

Science for Arts of the Netherlands



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William Hogarth, *Time blowing smoke on a painting*, Rijksmuseum, Amsterdam.

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Contents	Page
Summary	7
Preface	9
Introduction	11
The artwork changes	11
Why a new impetus for scientific research?	15
Why now?	15
Four urgent challenges from the knowledge center	16
Research agenda	26
Valorization	28
Producers of this document	32
Photo credits	33

Summary

Science for Arts of the Netherlands is an initiative from the Physical Sciences division of the Netherlands Organization for Scientific Research (NWO), which aims to establish in conjunction with the Humanities division of the NWO, a new innovative interdisciplinary research center uniting art history, art conservation and science. The focus of the research lies with Dutch art; this is not only cultural heritage of national importance but also, and primarily, world heritage.

The center will work in cooperation with the Rijksmuseum, the Cultural Heritage Agency of the Netherlands, the University of Amsterdam and the Delft University of Technology. Collectively these partners cover a broad range of research on art and cultural heritage. In addition, the knowledge center is supported by the Netherlands Forensic Institute, TI-COAST, the Van Gogh Museum, the Royal Picture Gallery Mauritshuis and the Metropolitan Museum of Art in New York. The center invites other organizations – independent of size – to participate in the research.

Urgency

Works of art provide a source of inspiration and reflection not only in the time that they were made, but also for subsequent generations. Art objects embody an indispensable source of information about the cultural, political, religious, social and economic aspects of the society in which they were made and how they functioned, and therefore offer unexpected insight into our own history and identity. They have not only an inestimable experiential value but also educational and economic worth. Art and cultural heritage link people to the past and to one another. It is an obligation therefore, in light of the (art) historical, economical, societal and educational significance of cultural patrimony, to manage and preserve these unique works for future generations.

The current state of conservation practice and knowledge is not always adequate for the task of formulating strategies for the sustainable management of art objects. As a result numerous works have been damaged or even lost. It is therefore imperative that we build on our fundamental knowledge of materials and their ageing processes as well as the historic and aesthetic aspects of artworks. For this purpose an interdisciplinary approach is necessary, in which the pertinent disciplines – science, conservation and art history – work together in an integrated manner. This collaboration will serve to ensure a solid basis that is necessary for the development of improved conservation strategies, optimal preservation environments and for a more complete understanding of art objects and their history.

Mission

The Netherlands has established a strong reputation in the development of non-destructive diagnostic techniques for the examination of art objects, and in the research of chemical and physical (degradation) processes of art materials as well as the innovative application of ICT in these areas. Above all, the Netherlands occupies a leading role in the area of technical art-historical research, as well as art research in which the sciences, art history and conservation are integrated. It is the aim of *Science for Arts of the Netherlands* center to further develop, consolidate and carry forward the underlying connections between the three disciplines: science, conservation and art history.

Science for Arts of the Netherlands aspires to assemble global scientific expertise and research from academic institutions, museums and heritage organizations while simultaneously ensuring knowledge transfer within society and to those who safeguard cultural heritage.

Vision

The Science for Arts of the Netherlands center will focus on the following four areas of research:

- Material dynamics: from a static characterization of materials to a fundamental understanding of the degradation- and aging processes of materials;
- Diagnostics: from destructive, localized sample-taking to a fundamental understanding of artworks and a *scientifically-supported prognosis* for conservation treatments (analogous to developments in medical science);
- A new type of art history: from traditional art history to a multi-disciplinary approach in which the material, the production process and the historic context of an artwork is examined. This will involve the integration of technical and scientific analysis and traditional humanities-based research methods (archival studies, stylistic analysis, iconography);
- Conservation treatments: from a case-based approach to a coherent methodology that takes into account an improved understanding of material degradation as a dynamic process.

Research agenda

In order to create and maintain collaboration between the four areas of research, two cross-disciplinary research themes have been formulated:

1. The origin of the artwork: material manipulation and visual effect;
2. The life of the artwork through time: the dynamic of material alteration and change in context.

The Atelier Building in Amsterdam

The core of *Science for Arts of the Netherlands* center is housed in the Ateliergebouw ('*Atelier Building*') on the Museum Square in Amsterdam; an inspiring location where researchers from the Rijksmuseum, the Cultural Heritage Agency of the Netherlands and the University of Amsterdam already work together in the areas of research and education (MA-, MSc-, PhCon- and PhD-level) on the conservation and material-technical aspects of art.

Science for Arts of the Netherlands

Preface

The center *Science for Arts of the Netherlands* is an initiative from the Physical Sciences division of the Netherlands Organization for Scientific Research (NWO), which aims to establish in conjunction with the Humanities division of the NWO, a new innovative interdisciplinary research centre uniting art history, conservation & restoration and science. The center will work in cooperation with the Rijksmuseum, the Cultural Heritage Agency of the Netherlands, the University of Amsterdam and the Delft University of Technology.

Collectively these partners cover a broad range of research on art and cultural heritage. In addition, *Science for Arts of the Netherlands* center is supported by Netherlands Forensic Institute, TI-COAST, Van Gogh Museum, Royal Picture Gallery Mauritshuis in The Hague, Metropolitan Museum of Art in New York (**inset 1, page 10**). The center invites other organizations – independent of size – to participate in the research (**inset 2, page 11**).

The focus of the research in the center lies with Dutch art; this is not only heritage of national importance but also, and primarily, world heritage. The *Science for Arts in the Netherlands* center examines art that is made by both Dutch and foreign artists in the Netherlands as well as artworks by Dutch artists created in other countries. The largest collection of these works of art is in the Netherlands, including the relevant archives and historic source materials that are necessary to research these artworks. The focus on Dutch art does not exclude the study of works by foreign artists in Dutch collections.

The core of the *Science for Arts of the Netherlands* center is housed in the Ateliergebouw ('*Atelier Building*') on the Museum Square in Amsterdam; an inspiring location where researchers from the Rijksmuseum, the Cultural Heritage Agency of the Netherlands and the University of Amsterdam already work together in the areas of research and education (MA-, MSc-, PhCon- and PhD-level) on the conservation and material-technical aspects of art (**image 1**).



Image 1: The Atelier Building, Hobbemastraat 22 in Amsterdam, will house the core of the knowledge center *Science for Arts of the Netherlands*. Currently on this site there is already collaboration taking place between the Cultural Heritage Agency, the Rijksmuseum and the Conservation and Restoration training program of the University of Amsterdam.

Representatives of the above-mentioned institutions have jointly established the goals of the *Science for Arts of the Netherlands* center and together have developed the present vision document. A list of authors who have contributed to this document can be found at the end of the document.

Inset 1: Primary partners in *Science for Arts of the Netherlands*

The *Rijksmuseum* (RM), as the national museum for art and history, administers and exhibits a collection of art, applied arts and historical objects representative of the Netherlands from the Middle Ages to the present, as well as major aspects of European and Asian art. The Rijksmuseum keeps, conserves, restores, researches, cultivates, collects, publishes and presents its collections both on its own premises and elsewhere, for a broad-based (inter-) national public.

The *Cultural Heritage Agency for the Netherlands* (RCE) is concerned with the management, sustainable development and accessibility of heritage in the Netherlands. The RCE links science, policy and practice. The RCE advises and disseminates information and expertise.

The Humanities Department of the *University of Amsterdam* (UvA) is the only university in the Netherlands to offer training for the Conservation and Restoration of Cultural Heritage with eight specialties (Book and Paper, Glass, Ceramics and Stone, Metal, Textiles, Historical interiors, Paintings, Modern and Contemporary art, Wood and Furniture). Additionally, the Faculty of Sciences conducts research into the chemistry of ageing processes in paintings, physical studies on porous art materials such as stone sculptures, as well as mathematical and ICT investigations of artworks.

The *Delft University of Technology* (TUDelft) has established a strong reputation in the development of new non-destructive diagnostic techniques for the analysis of art objects, and art research in which science and art history are integrated.

The *Netherlands Organization for Scientific Research* (NWO) has the task of promoting scientific research in the Netherlands. NWO funds research at Dutch universities and institutes, and facilitates international collaboration for researchers.

Participants in *Science for Arts of the Netherlands*

The *Netherlands Forensic Institute* (NFI) strives to be the most innovative and customer-oriented provider of forensic products and services. The institute has nearly 70 years of experience in the detection, characterization and interpretation of minimal traces of biological and material-technical nature.

The *Top Institute for Comprehensive Analytical Technology* (TI-COAST) is the Dutch public-private partnership for analytical science and technology. The foundation brings more than 40 companies and 30 research institutions together to implement an integrated strategic agenda of research, infrastructure and education in the field of chemical and physical measurement.

The *Royal Picture Gallery Mauritshuis* houses one of the most important collections of Dutch paintings from the Golden Age. The museum is a pioneer in the art historical and technical research of Dutch paintings and works both nationally and internationally with other leading institutions.

The *Van Gogh Museum*, with its world-renowned collection of Van Gogh's works, is dedicated to art between 1840 and 1920. The museum has an outstanding reputation for research-driven museum activities, including conservation and restoration, presentations, (international) exhibitions and publications. It promotes art historical and technical research in the field of late 19th-century Western art, especially Van Gogh.

The *Metropolitan Museum of Arts* in New York aims to collect, preserve, show and research valuable art. It has a large in-house conservation and research department in house who are involved with a wide variety of objects.

Introduction

Every culture has produced special objects that differ from everyday objects by virtue of their costly materials, artful craftsmanship or exceptional design. These works of art provide a source of inspiration and reflection not only in the time that they were made, but also for subsequent generations as well. Art objects also embody an irreplaceable source of information about the cultural, political, religious, social and economic aspects of the culture in which they were made and used, and can therefore offer unexpected insight into our own history and identity. Art and cultural heritage serve to link people with the past as well as with one another. In light of the social, scientific, economic and educational importance of these unique works of art, it is our task to manage and preserve them for future generations.

Inset 2: What happens in the *Science for Arts of the Netherlands center*?

Science for Arts of the Netherlands researchers investigate both the materials and production technology of artworks and examine how these objects change over time. This research focuses on developing an understanding of the original appearance, context, meaning and function of artworks, the processes of change and aging of the materials, and the reception of the artwork both at its inception and in later times. This information is used to develop scientifically-based conservation methods and to optimize storage and display conditions. With these goals in mind, new methods and techniques for analysis and data processing are being developed. This knowledge impacts the fields of art history, science and art conservation by providing important contributions to art policy, art and science education as well as stimulating the development of new non-destructive analysis techniques.

The artwork changes

A work of art is a dynamic object that from the moment of its creation is subject to chemical and physical changes that ultimately results in an altered appearance. The quality of the materials the artist chose, as well as the production methods used in the object's creation determines these changes (**images 2, 3**). The degradation process can be accelerated through environmental factors such as exposure to light, fluctuations in temperature and relative humidity, airborne pollutants (**images 2, 3, 4**), as well as human intervention due to restoration treatments for example undertaken during the object's lifetime (**inset 3, page 14**).

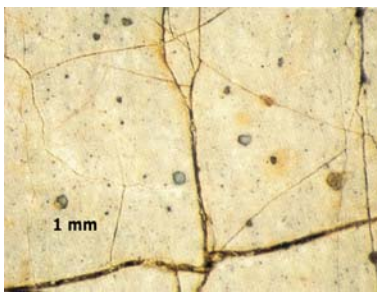


Image 2: The paint surface of Rembrandt's *The Anatomy Lesson of Dr. Nicolaes Tulp* (1632, canvas 169.5 x 216.5, Mauritshuis, The Hague) is characterized by many small craters which are filled with a transparent or white material (see macroscopic detail). These so-called protrusions appear in countless paintings and disrupt the paint surface, and can lead to paint loss. Research from the NWO-subsidized programs MOLART and De Mayerne has shown that the lead white pigment in the painting has partially disappeared due to reaction with the fatty acids originating in the oil binder. This results in the formation of lead soap aggregates, which subsequently swell and eventually break through the paint surface (see paint cross-section).

In the case of Rembrandt's painting the daily warming of the wall behind it is suspected to have influenced the degradation process. It appears that the relative humidity and degree of acidity as well as the use of solvents have also played a role in accelerating lead soap formation. This seems to indicate that certain restoration methods which are often used, such as solvent cleaning and wax-resin linings, can catalyze and/or accelerate these degradation phenomena. How we can best deal with paintings which exhibit these phenomena, and which restoration methods can best be chosen requires more research (research: P. Noble et al.; Mauritshuis, Den Haag/J. Boon et al.; FOM-institute AMOLF, NWO).



Image 3: *The History of Cephalus and Procris*, wall tapestry, probably after a design by Karel van Mander, woven in the atelier of François Spiering, Delft, c. 1595-1610, 351 x 542 cm, Rijksmuseum, Amsterdam. By comparing the front of this tapestry (left) with the reverse (right) it can be seen that the parts woven with originally dark purple-red wool are strongly discolored at the front. This is caused by the use of orchil, a colorant which is extracted from lichens.

The poor lightfastness of the orchil-dyed threads has long been known and Spiering must also have been aware of it. In spite of this he used orchil-dyed wool in a large number of his wall tapestries. The reason for his choice is not known but we can guess that orchil had certain qualities that led Spiering to prefer it above the other purple-red colorants available at the time.

Reconstructions are currently being made using historical dye recipes with orchil, which will be (artificially) aged. In this way better insight will be gained into the characteristics of this dye (research: S. Meijer, M. van Bommel, A. Néss Proaño Gaibor; Rijksmuseum, RCE and Akzo Nobel).

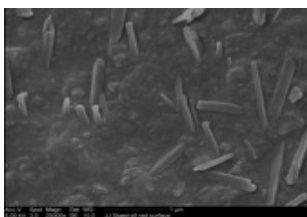


Image 4: The surface of the canvases of Jasper Johns' *Untitled* 1964-1965, oil paint on canvases, 182.9 x 478.0, Stedelijk Museum, Amsterdam, has been altered because magnesium carbonate in the paint reacted with sulfur dioxide from the air. The formation of water-soluble crystals of magnesium sulfate at the surface (which can be seen with an electron microscope, photo right) has rendered this painting extremely sensitive to solvents. Surface cleaning has become much more challenging (research: K. J. van den Berg et al., RCE, Cortauld Institute of Art, Stedelijk Museum, Amsterdam).

The meaning and function of the art object also change over time as most works of art are no longer found in their original (and relevant) cultural contexts. Changes in taste as well as political and religious developments over the centuries have strongly influenced the relation with, and the appearance of works of art (**image 5**). It is logical that the material and contextual changes are deeply intertwined and that physical alterations caused by ageing can influence (also negatively) the appreciation of the object and how it is treated. Conversely, interventions can also influence the material changes and ageing of an object (**inset 3, page 14**). It is, therefore, the material and contextual changes that determine the “biography” of an artwork.

It is essential to obtain a proper understanding of the material and contextual changes. Without this the perception of the original materials, appearance and function of the artwork are flawed.



Image 5: Rembrandt's *Young woman in fantasy costume*, signed 1633, oval panel 65 cm high, 48 cm wide, Rijksmuseum, Amsterdam, was at one point changed into a square panel. For this purpose a panel from Marten van Cleve (1527-1577/81) was sawn in pieces and overpainted with a color matching Rembrandt's portrait. During the latest restoration this overpaint was removed so that a few of the peasant figures so typical of Van Cleve can again be seen (photo left, and photo right an example of a peasant scene by Van Cleve (Centraal Museum Utrecht)). Rembrandt's painting is now exhibited in the Rijksmuseum in a rectangular frame with an oval cut-out, which removes Van Cleve's panel from sight and allows the portrait to be seen again in its original form. This example shows how changes in taste have completely altered the material condition of two paintings (research: G. Weber, Rijksmuseum).

Inset 3: Integrated approach

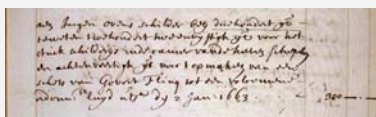
Around 1660 Govert Flinck and Jürgen Ovens created an immense canvas painting, *The nocturnal conspiracy of Claudius Civilis*, for one of the galleries in the former Amsterdam town hall (currently the Royal Palace, Amsterdam). Because of its dark appearance and rough and sketchy execution, this canvas stood out as quite different from all the other gallery paintings. As a result, art historians in the past referred to the canvas as “of no value” and were scandalized by the fact that this work had been once placed in the gallery instead of Rembrandt’s masterpiece of the same theme, from which today only a fragment is preserved (National Museum, Stockholm). However, the reason why Flinck and Ovens – both painters of the highest level – had made such an inaccessible canvas remained unclear, despite the various archival documents that inform us about the commission.

The recent restoration (2007-2009) of the painting by *Stichting Restauratie Atelier Limburg (SRAL)* provided an excellent opportunity to carry out technical study of the material components of the painting and to examine the findings in combination with the existing archival documentation. This integrated approach made it possible to answer all the important questions surrounding this mysterious painting. The new technical information aided in the interpretation of the historical sources, while the archival documents in turn contributed to the formulation of relevant research questions and the determination of the correct analytical techniques.

It was found that the painting was originally executed in aqueous paint on a finely woven linen cloth only tinted with a pigmented glue layer - a technique that Flinck had consciously chosen because the painting was intended to be a temporary decoration for a civic celebration.

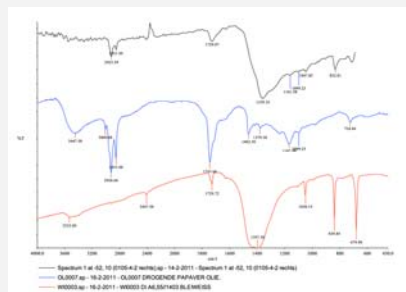


Govert Flinck and Jürgen Ovens, *The nocturnal conspiracy of Claudius Civilis in the forest*, 1659 and 1662, canvas 550 x 550cm, with rounded top. Royal Palace Amsterdam.



Various archival sources provide information about the commission.

A few years later, in preparation for an event in the city hall, the painting was subsequently modified by Ovens with numerous colorful brushstrokes. Again it was intended as a temporary decoration to be replaced later with a permanent work but for various reasons that never came to pass. The canvas, so unappreciated by earlier art historians, was therefore found to be an extraordinary object. In the past, countless temporary monumental decorations were made in aqueous paint, of which hardly any still survives. The fact that one such object remains *in situ* in the former Amsterdam town hall is of great importance: rather than being a painting of *no* value it is a painting of *great* value. The integrated research also made it possible to interpret the current appearance of the painting. Over the course of the centuries the canvas was worked on by many hands, first by artists and later by restorers. Because they did not understand what type of object they were dealing with, they have repeatedly treated it as if it were a regular oil painting: treatments which were disastrous for an aqueous bound painting. Old glue linings had partly dissolved Flinck’s original water-bound paint and the once-matte paint had been covered with a glossy varnish. In 1963 the painting was given a wax-resin lining which resulted in a strong brown overall discoloration, as revealed by the research. All this information was essential to the development of the treatment strategy for the recent restoration. The remains of the later interventions cannot be removed. Therefore a balance was sought between reasserting aspects of the original appearance and the unfortunate effects of the treatment history. (Research: M. van Eikema Hommes, E. Froment, et al.; SRAL, RCE, UvA, NWO).



A paint cross section (see above) shows the paint of Govert Flinck (white) on top of which we see the brushstrokes of Jürgen Ovens (orange), separated by a transparent binding layer. Binding media analysis with ATR-FTIR imaging (see spectrum), staining and GCMS make it possible to identify the binding media of the various paint layers.

Why a new impetus for scientific research?

Within the past ten years numerous important trends have arisen in art research. The field of *conservation science* has developed into a mature discipline in its own right, as evidenced by the quality and quantity of publications, themed conferences and the establishment of high-impact professional journals. At the same time a reorientation is taking place within art history in which technical research becomes increasingly important and is being integrated with the traditional humanities-based research methods (archival study, stylistic analysis and iconography). At the same time in the Netherlands, the field of conservation has grown into an academic discipline where decisions about the treatments of works of art are increasingly supported by science.

Through NWO programs and subsidies (MOLART, De Mayerne, Science4Arts, personal grants) the Netherlands has built up a strong reputation in the development of new non-destructive diagnostic techniques for art objects, research into the chemistry of materials and their ageing and the innovative application of ICT in these areas. Thanks to the research programs the Netherlands plays a leading role in technical art historical research and studies in which science, art history and art conservation are integrated. This integral approach is exceedingly fruitful: with this approach results and solutions have been found that would have been impossible with a mono-disciplinary research approach (**inset 3, page 14**).

The time is right, therefore to break down the compartmentalization of the three disciplines and join forces, to consolidate, build on and further disseminate the knowledge of each discipline. Furthermore there are important new developments that can be achieved within the three disciplines and with that, a major improvement in quality with regard to understanding, preservation and presentation of artworks. Such an integrated approach enriches art and science education, art policy and preservation, the experience of art by the general public, and understanding of materials, methods and techniques for heritage professionals and industry. In this way the Netherlands will occupy a leading role in the field of heritage studies. An inherent stipulation is that the three separate core disciplines continue to strengthen their own expertise by carrying out fundamental research. Only in that way can the three fields continue to feed the interdisciplinarity.

Why now?

In order to preserve works of art and the inestimable value they represent for future generations, it is necessary to conserve, restore and present them in a more scientifically supported manner than has been possible up to now. Increasingly we are confronted with numerous problems and risks that our current knowledge cannot address. The NWO research of the past few decades has provided much insight into the material degradation of artworks. As a result we have a better understanding of the complexity of these processes and realize how limited our current knowledge is, to the extent that it is sometimes difficult to choose the most suitable treatment.

Although an understanding of the material aspects of an artwork is essential to any successful conservation treatment, it has become increasingly clear that insight into the historic and aesthetic aspects of an artwork is of crucial importance, as well as the contextual changes that the object has undergone. In this regard our knowledge is still insufficient and as a result objects can be misattributed, inappropriately presented, or unintentionally damaged by misguided conservation treatments (**inset 3, page 14, and image 6**), or - certainly outside the museum field - even fall prey to ruin and damage.



Image 6:

This exceptional painting was made in the late seventeenth century on ceiling panels in a house located at Keizergracht 412 in Amsterdam. The painting was in 2003, due to inadequate legal protection, (legally!) removed and sawn apart. In the autumn of 2013 two of the sawn-up scenes appeared in a German auction house under the attribution "Flemish master, 18th-century". Dealers prefer to sell ensemble paintings singly because the works are easier to sell, and they can set the price higher.

A lack of understanding of the value of the object is to blame. In this way, valuable traces in and on the surface of objects that could tell us about their manufacture, original appearance and history (**image 7**) are often unknowingly destroyed.

Four urgent challenges from the knowledge center

In order to address these concerns, the partners in the *Science for Arts of the Netherlands* center will focus on four areas of research with the potential to bring the understanding, preservation and presentation of art to radically higher level:

- Material dynamics: from a static characterization of materials to a fundamental understanding of the degradation- and aging processes of materials;
- Diagnostics: from destructive, localized sample-taking to a fundamental understanding of artworks and a *scientifically-supported prognosis* for conservation treatments (analogous to developments in medical science);
- A new type of art history: from traditional art history to a multi-disciplinary approach in which the material, the production process and the historic context of an artwork is examined. This will involve the integration of technical and scientific analysis and traditional humanities-based research methods (archival studies, stylistic analysis, iconography);
- Conservation treatments: from a case-based approach to a coherent methodology that takes into account an improved understanding of material degradation as a dynamic process.

Further in this document two main themes are described that combine these four areas of research.



Image 7: Recent NWO-funded research shows that plaster ceilings originally often had a colorful finish in imitation of unusual types of wood and stone. Nowadays these original finishes are almost always hidden from sight by a series of later paint layers. The current bright white plastered ceiling in the salon from *Huize de Dieu* (1744) in Alkmaar originally had a brown-red finish, which presumably imitated mahogany. The cross-section shows a pink paint layer covering the plaster, with a transparent brown-red layer above it (both part of the original finish). On top of this is a thick series of later white overpaint layers (research: I. Verslype, H. Sigmond; TUDelft, RCE, Rijksmuseum, NWO).

The woodwork also appears to have originally had an imitation mahogany finish. Therefore the painted wall-hangings were initially positioned within a mahogany wood surrounding. In these fairly dark brown-red surroundings the lighter-tinted landscapes effectively functioned as illusionistic windows to a view outside. In the current dead white-painted wood and plaster setting, the wall hangings now stand out as dark elements, negating their intended illusionistic effect.

Current owners often request removal of later paint layers on the plasterwork in order to regain its original sharp detail. Outside museums this occurs in practice by plasterers who almost without exception use coarse tools, abrasives and paint strippers. Valuable traces of the original color finish are thus irrevocably removed, and awareness and understanding of the original appearance are lost. Luckily there are also examples where plasterwork is treated by specialized restorers and the later paint layers are removed with the utmost precision. (see image 20).



Image 8:

In this panel with the Annunciation from Maarten van Heemskerck's Draper's Altar (1546), panel 260 x 122 cm, Frans Hals Museum, Maria currently has a spotty yellow-grey cloak. Originally this cloak was deep blue. Discoloration of the pigment smalt, which is made of blue-colored glass, is responsible for the color change.

Material dynamics: knowledge of the present and past in order to predict the future

Artworks all over the whole world are threatened by an endless variety of often unknown ageing phenomena. A few examples of this are smalt discoloration in paintings (**image 8**), ink discoloration in drawings (**image 9**), glass disease (**image 10**), microbial conversion of lead glazes on ceramics (**image 11**) and collapse of embossed silver plaques (**image 12**). In order to address these and other similar threats it is necessary to understand the material aspects of art works on a fundamental level. We need to know how materials change as they age and interact with one another, as well as to understand the rate, extent and under which circumstances these changes take place.



Image 9: Vincent Van Gogh, *Montmajour*, 1888, pencil, pen, reed pen and brush in purple ink on vergé paper 48.1 x 31.4 cm, Van Gogh Museum, Amsterdam. The original deep purple ink of this drawing is currently discolored to a pale brown. This has occurred because the main component of the ink, methyl violet, is bleached under influence of light. The color remains well-preserved only where the ink has been covered by the frame. Because of the discoloration the image is now barely visible. This is also due to spottiness and severe darkening of the paper. A reproduction from 1928 (photo at right) gives a good impression of the original appearance of the drawing (research: H. Neevel, et al.; RCE, Van Gogh Museum, Amsterdam).



Image 10: This beautifully engraved beaker (England ca. 1676, Corning Museum) is seriously damaged as a result of “glass disease”. There are numerous tiny cracks throughout the glass (see detail from a similar glass), which cause the glass to lose its transparency. “Glass disease” occurs because the earth-alkali ions, which are added during the fabrication process to lower the melting temperature of the glass, slowly leach out of the glass over time. The leaching of the earth alkali ions results in changes in the glass composition and tension within the glass. Primarily with rapid changes in relative humidity, miniscule cracks form in the glass (research: G. Verhaar, N.Tennent, M. van Bommel, B. Lamain UvA/RCE/Rijksmuseum).

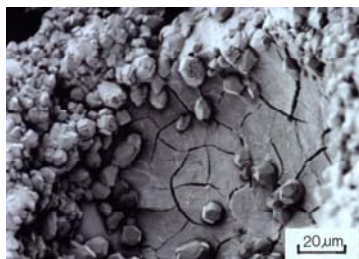


Image 11: After excavation of Delft plate (1670-75) from a cesspit, it was determined that the formerly deep blue and white lead glaze had been converted to a black lead sulfide by micro-organisms. One method to re-convert blackened glazes to their original composition and thus restore the blue and white colors, is to re-fire the plate. The outer left and right sherds, which have not been heated, exhibit the black lead sulfide-containing glaze. The SEM results show crystals of the black lead sulfide from the sherd after burial in a cesspit. The four sherds in the middle show the effect of re-firing in an oxidizing oven; each is re-fired at a single temperature between 560°C and 920°C. At the highest firing temperature, second sherd from the left, enough of the original glaze is re-formed to restore the blue color. The current research focuses on the restoration of the blue-white glaze by means of photochemical conversion of lead sulfide. This method is not only milder than re-firing but also produces better results (research: N. Tennent, UvA).



Image 12: Matthias Melin, *General Ambrogio Spinola during the siege of Gulik in 1622*, silver 23.5 x 54.5 cm, Rijksmuseum. Severe stress-corrosion cracking in this bas-relief plaque in embossed silver has resulted in a large hole in the middle of the scene. The causes of cracking in embossed silver are still not very well studied. However the effects of this ageing phenomenon are dramatic and lead to loss of material in many more objects than is currently recognized (research J. Van Bennekom, et al.; Rijksmuseum, National Aerospace Laboratory).

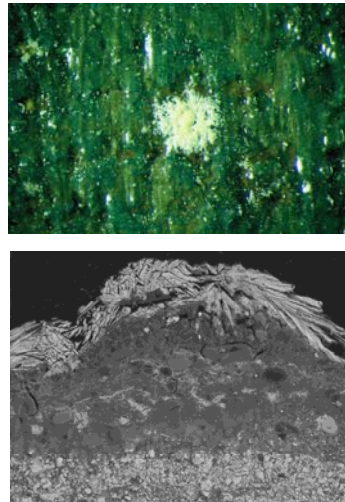


Image 13: The formation of lead soap crusts on the surface of Sigibert Bosch-Reitz, *Portrait of P.J. Teding van Berkhout, 1891*, canvas, private collection. Lead soaps have formed over the years in the ground layer, and subsequently migrated to the surface. In the electron-microscopic image it is clearly evident that these lead soaps have mineralized and become fully integrated with the paint surface (research K. Keune, K. Kirsch, J. Boon, HIMS-UvA, Restauratieatelier Amsterdam, FOM institute AMOLF).

As a result of NWO research of materials and ageing processes that took place in the last decades it has become clear that artworks are not static objects but are subject to continuous change. However, at present the fundamental chemical and physical *kinetics* of most ageing processes are not well understood (**image 13**). We are still in the dark with regard to changes at molecular and microscopic levels and how they relate to one another and, in turn, how these translate into changes on a macroscopic level. There is little understanding as to how ageing- and degradation phenomena develop, or the extent to which they will continue in the future and what the impact of treatment is. While we may be able to analyze phenomenon as we see it, we do not know how it has come about and where it is going. In other words: we only analyze the present, while it is also necessary to understand the past and to predict the future (**image 14**).

The recent NWO research has identified an excellent means for addressing the questions presented above. For paintings, for example, the fundamental mechanism behind several degradation phenomena has now been elucidated (lead soaps; many forms of discoloration) (**image 2, 8, 13**). In these cases it is now possible to make the step from diagnostic research to research that focuses on preventative treatment (**image 2**).

Understanding change is not only necessary with regard to the material of the art object itself, but even more so for the materials used for treatment of artworks. In the past, and still today, conservators use materials that are not directly intended for artworks. Because the chemical and physical properties of these materials and their interaction with the 'original' materials of the artwork are not fully understood damage can unknowingly result. Paradoxically in such cases, the condition of the artwork is worsened. This is because conservators often rely on industrial products or methods which are not *per se* developed or tested for the treatment of cultural objects. For industrial applications it is often only the short-term ageing characteristics of the material that are studied, but knowledge of the long-term effects of contact with an art object is lacking. Research into the behavior of materials used for conservation and eventual development of new products is

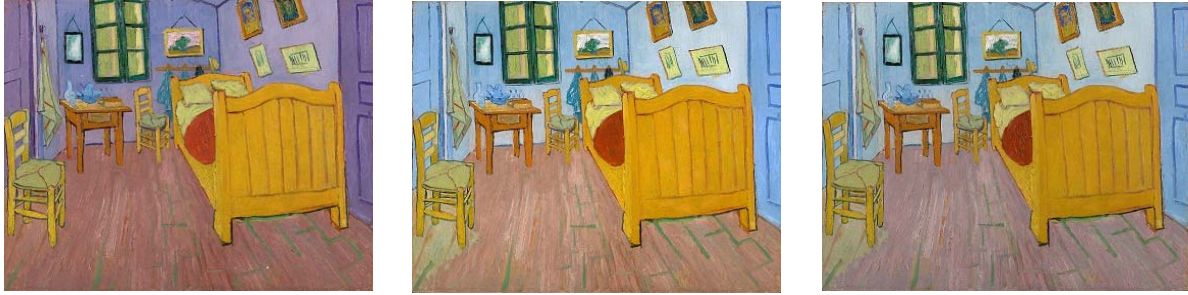


Image 14: Vincent van Gogh's *Bedroom* (1888; canvas 72 x 90 cm, Van Gogh Museum, Amsterdam) in different stages of aging under the influence of light. At left, a digital reconstruction gives an impression of the original appearance of the painting. In the middle, the current state of the painting can be seen. At present the lavender walls and doors are light blue, and the pink floor is pale purple with a strange pale green spot under the chair on the left. The image to the right predicts how this process will proceed in the coming thirty years if the painting is exposed to a light dose of 4 Mlx.hour (equivalent to, for example, lighting at 100 lux with an average exposure period of only 3.5 hours per day). The floor will be even paler and grayer and the red lines on the bed will almost disappear (research: E. Hendricks et al.; VGM, RCE, NWO in cooperation with Prof. R. S. Berns, Munsell Color Science Laboratory).

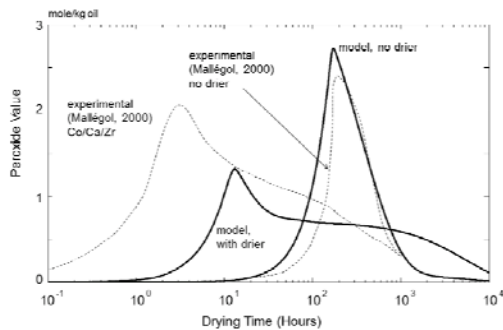


Image 15: Mathematical modeling of a drying oil paint system. The simulated data (solid lines) describe the first stage of the drying of oil, peroxide production, with and without dryer. The mathematically modeled data agree fairly well with the experimental data (research: P. Iedema, HIMS-UvA).

therefore an important focus for conservation science. In this regard the recent development of *smart materials* in various industrial applications, which seem to hold promise for conservation applications, is also relevant.

With the help of new analytical techniques, computational expertise, chemical experimentation, historical reconstructions and artificial ageing, the *Science for Arts of the Netherlands* center aims to achieve a coherent understanding of the kinetics of degradation of both original and conservation materials present in art objects (**image 15**).

Diagnostics: use of non-destructive methods to achieve fundamental understanding of artworks, and a scientifically supported prognosis

In order to determine a scientific diagnosis and prognosis, and to reconstruct the original appearance of an artwork, it is necessary to have a clear understanding of the composition and distribution of the materials both within the object as well as on the surface. Currently, research is conducted on the surface of artworks with non-destructive macroscopic imaging techniques. In recent years there have been important improvements in this field (**image 16, 17**). The effectiveness of these new techniques, however, has limitations for the following reasons:

1. Insufficient insight into the three-dimensional spatial distribution of materials on a microscopic and molecular scale;
2. Limited information about the chemical and physical ageing processes;
3. Limited information about the quantities of materials present. Sampling remains the

most accurate method for determining the quantities of materials, however, because of its invasive nature and limited representation, sampling is – and should be – used conservatively. Current macroscopic imaging techniques should be improved to the extent that they greatly reduce the need for sampling or, better, render it unnecessary.



Image 16: The macro-X-ray fluorescence (XRF) scanner scans Jan van Eyck's *Three Marias at the grave* (c. 1425-1435; panel 71.5 x 90 cm, Museum Boijmans van Beuningen, Rotterdam). The macro-XRF scanner, developed by TUDelft and the University of Antwerp, provides in a non-destructive manner a two-dimensional image of the elemental composition; this gives information about the paint composition, paint layer structure and painting technique (research: TUDelft, NWO).

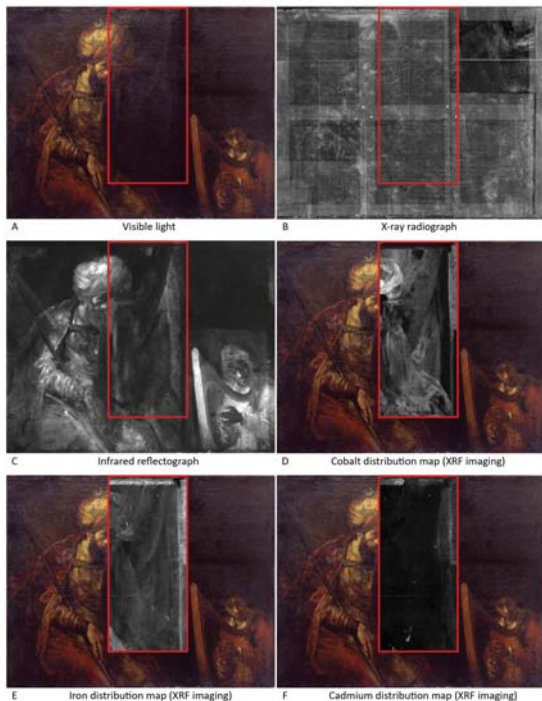


Image 17: Research into paintings traditionally makes use of non-destructive macroscopic imaging techniques, such as UV, X-ray radiography and infrared reflectography. However, the information which these techniques provide is limited, depending on the composition of the object. The recent development of macro-X-ray fluorescence (XRF) scanning produces, in a non-destructive manner, a two-dimensional black-white contrast image of the individual elements in the paint. For this painting, Rembrandt and/or atelier, *Saul and David*, c. 1652 (Mauritshuis) this technique makes it possible, for the first time, to visualize the original curtain between the two figures, without removal of the varnish and overpaint. This provides essential information for the treatment of the painting (research: P. Noble, A. van Loon; Mauritshuis, The Hague, TUDelft, NWO).

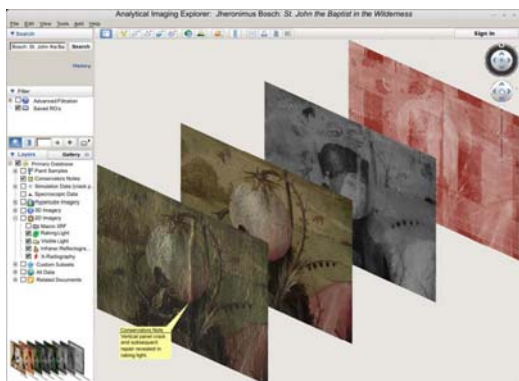


Image 18: A systematic mock-up illustration provides an image from a newly-developed user interface which can compare and combine various analytical imaging data from paintings. The data model and "interface" design are inspired by Google Earth. Such a visualization of research results allows for a good integration of various types of information and is a powerful aid in presenting research results in an engaging way to a broad general public (research: J. Dik, R. Erdmann; TUDelft, Rijksmuseum, The University of Arizona).

A further challenge is to develop an effective means for integrating all of the information that is collected (in the future primarily by non-destructive means) on a molecular, microscopic and macroscopic scale. The end result being a *fundamental understanding of the artwork* in which all relevant chemical, physical, mechanical, optical and topographical aspects of the art object can be characterized, visualized and related to one another in detail. Recent developments in detector technology, miniaturization of analytical instrumentation and breakthroughs in imaging diagnostics will provide numerous new possibilities for art research in the coming years. Contributions to this effort by chemo-metric and IT-expertise (data management, correlation, data mining, data visualization) will be essential (**image 18**) for effectively managing the enormous amounts of data that will be collected.

On the basis of the resulting diagnosis, together with knowledge about characteristics of materials and the ageing processes that take place within them (see above), an informed prognosis can be made regarding degradation which can be expected in the future, and the most suitable conservation method can be chosen.

The challenges presented in the research of artworks show great similarities to those faced by the industrial participants in TI-COAST. Therefore it is natural that there should be intensive cooperation between the members of *Science for Arts of the Netherlands* and TI-COAST.

A new type of art history: material-technical research integrated with traditional research methods

Knowledge about the materials and techniques with which an artwork is fabricated is necessary in order to interpret and value an artwork in all its facets. An understanding of its original appearance, context, meaning and function, as well as the intention of the artist and that of the buyer or commissioning patron is also necessary. Furthermore, it is important to know how the object was presented, received and treated in later times.

Within traditional art history these elementary questions have not always received the attention they deserve. This discipline was primarily devoted to the classification of artwork and the investigation of its meaning using humanity-based research methods and approaches, including archival and source research, style criticism and iconography. This traditional type of research was primarily philological by nature, an approach which art history shares with literary studies. Little attention was given to the material aspects of artworks.



Image 19: Among the gallery paintings in the Royal Palace Amsterdam it is not only the canvas from Flinck and Ovens (**inset 3**) which has severely darkened: recent research has demonstrated that the other oil paintings have also acquired a darker appearance - although much less dramatically - through ageing. As a result they stand out as dark “islands” against a bright white architectural surrounding (image left). However, architectural color research and archival evidence show that both the vault and the upper walls in the galleries were originally the color of sandstone. The tonal contrast between architecture and painting was therefore initially much less pronounced than it is now.

During the exhibition *The Batavian Commissions* which was devoted to the gallery paintings, the original tonal balance was reconstructed by means of a lighting concept: the paintings were locally spotlighted and color was added to the architecture by adjusting the lighting of these areas. The large chandeliers were also turned off in order to more closely imitate the seventeenth-century lighting situation. The paintings appeared much more readable in this setting (image right) (research: M. van Eikema Hommes, E. Froment, et al.; SRAL, RCE, UvA, NWO).

Questions about the materials and techniques used, the original appearance of the object and how it has changed over time is often not considered.

A change is now taking place in the development of a new type of art history where the materials and fabrication technology of an artwork are considered essential components for its full interpretation. Expertise which has been built up in the chemical and physical analysis of art objects, and the development of (non-destructive) diagnostic equipment make it increasingly possible for the art historian, in consultation with specialists in the field of conservation, to use the artwork itself as a source of information about its fabrication process and history (**inset 3, page 14**). Dutch research has played an important role in these developments.

Technical information also contributes to better answers for numerous fundamental art historical questions. The combination with traditional humanities-based research methods is extremely fruitful. This integrated and interdisciplinary approach also leads to the development of new research questions and themes. At the boundary of these old and new working methods, groundbreaking insights can be made which can be of great importance for preservation and responsible management of cultural heritage (**inset 3, page 14**). Indeed, the new expertise offers an enormous potential to increase the value of artworks through publications and informed and/or historically responsible presentations (**images 19, 20, 21**). The new attention to materiality and the combination of technical information and traditional research methods will lead to a paradigm shift within the field of art history.



Image 20: The Beuning Room in the Rijksmuseum comes out of a house on the Keizersgracht 187 in Amsterdam, which was demolished in 1896. The property was inherited in 1744 by the merchant Mathijs Beuning, who had a new structure built behind the house, including this reception room with beautiful mahogany paneling, marble fireplace and a spectacular plaster ceiling. The room was recently restored and the plasterwork was also treated. With the utmost precision the later paint layers were removed, so that the decorations can be seen in their original sharp detail (research and restoration: B. Delmotte, P. van Duijn; Rijksmuseum).



Image 21: Use of the Augmented Reality (AR) application for the iPad makes it possible for museum visitors in Museum Catherijne convent to closely follow the painting process of Rembrandt's student Govert Flinck (1615-1660) for his earliest signed work *Isaac blessing Jacob* (canvas 125 x 151 cm). AR-Software reveals underlying paint layers and adds scientific information directly to the actual painting. By holding the iPad up to Flinck's picture, the public can see, as it were, through the paint layer, and follow the fabrication process step by step. The research into Flinck's painting is an example of successful cooperation between the RCE, RM and UvA in the Atelier Building. The AR-application was commissioned by the RCE and is a product of the Research Agenda 2009-2012 of the RCE (AR-Application: AR-Lab, Royal Academy of Art).

Conservation treatments: from case studies to a coherent methodology

The conservation of artworks is a young discipline whose development can be compared to that of nascent medical science. In recent decades, the field has developed into an academic discipline whose decision-making is intrinsically linked to empirical and analytical methods of analysis. For conservation of artworks, empirical findings form a very important source of knowledge. However, the insights achieved through conservation often remain limited to the particular case. In addition to empirically acquired information, it is necessary to have fundamental knowledge about the materials and techniques with which an object was manufactured, how these materials chemically and physically changed and what influence past restorations have had. All these facets are necessary in order to gain insight into both the original appearance and the ageing processes of art objects. In this manner it is possible to phase out a case-by-case working method and to establish a scientifically supported diagnosis and prognosis. This is the only way to deploy conservation methods and treatments that can effectively slow down or stop material deterioration, or better yet, even reverse these processes.



Image 22: Within the NWO program Science4Arts the influence of the (museum) environment on wooden objects, in particular furniture and panel paintings, will be investigated. Old photographs help to visualize changes in the marquetrie of cabinets. The chest pictured here is located in the Amerongen castle (research: P. van Duijn et al.; Rijksmuseum, RCE, Eindhoven University of Technology, NWO).

The improvement of storage and display conditions (preventive conservation) is also a main priority. To this end it is necessary to understand the relationship between the building, environmental conditions and interior climate on the one hand, and the ageing of the object on the other (**image 22**). The current knowledge in this area is still based on models and individual cases, while there is an urgent need to better understand the bigger picture, the physics behind the relationship between environmental factors – building – interior climate – ageing. The enormous costs and energy output required for maintaining climate control have recently prompted questions as to whether the current stringent guidelines for (museum) interior climate might be eased. But before that question can be answered more knowledge is necessary about the role of environmental conditions on the chemical and physical degradation processes of art objects.

In order to move from individual case studies to a coherent methodology for larger groups of objects, the underlying chemical and physical processes behind the phenomenological changes need to be investigated. The quantitative and qualitative data can then be extrapolated to be able to predict scenarios for a variety of media.



Image 23:

Wenzel Jamnitzer's *Table Ornament* (1549; silver and enamel, 99.8 x 46.0 cm, Rijksmuseum, Amsterdam) is an ode to the earth and everything which it brings forth, and at the same time an unparalleled display of artistic and technical expertise. The stem of the dish depicts Mother Earth. She is surrounded by flowers, herbs and small animals which are all cast from examples collected in the wild. This exceptional casting technique is at present being studied within the Rijksmuseum (research: J. van Bennekom, et al.; Rijksmuseum).

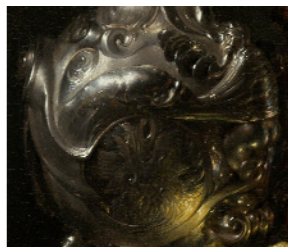


Image 24:

Willem Kalf, *Still-life with silver flagon*, 1655-1660; canvas 73.8 x 65.2 cm, Rijksmuseum. A superb control of the painting materials, together with a profound knowledge of the precise rendering of material effects and insight into human perception, made it possible for seventeenth-century Dutch painters to imitate their subjects in an extraordinarily realistic manner. The techniques the artists used to achieve these exceptional effects have to this point been subject to very little research.

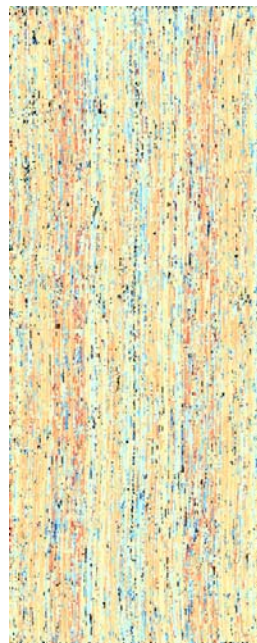
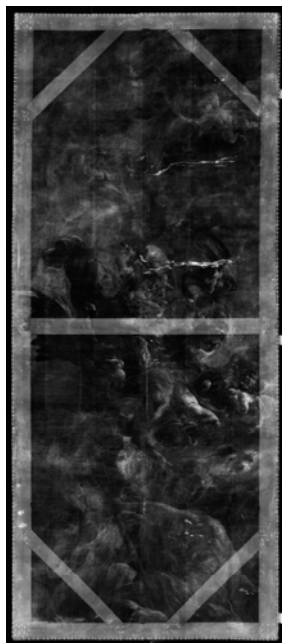


Image 25:

For decades x-radiographs have been used to examine canvas fabric, because the canvas is almost always hidden behind later linings. What can be seen in the x-radiograph is not the threads themselves, but their impression in the ground layer. Using these x-ray images, the number of warp and weft threads used to be manually counted in numerous locations. The information thus gathered about the structure of the fabric can help to determine whether or not canvases were cut from the same roll of cloth. In the last few years scientists, aided by computer generated techniques, have been able to digitally analyze the canvas X-radiographs. This makes it possible to measure the average thread count over the entire surface, and to produce an image of deviations from the average thread-count within a canvas by means of color-coded maps. Measurements thus obtained provide much more accurate results.

The picture on the right shows the "thread-density map" of the vertical threads made on the basis of the X-radiograph (center image) of the right canvas of a three-part ceiling painting Gerard de Lairesse painted in 1672 for a house at Herengracht 446 (440 x 182 cm; currently the Peace Palace, The Hague, image left). The thread patterns in the left and right sides are identical although mirrored. This indicates that two strips of canvas from the same roll have been used, and one strip was turned over before they were sewn together (research: Thread Count Automation Project, R. Johnson, Rice University (USA) and D. Johnson, Cornell University (USA), M. Eikema Hommes, TUDelft).

Research agenda

These four knowledge areas relate to innovations and improvements within three different disciplines: conservation, science and art history. To realize these innovations a strong and structural bond among the three disciplines is needed. In order to combine strengths and guarantee cooperation two cross-disciplinary research themes have been formulated:

1. The origin of the artwork: material manipulation and visual effect
2. The life of the artwork through time: dynamic of material change and changes in context

1. *The origin of the artwork: material manipulation and visual effect*

The creation of an artwork requires not only specific, often special, materials but also, an enormous technical knowledge, manual dexterity, insight and ingenuity in order to manipulate these materials in a way that results in an object with the desired visual effect. The manner by which artists achieved these effects, which evoked wonder and astonishment in the viewer, embodies one of the most important aspects of historical studio practice (**images 23, 24**). Strangely enough, this theme “the mystery of mastery” has received up to now only limited attention within art historical research. However, to comprehend the technical knowledge and the material-technical and mental processes that lie behind the “masterful” visual effects is a precondition for understanding one of the most fundamental aspects of art.

A meticulous material-technical analysis of the artwork itself forms the basis for research within *Science for Arts of the Netherlands* center supplemented by inquiries into historical sources including (art)technical and theoretical treatises, contracts, patents, letters and diaries (**image 25, 26**).



Image 26: William Beurs, *De groote waereld in 't klein geschildert, of schilderaghtig tafereel van 's Weerelds schilderyen. Kortelyk vervat in ses boeken. Verklarende de hooftverwen, haare verscheide mengelingen in oly en der zelve gebruik* (The great world painted small, or painterly scene of the world’s paintings. Briefly summarized in six books. Explaining the main paints, their different mixtures in oil and their use). Amsterdam 1692. Handbooks and treatises with artists’ recipes are of great value in the study of techniques of the Old Masters. The Rijksmuseum has a large collection of such exceptional historical sources.



(a)



(b)

Image 27: Authenticity questions surrounding bronze sculptures can in recent times be better answered with the help of new analytical techniques such as neutron imaging and neutron diffraction. The bronze sculpture *Walking Nobleman* (Rijksmuseum), which was recently examined with both techniques, has traditionally been attributed to the Amsterdam sculptor Hendrick de Keyser. Neutron imaging made visible diverse structural elements on the interior which show that the arms and lower legs were attached as separate parts, and were not cast all as one piece. This sculpture appears to have been intended as a moving figure, part of a clockwork or automaton. With this information the earlier attribution to de Keyser was discarded. Currently it is assumed that the object was manufactured in South Germany around 1580 -1600 (research: R. van Langh et al.; Rijksmuseum).



Image 28: Whether or not Van Gogh painted this *Flower still life with wildflowers and roses* (canvas, 100 x 80 cm., Kröller-Müller Museum, Otterlo) was for a long time unclear. A macro-X-ray fluorescence (XRF) scan made an underlying scene of two wrestling men visible. In a letter written in Antwerp in 1886 Van Gogh wrote that he had painted this scene. This information, together with other material-technical data which came to light during the investigation, provided concrete evidence that Van Gogh is the creator of the current still life (research: Kröller-Müller Museum, Van Gogh Museum, TUDelft).

Insights from forensic science, statistics and perceptual psychology are also of great value in this regard. Together, these investigations will contribute to understanding how the artwork was conceived, produced and judged. Further insight will be gained into how material-technical and visual knowledge was transmitted between artists and how they responded to availability of new materials and techniques in their lifetimes, subjects about which very little is known.

The resulting expertise will be of great importance for the proper understanding of the materials used in creating artworks, and their original appearance. This knowledge is necessary for the understanding of the ageing processes and for selecting the most appropriate treatment method.

This expertise is also of great importance in authentication investigations. In-depth understanding of the use of materials and the technical and visual methods of an artist will make it easier to assign attributions to artworks (**image 27, 28**) than it is today, where attributions are often made only on the basis of broad stylistic features. The newly acquired knowledge can offer a significant contribution to the prevention and detection of art fraud. In this regard we foresee a productive relationship with the Netherlands Forensic Institute, particularly in the area of statistical analysis, the application of the newest forensic research techniques for detection of biological and micro-traces and the development of non-destructive portable equipment (see valorization section).

2. *The life of the artwork through the ages: dynamic of material and changes in context*

As previously discussed, an artwork is not static but dynamic. From the moment that it is created continuous chemical and physical changes take place by means of numerous internal and external processes, which result in visual change. It is of the utmost importance to understand these processes in order to learn more about the original composition and appearance of the object (**images 2, 3, 14, inset 3, page 14**) and the ageing processes which have already taken place or will take place in the future. This knowledge is crucial for the art historian as well as the scientist, but perhaps even more so for the conservator. The conservator must evaluate the current condition of an artwork in order to make responsible deliberations regarding eventual interventions and the risks they involve.

For research into ageing processes new analytical methods and models must be developed which can study degradation processes and can simulate them on a short time scale. New analytical techniques already provide better options for detecting small scale chemical and physical changes. Historical art-technical sources are an important aid in the interpretation of analytical research results because these texts inform us about the original materials used.



Image 29: Paul Gauguin, *Spinning Breton girl* (1889), oil paint on plaster, 134.3 x 62 cm, Van Gogh Museum, Amsterdam.



This painting originally formed part of a larger decorative series in the dining room of a French establishment (La Buvette de la Plage, Le Pouldu). In 1924 the paintings were discovered under layers of wallpaper.

Gauguin's painting was sawn out and is now presented in the Van Gogh museum as an isolated scene (photo in the middle). The image at right shows the wall paintings in the dining room as they were found after the removal of the wallpaper in 1924 (research: R. Boitelle, Van Gogh Museum).

In order to understand the current composition, condition and appearance of the art work, it is necessary to have an awareness of the original context, meaning and function as well as the reception and treatment the object received in later times. Indeed, the treatment of an object affects the ageing of the materials and, conversely, the material ageing influences the appreciation of the object and its treatment (**image 5, inset 3, page 14**). Material and contextual changes therefore together form the “biography” of the artwork. Knowledge about the original and later context is especially necessary for the countless artworks which were created for a specific location and/or in conjunction with other artworks, but which are now scattered among museums, institutions and private collections (**image 29, 6**). Even when decorations find themselves in their original location the original context has seldom been preserved (for example because of re-painting and renovations, **image 7**). As a result the meaning and visual function of the objects is often no longer recognizable. Understanding the contextual changes is a prerequisite for answering questions surrounding restoration of an artwork and for making sound decisions for presentation and conservation (**images 4, 12, 22, 19, inset 3, page 14**). Besides historical research, the “forensic” approach to investigating evidence on the work itself is hereby essential.

Valorization

The new knowledge and interdisciplinary research methods developed by *Science for Arts of the Netherlands* center will result in:

- sustainable cultural heritage: preservation, management, and the development of cultural heritage with future generations in mind;
- bringing together conservation, art history and science for a new innovative interdisciplinary research partnership. The *Science for Arts of the Netherlands* center thus establishes a unique research infrastructure, where researchers from these fields in the Netherlands and abroad can work together. This collective is a forerunner in the field of technical art history and is a favored partner to the most important art collections and research centers in the world;
- trained doctoral students who will primarily concentrate on the maintenance of tangible Dutch culture, forensics or a related scientific field;
- the partners within *Science for Arts of the Netherlands* are committed to disseminating the expertise gained within the collective to their own institutions, staff and collections;



Image 30: Paul van Duijn (Conservator of Furniture, RM) and Jessica Roeders (Instructor in paintings conservation, Conservation and Restoration of Cultural Heritage, UvA) together led a workshop for the first-year masters students from the UvA training program Conservation and Restoration of Cultural Heritage, in which a cradle had to be removed from the reverse of a panel. This was necessary because the cradle was no longer supporting the panel but was instead deforming it.

- successful acquisition of external research funding. This includes not only Dutch, European and international resources but also “personal grants” i.e. funding for talented individual researchers. Through these personal funds that *Science for Arts of the Netherlands* can maintain leadership in identifying, acquiring and managing international research projects;
- *spin-off* businesses which conduct research for the field of cultural heritage in all three disciplines (sciences, art history and conservation) and in the areas where these fields overlap. These businesses will in turn be stimulated and supported by *Science for Arts of the Netherlands*;
- mutually-beneficial collaborations between museums, scientists, cultural heritage caretakers and industry that help identify and realize like-minded goals;
- *Science for Arts of the Netherlands* regularly receives requests from respected national and international agencies to perform authentication research and investigations concerning possible forgeries and art thefts. In this respect the group is recognized as an independent center for expertise.

The expertise from *Science for Arts of the Netherlands* will be disseminated and valorized within the fields of education and industry in the following specific ways:

Education

- Educational programs:
 - ◊ *Training in Conservation and Restoration (C&R) of Cultural Heritage*, University of Amsterdam. The University of Amsterdam is the only university in the Netherlands to offer training for the Conservation and Restoration of Cultural Heritage with eight specialties (Book and Paper, Glass, Ceramics and Stone, Metal, Textiles, Historical interiors, Paintings, Modern and Contemporary art, Wood and Furniture; **image 30**). The conservators learn from hands-on experience, which will have a direct effect on heritage preservation.
 - ◊ Along with conservation and restoration training, the UvA intends to offer a Master’s degree program *Technical Art History*. The sciences and humanities will be integrated within this training program, and it will be offered in close cooperation with other partners, in particular TUDelft.
 - ◊ This program is being developed with the idea that collaboration between future generations of conservators, conservation scientists and art historians is invaluable in the pursuit of safeguarding cultural heritage.
- Exchange of information between scientists, museum leaders and professionals, curators, conservators, architectural restorers and other cultural heritage caretakers takes place by means of symposia, congresses, workshops, seminars and publications. A direct translation of this information into practice is achieved via the Program for Continuing Education offered by the C&R training program at the UvA for mid-career conservators and other heritage professionals. Knowledge is also successfully disseminated within Dutch institutions via the Cultural Heritage Agency for the Netherlands.;

- Knowledge about the materials and manufacturing techniques will be taught in art academies and technical schools. It is indeed important that future artists are aware of the durability of the materials and/ or the most suitable technique that they choose to use in their art;
- The model for talent programs in the *human capital agenda* of COAST is available to the members of *Science for Arts of the Netherlands*. Cooperation from this program with the above training programs offers talented technical students the opportunity to take part in the art research, and offers talented students from the aforementioned training programs the chance to gain experience in analytical-chemical research;
- An important role is reserved for educating the general public. Consciousness within society of both the value and vulnerability of art is essential for the preservation of art. This can be achieved by developing the following:
 - ◇ Teaching programs for educators;
 - ◇ Informing the interested public through television programs, websites, lectures, etc.;
 - ◇ Presentations and exhibitions for museums. Informative, historically responsible presentations through which the visual content and function of works or art are done justice (**image 30**). In this regard, recent digital visualization techniques, such as Augmented Reality, offer many possibilities for presenting the insights of scientific analyses to the general public in an engaging and informative way. (**image 21**).

Industry

- The analytical-chemical challenges in the private sector are similar to the challenges earlier described in this document for physical and chemical characterization of art objects. Whether it concerns the food industry, the paint industry, the pharmaceutical industry or the development of new medical-diagnostic methods, all require progress in analytical science and technology. Data management, data mining and data visualization also play important roles. Therefore analytical strategies for non-destructive testing will be deployed in all these areas, improving chemical and spatial resolution and examining processes of chemical change.

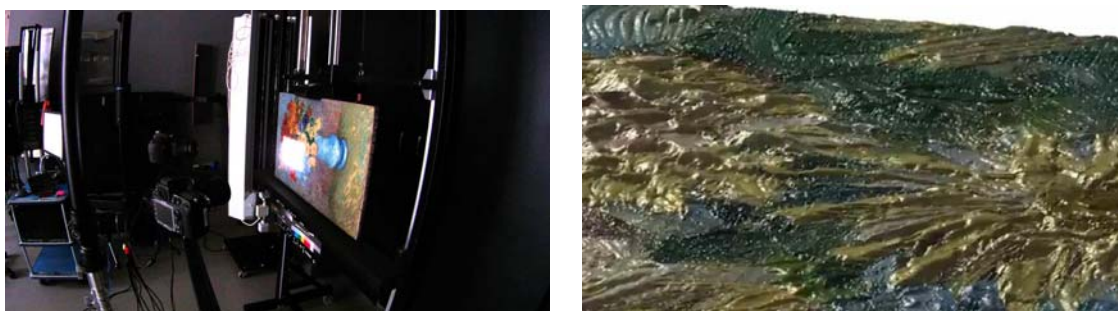


Image 31: The recently-developed 3D scanner was used to scan *Flowers in a blue vase* from Vincent van Gogh (1887; canvas, Kröller-Müller Museum, Otterlo).

With an advanced inkjet printer from Canon/Océ the 3D-scan was printed layer-by-layer in 3D. In this way every brushstroke has been copied and the final result closely resembles the original. Such reconstructions can be helpful to art research in the future. For example, in order to reconstruct the original appearance of artworks, or the effect of artworks placed in their original location (research: TUDelft, Canon/Océ).

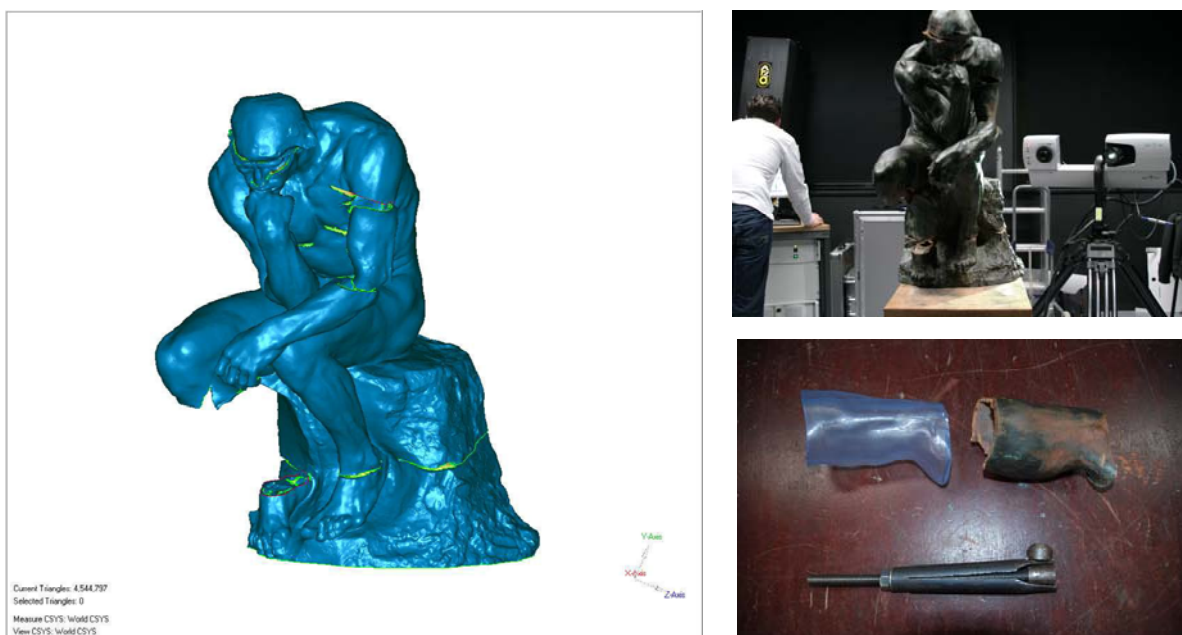


Image 32: The bronze sculpture *The Thinker* by August Rodin (1881, Museum Singer, Laren) was heavily damaged after being stolen in 2007. Parts of *The Thinker* were mutilated with a grinding tool (above right), because the criminals were after the copper. For the restoration *The Thinker* was scanned in great detail so that the damages could be well-documented (left). With a 3D printer the missing parts were then printed in plastic (below right). From this basis it was possible to cast the missing parts in bronze and a bronze/epoxy composite, and to place these “prostheses” back in the sculpture (research: T. Beentjes, UvA).

- A joint formulation and approach for the analytical challenges by industry and *Science for Arts of the Netherlands* will increase benefit from investments and promote the cross-pollination of ideas and technology. In this way, a more fundamental improvement of analytical capacities will take place than when each sector takes on the challenges alone. This strategy is developed in the Dutch private-public community for analytical science and technology (COAST) and is successfully applied in cooperative research projects. The COAST-participants have recently expressed their interest in cooperation with the Dutch heritage sector. The interaction of the heritage sector with COAST-participants and the *Science for Arts of the Netherlands* center will achieve scientific cross-pollination as well as so-called silent diplomacy of art in industry. Raising awareness of the issues concerning art analysis and conservation and the involvement of industry in solving them will be strongly promoted by the intensive cooperation characteristic of COAST.
- *Science for Arts of the Netherlands*, along with developments from analytic-chemical strategies, will make contributions to industry and the aforementioned institutes such as the NFI. The research provides new knowledge about the characteristics of materials that cannot be acquired by means of basic laboratory techniques. There are also possibilities for valorization and cooperation with technological multinationals and SMEs. Examples of this are: the current partnership between the Rijksmuseum and AkzoNobel in cooperation with the UvA and the TUDelft for research into the discoloration of modern paints; the development of analytical equipment (TUDelft and Bruker AXS; **image 16, 27**); the development of 3D-printing technology (TUDelft and Canon/Océ; **image 31, 32**). *Science for Arts of the Netherlands* will play a leading role in the marketing of new knowledge, expertise and analytical instrumentation. The development of methods and products for the preservation of artworks and of prognoses concerning the lifespan and behavior of the original materials that make up the artwork, as well as that used for conservation treatments, are valuable for industry.

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Image inset 3: Left above: Erik & Petra Hesmerg at request of Stichting Koninklijk Paleis Amsterdam; Left below: M. van Eikema Hommes, TUDelft/RCE; Right above: E. Froment, UvA; Right below: K. Keune, UvA;
Image 1: D. Malagamba;
Image 2: Left: Mauritshuis, Den Haag; Middle; P. Noble, Mauritshuis, Den Haag; Right: A. van Loon, Mauritshuis, Den Haag;
Image 3: S. Meijer, Rijksmuseum;
Image 4: Stedelijk Museum Amsterdam; Details and electron microscopic image: A. Burnstock, Courtauld Institute of Art;
Image 5: Left: Rijksmuseum; Right: G. van der Haar at request of the Centraal Museum, Utrecht;
Image 6: http://commons.wikimedia.org/wiki/Category:Keizersgracht_412,_Amsterdam;
Image 7: Left above and right above: J. Elsinga, at request of de Gemeente Alkmaar; Left below and right below: I. Verslype, H. Sigmond, TU Delft/RCE;
Image 8: T. Haartsen at request of het Frans Hals Museum, Haarlem;
Image 9: Van Goghmuseum Amsterdam (Vincent van Gogh Foundation);
Image 10: S. Koob, Corning Museum of Glass, N. Tennent UvA;
Image 11: N. Tennent, UvA;
Image 12: J. van Bennekom, Rijksmuseum;
Image 13: K. Keune, K. Kirsch, J. Boon, FOM Instituut AMOLF, HIMS-UvA;
Image 14: Left: Van Gogh Museum Amsterdam (Vincent van Gogh Foundation) en R.S. Berns, Munsell Color Science Laboratory, Rochester, NY; Middle: Van Gogh Museum Amsterdam (Vincent van Gogh Foundation); Right: Van Gogh Museum Amsterdam (Vincent van Gogh Foundation), Rijksdienst voor het Cultureel Erfgoed, R.S. Berns, Munsell Color Science Laboratory, Rochester, NY;
Image 15: P. Iedema, HIMS-UvA;
Image 16: Left: Michael Haschke, Bruker AXS; Right: Museum Boijmans van Beuningen, Rotterdam;
Image 17: P. Noble, A. van Loon, Mauritshuis, Den Haag, TUDelft;
Image 18: R. Erdmann;
Image 19: J. Schlomoff, Amsterdam;
Image 20: B. Delmotte, P. van Duijn, Rijksmuseum;
Image 21: M. Eikema van Hommes, TUDelft/RCE;
Image 22: Left: B. Ankersmit, RCE; Middle: Stichting Kasteel Amerongen; Right: R. Gerritsen, Amsterdam;
Image 23: Left: Rijksmuseum; Right: J. van Bennekom, Rijksmuseum;
Image 24: Rijksmuseum;
Image 25: Left: Eric Smits Photography; Middle: Milko den Leeuw; Right: Thread Count Automation Project;
Image 26: M. van Eikema Hommes, TUDelft/RCE;
Image 27: R. van Langh, Rijksmuseum;
Image 28: Left: Kröller-Müller Museum, Otterlo; Middle: TUDelft; Right: TU Delft, Universiteit Antwerpen, Kröller-Müller Museum;
Image 29: Left: Van Goghmuseum Amsterdam (Vincent van Gogh Foundation); Middle: photographer unknown; Right: V. Honoré;
Image 30: UvA;
Image 31: Left: Canon/Océ; Right: TUDelft, Canon/Océ;
Image 32: T. Beentjes, UvA.

