# Dyes and Light.

A display demonstrating the destructive effects of light on dyed materials, particularly textiles, arranged in the Nordiska Museet simultaneously with the ICOM Committee on Museums Display, held in Stockholm, May 1950.

The main purpose of the display is to present the most impressive specimens available of damage due to the effect of daylight and artificial light. These devastating colour and other changes have in all instances occurred after the objects in question were acquired by the museums. All particulars, such as the length of time the objects were displayed (as well as the conditions under which they were displayed) are given as accurately as possible on the labels. With a few exceptions all the exhibits date from before 1850, when modern synthetic dyestuffs were discovered.

In time, all textile fibres suffer a consirable loss of tearing strenght through the agency of light. Some pieces of silk, for instance, have become not only discoloured but have in parts quite perished - even though those parts have not been directly exposed to the rays of the sun. A taffeta belt, the property of the Royal Armoury in Stockholm, has for about 50 years hung in one position, in the form of a rosette, in an almost dark chamber in Gripsholm Castle. Yet the silk on the outer part of the folds have been eaten away by the light, and the original colour is only visible between them.

However, photo-chemical reaction takes place only on the surface of a fabric. The thickness of the material diminishes the effect to some extent, and in this connection we may mention the chrome colours used for dyeing wool. But silk is extremely sensitive, and although we refer here only to artificially cultivated silk, the fact remains that this is probably the most common variety in European collections. Silk from worms living in the natural state - Tussah silk - possesses much more resistance to the ruinous effects of light, although we have no exact figures available. The fellewing table presents comparisons regarding the effect of light on the durability of various textiles, and although it may not seem very informative without further details about the precise conditions of each test, it does at least tell something

about the relative losses of tear strength:

| Time sufficient to reduce the tearing strength of the fibres by 50 % when exposed to full sunlight without any protection. | |
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| Cotton | 940 hours |
| Flax | 990 " |
| Jute | 400 " |
| Wool | 1200 " |
| Wool, chrome dyed | 1900 " |
| Silk, cultivated | 200 " |

Colour changes caused by the action of light are generally described as "fading", and it is a very complicated process which is as yet not very well understood. But the nature of the Light-source is not the sole factor involved - others are the temperature, the relative humidity of the atmospehre, the nature of the material itself, the concentrations of dye within the threads, the type of dye used and the methods adopted in using it. During recent decades, chemists concerned with dyeing and colouring have learned a lot about what really happens during the many different dyeing processes which are in use, but there are still some which remain something of a mystery. We certainly know a good deal about why and how the actual dye becomes united with the texture of the fabric, and about the conditions under which it may become disconnected again. But there is some difficulty in the fact that most of the scientific investigations into dyeing and the durability of colours is nowadays directed towards the practical use of modern coal-tar colours. Chemical analyses and tests relating to contemporary standard methods are of very little help in solving the problem which confronts the museums, viz: how to preserve colours which are produced in the old-fashioned way, from non-standard mixtures or combinations directly derived from natural sources, and subject to all sorts of variations because of climate, soil, and even the human element. It is now very difficult to obtain even an approximate estimate of the fastness to light of these old-time colours. In the past as well as now, many shades could be obtained by mixing several dyes together, and we know that one element may fade very quickly while the others remain seemingly unaffected. The most familiar example of this is the so-

called "blue-sickness" in old tapestry, where the yellow component of the original green has been destroyed. Further, colours of widely varying durability may exist side by side on a single fabric.

For the convenience of the dyeing industry, the fastness to light of modern coal-tar colours is nowadays classified according to 8 standards, i.e. I to VIII inclusive. Each higher number represents a standard of fastness about double that of the one below. In this table of standards, fastness is described as foloows:

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| I | = slight |
| III | = limited |
| V | = satisfactory |
| VI | = good |
| VII | = very good |
| VIII | = excellent |

Standard No. I serves to grade those colours which fade to a noticeable degree when exposed to sunlight for 1 to 3 hours. No. VIII, the most resistant, serves to grade colours which appreciably change on exposure in a fadeometer for a period equal to between 930 and 1920 hours of sunlight. The Swedish Government's Testing Institute made an investigation in 1932 (see note below) in order to determine the fastness to light of the vegetable colours which were most frequently used in old Swedish peasant weaving and embroidery, and one section of the conclusions is given in a table. This investigation showed quite clearly that most of the old-time "natural" colours possess a fastness to light only equal to No's II to IV in the standards. Out of 40 test specimens only 8 may be said to possess a good fastness to light, equal to No. V or higher. The result of the investigation is however misleading on one point. All the test samples dyed with indigo - exclusively or with madder or cochineal - show a very poor fastness to light. But all practical experience shows that on the contrary the old natural indigo possesses a very good degree of resistance. The explanation is that the old indigo-dyers used what is called an indigo vat, while in the test specimens the indigo was applied in a quite different manner, with the result that the blue and the blue component in the red colours were easily destroyed.

Especially for this display, a very similar test has recently been made by The Graphic Arts' Industrial Research La-

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Note: Köhler, Sigurd, in Form, a periodical issued by Svenska Slöjdföreningen, Stockholm 1932, (5)

boratory in Stockholm. 30 test specimens consisted of wool dyed with natural dyestuffs, and of various old pieces of silk, cotton, linen and woollen fabrics, manufactured in the 18th century or at any rate before 1850. In most cases the dyeing-stuffs used are known. The samples were exposed in a fadeometer along with a set of the 8 standards as used in Germany and Great Britain. The standards used in the United States are slightly different. The fadeometer has a carbon arc lamp radiating a light with a spectrum which only slightly differs from that of the sunlight. 24 hours in the fadeometer is supposed to be equivalent to 60 hours of full sunlight in the summer between 9 a.m. and 3 p.m. (Chicago horizon). The exposure lasted for 48 hours = 120 hours of sunlight. The extent to which these old colours faded may be studies at first-hand in the display. The standards were later exposed for 24 hours = 60 hours of sunlight while partly protected by dark yellow cellophane of the kind that is recommended as a guard against fading. But the protective powers of this material have been highly overrated, for it is barely possible to distinguish between those parts which were "protected" and those which were not. This test only confirms the impression produced by earlier tests, that the old methods of dyeing were very unreliable as far as fastness to light is concerned. This ought definitely to put an end to any possibly still lingering romantic idea about the skill and cunning of the old workmen being on that particular point superior to modern science and industry.

There is another widely spread superstition, not at all scarce even among museum officials, that when colours have already faded to some extent, the process - as by some miracle - may be expected to cease all of a sudden. Those who arranged this display most strongly and most emphatically wish to challenge this erroneous idea. All the men of science consulted in this matter agree that if the light effects the structure or the colouring of a fabric at all, if there is any reaction produced by the radiant energy of the light, no matter whether it is photo-chemical or thermo-dynamic, it will go on until there is nothing left to be affected. The fading process may not accelerate, but it goes on to the bitter end, and with our present knowledge we have no means of stopping it. The sooner this fact is generally acknowledged, the sooner we will find ways and means at least to delay the destruction as much as possible.

How much has already been irreparably lost is evident from the specimens displayed. Two tapestries from Beauvais, each designed by Boucher, constitute a rather suggestive illustration. One of these specimens is really only a section of a complete tapestry which in its turn was one of a set of six ("la teinture chinoise"), which during the 1750's (1758?) were presented by Louis XV to Count Adam Moltke, the Master of the Danish Royal Household. Three of the other six are still in the palace built by Count Moltke, which is now part of the Royal Palace of Amalienborg. The odd piece was cut off when the tapestries were hung up, because it did not properly fit the wall. It has never been used and never displayed in any way, and the colours are still as fresh as they were in the loom. The other tapestry in our display belongs to a set of the same period in the Royal Palace, Stockholm, and has been subjected to just the ordinary amount of use.

At the request of Keeper of the Royal Collection in Stockholm, whose duties include the care of a great many old tapestries, the Gothenburg Institute for Textile Research in 1948 made an investigation (see note below) for the purpose of finding out if the original colours of faded textiles could be restored. In certain cases this may be theoretically possible, but the textile materials in museums are however of a nature that renders experiment in the matter impossible.

Fading caused by artificial light is a treacherous process because it is comparatively slow. The radiant energy output of a 40 watt incandescent lamp is vastly less than that of the sun, but in the long run it is quite as dangerous. To a highly sensitive colour it may mean disaster even after a short period of exposure. This is illustrated by the fading of the blue linen used as background in a showcase, the latter standing in a practically dark room with the lighting mounted inside. A photograph shows the fading due to flourescent lamps during a period of 4 months. At the end of this time the lamps were exchanged for incandescent ones and the fading continued at almost the same rate. The distance from the lamps to the top of the blue background was in both cases 25 cm. The blue has now turned a colourless grey in those places nearest to the source of light. Other examples of the fading effect of incandescent lamps prove that the light from

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Note: Kärrholm, Marianne, in Svenska Museer, periodical edited in Stockholm by Svenska Museimannaföreningen, 1948 (3).

one strong lamp is more injurious than the same sum of light from several weaker lamps (see note below).

At the request of the Nordiska Museet the Swedish Government's Testing Institute in 1937 began a series of tests to investigate the variations in rapidity of fading on exposure to direct sunlight, diffuse sunlight, and incandescent lamps. The investigation had to be suspended during the war and is not yet completed, but the following facts may be of interest.

Standard No. I exposed to direct sunlight behind ordinary uncoloured glass faded visibly after 24 hours; exposed to diffuse sunlight after 7 days; and exposed to a 25 watt incandescent lamp at the distance of half a metre after 30 days. After 3 years No's V and VI exposed to diffuse sunlight were slightly faded and No. IV exposed to artificial light had just started to fade. The conclusion that can be drawn from these facts is that colours possessed of what we call fairly good fastness to light nevertheless fade in a short time when exposed to daylight, even if it is not direct sunlight. Incandescent lamps will in a short time affect colours with a low degree of fastness to light, while colours which are nowadays in common use and considered fairly good will fade rather slowly with such lamps.

The technique of leather dyeing is quite different from that used in textiles. The material itself imposes several limitations. It is adversely affected by heat, which means that only a few selected dyestuffs may produce good results - to mention only one of the difficulties. As a rule the dyed leather is very apt to fade and its fastness to light must be rated very low in comparison with textiles.

Light does not bleach wood. On the contrary, the tendency - particularly with wood containing a high percentage of tar, such as the core of the pine - is towards darkening. The bleaching of wooden furniture is as a rule due to chemical changes in the polish and to an increasing dryness in the wood. When the polish is removed and the wood slightly oiled and polished anew, the material will recover its original colour. Dyed wood of course becomes descoloured by the light in much the same way as textiles. At the State Historical Museum, the Committee has already seen something of the research work which is going on for the purpose of finding filters capable

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Note: Geijer Agnes and Olson, Gillis in Svenska Museer, Stockholm 1949 (2) with an english summary.

of neutralising the effects of the most injurious parts of the spectrum. In 1936, samples of yellow cotton fabric used for blinds were tested with a view to finding out just how much light passed through, and in addition, the efficiency of these fabrics as regards shutting out undesirable elements in the light (see note below). The investigation revealed that each lot of blinds had to be tested separately, for the reason that a quantity of such fabric, from one and the same mill, and passed-off on the market as being "all the same", in fact embodied great variations which considerably modified its general suitability for blinds. But if such blinds are meant to be drawn right down whilst the museum is open to the public, a balance must be struck between the amount of light required and the protection demanded. And that means a compromise.

Conclusions.

The choice and arrangement of lighting in museum is not a merely aesthetic problem. The destructive powers of the light must be equally considered. The idea that diffused daylight or artificial light is less dangerous than direct sunlight is pure illusion, the difference being just a question of time. In cases where the most dangerous part of the spectrum can be eliminated by filters, this of course ought to be arranged. A very simple precaution that might be undertaken immediately is to keep store rooms and exhibition rooms containing objects sensitive to light in absolute darkness when the museum or gallery is closed.

For further understanding of these matters, it is not only necessary to study the different kinds of light. It is equally necessary to acquire at least a general idea of how different materials and dyestuffs react to light.

Cooperation with research institutes working on textiles for the benefit of modern industry is necessary, but very little has hitherto been done in that direction. Such institutes exist in almost every country and the periodicals and various publications of the following institutes are recommended for study:

England: The Society of Dyers and Colourists, Manchester.

France: Institute textile, Paris.

Germany: Die Echtheitskommission, der Fachgruppe für Chemie der Farben- und Textilindustrie im Verein Deutscher Chemiker

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Note: Lenk, Thorsten and Olson, Gillis, in Svenska Museer, Stockholm 1936 (1).

Sweden: Svenska textilforskningsinstitutet, Göteborg.
Switzerland: Die Prüfungsanstalt, S:t Gallen.
United States of America: The Society of Dyers and Colorists, New York.

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