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A well-founded and far-sighted policy of conservation can invoke a great deal of interesting scientific research, the author argues. The result could be the saving of many treasures which otherwise threaten to deteriorate comparatively quickly.

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water. Deposition often occurs underneath the paint surface, causing it to blister and flake.

True frescoes are constructed by applying pigment in water to a still-wet lime (calcium hydroxide) plaster. The pigment is bound to the surface by the conversion of hydroxide to carbonate. This is where the reaction ends—until sulphur dioxide strays into the atmosphere as a by-product of industrialization. Oxidized to sulphuric acid, the gas readily converts a firm layer of carbonate to a powdery one of sulphate. Transfer of deteriorating frescoes has been undertaken so that they can be re-displayed in a safer environment, such as a museum. In other cases frescoes have been brought to museums from remote localities, for example from Sinkiang to Leningrad.

The safety of the paint layer is first assured by applying a “facing”. This is a textile or paper, bonded to the paint surface in several layers by an adhesive which can later be removed without damage to the paint. The facing must be supported to take the weight of the detached fresco. Fresco and wall are then parted, using one of several methods, all calling for skill and patience. The plaster back may then be further thinned and levelled so that it can be mounted on a new support and the facing removed. Synthetic adhesives have been used for both facing and final support, but they have by no means yet replaced traditional glues.

Preventive treatment of fresco decay in situ, as opposed to rescue operations, calls for architectural knowledge of damp-proofing. The removal of sulphur dioxide from enclosed environments is an undeveloped technology which is entitled to more help than it gets from museums, the main beneficiaries.

Electrolytic treatment—While picture and textile restoration proceed in the atmosphere of the studio, metalwork is dealt with under more rugged laboratory conditions. Electrolytic techniques have been associated with museums since at least the 1920s. A large museum laboratory such as that at the British Museum will have facilities for the electrolytic reduction of corrosion on silver, copper, bronze, lead and iron, as well as apparatus for intensive washing.

Much more important than the improvement in appearance brought about by reduction of corrosion is the detection and elimination of “bronze disease”, which arises through the presence of cuprous chloride and its conversion in the museum to green cupric chloride, resulting in active corrosion. A good bronze patina is usually preserved for its beauty, but any signs of “bronze disease” are ruthlessly eradicated; practical methods have been worked out for doing it. This is an example of how conservation research has got no further than the need to solve particular problems of treatment. But further progress on this
The state of conservation cellulose as textile and paper also well illustrates the state of the art as a whole. As in medicine, the very sick and very important are painlessly operated; missing pieces are duplicated; the process is stuck to supporting fabrics; documents are laminated by a process which takes long enough to prevent its application on a large scale.

Meanwhile, because of lack of funds or misdirected enthusiasm, strong sunlight continues to play on delicate textiles, museums—new even ones—remain without humidity or ultraviolet control, and the sulphur dioxide concentration both outside and inside museums shows no signs of falling.

The technique which lends some semblance of science to paper conservation is exemplified by the well-established Barrow process (see New Scientist, Vol. 17, p. 130).

Since Barrow has worked for years specifically on the conservation of paper, this is not a borrowed technique but one for which conservators can take almost the full credit.

Book papers become acid either because acid materials like alum were used in their manufacture or because of sulphuric acid from sulphur dioxide pollution. Acid embrittlement by hydrolysis of the cellulose. Barrow soaked paper first in calcium hydroxide, which neutralized the acid present, and then in calcium bicarbonate, when the excess lime is precipitated as carbonate. A later development for books involves a single spray of magnesium bicarbonate. The paper therefore comes out of this treatment impregnated with a slight excess of solid alkali. The paper is physically weakened by this deacidification process, and is therefore laminated between sheets of specially plasticized cellulose acetate, at about 160°C.

The literature on cellulose degradation is woolly and contradictory. Neither the mechanism of "dark attack" by sulphur dioxide nor that of photo-dissociation is understood with any clarity. The part played by constituents, added during manufacture is even more obscure. But cellulose is a highly variable natural material, and there is bound to be a complexity of interacting degradation processes. Chemistry has only just evolved to the stage when it is capable of dealing with such problems.

The Future—These three examples are perhaps untypical in that they look to the prevention of future decay. It would surprise most readers to discover that the largest part of contemporary "conservation" throughout the world is concerned predominantly with present appearance. Where the future is considered this is mainly from the negative point of view that the materials used in repair should be at least as durable as the object repaired, and that they should in general be removable with safety if anything goes wrong in the future. Even this is a comparatively recent change, contingent upon the introduction of synthetic resins.

Good scientific research is self-perpetuating. There must be a programme, the significant growing points are few; where things don't go as expected, and the significant scientists are the ones who discover these anomalies.

To convince the sceptic how necessary research is, we need only re-examine the three examples above from a forward-looking point of view. Through the fundamental questions which they raise, fresco transfer, reduction of corrosion, and deacidification of paper could become the inspiration for the following studies:

1. (a) The effects of moisture movement on slow change.
   (b) The chemical effects of air pollutants on museum material.
2. Slow corrosion processes in metals before and after their transfer to museums.
3. Surface chemistry, with emphasis on photo-oxidation, of museum material.

The point I must emphasize is that any conservation problem, while appearing to require a mere mechanical solution, entrains a host of unanswered questions. It is not even easy to ask the right questions. The four studies above would each have to be broken down to a number of precise questions from which research could be hopefully initiated: such as whether moisture cycles can induce fatigue failure in moisture-absorbant materials; what the detailed course of the degradation by SO₂ of cellulose is; whether diffusion through micro-pores rivals ionic diffusion in a typical slow bronze corrosion; or how surface reactions differ from those at 10 microns depth in an organic surface film.

Note the two characteristics which stand out in this branch of chemistry: solid-state reactions and an emphasis on very slow processes. Now the success of science in conservation research should be judged not only on its usefulness but on the general progress of scientific knowledge. Is this proposed research already in progress with better facilities elsewhere?

Though the chemistry of solid-state reactions is relatively new and undeveloped (apart from metals) we can expect much help from it. Metallic corrosion, being of huge economic importance, is laboriously researched, though little of this research is applicable to antiquities. To a smaller extent, the smogs of Los Angeles have forwarded the progress of air chemistry.

The emphasis, then, is on reactions too slow to be the concern of this world of planned obsolescence. These are almost outside the range of existing institutions, and may be different in interesting ways.

University or museum laboratory—

The hard figures on employment of science graduates in conservation in Britain at present are as follows:

British Museum Laboratory 5
National Gallery Laboratory 3
Victoria and Albert Museum 2
Conservation Department 2
London University Courtauld Institute of Art 1
Ministry of Public Building and Works Ancient Monument Laboratory 1

More by chance than by good management I think it would be fair to say that Britain is in the lead in research and scientific advice—but the resignations of only one or two scientists could put us near the bottom of the ladder.

Furthermore the desire to solve problems in a fundamental way, whether strong or weak, is likely to be defeated by circumstance. Most of these scientists are employed to advise, and this means that they must spend much of their time explaining scientific facts in non-technical terms, and carrying out rather lowly experiments on the behaviour of manufactured products. Both are admirable exercises—in moderation. This is the line of least resistance, and the country has the right to expect more from scientific conservation. I don't frankly think that the training of conservators and scientific research could be organized together. Certainly training could not be modelled on the lines of university teaching, since a proportion of both teachers and students would not be science graduates, so that there would be a much bigger gap between teaching and research.

In the hope that some unified policy can one day be formed, I will end by listing only what is needed for proper scientific research. First, there must be enough science graduates to form a viable group; the "critical mass" is probably about 4-6.

A set-up with one scientist in charge and one or two others on limited research grants is self-defeating parsimony. Next, there must be clear priority for long-term research. The group would plan its own objectives, and should be allowed to continue so long as it retains the respect of other scientists. Also, one needs adequate laboratory facilities and assistance, close contact with a national museum, and a university.

Finally, there must be an open door, by which I mean the laboratory must not become an over-specialized dead-end for its staff. Moreover, when reactions take hundreds of years, research must rely on a study of ancient materials for its primary data. Therefore the structure of research must be based on advanced facilities for analysis.