Paintings in the laboratory: scientific examination for art history and conservation

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Perspectives on the evolution of science for art history and conservation, and its current state

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“You look for salvation in another Faculty: you, an art investigator, make the amazing proposition to have the colours examined by a chemist”.¹ That is how Charles Sedelmeyer, an art dealer based in Paris, addressed Dr. Abraham Bredius, the Director of The Mauritshuis, in an open letter during the controversy in the early years of the twentieth century over The adulteress before Christ, a work judged by some authorities to be an autograph Rembrandt, while others branded it a fake.²

Before the founding of the Central Research Laboratory, in Amsterdam, in the early 1960s (see below), the scientific examination of paintings in The Netherlands had been undertaken as the occasion arose and often had to do with questions of authenticity. These questions had their forerunners in archaeology.³ Questions of authenticity were posed by expert connoisseurs - whose judgement was informed by intuition - especially in cases where the authenticity of already famous old masters was at stake. The adulteress before Christ had aroused Bredius’ suspicion when it was exhibited at the Rembrandt exhibition in the Rijksmuseum in Amsterdam, in 1898. After the exhibition, he had it sent to Berlin, where Alois Hauser, restorer at the Kaiser-Friedrich-Museum,⁴ found that it had been painted with pigments that were not in use until after 1700, certainly not in the seventeenth century.⁵ As illustrated in the account of the conflict surrounding The adulteress before Christ, it was not generally accepted, in Holland as elsewhere, for an art expert to consult a chemist. In 1925 it came to a court case over the panel Een vroolijke man (A merry man) that had been sold as a painting by Frans Hals.⁶ In the introduction to his written defence in the Hals process, Hofstede de Groot, writes that he refuses to address Dr. F.E.C. Scheffer, Professor of


² For an extensive account on the subject see: Catherine B. Scallen, Rembrandt, reputation, and the practice of connoisseurship, Amsterdam 2004.

³ R. Munro, Archaeology and false antiquities, London 1905.

⁴ The same professional is called ‘conservator’ in English-speaking countries. The term ‘conservator-restorer’ was introduced after the paper ‘The restorer - a definition of the profession,’ with the final version of the paper: ‘The Conservator-Restorer - a definition of the profession,’ ICCROM Doc. ST 1/3, 29 November 1978. See: H.C. von Imhoff, Introduction to the Working group Training of Restorers, Preprints, ICOM Committee for Conservation, 6th Triennial Meeting, Ottawa 1981, pp. 81/22/0-1. In this article both ‘restorer’ and ‘conservator-restorer’ will be used.

⁵ A. Bredius, The Adulteress before Christ. A picture by Rembrandt. A reply to an Open Letter to Dr. Abraham Bredius concerning the authenticity of this picture, The Hague 1912, p. 2.

Inorganic Chemistry at Delft: “one cannot fight over art with a chemist”. When it came to painting, the eye was “the highest authority, just as the ear is for music. Here not the tuning-fork, there not the test-tube”. He was willing to talk only to the expert in the court case, Prof. Dr. W. Martin, the Director of the Mauritshuis, his ‘Amicus Martin, magis amica veritas’. He would not even address Martin’s colleague Sir Charles Holmes, Director of the National Gallery in London since Holmes was not an expert on Dutch painting. In the 1920s, it was clearly unacceptable to trespass on someone else’s discipline. Interdisciplinary co-operation between ‘expert connoisseurs’ (art history was still in its infancy) and (natural) scientists obviously was not taken for granted.

Both pictures, *The adulteress before Christ* and *A merry man*, have been removed from public view and cannot be found. It is unlikely that the restorer Hauser performed chemical analyses to prove the pigments’ identity. *The adulteress before Christ* is painted on canvas and bears the date of 1644; it would therefore have been a prime candidate for an investigation of a possible origin in Rembrandt’s workshop, as one can read in the second article in this thesis. The technical report in the publication on the Hals case is convincing - the paint appeared to dissolve in water and typical 19th century pigments were identified. Advances in instrumental techniques for chemical analyses since c. 1900, and in knowledge of traditional painting techniques, would probably have confirmed the early analyses on this painting.

### The early years of science in the service of art

Scientists have been involved in the examination of works of art for well over two hundred years. Chemical analyses could initially only be done incidentally, as will be shown in a few examples below.

Over the years there has been an ever growing interest on the part of art historians, curators, conservator-restorers and the general public in the materials and techniques that famous artists used for making their pictures and in how scientists could uncover these ‘secrets’.

This interest originated, as sheer curiosity, as long ago as the Renaissance - a term that is used here in the sense of revived interest in the classical world - when the material remains of man’s prehistoric past were found and studied by sixteenth century scholars in Italy and travellers from abroad to Italy and Greece. This interest in how ancient objects were made continued. In the eighteenth century, scientists – chemists in particular – started to figure in the study of objects from antiquity. The chemist Martin Heinrich Klaproth (1743-1817) began to perform chemical analyses on historic cultural objects in eighteenth century Berlin. He determined the approximate composition of Greek and Roman coins and ‘antique glass paste’, probably pieces of Roman glass. In the eighteenth and, more especially, the nineteenth century, particularly during the Napoleonic wars, numerous portable antiquities were collected and studied by scientists who sometimes accompanied the Napoleonic expeditions. For example, the expedition arriving in Egypt

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7 Hofstede de Groot, op. cit., see above, p. 5: “...omdat men over kunst nu eenmaal niet met een chemicus kan redetwisten. In zake schilderkunst moet het oog de hoogste instantie zijn, evenals in muziek het oor. Hier niet de stemvork, daar niet de reageerbuis”.

8 A technical report has, so far, not been found in the Zentralarchive in Berlin, nor in the Archive of the Rathgen.

9 Hofstede de Groot, op. cit., note 6, pp. 74-78.


11 A. Mark Pollard and Carl Heron, *Archaeological Chemistry*, Cambridge, 1996, p. 3. Also: http//bibliothek.bbaw.de for a selection of articles by Klaproth, three of them are on materials from cultural objects.
in 1798, was accompanied by Déodat Gratet de Dolomieu. Dolomieu was a mineralogist.12 (These expeditions also illustrate the common history of archaeology and geology). Another chemist, Humphrey Davy, in 1815, published his work on the identification of ancient pigments found in Rome and Pompeii, among them a synthetic pigment, later named Egyptian blue.13

It was admiration for the skills of our ancestors that first prompted chemical analysis of the objects’ materials. Later, in the nineteenth century, it would be to provide data to establish a chronology (stone, bronze, iron ages) for the emerging speciality of archaeology. The question of how to preserve the finds and, subsequently, the concern with the appearance on the market of dubious antiquities, also began to play a role.

**Specialised laboratories**

The collaboration between archaeologists and chemists resulted in the establishment of the first ever museum chemical laboratory, in 1888, in the Kaiser Friedrich Museum of the Königlichen Museen in Berlin, with Friedrich Rathgen as the first chemist appointed by a museum.14 The British Museum followed next, in 1922. In the 1930s leading scientists showed increased awareness of the profession of restorer: the way it had been practised for a few hundreds of years needed to be reformed. Restoration, and conservation, needed to include scientific methods of examination. Thus museum laboratories were established. The Fogg Art Museum (the oldest of Harvard University’s art museums) established its Department for Technical Studies in 1928 (renamed in 1931 the Department for Conservation and Technical Research).15 Also in 1934, in Brussels, Paul Coremans, an analytical chemist, together with Egyptologists, set up an analytical laboratory at the Brussels Musées Royaux d’Art et d’Histoire,16 now the Institut Royal du Patrimoine Artistique (IRPA). IRPA was the first national institute, not attached to any particular museum. Coremans initially spent most of his time in his Brussels museum laboratory on questions of authenticity and the state of preservation of Egyptian works of art, publishing on air conditioning in museums (an indication of the growing awareness of the influence of the environment on the condition of art works). He subsequently worked mainly with pictures. At IRPA, in the late 1940s he contributed to unmasking the fraud perpetrated by Van Meegeren.

In 1930 there was also the stimulating International Conference on Examination and Conservation of works of Art, held in Rome. However, changes in the attitude towards restoration happened only very slowly.17

In The Netherlands, a specialised laboratory, modelled after IRPA, was founded on 1st March 1963 for the analysis of the materials from cultural objects and for developing restoration

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12Dolomieu’s name was given to the natural mineral dolomite since he had discovered it. He found the mineral in what is now northeastern Italy and proved it to the different from chalk: unlike limestone or chalk it did not effervesce in acid, from: en.wikipedia.org/wiki/Déodat_Gratet_de_Dolomieu.

13 Humphrey Davy, ‘Some experiments and observations on the colours used in painting by the ancients’, *Philosophical transactions of the Royal Society of London*, 105 (1815), pp. 97-124.

14 The Kaiser Friedrich Museum was renamed Bode Museum in 1956, after its first curator Wilhelm von Bode. The laboratory is now the Rathgen-Forschungslabor der Staatlichen Museen Preussischer Kulturbesitz.

15 Other museum laboratories followed soon: The Louvre in Paris 1931, Scientific Department at the Courtauld Institute in London 1934 and at the National Gallery in London in 1934, etc.

16 Koninklijke Musea voor Kunst en Geschiedenis (Royal Museums of Art and History).

methods and materials for the conservation of the objects: the Centraal Laboratorium voor Onderzoek van Voorwerpen van Kunst en Wetenschap (Central Research Laboratory for [the examination of] Objects of Art and Science, from here on referred to as CL.)\textsuperscript{18} Like IRPA, CL had laboratories and restoration studios. H. Lodewijks was its Director. At the outset, the Advisory Board for CL, consisted primarily of scientists. (Non-scientists were its secretary, D.F. Lunsingh Scheurleer, and A.F.E. van Schendel, then curator of paintings at the Rijksmuseum.) Lodewijks and J.W.H. Uytenbogaart,\textsuperscript{19} another member of the Board, were both chemical engineers from the, now called, Delft University of Technology, in Delft. The chemist R. J. Forbes’ field of study was the history of science. He published, among other things, on bitumen and petroleum in antiquity.\textsuperscript{20} Van Schendel had an affinity with painting conservation and restoration. Inspired by Coremans, who used methods from the natural sciences for the examination of paintings (x-radiography and microscopy for identifying pigments), Van Schendel pled for an interdisciplinary approach to conservation: art historians, scientists and restorers should work closely together.

The author was employed by CL from the beginning of 1969. Before the foundation of CL, there were discussions on the connection between archaeology and the natural sciences, reflecting developments abroad. Judging from publications, in the Netherlands it was predominantly C-14 dating, performed in Groningen, that preoccupied archaeology.\textsuperscript{21} The reason for founding a special laboratory in The Netherlands for the examination of cultural objects other than the prehistoric artefacts of interest to archaeology lay in the poor conditions of storage and preservation of historic objects. There were huge quantities of neglected objects, in collections, archaeological and otherwise, in small museums and other public buildings all over The Netherlands.\textsuperscript{22}

**Interdisciplinary co-operation**

The reason for setting up specialised laboratories in the museums rather than using existing laboratories in universities and industrial companies is that the latter are generally not adequately equipped - with instruments and analytical chemists - for the identification of the components in tiny, complex, inhomogeneous samples from art objects. The focus of university and industrial laboratories is not on art, nor on the manufacture and preservation of the objects nor on the development of materials for their conservation. It is not in the interest of industry to develop products whose application can be reversed, if necessary, after a hundred or more years. Even more importantly, unlike workers in industry and in fundamental research in the universities, scientists working in the field of art conservation have to dare to step across the border of their own

\textsuperscript{18} This is not the place for a full history of CL and the choices that were made when CL was founded. Hopefully this history will be written sometime soon.


discipline, into art history, conservation and restoration and other areas, while people in the arts have to try and understand natural scientists. Prior to the twentieth century there was no such strict division, but over the past century it has become increasingly difficult for different disciplines to truly understand each other. Each particular science or arts discipline has its own terminology. When C.P. Snow, a scientist by training, introduced the term ‘two cultures’ in his 1959 Cambridge lecture to refer to the communicative gulf that had arisen between the sciences and the humanities, he cited the example of poets occasionally using scientific expressions, for instance, ‘polarised light’. Poets were not aware of the specific meaning of the term, said Snow, they used it “under the illusion that it was a specially admirable kind of light”.23

Coremans, the analytical chemist mentioned above, was a strong supporter and even the initiator of interdisciplinary collaboration. He was the editor of the exemplary 1953 publication The Mystic Lamb in the Laboratory, on Van Eyck’s famous altarpiece in Ghent, exemplary because the publication is at the same time a document on (the examination of) Van Eyck’s technique and on the restoration of the artwork.24 In his publication, Coremans states that it would not do to report that the Mystique Lamb was ill, that it was treated and that the result was satisfactory: Such a cornerstone of art history demanded more attention. Therefore it would be “not only desirable but essential to characterise the symptoms of the illness, describe the treatment and relate the results obtained about the materials used by Van Eyck to artists, art historians and laboratory researchers and technicians”. Of course, sick works by less famous artists deserve the same attention.

The scientist is in a position to bridge the gap between restoration and science in situations like the above. He or she can ‘translate’ questions asked by the conservator-restorer into scientific ones. For instance, the analytical instrument to be chosen, and its optimal conditions for analysing certain specific materials. A specialised analytical chemist can only do such a judgement. However, analytical work is only one small aspect of what science can do for conservation. Since the 1950s, there has been an ongoing dialogue, first on ‘science for conservators’, and, more recently, on ‘science within conservation’, namely incorporated into the training of conservator-restorers.25

Publishing

Publishing reports and results of the technical and scientific examination of art objects, not only on materials and techniques used by artists, but also on conservation treatments and the evaluation of such treatments (deterioration processes, restoration materials, changes in ethics towards conservation and restoration, etc.) is essential. Findings, from such examinations, by all parties in the interdisciplinary community, should be accessible and of use to the conservation community at large, rather than being hidden in internal files or within an institute. The conservation community, although relatively small, is scattered all over the world (like the cultural objects) and publications provide a means of communicating. Difficulties in communication due to the fact that the work involves different disciplines - from art and art history to chemistry, physics, geology and more - have to be overcome. Of course the demands for keeping up-to-date on knowledge do not differ from any other very specialised profession.

23 C.P. Snow, Two cultures and A second look, Cambridge 1972, p. 16.
International professional relationships resulted, in 1932, in the quarterly journal *Technical Studies in the Field of the Fine Arts* published by the Fogg Art Museum.26 It ran up to 1942 and, in 1952, continued as *Studies in Conservation*, after IIC [International Institute for the Conservation of Historic and Artistic Works] was founded in 1950.27 The goal of publishing Technical Studies was to spread ideas about conservation, underpinned by scientific examination, among a larger audience of conservators/restorers, curators and perhaps the general public. As stated in the *Editorial* to the first issue of SIC, ‘the whole outlook (of the journal) has been conditioned by the experience gained with ‘Technical Studies in the Field of the Fine Arts’.28 In the *Editorial*, the need of such a journal for conservator-restorers is stressed: they had, since 1942, been bereft of any medium of communication of a strictly comparable type. There was no pre-conceived planning as to the division of contributions into ‘theoretical’ and ‘practical’ categories. Thus the selection of articles for publication in SIC depended on who was willing and in a position to write, and on the mood-of-the-moment. In the early days, the authors were the people who had been active in advancing science for conservation, for instance Paul Coremans, who continued reporting on the technique of the Flemish Primitives, including Van Eyck’s *Mystic Lamb*, in SIC.29

Publishing findings has remained important up to the present. SIC has lived up to its promise; it is a truly interdisciplinary and international journal. Objections by conservator-restorers, who find the current SIC impossible to read, with its excessive charts and graphs, too much data, and lack of “usable” information, were - rightly - brushed aside by the editors: “IIC members should be proud that Vol. 54:4, the volume scrutinised by the editors as a basis for their response, represents the work of a broad range of professionals (chemists, biophysicists, biologists, material scientists, conservators, geologists, archaeometallurgists) from six different countries.”30 Other conservators, sensibly, skip the passages with graphs and read the abstracts carefully.31 The growth of interdisciplinary work in the field of conservation science is reflected by the enormous increase in the number of publications and the number of their authors in recent years. It is not exceptional to find up to eight authors of a single article, with at least one of them a conservator. Many of these articles could have been published in recognised specialist science journals, as tends to happen increasingly in any case - another reason for SIC to remain as it is; it is more accessible for conservators than science journals. There are also new, specialised, journals, for instance the *Journal of Cultural Heritage*, a multidisciplinary journal of science and technology for conservation and awareness, published since 2008.32

It is worth of note that curators and art historians are missing in the summing-up of the SIC editors (see note 30). Fortunately, they do offer opportunities for publishing on the technical examination of paintings, in museum journals and museum and exhibition catalogues. The articles

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31 Personal communication with restorers.

on Frans Hals and Judith Leyster in this thesis are examples; they were originally published in exhibition catalogues. The paintings selected for the study of the painting technique by these particular artists were, as far as possible, those that were chosen by the curators to be exhibited. The articles are the result of the technical examination of paintings in close collaboration between a conservator and a scientist, as described below.

The popularity of exhibitions that include the technical examination of the paintings in them proves that the general public is also interested in the technical aspects of paintings, sometimes attracted by questions of authenticity. A recent example is ‘Master piece or copy?’, the exhibition in Museum Boijmans Van Beuningen, showing two versions of Anthony Van Dyck’s *Saint Jerome with an angel*. The makers of the exhibition led viewers through the process of the examination (which involved mainly judging photographic material by the use of one’s own eyes) for concluding which painting is ‘real’, that is: made by the master. An extra bonus in the educative show was that the viewers came to realise that the non-real painting was not to be called ‘a fake’, but ‘another version, possibly a studio copy of the ‘real’ Van Dyck painting’.33

Science for conservation and art history

The time-consuming aspect of the work – the microscopist and the restorers peering constantly through microscopes - can surprise those not directly involved in the work on pictures. To everyone’s surprise, in the case of *The Mystic Lamb*, the examination, in advance of actual treatment, took a long time. It was still a novelty in the 1950s to spend so much time on the patient technical examination of paintings. (Nowadays the time allotted to examination by trained restorers and scientists is threatened by the pressure of making pictures presentable for loans). However, the time spent on the examination is, as Coremans states ‘a prime condition for the reunion and the confrontation of elements from the historical, scientific and aesthetic order’, and ‘without the appreciation of these elements no one has the right to take the responsibility for the treatment of an important art work. The time when one would permit a work of art to disappear for several months into the studio of a restorer-alchemist with a keen interest in secret and magical formulae, is over’.34 That time is indeed over. The present-day restorer is trained in chemistry, examines a picture before treatment, preferably and sometimes necessarily in interdisciplinary collaboration.

This is an essential part of conservation. The examiner is trying to interpret what he sees, trying to connect the build-up of paint layers with the observations on the picture surface.

Coremans’ words imply that the technical examination and restoration/conservation can be used for answering art historical questions. This is indeed the case. However, in contrast to the collaboration between restorers and scientists, the ‘two cultures’ are much more evident with scientists and art historians. At the technical, practical part of the ‘Rembrandt after three hundred years’ symposium, held by The Art Institute of Chicago in 1969 and organised with the aim of hearing what scientists could contribute to art historical Rembrandt research, Nathan Stolow - a scientist - in the round-table discussion remarked that ‘the art historians are ready to devour us even in advance of what we might want to say’. Von Sonnenburg, trained in art history as well as in restoration and conservation, tried to soften the presence of scientists by remarking that ‘a number

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34 Coremans, op. cit., note 24, p. 9.
of the methods referred to (in the examination of paintings) are extensions of the human eye which need interpretation, adding that the term ‘scientific’ does not apply to these.35

In conservation there is clearly a need for the examination of paintings using the human eye, whether extended by microscopes and chemical analyses or not, while in art history the need for such an extension is not always acknowledged. Even nowadays, with very few exceptions, it is not the art historian or curator who asks for a scientific examination and incorporates the results of such examination in his or her art historical theory. Archaeologists are good at requesting science. For example geoarchaeology, set up at the Vrije Universiteit in Amsterdam, bridges science - geology - with archaeology. It is incorporated in the Faculty of Earth Sciences. The way of working of the art historian seems to conflict with that of the scientist (expecting clear and unambiguous answers from scientists, publishing in books rather than journals).36 However, a few art historians do regularly use technical means of examination in their work as researchers in a conservation department.37

In conservation/restoration, scientists are welcomed with open arms and an open mind. Restorers feel the need for scientific examination and analyses. For example, to arrive at a diagnosis one asks: where does the bloom spring from; should it be removed and which solvent would remove it; are there later additions and alterations in the composition; is there any varnish left, or has the paint layer itself changed in appearance; is it a later copy altogether, etc.? Obviously the answers to all these questions have an impact on the art historical appreciation of the object by the change in appearance of the object after restoration. The conservator- restorer has to convince the art historian or curator of this desirability of such a change; he needs arguments, results from scientific examination. The technical examination of paintings is really part of conservation, and of great importance to art history; it is an extension of an art historical approach. It should not therefore be termed technical art history, which would imply that the examination of paintings is a different type of art history, instead of part of it. And the term archaeometry is used for archaeological science, it would not seem to include art works.38

The conservator-restorer has to convince the art historian or curator of this desirability of certain interventions that would change the perception of the picture. He needs arguments, results from scientific examination. Over the years restorers’ attitudes have changed towards minimal intervention. The times when a curator could say “these blue leaves, just paint them over, make them green” are over. Even if the examination helps in explaining the appearance of the picture, we cannot be sure what it looked like in the past.39 The viewer should not be looking at the restorer’s ‘hand’. Not only the museum curator, also the commercial art world, nowadays, accepts alterations and traces of ageing in pictures.

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37 There are, for instance, Melanie Gifford at the National Gallery of Art in Washington, Margriet van Eikema Hommes at ICN and Arie Wallest at the Rijksmuseum in Amsterdam.

38 ‘Archaeometry’ does not exist as a word; it is not included in the 1979 edition of Collins Dictionary of the English Language, nor in the recent on-line version of the Dictionary. The term seems to be the clever contraction of two words, since 50 years the title for the Oxford journal Archaeometry, with half of the title printed in bold.

Ways of seeing

The visual examination of paintings, and cultural objects in general, is often crucial in guiding the conservator’s approach and in questions of attribution. This starts with the examination by the naked eye, followed, if necessary, by further visual examination assisted by magnifiers and technical photographs. The examination enables one to discern features that are not visible to the naked eye. Not only before treatment, but also during the restoration itself, the trained restorer continuously asks him or herself questions about the build-up of the paint layers. By working in close collaboration with scientists/microscopists during their training, in the last decades, restorers have learned to recognise specific features in the paintings. The examination is not just interdisciplinary in a loose sense; part of the work of scientist and restorer actually overlaps here. The scientist has to understand the painting as well as possible in order to be able to answer the restorer’s questions satisfactorily, by choosing the correct follow-up methods of investigation. The answers to these questions have consequences for the restoration (which is, of course, the restorer’s responsibility) and thus for the perception of a picture, as stated above.

At the beginning of 1973, a small department for art history was formally added to the CL, whose task consisted of art historical research for restoration, conservation and science projects at CL. In addition, the history of restoration was to be studied as well as written sources on artists’ techniques. Ernst van de Wetering, member of the Rembrandt Research Project (RRP), became the head of this department. The RRP had been set up in 1968 with the stated purpose (in the first volume of A Corpus of Rembrandt Paintings) to conduct ‘conscientious examination, making use of up-to-date methods of investigation whenever possible’. Before any scientific examination, each painting was to be described, including its purely physical features: the paint layer, the ground, and the support. This was a novelty in art history – and in science too. Van de Wetering, who had not only been trained as an art historian but also as an artist, introduced the concept that a coherent view of an artist’s technique, in this case Rembrandt, had to be known as part of the basis for attribution. In order to know the technique, the stratified structure of a painting resulting from the actual painting process had to be examined. X-radiographs served this purpose best, plus the use of the stereomicroscope and paint samples. However, results from the analyses of samples, obtained by different institutes so far, and presented at the 1969 Chicago Rembrandt symposium, had not given a coherent picture of Rembrandt’s working process. Furthermore, the range of pigments used had been shown to be limited. It turned out that it was necessary to think as an artist, to look at how the master did it as if one were his pupil. The author joined the Rembrandt project at the stage when it was decided that a number of paintings would be systematically examined with the use of a microscope. Not only the art historian, but also the scientist should adopt the same viewpoint – what questions to pose to the painting and how to interpret analytical results. We started the examination of paintings by the young Rembrandt, produced in his Leiden years (1625 -1631). Layers comprising middle tone, highlight and shadow were found not only while looking through the stereomicroscope at the surface of the painting, but also in the paint cross-sections. Conversely, the information obtained from paint cross-sections could be extrapolated to the paint surface. The investigation of the artist’s working method by laborious scrutiny of the paint surface contrasts with ‘point analysis’, a term sometimes used to refer to the examination of paint samples. Rembrandt’s earliest paintings - all on panel - were all found to have the traditional priming for panel as

40 J. Bruyn e.a., A Corpus of Rembrandt Paintings, I, The Hague, Boston, London 1982), Preface, p. IX.
42 Bruyn in op. cit., note 40, p. XV.
described by Theodore De Mayerne in 1620. These findings were new. An account of Rembrandt's way of working on these early panels, using a specific method and working economically (starting with a middle tone, followed by the lights and the dark tones) was published in *A Corpus of Rembrandt Paintings* and in articles in *Oud Holland*. In retrospect it is remarkable that the work was published in two separate articles. I was the one who was still clinging to a world of 'two cultures'. In the Bardwell article (see list of articles in this thesis) we clearly stated who wrote which part within one article.

Since the examination of the young Rembrandt, the examination of paintings has always been carried out with this question in mind: how did the artist do it? To answer questions posed by restorers, a scientist always has to translate the question into a scientific one and has also to be very critical about why one wants to know what. Therefore, scientists should also know the picture inside out, by looking at it and through communication with others. The way of looking at paintings described here was introduced to trainee painting conservators at the Hamilton Kerr Institute, University of Cambridge, UK, (HKI) and later at the Stichting Restauratie Atelier Limburg (SRAL), modelled after HKI. Both institutes have small in-house laboratories. Paintings were examined in a close collaboration between the analyst-microscopist and the trainee restorer. This part of the training involved the scrutiny of the picture’s surface, all the while pointing out and discussing the particulars being observed. It was a true master-pupil relationship. Paint cross-sections were studied using an instruction microscope, i.e. a microscope with two pairs of eyepiece lenses (objectives) and a pointer. In our digital era, a screen for digital images can be added, making the exercise a true masterclass. Paint cross-sections were studied in the same way. Whereas in the 1960s and 70s, at CL, restorers were not supposed even to look through a (research) microscope – which was, after all, the domain of scientists – things had changed drastically, partly out of necessity: too many requests for time consuming work by too few scientists.

**Conservation science**

After the visual examination further examination is often needed, by scientists. Instrumental analysis should remain in the domain of the scientists, as stated above. Only they can judge what instruments to use for answering certain questions and interpret the results obtained. This, depending on the question asked, often includes the examination of paint cross-sections, as will be shown in a few examples below.

The term *conservation science* became part of the conservation community’s vocabulary c. forty years ago; it is not possible to be specific. What it refers to is the interface of science and conservation. The examination of paintings and materials from them - sometimes erroneously referred to as the ‘technical study of paint cross-sections’ - in my opinion and experience belongs to conservation science. The problem with the term *conservation science* lies not so much in the question of whether the restorer uses the outcome of the investigation for his approach or not, but in the fact that the examination is part and parcel of conservation and, through conservation, of art history. In the museum, the person responsible for decision-making is the director. But, the curator, endorsed by the director, can make a reasonable decision only if he takes material aspects into account.

The technical examination is often of consequence in the work of the restorer. Unfortunately, reports of such examinations do not often reach the stage of publication; they tend to

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disappear into documentation files in the institutions concerned. In this thesis, however, the article on Rembrandt’s binding medium, the three articles under ‘Changing colours’ and the last article, on Vermeer’s *Girl with the pearl earring*, relate to aspects of conservation or are wholly concerned with conservation.

In the past, not much was known about the manufacture of paintings based on scientific examination. Max Doerner’s *Malmaterial und seine Verwendung im Bilde* (*The materials of the artist and their use in painting*), first published in 1921, was not based on scientific analyses but on Doerner’s experience as an artist when copying old master paintings: the paint did not show wrinkles as it did in the works by his - much later - followers who used oil.⁴⁴ Doerner warns restorers erroneously about the vulnerability of the ‘strongly resinous nature’ of Rembrandt’s (and Rembrandt’s pupils, and Vermeer, Hals, Rubens) painting medium (Venice turpentine, mastic and thickened oil), a warning that has unnecessarily prevented the cleaning of paintings for many years. In fact it is safer to remove the resinous, darkened varnish from oil paintings than from paintings made with a resinous medium. The book is still in demand with students in art academies and some of the art academy students become restorers.

Numerous later impressions, revised editions with sometimes up-to-date extensions, and translations of Doerner’s book have appeared. Comparing these, one gets a very interesting insight into the development of conservation through history, and into different attitudes - towards the book - internationally. But it is not the goal of this article to compare fully these editions. However, in the 16th German impression from 1985, Doerner’s warnings about Rembrandt’s strongly resinous paint have still not been adjusted. By the time of the 17th German edition, in 1989, they have been, by Hans Gert Müller, using the information from scientific analyses. The outcome of these analyses is, that the binding medium used by Rembrandt is a drying oil,⁴⁵ a fact also mentioned in the 1993 Dutch edition, translated from the 17th German edition.⁴⁶ The latest, 22nd, German edition appeared as recent as 2007. An English edition first appeared in 1934, with more imprints up to 1984, all more-or-less literally translated from the 1921 German edition, without the note on the scientific analysis of Rembrandt’s binding medium.⁴⁷ Doerner’s book is in some aspects exemplary, but the chapters on the painting techniques of the old masters no longer fit the knowledge required by restorers. That may well be the reason for no further English editions after 1984.

Doerner’s resinous Rembrandt copies may not have wrinkled, they have darkened, the way a varnish would, differently and far more than the original Rembrandt - oil -paintings.

Translucent top paint layers or glazes, i.e. medium-rich paint, have always been a concern when cleaning. The problem is two-fold. Firstly, their recognition by the restorer. Is an original glaze present, which should be preserved, or is this brown material a later applied varnish to be removed? Secondly, is their solubility possible? The microscopical examination of paint samples has shown that (organic red) glazes can be found in paintings by Rembrandt and other seventeenth century painters. Fortunately these glazes constitute oil paint - at least in the seventeenth century as stated above. When glazes have gone, this is mostly due to rough cleaning in the past. (Nineteenth century paintings are often impossible to clean because of their soluble - resinous - paint layers including glazes). Because of chemical analyses, we now know that cleaning a painting by


Rembrandt is no more hazardous than cleaning any other seventeenth century oil painting, as far as the material aspect is concerned.

In Johannes Vermeer’s *Girl with the pearl earring*, it was the problematic background that needed investigation during the restoration. The background appeared uneven and spotty. The poor state of the painting may be related to earlier restoration procedures. Investigation was undertaken for understanding the background (as part of a larger study of the techniques and materials used by Vermeer).

Questions asked by restorers are often about the originality of surface layers and the decision that has to be made: is there a layer that should be removed or is it original? If original, ethics in restoration dictate that it should be left alone, even if it does not have the appearance meant by the artist. Original green layers can have turned brown and therefore difficult to distinguish by the naked eye from varnish layers (see the article ‘Towards identification of brown discolouration on green paint’ and its update in this thesis); green paint can have turned blue (see the article ‘the foliage tends almost to blue’ in this thesis); surface layers can have turned white for reasons of discolouration of the pigment or chemical or physical changes in the binding medium, etc, etc. Combinations of these factors, plus irregular treatment in the past, were recently witnessed again in Cornelis van Haarlem’s *Maaltijd van de Haarlemse schutters en de Cluveniers* in the Frans Hals Museum in Haarlem, where, surprisingly, discoloured smalt, mixed with red lake, was found, intended originally as a glaze of a purplish colour, on top of a half-glaze containing red lake. The question by the restorers had been if there were remnants of old degraded (oil) varnishes left on the surface, or whether the origin of the degraded (‘blanched’) appearing surface lay in the paint layer itself. After the examination of the samples it has become much clearer what spot constituted the remnant of varnish and where the original, degraded smalt/red lake glaze was still present. It has also been ascertained which spots had been over-cleaned in the past, actions that had caused degradation of part of the original binding medium of the glazes in this painting.

On paintings which were formerly thought to be less remarkable, and therefore treated less, one sometimes, unexpectedly, comes across glazes when using an ultraviolet lamp; subsequent examination of a paint cross-section from the same area does indeed reveal a beautiful, intact glaze. If the painting had not been examined technically in that way, the glazes would have escaped notice. The glazes had deluded the naked eye and the stereomicroscope. This was for instance the case with a Cornelis Dusart’s *Gelagkamer in een dorpsherberg* in the Frans Hals Museum, where red glazes, related to specific forms, were detected in this way. It makes one suspect that on other paintings, glazes may have disappeared in the past.

At the Hamilton Kerr Institute, where the author for nearly ten years ran a small laboratory next to the restoration studio, the adage concerning surface layers was: ‘when in doubt leave well alone.’

**Low-tech science for art history**

A lot of data, gathered over a long period are needed for answering some of the questions posed by art history. Not only chemistry, also knowledge of geology, written sources, archival and other material is needed for answering certain questions. ‘High tech’ instruments are not always needed.

It is clear from the second article in this thesis, ‘Grounds in Rembrandt’s workshop and in paintings by his contemporaries’, that a low-tech investigation is sometimes sufficient for answering art historical questions. In this case the question was: is the use of quartz grounds restricted to Rembrandt and his studio, a question already posed by Kühn and discussed at the...
Rembrandt symposium held by The Art Institute of Chicago in 1969. In general, sufficient information was obtained by using a light microscope together with an electron microscope, with the energy dispersive X-ray analysis (SEM-EDX) for identifying chemical elements in tiny areas of the paint cross-section. In a few cases it needed approximately 30 µm thin sections, made of the embedded paint sample, so that these could be examined in transmitted light. X-ray diffraction analysis was also carried out, specifically to show that the quartz present is alpha-silica, or ordinary sand. The difficulty in answering the question concerning the quartz ground lies not so much in the analytical instruments used, but rather in the availability of sufficient samples to permit a statistical assessment. The answer could only be given after many samples had been analysed. The present author has been studying Rembrandt paintings in collaboration with and in the context of the Rembrandt Research Project since 1973 - first at the CL and later at the Hamilton Kerr Institute in Cambridge and the SRAL in Maastricht. A Corpus of Rembrandt Paintings Vol. 4 appeared in 2005. It thus took more than forty-five years - since Kühn’s and Coremans’ investigations and publications on the quartz ground found in the Stuttgart Self-portrait - before the answer to the art historical question could be given. In many cases, samples taken and analysed earlier had been removed with another objective than that of studying the build-up and the composition of the ground layers. Often the original question had to do with treatment of the painting.

Since the Rembrandt research on ground layers, the examination of them has become an important area of attention. This may seem surprising at first. Why bother to look at the ground? One should look at the paint, as Norman Brommelle - former Director at HKI - remarked. The importance of knowledge of the materials used for the ground preparation of canvases lies in the fact that materials used for it could be local and therefore useful in attribution. Most pigments used in seventeenth century Dutch painting had to be obtained from afar since Holland does not have minerals apart from clay and sand. In the case of Van Gogh’s paintings, ready-made (tube) paints were available from ‘colour-men’ and shops by the late nineteenth century, but investigating the grounds of his paintings – besides the pigments in the paint - could still provide information on provenance and dating. The same techniques of investigation were used as in the investigation of Rembrandt’s grounds - optical and electron microscopy. It turned out that Van Gogh (and Gauguin) first tried chalk as filler in the ground preparation, then barium sulfate and then lead white and finally lead white/zinc white mixtures. These findings were related to the date and place where the artists worked. The investigation has now been extended to a large comparative technical and art historical study of preparatory layers, and canvasses, in paintings by Van Gogh, Gauguin, Monet and Renoir, at The Art Institute in Chicago, supported by The Getty Foundation.

The identification of chemical elements in paintings - interpretation of the results

Whether the result of the examination under the microscope, or through the use of nuclear facilities, results obtained always need interpretation. Most of the analyses using high tech instruments need microscopy for the interpretation of the results obtained. This can be stated for every specialised laboratory.

Thus, in the first year of the CL’s existence, Lodewijks, the director, in the 1960s, remarked that the activities in the laboratory were considerably limited by the lack (due to the long time of

48 Op. cit. note 35, p. 84. See also ‘Grounds in Rembrandt’s workshop and in paintings by his contemporaries,’ in this thesis.

delivery) of several instruments that were indispensable for the research, especially a large research microscope for the identification of pigments.\footnote{Nationaal Archief in The Hague, archiefvormer No 2.14.76, Centraal Laboratorium voor Onderzoek van Voorwerpen van Kunst en Wetenschap, 1963-1997. Annual reports, written by J. Lodewijks, 1 mei 1963.} At the same time the Petten Research Centre offered CL their nuclear reactor facilities for the examination of art objects. Petten very much wanted ‘something with art’, to show the Queen, when she would visit the nuclear plant, something different from the scary radioactive facilities.\footnote{Oral communication J.R.J. van Asperen de Boer.} Art is always more attractive to look at. Neutron activation analysis (NAA) was a method that was rather popular abroad for the identification of chemical elements in works of art.\footnote{E.V. Sayre, \textit{Proceedings of a Seminar on the Application of Science in Examination of Works of Art}, Boston (Museum of Fine Arts, Research Lab.) 1958, pp. 153-177.} Also, the investigations by A.M. de Wild of the pigments used by Dutch Masters (by means of microscopy and micro-chemical methods) had shown that a relatively large number of pigments had been in use over a very long period and could not provide information for the precise dating of paintings. (A.M. de Wild, a Chemical Engineer from Delft, in 1928 wrote his PhD thesis on the scientific investigation of paintings: \textit{Het natuurwetenschappelijk onderzoek van schilderijen}\footnote{A.M. de Wild, \textit{Het natuurwetenschappelijk onderzoek van schilderijen}, The Hague 1928. Translated into \textit{The scientific examination of pictures}, London 1929.}. It therefore seemed likely that more information could be obtained from impurities present, since pigments prepared nowadays will be prepared from better purified base material. Lead white especially was a good candidate, because lead white contains silver and the extraction of silver would have improved over the years.

NAA can be used either on objects - then the method is also referred to as autoradiography - or on samples from objects. When used on objects, results can be read from a series of photographic plates that were sensitised by $\beta$-particles, emitted from the painting after radiation.\footnote{For a description of the technique as it is used on paintings see, P. Meyers e.a., ‘The technical procedures and the effects of radiation exposure upon paintings’, in \textit{Art and Autoradiography}, New York (The Metropolitan Museum of Art) 1982, pp. 105-110.} For the interpretation of the photographic plates - at what depth in the layer structure is a particular chemical element sitting? - samples had to be taken and cross-sections studied and analysed.\footnote{P. Meyers, M. Ainsworth, K. Groen, ‘Pigments and other painting materials’, in Meyers e.a., see above, pp. 100-104.} Radiation of samples permits the identification of trace elements. Dr Hermann Kühn, then scientist at the Doerner Institute in Munich, found that NAA could indirectly be used for provenance studies and therefore for the purpose of authentication and dating.\footnote{H. Kühn, ‘Trace elements in white lead and their determination by emission spectrum and neutron activation’, \textit{Studies in Conservation} 11 (1966), pp.163-169.} At Petten, in the end, in the sixties, the method was tried on art objects, (coins, alabaster) rather than paintings. Samples from paintings were radiated at the Reactor Institute of the Chemistry Department in Delft, where Prof. J.P.W. Houtman was the Scientific Director and Head of the Department. Houtman and co-workers confirmed Kühn’s findings: the concentrations of copper and silver especially were rather constant over a period before approximately 1850, after which they dropped to about one tenth of the earlier value.\footnote{J.P.W. Houtman and J. Turkstra, ‘Neutron activation analysis of trace elements in white lead and the possible application for age determination of paintings’, \textit{International Atomic Energy Agency Symposium of Radiochemical methods of analysis}, Salzburg, 19-23 October 1964, Paper No. SM-55/91.} Houtman worked on Netherlandish paintings only; Kühn found a high copper content in lead white in early Venetian paintings. Zinc and antimony were low before 1940 and have increased strongly in more recent times. The most likely explanation, according to Houtman, was the change
in purification methods for lead white and the adulteration with zinc white in modern times. In the
nineteenth century new methods for the manufacture of lead white did indeed come into use, although not in Holland, where the traditional method, named the ‘Dutch stack process’, continued well into the twentieth century. Years later, in 1987, J.R. Lancelot and A. Allegret in their ICOM-paper confirmed Houtstra’s analytical data (as far as the detection limit of their technique permitted, for some of Houtman’s results were below their detection limit), but explained the results differently. According to them, the early lead white would indeed have been manufactured in Holland (as well as in England) from English lead ores, but, during the industrial revolution in the nineteenth century things changed. Through commercial exchanges with North America and Australia a different type of lead was imported into Europe. Also, in the nineteenth century Germany and Austria dominated the production of lead white, and from the end of the nineteenth century it was America that dominated the world production of lead white. The change over time in the concentration of trace elements in lead white should therefore be attributed to the use of different lead ores. Lancelot and co-workers backed up their thesis with data from lead isotope (206Pb/204Pb) ratio measurements, (the approach used by Keisch and co-workers in Pittsburg, with the purpose of identifying the source of the lead ore used for the manufacture of lead white). They found, interestingly, that Pb isotope ratios are more or less constant in Middle and Southern Europe, the lead originating all from the same continental crust of 600.10⁶ years old. In Scandinavia and Scotland the crust is much older, in the order of 2000 x 10⁶ - 2700 x 10⁶ years. The conclusion is that lead isotope ratios in paintings originating in Holland, France and Italy are the same till the end of the eighteenth century. From then on, lead (white) originating from an exotic, non-European (America, Australia), reservoir was introduced and mixed with the European source.

The reason for relating this account of early work on trace elements and lead isotopes in some detail is to show that a simple question - of authentication, dating or otherwise - can take a long time, effort and money to answer. Trace and Pb isotope measurements cannot easily be carried out on a routine basis. In the past, these measurements needed a nuclear research facility. Since the middle of the 1970s, (accelerator) mass spectrometers are being used for separating (stable) isotopes. These analytical instruments can rarely be afforded, nor maintained, by museum laboratories. The opportunity to conduct such research only sporadically presents itself and rarely through a sponsoring connection. These opportunities sometimes arise because researchers at the facility are personally interested - and sometimes on a commercial basis.

Although the ultimate hope, expressed by Lodewijks that the identification of trace elements in the paint of the different layers in paintings, by using neutron activation, would give an insight in the characteristic properties of a particular artist’s work had not been fulfilled, he was on the right track. Kühn’s and Houtman’s pioneering work, in a close interdisciplinary co-operation, demonstrated that it could to some extent be used for dating purposes. There is still scope for further work: for instance, lead isotope ratio measurements could probably be refined. Might there

58 For instance the Pattison process, a process dependent on the fact that lead which has least silver in it solidifies first on liquefaction. A.I. Kossolapov and A.V. Sizov, ‘Impurities in white lead and the metallurgy of lead,’ Preprints, ICOM Committee for Conservation, 7th Triennial meeting, Copenhagen 1984, pp. 27-28.

59 J.R. Lancelot e.a., ‘Analyses de pigments blanc appliquées à l’étude chronologiques des peintures des chevalet - 1 blanc de plomb,’ Preprints, ICOM Committee for Conservation, 8th triennial meeting, Sydney 1987, pp. 67-73.


61 Lancelot e.a., op. cit., note 59, p. 70.

62 In 1968, after Coremans’ death, Houtman took his place on the Board of Advice of the CL (Central Laboratory Annual Report).
not be small differences within Europe? Since the early studies, provenance studies using lead white was continued, in Oxford, by measuring lead isotope ratio’s in carefully selected ore deposits; only those ores relevant to archaeology and art history were studied, first the Mediterranean, then British lead and copper deposits.63

The identification and the explanation of their meaning of main elements is less complicated than it is for trace elements. In 1973 CL obtained a Laser Micro spectral Analyser (LMA) with quartz spectrograph, after it had been proven beyond doubt that chemical elements could be identified in individual layers in paint cross-sections, without having to resort to a nuclear plant. At the Vrije Universiteit (VU) in Amsterdam, an electron microprobe had been used for elemental analyses at the CL’s request.64 The short article in my thesis, a preliminary report on the brown discolouration of green paint, rests on the results obtained at the VU. The LMA, manufactured by Carl Zeiss in Jena, East Germany, was an instrument suitable for qualitative analysis of the chemical elements in small, solid samples, (sample spot diameter c. 20 µm), but its detection limit did not permit precise quantification of trace elements.65 CL was the second lab in Holland, after the Institute for Forensic Science in The Hague, to purchase a LMA, which illustrates that the examination of paintings (and other cultural objects) has at least one feature in common with forensic science: small samples that stretch the limits of analytical instrumentation. The introduction of electron microscopes and X-ray analysers put an end to the use of LMA; the necessary glass plates for reading the LMA spectra were no longer produced, the instrument had become obsolete and was transported to the science museum, Museum Boerhaave in Leiden.

**Boundaries and limits**

When investigating paintings technically, non-destructive techniques are preferred (when a sample is taken, but is not destroyed by the analysis) and if possible, non-invasive techniques (which involve taking no samples). The term micro-destructive was introduced for the examination of samples using microscopy, FTIR and XRD.66 For obvious reasons, non-invasive investigation seems the most attractive. It can be done using the naked eye, magnifying glass and/or stereomicroscope, by using photographic techniques and some instrumental analyses. As an example, synchrotron radiation induced X-ray fluorescence spectroscopy mapping (which produces fluorescence spectra for each pixel) was used to visualise a hidden portrait under a Van Gogh painting. The work was carried out by a collaborative team of scientists, curators and conservators: the Technical University in Delft, the University of Antwerp, Deutsches Elektronen-Synchrotron (DESY) in Hamburg and the Kröller Müller Museum.67 Pigment analysis and the degradation of pigments, for example the degradation of cadmium yellow (CdS) in paintings by James Ensor (1860-1949), was also studied using synchrotron radiation based X-ray techniques. In the end,

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65 Lancelot, op. cit., note 59, had invalidated the report by Kossolapov about the use of Laser microprobe micro spectral analysis for trace elements in lead white: A.I. Kossolapov see op. cit., note 58, pp. 27-28.


micro-destructive cross-sections had to be analysed as well as scrapings for XRD in order to interpret the resulting data, a fact learned from experience and noted above.68 The most important question is: does the research have consequences for the restoration? The research has elucidated the chemical transformation and subsequent physical processes that led to the fading of the pigment, but what circumstances would have triggered the process, and when, is still a mystery.

Apart from the particular technique itself, the above collaboration is a contemporary example of the early beginnings of the Central Research Laboratory, with scientists offering their sophisticated equipment for research in the field of cultural heritage. Were there others motives for them to do this apart from pure altruism? An obvious reason for scientists is that it sets them a tangible problem-solving goal. There is also the attraction of working with beautiful and precious objects: Rembrandt and Van Gogh have never had much trouble attracting scientists to work with them. However, there have been other more practical gains from the advances made in the course of this research on paintings. During period in the 1990’s when scientific investigations related to the Rembrandt Research Project were sponsored by DSM, this sponsored research led to an improvement in the analytical techniques for identifying trace amounts of proteins in one of their industrial products, aspartame, which they were producing on a world-wide scale. Chemically, aspartame is a methyl ester of the dipeptide aspartic acid/phenylanaline. Contamination by breakdown products renders the artificial sweetener aspartame toxic. Long-term conservation research can therefore assist research in other areas by the testing of high tech instruments, and through testing their improvement and refinement. Cultural objects, especially paintings, stretch the ability of the instruments to their limits, as samples from them are minuscule. To my surprise, I learned that DSM undertook to sponsor art when it was in a bad shape financially, reasoning that art would improve its reputation and thereby indirectly lead to an improvement in the financial situation. Had the financial figures been better, it seems they would not have undertaken the sponsorship. Further, DSM management assured me, they would also have sponsored the research if it had been Gerard Dou instead of Rembrandt, confirming that other motives played a role than pure interest in Rembrandt’s oeuvre.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) is another technique that attracts attention in the field of cultural heritage.69 Disadvantages of LA-ICP-MS are that it is more expensive than X-ray fluorescence, that it is non-portable and its use is micro-destructive (although sample amounts as small as 900 ng have been mentioned in the literature.70) Although such emerging technologies are attractive, the required information can often only be obtained using conventional techniques with samples from the object. A multi-technique analytical approach

68 G. van der Snickt e.a, ‘Characterization of a degraded cadmium yellow (CdS) pigment in an oil painting by means of synchrotron radiation based X-ray techniques’, Analytical Chemistry 82 (7), (2009), pp. 2600-2610.

69 This technique enables spatially resolved information for multi-element analysis in a wide range of concentrations (µg/g to % level). It is used on surfaces of small objects or samples from them, it is micro-destructive, (ng level) with a spatial resolution of a few µm. The sensitivity is 0.01-0.1 µg/g. Both spatial resolution and sensitivity of LA-ICP-MS are higher than (portable) X-ray fluorescence. The sensitivity of LA-ICP-MS is also of an order of magnitude more than twice (depending on the material analysed) that of NAA, the technique mentioned above for Pb-isotope ratio measurements and trace elements, and also better than other conventional techniques used for the purpose, such as Thermal Ionisation Mass Spectroscopy (TIMS). LA-ICP-MS can indeed be used for Pb isotope ratio measurements, and for the isotope ratios of other elements. It is the best method for fingerprinting purposes. Spatial resolution is especially important in the study of paint cross-sections using LA-ICP-MS. With sufficient spatial resolution, profiling of cross-section would be interesting.

is necessary for the interpretation of the results: SEM-EDX and Raman allowing structural information to be obtained in this case.

For conservator-restorers it is very tempting to accept the research offered by scientists in industry and universities, especially if a non-destructive investigation involves no transport of the object to the research facility and is free of charge. We - conservator-restorers and conservation scientists - are all grateful for the pioneering role in conservation taken on by (high tech) scientists. But, does it provide the answers to the questions that conservator-restorer’s crucially require? Do the results contribute to decisions for the treatment of the object? This has not always been the case.

For art historians/curators nowadays, conservation research must be an even more daunting prospect than it is for (trained) restorers. For some, the language gap is impossible to breach and just as in the old days they still prefer not to talk to chemists. They simply cannot understand each other. Fortunately, there is an increasing willingness on the part of scientists to explain what they are doing to the conservator and art historian without resorting to technical jargon.

From the beginning of CL it was clear that the task it had been set was immense. During the first year, its Director J.Lodewijks, was astonished by the huge number of requests, from many different museums and other institutions, for the examination of a range of objects of varying material composition, including paintings.\(^71\) To cite a few examples: the Koninklijke Bibliotheek (Royal Library) wished to know if the visibility of the almost completely scratched out Erasmus signature could be improved. Other questions involved possible overpainting on murals, the origin of a wooden case – ‘could it be Coptic?’ – how to preserve imitation gold leather wall hangings, and much more beside. There were so many requests, some of which would take not only research, but long-term restoration work as well, that an analyst was employed in January 1964 specifically to travel around the country to attend to these requests. This, of course, was only part of the solution. In the 1990s there was still the problem of how to deal with large numbers of requests for analyses, often time-consuming and often wishing instant solutions. This continued in the twenty first century, leading to the retrieval of an old idea. To solve part of the problem, a first aid room was incorporated in the architectural design for the new housing of the laboratory of the Institute of Cultural Heritage (ICN) in the Ateliergebouw.\(^72\) Unfortunately, due to constantly changing policies, this policlinic never materialised. The problem was provisionally solved, however, by the scientific training of picture restorers and by their own subsequent action in the museums when they were employed there. In the Mauritshuis, Rijksmuseum, Van Gogh Museum and Rijksmuseum Twenthe, small laboratories were established, mainly for microscopy. In cases of difficulty – for example, where the research microscope is not as good as the one at the ICN, or a question is too difficult to solve with microscopy alone, or the restorer’s eye is not sufficiently adapted to the examination of cross-sections – there was ICN to fall back upon. Also, extensions of the human eye need interpretation, by a scientist, since microscopy is often only the first step for further scientific investigation. Currently ICN provides for chemical analyses on a commercial basis. Of course, restorers feel free to accept offers for instrumental analyses on their museum’s pictures by research groups and institutes other than ICN. It is possible to shop. The long-term running NWO-sponsored projects ‘Molart’ and ‘De Mayerne’, unfortunately finished now, have provided, not only access to

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\(^72\) The Ateliergebouw is owned by the Rijksmuseum. It houses the restoration departments of the Rijksmuseum, the University of Amsterdam Opleiding voor Conservering en Restauratie (School for conservation and restoration) and the ICN laboratories. CL is part of ICN, following a merger in 1997. From January 2011 onwards ICN will cease to exist in a merger with the Rijksdienst voor Cultureel Erfgoed (RCE).
instruments, but also ultimately increased numbers of scientists trained in the examination of materials from art objects.

To return to 1912 and the conflict between Sedelmeyer and Bredius over the material investigation of paintings. Is it after all the case, as Sedelmeyer dismissively remarked, that one might “just as well send pictures to a chemical laboratory” for investigation? The answer is ‘no’, but ‘yes’, provided... To quote another art connoisseur: “The eye is the highest authority”.73 This principle holds still, with the provision that it is not only the art connoisseur or art historian/curator who uses his eyes, but also the conservator-restorer and the scientist as well – and provided we are all able to interpret the meaning of certain phenomena seen through stereo and research microscopes. In the past, conservators used only a magnifier to examine their paintings. The modern use of the stereomicroscope by conservators before deciding on treatment is a great advance. An unexpected result of this is that it has greatly increased the demand for high tech scientific analyses. We see more and more with the technologically assisted eye, with the danger that every minor aberration stares at us as if it were a major defect in the paint film that needs to be investigated by high tech science. The question sometimes occurs: was not the phenomenon always present, only previously we could not see it? Even if Stolow (cited above) was right in saying that using an extension of the eye is not science, people using these extensions must think as scientists, that is applying ‘A systematic, ordered approach to the gathering of data and the solving of problems.’ To continue this definition of scientific thinking: ‘The basic approach is the statement of the problem followed by the statement of a hypothesis. An experimental method is established to help confirm or negate the hypothesis. The results of the experiment are observed, and conclusions are drawn from observed results. The conclusions may tend to uphold or to refute the hypothesis”.74

Innovative thinking and advances in preventive conservation surely depend on the increase of knowledge. Increase in knowledge comes about by using not only the eyes, assisted or non-assisted, but also invasive and non-invasive instrumental techniques. All these approaches will lead to further advance if rightly interpreted and communicated. There are boundaries and limits, between art history, conservation and science. Communication is essential in interdisciplinary cooperation in the multidisciplinary field of the care for cultural heritage in order to minimise the boundaries.

73 Hofstede de Groot, op. cit., note 6, p. 12.