important event of my life and has determined my whole career", he did not reveal, and we still do not know, precisely why and how. The main unresolved issue concerns the transmutation of species, a subject with which Darwin had been familiar since his studies in Edinburgh and from his grandfather's *Zoonomia*, plus his reading during the voyage of Charles Lyell's *Principles of Geology*. Nine months after his return, Darwin wrote that he had started thinking seriously about the subject in March 1836, when the ship left Australia to start the long (and for Darwin, contemplative) trek home. The immediate triggers were fossils and species on the Galapagos Archipelago, which he visited in September and October 1835.

Keeping things strictly chronological, Keynes writes brilliantly about what happened when and where, and how Darwin wrote it up in diaries, notebooks and manuscripts. But there is little mention of the enormous literature on the voyage, and in the end Keynes has not shown us anything new about the development of Darwin's philosophical thinking on questions of creation or transmutation over the period from 1831 to 1836. The result is a work of great erudition and a valuable addition to the literature, but the principal questions remain, as I suspect Darwin always intended, unanswered. ■

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Science in culture

Leonardo's layer?

A scientific examination of Leonardo da Vinci's *Adoration of the Magi* turns up some surprises.

Martin Kemp

Science has revolutionized what we can see in paintings. Non-invasive techniques bear witness to otherwise invisible changes of mind (using X-rays), disclose hidden underdrawings (with infrared rays), and detect pigments that were added to the painting after its completion (through infrared and ultraviolet illumination). X-ray fluorescence provides analyses of the inorganic pigments, and photometry measures the spectrum of the reflected light. Gas chromatography identifies organic materials such as binding media and varnishes from tiny pigment samples, and microscopic cross-sections reveal the stratigraphy of the paint and varnish layers.

The new data clearly provide a great resource for art historians. However, as with any body of evidence, we need to learn how to see what is significant in the visual output and how to interpret it in the context of other types of established knowledge in the field. Science does not provide absolute answers for the art historian, but it allows us to ask ever more complex questions about the physical composition of pictures, and propose solutions with increasing confidence.

The context for these remarks is the exciting evidence beginning to emerge from the technical examination of Leonardo da Vinci's famous *Adoration of the Magi* (below), which hangs in the Uffizi Gallery in Florence, Italy. The altarpiece was subject to a complex agreement with the monks of San Donato a Scopeto in 1481, which decreed that the painter should receive a portion of the deceased patron's country property and deposit a sum in the Florentine dowry bank in favour of the patron's granddaughter. Unhappily, the painting on the large square panel had not progressed beyond an underpainting when Leonardo left for Milan, probably in 1482, having also defaulted on his obligations to the young lady.

Infrared reflectography, which can disclose carbon-based underdrawing on the white gesso priming, had already revealed more of the subtle beauties of Leonardo's touch than is visible on the discoloured surface of the present picture. The obvious question arose: should the painting be cleaned ? When the possibility was made public, inevitable controversy ensued. Maurizio Seracini in Florence, who had previously provided the infrared data, was then asked to undertake a full-scale technical examination.

On my recent visit to Florence, Seracini was kind enough to provide a briefing on what he is discovering. The most surprising implications arise from his microscopic examination of cross-sections of the paint and varnish layers. As yet these are too scattered to allow definitive judgements, but his observations indicate that we will have to revise our thinking about the painting.

The cross-sections suggest that Leonardo unprecedentedly laid a semitranslucent layer of white lead over his delicate underdrawing, which had been undertaken with a fine brush for its linear design and a broader brush with diluted pigment for the shading. On top of this layer he added the central trees, but he abandoned the picture before completing it with any final strata of fully coloured pigments.

Seracini also questions the authenticity of the heavier brownish layer that begins to establish the background of shadow from which some of the figures emerge like ethereal spirits. It seems likely from the cross-sections that this paint layer is not part of Leonardo's original structure, not least because it has seeped into cracks in the lower strata — implying that it was added much later.

But nothing is ever simple where Leonardo is concerned. So little is known about the history of the panel for almost 300 years after it was painted that we have no explanatory model for when, where, by whom or for what purpose the brownish pigment might have been added, if it were not done by Leonardo himself. One question that I believe is nearer to an answer is whether the painting should be cleaned. It looks as if the layers that are definitely by Leonardo are integrated in such a complex way with those that might not be by him that we would be well advised at this point to leave well alone.

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