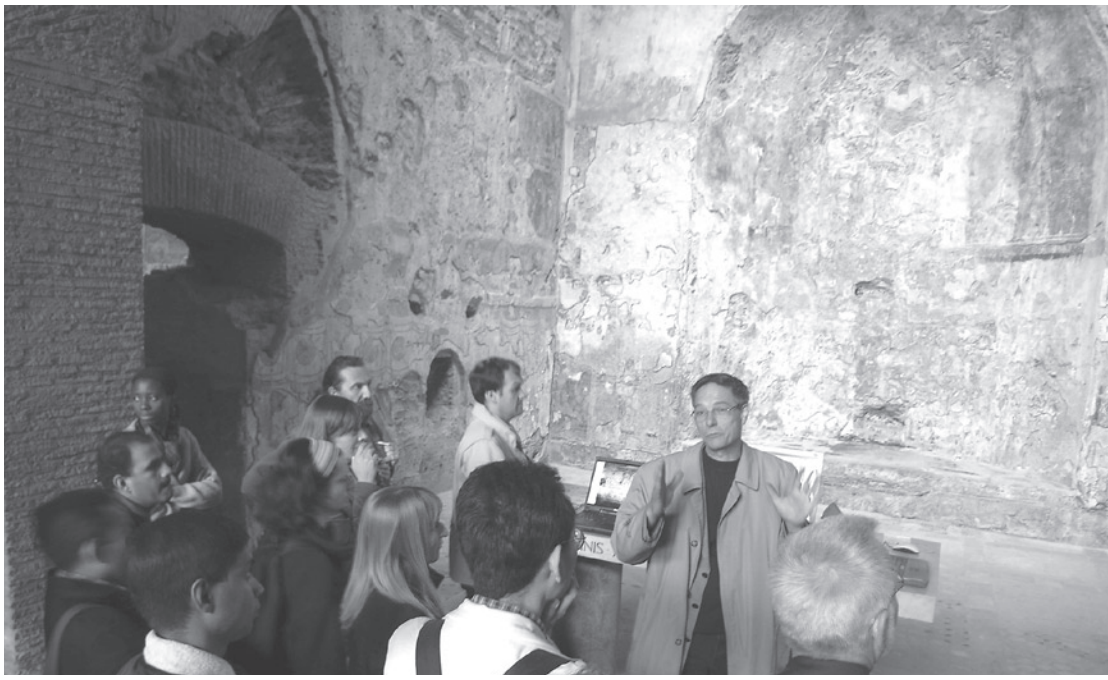
Francesca Piqué is the coordinator of the Organic Materials in Wall Paintings project and a freelance conservator based in Italy. She is a former project specialist with GCI Field Projects.

Scientific Partners

Courtauld Institute of Art, Wall Painting Conservation Department, University of London
The Getty Conservation Institute, Los Angeles
Forth Photonics, Athens
Istituto di Chimica Inorganica e delle Superfici–Consiglio Nazionale Ricerche CNR, Padua
Istituto Centrale per il Restauro, Rome
Istituto per la Conservazione e la Valorizzazione dei Beni Culturali CNR, Milan
Istituto di Fisica Applicata Nello Carrara CNR, Florence
Istituto di Scienze e Tecnologie Molecolari CNR, Perugia
Opificio delle Pietre Dure, Florence
Politecnico di Milano, Dipartimento di Fisica, Milan
University of Delaware: Winterthur Museum and Country Estate, Delaware
University of Perugia: Dipartimento di Chimica, Sezione di Chimica-Fisica, Perugia
University of Pisa: Dipartimento di Chimica e Chimica Industriale, Pisa
University of Parma: Dipartimento di Chimica Generale ed Inorganica, Parma
Laboratorio Scientifico dei Musei Vaticani, Vatican City

ICCROM/GCI Course in Rome

Instructor Werner Schmid discussing with course participants the photographic and condition recording of wall paintings at Santa Maria Antiqua—the oldest Christian structure in Rome's ancient Forum. *Photo:* Rand Eppich.



Sixteen senior architectural conservation professionals from around the world completed the monthlong course Architectural Records, Inventories, and Information Systems for Conservation (ARIS05), held in April 2005 in Rome. Designed in partnership by the GCI and ICCROM (the International Centre for the Study of the Preservation and Restoration of Cultural Property), this advanced course addressed the needs, methodology, and techniques for acquiring and using records, inventories, and information management tools for the conservation of cultural heritage.

The course was structured around three knowledge blocks:

- *documentation*—principles, theory, and guidelines;
- *recording practice*—generating records, archival research, and dissemination; and
- *information management*—planning, practice, access, and dissemination.

Specific topics of study included photography, photogrammetry, site surveying, geographic information systems, and dissemination. The curriculum featured a range of learning strategies that allowed participants to draw upon their professional knowledge while acquiring new information and skills through readings, discussion, and collaborative practical exercises. The courses were taught by leading experts from several European and North American institutions.

Practical recording exercises were carried out in the Piazza di Santa Cecilia with the support of Vatican cultural heritage officials. The UNESCO office in Venice and the director-general of cooperation for development, Italian Ministry of Foreign Affairs, also contributed to the course.

For information on additional training opportunities, please visit the ICCROM Web site at www.iccrom.org.

UNITAR Workshop

Gate marking the entrance of the Itsukushima Shrine, originally built in the late 6th century and now a World Heritage site, on Miyajima Island near Hiroshima. UNITAR participants visited this site in the context of the workshop. *Photo:* Jeff Cody.

In April 2005, GCI staff participated as instructors and resource personnel in a weeklong workshop entitled World Heritage Management: A Value-Based Approach, presented by the United Nations Institute for Training and Research (UNITAR) in Hiroshima, Japan. This is the second in a three-year series of UNITAR workshops on the management and conservation of World Heritage Sites. The first workshop was held in Hiroshima in March 2004 (see *Conservation,* vol. 19, no. 2).

Participants in the April 2005 workshop included trainers and decision makers from World Heritage administrations; midlevel officers from national governmental authorities such as ministries of environment, culture, or forestry; and World Heritage Site managers.

The workshop emphasized the value-based approach to heritage management introduced in the 2004 workshop. Participants received basic information and updates on the World Heritage organization, were introduced to current topics regarding heritage management, and studied leading policies and strategies, including examples of successes and failures. They learned legal and policy-planning techniques, discussed case studies, and performed practical exercises, which enhance long-term learning and exchange among the participants.

Two study tours to World Heritage Sites—the Atom Bomb Dome and Itsukushima Shrine—provided additional learning opportunities and case studies during the workshop.

The long-term objective of the course is to foster better use of the World Heritage Convention through national policy making and planning and the exchange of best practices and case studies.

For further information, visit the Web site of the UNITAR Hiroshima Office for Asia in the Pacific at www.unitar.org/hiroshima/.

Goce Delčev Award

Last May, authors Predrag Gavrilovič, William S. Ginell, Veronika Sendova, and Lazar Šumanov were awarded Macedonia's 2005 Goce Delčev Award for significant achievement in the field of science, for the GCI publication *Conservation and Seismic Strengthening of Byzantine Churches in Macedonia*. The award—named for Goce Delčev, organizer of the Macedonian revolutionary movement in the late nineteenth and early twentieth centuries—recognizes work of particular importance to the Republic of Macedonia and is conferred under the auspices of the Macedonian Ministry of Education and Science and the Macedonian Academy of Sciences. The award was presented in an official ceremony in the Macedonian Parliament in the presence of the president of Macedonia,

the president of the parliament, the prime minister, government ministers, and members of the scientific and diplomatic communities. This is the first time the award has been granted to work published outside of Macedonia.

Conservation and Seismic Strengthening of Byzantine Churches in Macedonia, published by the GCI in 2004, summarizes the results of a four-year study to develop and test seismic retrofitting techniques for the repair and strengthening of ancient Byzantine churches. The project was managed at the GCI by William S. Ginell, who was a senior scientist with the Institute.

The recipients of the 2005 Goce Delčev Award: Lazar Šumanov, William S. Ginell, Veronika Sendova, and Predrag Gavrilovič. *Photo:* Courtesy Pedrag Gavrilovič.

Future Events

ICCM Conference

Detail of a mosaic floor in the viridarium (octagonal garden) of La Voliere, a Roman villa in Carthage, Tunisia. *Photo:* Kathleen Louw.

The International Committee for the Conservation of Mosaics (ICCM) will hold its ninth triennial conference November 29–December 3, 2005, in Hammamet, Tunisia. The conference—entitled "Lessons Learned: Reflecting on the Theory and Practice of Mosaic Conservation"—is coorganized by the Getty Conservation Institute and Tunisia's Institut National du Patrimoine, with the support of ICCROM and the University of Cyprus.

Participants will include professionals in the conservation of ancient mosaics, art historians, and archaeologists of the Roman world, from Europe, the Middle East, North Africa, and the United States.

The deadline for early registration and the postconference tour to Libya is August 31; the deadline is October 15 for late registration. The complete updated conference announcement, including registration forms, is available on the Getty Web site at www.getty.edu/conservation/field_projects/mosaics/index.html.

For further information, please contact:

Demetrios Michaelides
ICCM
iccm05@yahoo.com

Kathleen Louw
The Getty Conservation Institute
klouw@getty.edu

Fall Lectures

The GCI announces its fall 2005 schedule for "Conservation Matters: Lectures at the Getty"—a public series examining a broad range of conservation issues from around the world. Lectures are held Thursday evenings at 7:00 PM in the Harold M. Williams Auditorium at the Getty Center. Events are free, but reservations are required. To make a reservation or for further information, visit the Getty Web site at www.getty.edu/conservation/public_programs/lectures.html. Reservations can also be made by calling 310 440-7300.

Pondering Apelles
October 20, 2005
James Coddington, chief conservator at the Museum of Modern Art in New York.

Erasing Boundaries between Artists and Conservators
November 17, 2005
Joyce Hill Stoner, paintings conservator and professor in the program in art conservation at the University of Delaware, will speak about the challenges conservators face when working with living artists.

Getty Graduate Internships

Applications are now being accepted for Getty Graduate Internships for the 2006–2007 program year. The Graduate Internship program offers full-time paid internships for graduate students currently enrolled in a graduate course of study or for students who have recently completed a graduate degree who intend to pursue careers in art museums and related fields of the visual arts, humanities, and sciences.

Internship opportunities at the GCI may include:

- learning to organize and implement field campaigns;
- developing laboratory research and its application to practical fieldwork;
- using scientific and analytical tests and equipment to understand processes of material deterioration; and
- contributing to the creation of curricula and didactic materials for continuing professional development.

Internships are also offered in the conservation laboratories of the J. Paul Getty Museum and the Getty Research Institute. The application deadline for the 2006–2007 program is December 15, 2005. For further information, including application materials and a complete list of internship opportunities, please visit the Grants section of the Getty Web site at www.getty.edu/grants/education/grad_interns.html.

Information is also available by contacting:

Graduate Internships
The Getty Foundation
1200 Getty Center Drive, Suite 800
Los Angeles, CA 90049-1685 U.S.A.
Tel: 310 440-7320
Fax: (inquiries only) 310 440-7703
gradinterns@getty.edu

Conservation Guest Scholars

The GCI is pleased to welcome its 2005–2006 conservation guest scholars. The Conservation Guest Scholar Program is a residential program that serves to encourage new ideas and perspectives in the field of conservation, with an emphasis on research in the visual arts (including sites, buildings, and objects) and on the theoretical underpinnings of the field. This competitive program provides an opportunity for conservation professionals to pursue interdisciplinary scholarly research in areas of general interest to the international conservation community.

Scholars—who are in residence at the GCI for periods of three to nine consecutive months—are given housing at a scholar apartment complex, a work space at the GCI, a monthly stipend, and access to the libraries and resources of the Getty. Now in its sixth year, the program has hosted scholars from around the world working on wide-ranging projects, indicative of the interdisciplinary nature of conservation.

Applications for the 2006–2007 scholar year are currently being accepted. The application deadline is November 1, 2005. For information on the program and on application procedures, interested established professionals should visit the Grants section of the Getty Web site at www.getty.edu/grants/research/scholars/conservation.html.

Information is also available by contacting:

Conservation Guest Scholar Grants
The Getty Foundation
1200 Getty Center Drive, Suite 800
Los Angeles, CA 90049-1685 U.S.A.
Tel: 310 440-7374
Fax: (inquiries only) 310 440-7703
researchgrants@getty.edu

2005–2006
Conservation Guest Scholars

Mary-Lou Florian, former research associate and conservation scientist at the Royal British Columbia Museum in Victoria, British Columbia

She will conduct analysis of "The Discoloration in the Irregular Shaped Fungal Fox Spots."

September 2005–February 2006

Lorenzo Lazzarini, professor of applied petrography, Department of Architectural History at the University IUAV of Venice

He will conduct research on "The Colored Stones of Ancient Greece: Quarries, History of Use, Characterization, and Deterioration."

September–November 2005

Alan Phenix, senior lecturer in the Conservation of Fine Art Department, School of Arts and Social Sciences, Northumbria University, Newcastle upon Tyne

He will work on a two-part project: "An Environmental Dynamic Mechanical Analysis of Artists' and Conservation Materials" and a textbook for conservation with the working title "Use of Organic Solvents in Art Conservation: Theory and Practice."

October 2005–June 2006

Henri Van Damme, professor, the City of Paris Industrial Physics and Chemistry Higher Educational Institution

He will research "Traditional Mineral Materials: A Gentle Introduction to Their Chemo-Mechanics."

March–May 2006

Edna E. Kimbro

Edna Kimbro with a Getty Seismic Adobe Project model at Stanford University's John A. Blume Earthquake Engineering Center. *Photo:* Fred Webster.

Edna E. Kimbro—renowned architectural conservator and historian, specializing in the research and preservation of Spanish and Mexican colonial architecture and the material culture of early California—passed away from cancer on June 26, 2005 at the age of 57.

Kimbro was a respected contributor to the work of the Institute, serving as a preservation specialist for the Getty Seismic Adobe Project (GSAP). Her encyclopedic knowledge of California architecture was instrumental in helping GSAP's engineers and scientists develop seismic stabilization and retrofitting solutions for historic adobe structures that balanced safety with conservation.

During the 1980s she was involved in the restoration of the Santa Cruz Mission Adobe for California State Parks. As a state historian for the California State Parks system, she aided in the preservation of numerous adobe structures in Central California.

Kimbro received a bachelor's degree in art history from the University of California, Santa Cruz. She studied seismic protection of historic adobe buildings at ICCROM in Rome. In 2003 she received the Norman Neuerburg Award from the California Mission Studies Association in recognition of her role as an advocate for the preservation and interpretation of California's mission past. Kimbro was working on a book on the California missions for the GCI at the time of her death.

Kimbro—who is survived by her husband and two sons—will be remembered for her enthusiasm, indomitable spirit, and substantial contribution to the preservation of California's historic adobe architecture.

Shawn Stang

Senior Staff Assistant, Director's Office

Photo: Dennis Keeley

Joy Etheridge

Accounting, GCI Administration

Photo: Dennis Keeley

Born and raised in Los Angeles, Shawn is the youngest of her parents' four daughters. Both of her parents encouraged an appreciation of art, particularly her father, an art teacher whose own paintings often hung in the house. Visits to museums were a regular part of her childhood. In high school, Shawn's interests turned to theater, and she served as stage manager for several of the school's productions. By graduation, she had decided to major in drama in college.

However, not long after Shawn started at California State University, Long Beach (CSULB), she shifted her major to communications studies, which she found more to her liking in terms of the material and the teaching. She also developed an interest in the music industry, and two years after entering CSULB, she began working part-time for a musicians management company, monitoring budgets for studio work, organizing label copy for CDs, and transcribing lyrics. While she learned a lot from the job, the experience made her recognize some of the limitations of working in entertainment, and after three years she was ready for something different.

Shawn moved to San Diego and took a job with a consulting firm in the pharmaceutical industry that helped facilitate clinical trials. Her tasks included ensuring that quality control checks were initiated and completed and that documentation was correct. She also produced an online quarterly newsletter to improve communication among various divisions of the company that were located in different parts of the United States.

In 2000 the company closed her division, and she moved back to Los Angeles with the hope of working for a nonprofit organization. She found temporary work with the GCI in Field Projects, frequently filling in for staff on leave. She liked the work environment and particularly liked the people she worked with. The following year, she joined the GCI as a regular staff member, working as a senior staff assistant in the director's office. There she assists the director and his executive assistant with expense reports, scheduling, and travel arrangements. The work of the Institute continues to be interesting to her, and she enjoys the teamwork aspects of the job.

A major personal accomplishment this year was walking in, and completing, the Los Angeles Marathon. She plans to begin training in September to move up to the run-walk category for next year's marathon.

In September 2002, Joy joined the GCI Administration staff, where she serves in a number of capacities, including accounting, auditing expense reports and purchases, and assisting Institute staff with accounting issues. She finds it especially meaningful to be working in an organization dedicated to conserving the arts and cultural heritage.

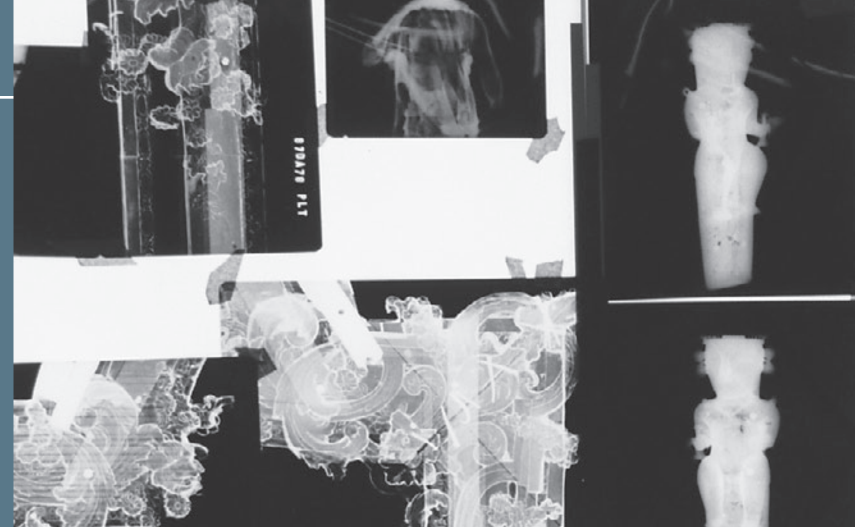
Joy grew up in Manistee, Michigan, the oldest of four sisters. She graduated second in her high school class, excelling in math. For a time she considered becoming a high school teacher—in math and/or physical education. She particularly liked long-distance track events and enjoyed competing in the 440-meter relay and the mile run.

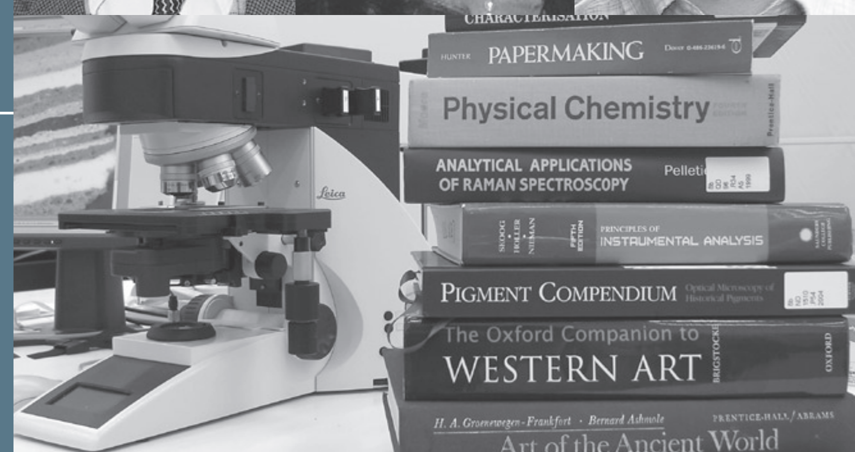
After high school, Joy traveled to Spain before starting college at Ferris State University in Big Rapids, Michigan. Undecided about the direction she should take in college, she took an aptitude test that indicated a talent for accounting. She went on to earn a two-year degree in accounting and a four-year degree in business finance. Following graduation, she returned to her hometown.

After searching for a position that suited her, she chose to work for the state as a bank examiner, traveling throughout Michigan as part of a team that conducted audits of financial institutions. Three years later, after moving to Southern California, she began doing similar work for the Los Angeles office of the Federal Reserve Bank of San Francisco. There she served on teams auditing international financial institutions with branches in California, Oregon, and Washington. She later took a job as an assistant controller with a bank closer to home.

A year after the birth of her first son—and with the impending birth of her second son—Joy became a full-time mom, an occupation she treasured. She spent many hours volunteering in her children's classrooms and assisting in various school fund-raisers. Even though she now works full-time at the GCI, she still volunteers at the schools on her days off. She has been cochair of the Jump Rope for Heart activity for the past five years and helps out whenever she is needed. She enjoys spending time with her two boys and attending their school activities, as well as their baseball and soccer games.

In her spare time, Joy likes bike riding, in-line skating, and playing sports with her sons, as well as regularly participating in several softball leagues.





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