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SCIENCE, CHEMISTRY AND CONSERVATION

One of the pleasures of being asked to give a lecture on a topic of my own choosing is that it gives me an opportunity to talk of general principles rather than to teach a particular subject or to expound pages of statistical results which I personally detest. What I as a professional scientist intend to do today is to look back on about 15 years spent in conservation in particular and 25 years of earning my living by chemistry in general, to show how the two are connected, in my own mind, at least. I don't pretend to be rigidly orthodox in my views, and am, I hope, like Georg Karl von Döbeln "Fritänkare jag nämmns, det är min heder", "I'm called Freethinker, and I count it glorious" (J.L. Runeberg, Fänrik Ståls Sägner).

Let us start with some definitions. Science has been defined as "Organised Common Sense" but this is a very loose and wide definition and should equally well describe the work of a housewife, though this isn't far from the work of a conservator. I prefer to think of science as being the effort to understand the nature of the physical world by the use of experiment, observation and logic. Whilst it is true that the rigid discipline of logic is basic to it, I feel that one of the marks of a bad scientist is his lack of organised common sense. Perhaps another definition can be derived from the words spoken by an angel to Caedmen, the father of Anglo-Saxon poetry. "Sing the Song of all Created Things".

Chemistry has been defined as "That branch of science which deals with the several elementary bodies, or forms of mat-

ter, of which all bodies are composed, the laws that regulate the combination of these elements in the formation of compound bodies and the phenomena that accompany their exposure to diverse physical conditions". My reason for being in this business is because everything that is in a Museum, a library or an archive is made up of chemical substances and that of course includes ourselves.

Conservation is, I think, "the Process for the care and repair of objects, which processes are directed by scientific principles towards the preservation of these objects for an indefinitely long period of time in a condition as close as possible to their original state". Obviously different branches of the profession will interpret this in different ways. The archivist will demand that, apart from the ravages of time, the object shall remain unaltered, where-as the restorer of prints will expect to make good damage rather than spoil a visual appearance. Provided that the conservator will, and can, use processes that can be reversed and materials that can be removed without harm to the object or the conservator, the chemist can be unhampered by the ethics of the several branches of conservation.

Dr. A.E. Werner divides conservation into two parts. Active and Passive. Active conservation is that form of conservation in which the object receives chemical or physical treatment of some sort, whereas in Passive conservation, the object itself is not touched, and the environment and surroundings of the object are altered or controlled to produce the maximum safety and durability for the object.

What I want to do today is to talk about three classes of conservation. The first is work done wisely and well. The

second is work done, I think, unwisely and the third is conservation where expediency is the dominant factor because there are not at present, or likely to be in the foreseeable future, materials or methods which would be acceptable, by the standards of archival conservation.

Conservation done wisely and well need be neither expensive nor elaborate. Possibly the simplest example is the old and continuing process of keeping papyrus fragments between two layers of glass, the edges being sealed with paper and with brown sticky tape used in tiny fragments to hold pieces in register. Glass we know to be transparent and, for our purposes, chemically inert. The brown paper sticky tape, with animal glue as adhesive is one material that years of experience has taught us to be easily removable and it matches the colour of papyrus. If ever it becomes necessary to remove the papyrus, a sharp knife is all that is required. Whilst it is true that modern acrylic resin sheet is lighter and less easily broken than glass, the electrostatic charge that it so readily acquires can give rise to serious problems and cases are reported of fragile papyrus being broken and even split when being removed from between plastic sheets. It can be argued that animal glue is one of the finest substrates for bacterial growth but since papyrus is kept as dry as possible, bacteria are extremely unlikely to attack in these conditions.

The correct climatic conditions for the proper care of illuminated manuscripts are easily stated - a temperature of about 15^{o}C, kept as steady as possible and a relative humidity of about 6o%, again, kept as steady as possible. What a very different matter it is to achieve these conditions in practice, bearing in mind the cost of air conditioning equipment, especially when one single object alone really is to be cared for. Thanks to simple scien-

tific thought by T.J. Padfield, there is a simple and cheap method of doing just this.

Cellulose has a "special relationship" with water. In all normal conditions, it contains about 7% of water by weight and this water is held, not as a thin surface film but by semi-chemical bonds between the molecules of cellulose within the fibres. This water content of the cellulose is dependent on the relative humidity of its environment, so it can be increased by placing the cellulose in a humid place. If we place a dessicated material in the same closed environment as the cellulose, then the dessicated material will compete with the cellulose for the water. Therefore, if we wrap a parchment book in a wrapping of partially humidified cellulose, the cellulose will gently humidify the parchment, but only to a limited extent, not to the point of excessive dampness at which mould growth can occur.

You can then ask, what can we do to enclose this beneficial environment? and the simple answer is, a box made of thick unpainted wood, for this too contains cellulose, and is also a good thermal insulator. But, you may say, what about the fire risk? Wood, particularly in thick layers is a thermal insulator and is therefore used for fire-resisting doors. There was an interesting experiment made at the Fire Research Station in England a few years ago. Two cabinets were made, one of wood and one of sheet metal and in each was placed a bottle, fitted with a glass stopper and partially filled with ether. A large blowlamp was turned on each for some time and then resulting fire was quenched. The metal cabinet was very hot inside, the bottle was unstopped and ether vapour, which is highly inflammable, was escaping. In the wooden cabinet, the temperature was sufficiently cool for the bottle not to be unstopped.

Here then, we have the combination of scientific thinking about the chemical behaviour of cellulose and water coupled with a simple experiment on the behaviour of materials in a fire, applied as practical common sense.

If we want a good example of clear thinking and careful investigation applied to a chemical problem in conservation we can do little better than to cite W.J. Barrow's classic work on lamination. Barrow was, for all practical purposes, the first man to pay real attention to the deleterious effect of acidity in paper and to devise methods to combat it. He also devised the first method of lamination that would protect documents within the limits set by the standards of archival conservation. What is even more important, though not a scientist himself, he was the first person to provide proper scientific evidence to justify the validity of the methods he used and he did this with a thoroughness and completeness that has set the standard for all of us to follow.

I suppose that no competent conservator can look back on one year's work, let alone ten, without saying to himself, "I should have done that job differently", and I will start my consideration of unwise conservation with some of my own early work. The first major object that I cleaned and repaired was a globe, from which the varnished paper gores were peeling in places. The removal of the varnish was easy enough and then I had to re-fasten the paper. No complete gore was detached, it was merely a case of putting new adhesive under small areas of the paper in about loo places and I was advised that a poly - (vinyl acetate) emulsion adhesive was the latest and very best material for such a purpose. Accordingly, I used a hypodermic syringe to do this, pressing each blister down with a swab of cotton wool soaked in acetone and I admit that this was a rapid and simple operation.

Later on, I learnt a great deal more about poly - (vinyl acetate) and poly - (vinyl acetate) emulsions, the first thing being that they are very different indeed. Poly - (vinyl acetate) is one of the most stable of the modern synthetic resins and is readily re-soluble in the common organic solvents after ageing. The poly - (vinyl acetate) emulsions, however, are not a simple mixture of the resin and water. They contain emulsifiers, thickeners, plasticisers and stabilisers and these are not as stable as the pure resin. They readily darken on ageing and, what is more important, are not necessarily soluble in a solvent once the emulsion has dried to a hard film. Whilst it is true that the film can be softened to a jelly, this is not the same as becoming a solution, and so the total removal of the adhesive, which would be required for archival work, is not possible. A few years ago, I had to repair a globe which had been, partially repaired with a poly - (vinyl acetate) emulsion and I have to expect that the curses I used on this occasion may well come back to me.

An older example of poor conservation methods for documents is shown by the treatment given, in the latter years of the 19th century, to a set of letters written by the philosopher John Locke. These were becoming fragile, and in order to preserve them a sheet of semi transparent paper was pasted over each side of them. I say "pasted", but the adhesive was in fact a mixture of a flour or starch paste and animal glue. This is exceedingly difficult to remove. Water alone is not effective, either hot or cold, and N-methyl-2-pyrrolidone will not dissolve glue. Fortunately, it has been found that by using enzymes of fairly high purity, at concentrations of ca. o.l gm per litre, using an amylase followed by a protease, the paste is removable.

We had a similar, but not quite so difficult a problem with the "shelf-copy" of the First Folio of Shakespeare which had received much the same treatment, but adhesive responded to hot water. The "play of Sir Thomas More" which may be, in part, a Shakespeare manuscript had also been encapsulated in the same way.

It is not unknown, too, for an early version of tracing paper to be used as a protection for documents. This material was made from a soft, short-fibred absorbent paper treated with linseed oil and is usually by now a dark yellowy-brown.

I ll - conceived chemical treatments are still being used. The British Museum Research Laboratory frequently receives requests for advice on the treatment of faded writing and the enquirer is quite often not pleased at being told to do nothing at all, because there is no completely safe method of restoring permanently the legibility of faded writing. However, we have to give the same advice to people who have already tried once and had the writing fade again within a few months.

If we assume, as I think we must, that we must consider the safety of the craftsman and of the reader as well as that of the document, I am bound to ask why there should still be references in print to the use of mercuric chloride as a fungicide, even in one instance, to mercuric chloride dissolved in a highly inflammable and highly toxic mixture of ethyl ether and benzene.

There must, I think, always be an element of risk in conservation, even when we have done our best to ensure that the materials and methods that we are using are safe and reliable. There are, however, as we all know, occasions when

conservation is essential but methods of proved safety are not available. This can be the case quite often with manuscripts. If deacidification is necessary, but the ink is fugitive, we have no real alternative to the use of barium hydroxide dissolved in methanol, though both are toxic. If it is necessary to remove an old master drawing from the mount to which it has been pasted down, and the ink is fugitive, there is at present no real alternative to the use of N-methyl-2-pyrrolidone, even though that is known to weaken paper. N-methoxy-methyl Nylon is known to cross link and become insoluble, yet there are times when we have no other consolidant for fragile paper with fugitive ink.

Oddly enough, some of the toughest documents produced today are some of the most difficult to handle for the purposes of conservation and these documents are maps. It may sound ridiculous to consider the conservation of strong and stable documents, but maps are not as strong as the engineer who may use them in field-work and they are subject to wear and tear even in respectable cartographic establishments.

A simple long term experiment at the Research Laboratory of the British Museum was carried out as follows. Parts of Ordnance Survey Maps and whole Geological Maps were measured all four sides and across both diagonals. They were then laminated by the several processes then available, measured again and left for five years before being remeasured and examined. The results were interesting. Some processes could distort the maps, one made some maps illegible, some colours fled, others changed completely, a serious thing with a colour-coded map. Experiments on delamination indicate that for the destruction of colour, it is an even more devasting in its effect than lamination,

so that a cardinal principle of conservation is predestined to be broken.

In short, then, anyone who wishes to mount or laminate a map must choose his methods by pure expediency rather than on proper conservation principles.

Having then described three separate styles of conservation, you might well say that you knew, or perhaps could foresee, what I have told you, and wonder what the real purpose of this lecture is. The real purpose of this lecture is to try to give you a clearer view, in a more exact perspective, of conservation as it is done so that you can understand how it should be done. Few people, and those bad, willingly do bad conservation. Most of the bad conservation done is done by people who do not think clearly enough, or who credulously accept what manufacturers and salesmen tell them. How many salesmen or advertisers really know what an archival document is?

The best example that I know of clear thinking in a similar situation comes from our first Elizabethan era, and though it may seem to be lengthy digression from science and conservation, it will, I hope interest you.

In the Easter Law Term of 1584, an action was brought in the Court of Exchequer against a man named Heydon regarding his intrusion onto certain pieces of land in Devonshire, to which he claimed to have a lease of 80 years. However this land had been the property of a monastery and there was a law, passed at the time that Heydon had taken the lease, forbidding monasteries to alienate their land by leases similar to that which Heydon held. The legal argument lay on the point, whether or not the Statute was to be interpreted to cover Heydon's lease. The Chief

Baron Sir Roger Manwood and other Barons all agreed that it was now I quote the Report by Sir Edward Coke. And it was resolved by them that for sure and true interpretation of all Statutes in General, (be they penal or beneficial), restrictive or enlarging of the Common Law, four things are to be discerned and considered:

(1) What was the Common Law before the Act.

(2) What was the mischief and defect for which the Common Law did not provide.

(3) What remedy the Parliament hath resolved and appointed to cure the disease of the Commonwealth.

and(4) The true reason and remedy; and then the office of all judges is always to make such construction as shall repress the mischief and advance the remedy and to suppress subtil inventions and evasions for the continuance of the mischief and pro privato commodo, and to add force and life to the cure and remedy according to the true intent of the makers of the act pro bono publico.

The questions formulated, collectively known today as "The Rule in Heydon's Case" are still enshrined in the Common Law of England, and I think can be of help to us, too. Let's rephrase them to fit our case.

(1) What was the traditional method of conservation before the new one was put forward.

(2) What was the mischief and defect for which the traditional method did not provide.

(3) What is the new material or method which has been put forward to cure that mischief and defect.

(4) What are the true reasons for the failure, and for the remedy, within the bounds set by the principles of sound conservation.

Now these questions are for the scientist and the craftsman to answer together. Where the really critical thought is required is in questions three and four for here we must not only analyse exactly of what the new method or material consist, but must be able to predict what will be the long term behaviour of both. This is where, I think, we have too often failed, too often grasped at a quick method to the exclusion of a tried one, without waiting to discover its defects.

It was for a good reason that I quoted not only the "Rules in Heydon's Case" but also the corollary, because if we accept that we ought to be guided by the rules we should accept the duties of the corollary. We should not buy a bad paste because we are too busy to make a good one, or because we argue that it is cheaper than the cost of manpower. Equally, we should not hesitate to reject the advice of a professor whose knowledge of the reactions of a chemical does not extend to its behaviour towards paper over a period of a few hundred years, because these are "pro privato commodo" and not "pro bono publico".

Looking to the future, what ought we to want to see. I would like to see scientists playing a larger practical part in conservation, not merely pontificating from a laboratory stool. We scientists must have real practical experience in conservation if we are to understand what the conservator knows to be mischiefs and defects for which traditional methods do not provide a remedy. We must also have a very thorough knowledge of conservators so that, if we have provided them with a remedy for one

situation, they do not turn it into a dubious pseudo-panacea for all diseases.

I would like to see much more effort being applied to simple and cheap methods of conservation. Large and expensive apparatus, whether it be laminators or air-conditioning apparatus is costly to buy, expensive to maintain and to use. It has its place, but in my country, the majority of all work in conservation is done in small Museums and record offices which cannot afford expensive equipment. Proper understanding by an architect, applied in the design stage, can reduce the cost of climatic control by a considerable extent. Those of us who visit old libraries where, over some centuries, care has been confined to proper maintenance of the building and good housekeeping of the contents, are convinced that this is the cheapest form of passive conservation, especially when we have to worry about the malfunctioning or poor maintenance of air-conditioning apparatus.

One case with which I was concerned involved work spread over four years, but the equipment, six cheap thermometers and graph paper, cost less than five pounds sterling and the very effective remedial work consisted of replacing 12 tungsten lamps by fluorescent tubes, turning off ten unnecessary radiators and moving a thermostat.

I would like to see a better understanding, by conservators, of what scientists can do to help them, though there are precious few of us in conservation for them to ask. You, I hope, realise that we cannot always give you the answer you want, let alone the answer that you need, because we just don't know all the answers and can't often find them out in time. There are still, perhaps, craftsmen who know that our advice is useless because we haven't served a trade apprenticeship in their craft and therefore won't

try to teach us, not realising that unless they will teach us we can't know, let alone understand, their problems. It is worth remembering that some of us are experienced in handling horribly dangerous materials and on assuming much responsibility for the safety of human life. Any scientist with practical experience will know, too, how desperately lonely one can feel working on a new problem of great human importance and can understand the feelings of a craftsman faced with difficult conservation problems in a priceless document.

I would like to see a much greater understanding of books and documents by curators. I wonder how many curators of Rare Book collections realise how much of the history of man's technical achievement could be recovered by a really intelligent man from Mars from a series of volumes of unwritten and unprinted leaves, one from every decade of the last millennium. You know, because it is your business, how much of this information is missing from a microfilm and you also know how much damage is done by thoughtless scholars, librarians and photocopiers.

It is my practice, with a major lecture, to write my text in long hand, amending as I go, to read and re-read amending as I go. I then have to read and correct, possibly amend also, the typescript, perhaps to read and correct printer's proofs, so that I know it rather well. It seems to me that I've preached rather a lot, strayed from my subject in places and preached at, rather than taught, you. But you have come here because you want to be better conservators and, I hope, because you want your problems to be better understood by people like myself. If I've taught you only two things, not to be afraid of scientists, and, to make sure that the scientist really under-

stands your problems then this sermon has been worth while. I close with a quotation

> "Though man as 'thinking being' is defined
> Few use the grand prerogative of mind
> How few think justly of the thinking few
> How many never think, who think they do".
>
> (Jane Taylor, "On thinking" from Essay on Morals and Manners)