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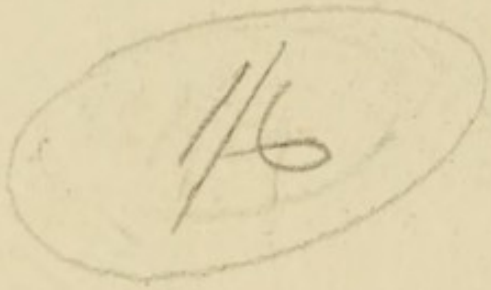

GREEK AND ROMAN METHODS OF PAINTING

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PICTURE IN MELTED WAX BY MR. BURNS

Frontispiece.

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BY

A. P. LAURIE, M.A., D.Sc.

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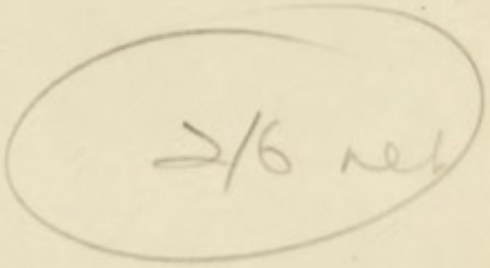

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PREFACE

THE analyses by Sir Humphry Davy and Chevreul, the experiments made by Wiegmann and the researches by Donner, were believed to have settled finally the question of the nature of the Pompeian frescoes.

But these conclusions have recently been most ably attacked by Herr Berger in his work, *Die Maltechnik des Alterthums* (Callwey, München, 1904), and the whole question has thus been re-opened.

Moreover, the full significance of the technique revealed by the wax pictures from Hawara and of Flinders Petrie's observations on painting with wax in Egypt, does not seem to have been realised.

I therefore resolved to look into the whole question afresh, confining myself as much as possible to the actual statements made by Pliny and Vitruvius, and testing their accuracy by new experiments. The following book is the outcome of this inquiry. I have, I believe, brought strong evidence to show that the older view of the nature

of the Pompeian frescoes was correct, and conclusive evidence that the ingenious but much criticised theories of Herr Berger have no foundation in fact. I have also, I believe, thrown fresh light on the method of painting with wax on panel, the nature of *γάνωσις*, and the Greek method of painting on marble surfaces.

In conclusion, I wish to thank Miss R. F. Forbes for her valuable assistance in translating difficult passages, and Professor Baldwin Brown, Professor Hardie, the Rev. G. C. Richards, Fellow of Oriel, and Dr. Degering of Berlin (who is now engaged on a German translation of Vitruvius), for help and advice in many ways.

I am also much indebted to Mr. A. B. Thomson and Mr. R. Burns, A.R.S.A., for their experiments in wax painting.

A. P. Laurie.

Heriot-Watt College,
Edinburgh, *January* 1910.

Note.—Since this book was completed Mr. Noel Heaton has shown (*Journ. Royal Soc. Arts*, Jan. 7, 1910) that the frescoes at Knossos are examples of Buon Fresco, that there are no signs of joins, and that the pigments are bedded in.

ERRATA

Page 9. For "Valentine" read "Valentin" Rose; and for "editions" read "edition."

Students of the subject are referred to the article by F. Gerlich, "Die Technik der Römisch-Pompejanischen Wandmalerei" (Neue Jahrbücher für das Klassische Altertum, 21. 2. 1908), which, on the whole, agrees with the conclusions come to in the text.

SOME COMMENTS ON THE STATEMENTS MADE BY PLINY AND VITRUVIUS ABOUT WALL AND PANEL PAINTING.

If we investigate the technical processes of past ages we find that changes were very slowly introduced, and that a method of attaining the desired result, having been brought to perfection, remained unaltered from generation to generation. This conservative habit is peculiarly to be found associated with the artistic crafts, which even to-day, in spite of the discoveries of chemists and the introduction of machinery, have undergone little modification.

The history of painting, with which we are here especially concerned, illustrates this habit very clearly. Although the properties of drying oils were known in the sixth century, and the use of such oils in painting was described by Theophilus in the *Schedula Diversarum Artium*, in the twelfth century, yet it is only in the fifteenth century that oil begins to replace egg, as the almost universal medium.[1]

[1] This statement probably requires modification as far as northern countries are concerned, judging by the records of Ely Cathedral and St. Stephen's Chapel.

The reasons for this conservative habit are easily understood. In the first place, the mastery of an artistic craft is only slowly and laboriously attained, and the pupil, having by years of practice gained facility of expression by means of the technique taught him by his master, finds the new technique inexpressive and nonplastic. In the second place, each technique leads to a particular form of artistic expression, and the artist having at last attained perfection in this expression desires no further change. Centuries may therefore pass before a man arises of sufficient originality to aim at new modes of expression, and to try to obtain these by mastering a new technique.

Even when the artist has at last accepted the new medium as preferable to the old, he uses it at first to imitate the old effects, and generations may pass before the full possibilities of the new medium are realised. The truth of this statement is so clearly revealed by a study of the pictures painted in oil from the fifteenth century onwards that it requires no further demonstration.

We are therefore quite justified, in an inquiry of this nature, in supplementing the information supplied by Pliny and Vitruvius by information gathered from older writers and older works of art.

Nor need we confine the source of such additional information to the neighbourhood of Rome, as we

may safely assume that such technical knowledge as was possessed by the civilisations which had grown up round the Mediterranean basin would be concentrated in Rome at the time of the empire.

Our inquiry may also be legitimately assisted by the examination of works of art produced at a time somewhat later than that of Pliny, in so far as we find on examination that they assist us in elucidating the descriptions of technical processes given by him.

For we cannot expect to find again in the history of art a series of wall paintings buried in the volcanic ashes of the eruption which killed the author who is one of our principal sources of information, and thus signed, sealed, and dated, forming the appropriate illustration to the author's own works.

We may also find in later writers information which will assist us in the interpretation of passages contained in the author under consideration, and, in the modified practices of the art in later times, indications of the methods of an earlier technique.

But the consideration of the extent to which we are justified in using information from later sources to enable us to understand completely the technique used at the period we are inquiring into, leads us to lay down the rule by which such an investigation must be governed.

The rule is this. The information supplied by the writers of the period under consideration must be

regarded as in essence complete, until it is clearly demonstrated by exhaustive experiments that some essential information has not been supplied by them.

The necessity for thus limiting and defining our inquiry has been so little recognised by many writers that it requires some further explanation.

Let us take a particular example.

In order to understand the technical processes used by painters in the time of Pliny, it is of the utmost importance to know whether they were familiar with the properties of the 'drying' oils which are used by painters to-day.

On examining the writings of Pliny we find that he describes the preparation of nut oil, which is one of the 'drying' oils, but makes no mention of its property of oxidising into a transparent elastic solid, or of its use in painting.

In the earlier writings of others there is also no mention of the properties of drying oils, and Dioscorides, who is almost a contemporary, while adding the description of the preparation of poppy oil, also fails to note their 'drying' properties.

The first mention of the 'drying' properties of nut oil, and its use as a varnish for pictures, occurs in Aëtius, a writer of the early sixth century.

If, therefore, we are to apply the rule which has already been laid down, we are bound to commence our inquiry with the assumption that the properties

of drying oils, and their consequent use in painting, were not known in the first century of the Christian era, but were discovered subsequently.

Against this conclusion many arguments can be used. In the first place, comparatively few of the books written in classical times have survived, and many technical treatises must have perished.

In the second place, portions of the authors which have survived have disappeared, and consequently a missing chapter may contain the information which is wanting.

In the third place, the authors themselves are often compilers with no practical acquaintance with the technical processes they describe, and probably preferred to copy from older compilers, rather than take the trouble of collecting information from the craftsmen themselves.

In the fourth place, as the craftsmen were taught by tradition, and jealously guarded the secrets of their craft, they may well have made use of processes which were only recorded centuries after their discovery, or have disappeared without ever being recorded at all.

In the fifth place, the author considered may often omit facts with which he must have been perfectly familiar, just as Pliny fails to tell us what medium was used by one school of Greek painters, although it is quite evident that some medium must have

been used, and Pliny must have been familiar with its nature.

In reply to these arguments, only one thing requires to be said. While we are justified in using all the information supplied by writers existing before the date which we have fixed as the limit of our inquiry (in this case the end of the first century of the Christian era), we are not justified in using new information contained in writers subsequent to this date, because we cannot prove that it is not the outcome of discoveries made after the period we are considering.

We are no more justified in assuming a knowledge of the properties of drying oils in the first century because they were described in the sixth century, than we should be justified in assuming a knowledge of aniline dyes in the first century because they are described in works on chemistry written in the nineteenth century.

Therefore the only possible working hypothesis is, that the descriptions given by our authors of technical processes are in substance correct, and that what is not stated by them was not known at the time when they wrote. A less rigid method of inquiry leads us to endless loose speculations, and makes all real progress impossible.

If this is to be our working hypothesis, let us next consider what conditions are necessary to justify

us in abandoning it. These are, in the first place, the discovery of an earlier or contemporary writer containing additional information. In the second place, the demonstration by means of the chemical analysis of a work of art of undoubted authenticity that our information is incomplete or inaccurate. In the third place, the demonstration, after exhaustive experiments, that a technical process described by the author is unworkable, or that a given contemporary work of art can only be reproduced by using methods not mentioned by contemporary writers. It is in this third case, however, that the utmost caution is necessary.

The original craftsmen had the advantage of the accumulated knowledge of centuries of tradition and of years of training in the use of the lost technical process. The modern experimenter has nothing to guide him but a few brief words of description.

His experiments must therefore be of a very thorough and exhaustive character before he ventures to decide that the process is impossible, or that the work of art must have been produced by another method.

In conclusion, where there are obvious omissions or obscurities in the information at our disposal, it is better to state frankly that we do not know, than to take advantage of the opportunity for ingenious

speculations. We must also resist the temptation of inventing a technical process which the contemporary writer does not describe, and then getting over the difficulty of his omission by assuming that one or two chapters of his book have been lost, which, no doubt, contained the proof of the correctness of our ingenious guesswork.

I may have seemed to have laboured too long in laying down the conditions essential to a scientific inquiry; but those who are familiar with the many writings on this subject, and the way in which ingenious hypothesis has been piled on ingenious hypothesis, will realise the necessity of bringing this department of research into line with the many other departments which have come in recent years under the control of those methods of exact investigation which we owe to the students of natural science.

Having now discussed at some length the principles on which such an inquiry as this should be conducted, I propose to describe briefly the pigments used in classical times.

Those who wish an historical survey of the various writers who have dealt with this subject can consult *Die Maltechnik des Alterthums*, by Ernst Berger, München, 1904.

As much that I have to say will involve a criticism of some of Herr Berger's conclusions, it is

only fitting to state in this place, that all students of this subject are immensely indebted to him for his learned publications.

Before going further, however, it is necessary to mention the actual texts of Vitruvius and Pliny consulted and quoted from in the course of this paper. These are: the edition of Pliny's *Natural History*, edited by Carl Mayhoff, and issued by Teubner in 1906; and the most recent edition of Vitruvius, *De Architectura*, by Valentine Rose, issued by Teubner in 1899, and containing some corrections on the earlier editions by Rose and Müller-Strübing.

To return to the pigments used in classical times, they can be briefly dealt with, because, though there are obscure descriptions in Pliny, and many pigments, especially those prepared from organic colouring matters, are difficult to identify, there is a sufficient amount of exact information to enable us, partly by the analysis of actual samples, and partly by the descriptions given by Pliny, Vitruvius, and others, to decide without doubt on the nature of a sufficient number of pigments to supply the painters of classical times with an extensive palette. As, moreover, there is no dispute as to the identity of those I shall mention, and I have little new to add to what is common knowledge, it would be tedious to give all the proofs and references.

It is, in the first place, evident, both from the

descriptions in Pliny, Vitruvius, and others, and from the analysis of pigments, that the painters in classical times were familiar with what are now roughly called the earth colours, such as the yellow and red ochres, terre verte, and probably the siennas and umber. The references to red colours are often somewhat obscure, but Pliny describes ochres from various sources,[1] and Vitruvius mentions both yellow and red ochres,[2] and the roasting of yellow ochres to form purples.[3] More than one white earth is mentioned by Pliny[4] as having been used in painting, and chalk, gypsum, and plaster of Paris were known. Other pigments described by Pliny have been identified with the blue and green copper ores.[5]

Blue carbonate of copper has been used as a pigment up to comparatively recent times, and was apparently known to early Italian painters as azzurro della magna. I have prepared a blue pigment from azurite. It is a beautiful blue and very difficult to distinguish in appearance from real ultramarine, as is correctly stated by Mrs. Merrifield.[6] It is of a sandy nature, and therefore difficult to handle in oil, in which it settles, letting the oil float to the top. Hence the directions, after the introduction of oil

[1] Pliny, Bk. xxxiii. c. 56.
[2] Vit., Bk. vii. c. 7.
[3] Vit., Bk. vii. c. 11.
[4] Pliny, Bk. xxxv. cc. 18, 19, 30; xxxvi. 59.
[5] xxxiii. 26, 57.
[6] *Ancient Practice of Painting*, cxcvii.

painting, to mix it with size or to dust it on dry, and the belief that it turned green in oil.[1]

The native sulphide of mercury, cinnabar, was also used as a pigment.[2] I have prepared a red from native cinnabar, which is very little inferior in brilliancy to vermilion, that is, the artificially prepared sulphide.

The native sulphide of arsenic, orpiment, was also used,[3] and has only recently disappeared from the artist's palette. It is a yellow of peculiar beauty, and unlike any other yellow in appearance. It is fugitive in oil, but permanent in a pure spirit varnish or pine balsam.

Coming to artificial pigments, they understood the preparation of white lead (cerussa),[4] somewhat inaccurately described by Pliny, but more clearly by Vitruvius. They were also familiar with several preparations of the oxides of lead, such as litharge, red lead, and other similar preparations.[5]

Sir Humphry Davy found an orange yellow oxide of lead pigment on 'a piece of stucco in the ruins near the monument of Caius Cestius.'[6]

The preparation of verdigris is also described by

[1] *Ancient Practice of Painting*, cciv.
[2] Pliny, Bk. xxxiii. c. 36; Vit., Bk. vii. c. 8.
[3] Pliny, Bk. xxxiii. c. 22; xxxiv. c. 56; Vit., Bk. vii. c. 7.
[4] Pliny, Bk. xxxiv. c. 54; Vit., vii. 12.
[5] Pliny, xxxiii. 35, 40; xxxiv. 51, 54; xxxv. 22; Vit., vii. 12.
[6] *Phil. Trans.*, vol. 105, p. 105.

Pliny and Vitruvius,[1] and the preparation of lamp black, charcoal black, and probably bone black.[2]

One of the most interesting of the ancient pigments was the copper frit which is frequently present both in Egyptian and Roman remains, and which occurs in Egypt as early as the twelfth dynasty.

There is no clear description of this pigment in Pliny, though it is probably referred to in chapter 57 of the thirty-third book, and again in chapter 38 of the thirty-seventh book, but Vitruvius gives a perfectly clear account of its preparation.

Vitruvius tells us that it was formerly manufactured in Alexandria and afterwards manufactured by Vestorius at Puteoli,[3] and that it is prepared by heating together copper, sand, and soda.

The analysis of the blue, however, reveals the presence, in addition, of lime and alumina. These may have been deliberately introduced, or have been present in the impure sand and soda used.

Professor Russell has made a special investigation of this blue, and has also prepared a green. A complete account of his experiments will be found in the *Proceedings of the Royal Institution*, London, 1893. The blue is easily identified by its appearance under the microscope, consisting of transparent glassy fragments, and by its giving the usual reactions for copper.

[1] Pliny, xxxiv. 26 ; Vit., vii. 12. [2] Pliny, xxxv. 25 ; Vit., vii. 10.
[3] Vit., vii. 11.

In addition to these pigments they were accustomed to prepare pigments from vegetable and animal dyes.

Both Pliny and Vitruvius mention the use of the purple dye of the murex for this purpose.

Pliny states that the pigment is prepared by adding to the dye a white earth which is used for cleaning silver, and which absorbs the dye more readily than wool.[1] This earth is probably infusorial earth, which has the property of absorbing and fixing basic aniline dyes without the use of any mordant or precipitating agent. Vitruvius mentions mixing the dye with honey.[2]

In addition, Vitruvius mentions the use of other vegetable colouring matters, including madder for dyeing chalk,[3] and Pliny describes a process for dyeing 'chrysocolla' (probably green carbonate of copper) with 'lutum,' in the same manner as flax or wool is dyed by the use of 'alumen.'[4]

An account of the nature and properties of 'alumen' will be found in chapter 52 of the thirty-fifth book.

The question as to what this substance was and how it was prepared or obtained, and how far it is identical with the double sulphate of alumina and potash known to-day as alum, is worthy of further investigation. It is evident from the account given in the thirty-fifth book that a white variety was

[1] Pliny, xxxv. 26.
[2] Vit., vii. 13.
[3] Vit., vii. 14.
[4] Pliny, xxxiii. 26.

known, and this white variety was used in the process of dyeing wool scarlet, and was also used for preparing vegetable lakes. This certainly seems to point to the substance being either sulphate of alumina, or alum, however obtained and prepared. We should, however, be departing too far from our present inquiry if we followed this question any further.

Such dyes as weld, woad, kermes, and madder were well known, and doubtless used for the preparation of pigments.

Sir Humphry Davy[1] examined a pot of pigment found in the so-called baths of Titus, of a pale red colour, which proved to be a vegetable or animal dye on a chalk base, and containing some silica and alumina.

But one of the most interesting of recent discoveries has been the identification of a rose pigment obtained by Mr. Flinders Petrie in Egypt, as a madder lake. Professor Russell,[2] who examined this pigment, found the base to be gypsum, and identified the colouring matter as alizarin by its absorption spectrum. He then succeeded in successfully imitating the pigment by heating madder root with lime water and gypsum, an entirely novel method of preparing a lake.

Indigo, both from India and from woad, was also known, and probably dragon's blood.[3]

The only other question of interest is whether the

[1] *Phil. Trans.*, vol. 105.

[2] Russell on *Ancient Egyptian Pigments*, Royal Institution, 1893.

[3] Pliny, xxxiii. 57; xxxiii. 38; viii. 12; xxxv. 27; Vit., vii. 14.

preparation of ultramarine from lapis lazuli was known in classical times.

No pigment was more prized by the fifteenth and sixteenth century painters of Italy, and its preparation is described in great detail in more than one fifteenth century MS.[1]

Among his descriptions of precious stones Pliny describes a stone called 'cyanos.'[2] From his description this stone is evidently lapis lazuli, and he goes on to speak of an artificial variety discovered by an Egyptian king. This account is probably taken from Theophrastus, because he also speaks of the discovery made by an Egyptian king of an artificial cyanos.

But the place where this statement is made in Theophrastus is chapter xcviii., in that part of the work where he describes earths, and more especially those suitable for pigments.

An earlier mention of 'cyanos' occurs in chapter lvi., where Theophrastus is describing the various precious stones and gems. He again refers to it in chapter lxv., contrasting it with the 'sapphire,'[3] and again in chapter lxx., where, if this chapter be taken as a continuation of the preceding chapter, he is apparently referring to the golden particles of pyrites the stone often contains. On the whole, therefore, the

[1] MS. Jehan Le Bègue, *Ancient Practice of Painting*, vol. i. p. 96. MS. Cennino Cennini, page 47 of translation by Mrs. Herringham.

[2] Pliny, xxxvii. 38, probably also xxxvii. 39, called 'sapphiros.'

[3] A variety of lapis lazuli, not the modern sapphire.

evidence is in favour of Theophrastus having described two, if not more, different blue stones under the one name, the first being lapis lazuli, and the last being of the nature of a blue earth used in painting, and the artificial variety being probably the Egyptian copper frit.

We may therefore safely say that there is no evidence in favour of the view that the preparation of ultramarine from lapis lazuli was known in classical times. The process, which is an elaborate and difficult one, either came from elsewhere, or was discovered at some time during the middle ages.

Some writers have gone so far as to assume a knowledge of the preparation of *artificial* ultramarine from the statements made by Pliny.

It is evident from the foregoing account that the painters of classical times had a very complete palette at their command, a palette which remained the same, with a few modifications, right through the history of painting and up to the dawn of modern chemistry.

The principal modifications were, the introduction of ultramarine, and the disappearance of the copper frit, and of pigments prepared from murex, and the introduction of artificial in place of native vermilion, of lakes prepared from dye woods, and after the discovery of Mexico of the cochineal lakes in place of kermes.

With the exception of the introduction of ultramarine none of these changes can be regarded as improvements on the palette used in classical times.

While I have refrained from going into detail, much more might be said on this subject, a comparison of the statements made by Pliny and Vitruvius respectively about the same pigments being alone of great interest. Pliny evidently copied some of his facts from Vitruvius, and in many cases copied inaccurately. The statements made by Vitruvius about the nature and preparation of pigments are evidently much more reliable, and we may suppose are due to actual practical knowledge. The statements in Pliny are in many cases quite unintelligible, and his evident ignorance of the method of preparation of so well known a pigment as the blue copper frit is very significant.

The suggestion that the white earth he describes as being used to prepare a pigment from the murex dye is infusorial earth is, I believe, new, and the experiments by Professor Russell on the Egyptian blue and Egyptian madder lake are not as well known as they ought to be. His experiments on the madder lake are especially interesting, as nearly all traces of lakes from madder disappear in the MSS. of the middle ages, right through to the seventeenth century, when a receipt is given in the *Ars Vitraria*.

We shall now proceed to consider what mediums

were used for painting on panel and canvas in and before the time of Pliny.

A medium suitable for the artist must fulfil several functions. It must, when mixed with the pigment, form a convenient means of transferring the pigment to the brush and from the brush to the picture, and it must serve to attach the pigment to the surface of the picture, and in addition some mediums serve to protect the pigment more or less perfectly from chemical and mechanical injury.

Among primitive mediums which serve to attach the pigment may be mentioned gum, glue, and white or yolk of egg. Such mediums can all be dissolved in or mixed with water, and while serving to attach the pigment do not really protect it from attack by air and moisture or prevent its easy removal.

Of the three, probably egg protects and preserves the pigment best.

But the discovery that certain vegetable oils have the property of 'drying,' that is of being converted by the oxygen of the air into elastic transparent solids, has supplied the artist with a medium which protects the pigment, and gives the picture a surface which is practically waterproof. Experiments [1] which I have made have proved that this protection is not so complete as has been supposed, and that dried films of linseed oil are pervious to water vapour, but there

[1] Appendix I.

is obviously a great difference between such an oil surface and a surface consisting of gum, glue, or egg.

The best known of these vegetable 'drying' oils are linseed oil, poppy oil, and walnut oil. Castor oil gets sticky when exposed to the air, but does not 'dry' with sufficient completeness to be of any practical use to the painter. There are other drying oils, but we need not consider them here.

If we wish to protect a surface from moisture we can use other means besides the use of a 'drying oil.'

Many resins exude from the trees in a semi-liquid form, and are known generally as balsams. This semi-liquid condition is due to the presence of volatile oils which subsequently evaporate and leave the hard resin behind. The semi-liquid turpentines from the various species of pine are excellent examples, such as Canada balsam from the *abies balsamea,* Venice turpentine from the larch, and others. On distillation the volatile spirits of turpentine, or 'turpentine' as it is usually called, is obtained, and the resin is left behind.

Such semi-liquid turpentines, on slightly warming, can be used as varnishes, but do not lend themselves readily to use as painting mediums without further admixtures on account of their sticky nature.

At the present day varnishes are prepared in one of two ways.

The dry hard resin is dissolved in a volatile

medium, such as spirits of turpentine, alcohol, or rectified petroleum, and brushed over the surface. The volatile medium then evaporates and leaves a layer of the resin behind. Such varnishes correspond to the natural varnishes or pine balsams, which may be regarded as natural spirit varnishes, in which the resin is dissolved in spirits of turpentine. (Distinctions are drawn by chemists between balsams, turpentines, and solutions of resin in spirits of turpentine, but the above statements are sufficiently accurate for our present purposes.)[1]

The other modern method of making varnishes is to dissolve the resin in a drying oil, which solution, when exposed in a thin film, 'dries' to form a hard elastic coating, owing to the oxidation of the oil, and contains the oil and resin intimately associated together. Such varnishes are usually diluted with turpentine.

It is evident then that if we wish to paint a picture which will resist the attacks of moisture, we have several different methods available.

We may use a drying oil as our medium, or we may use a natural balsam, or a spirit varnish, or an oil varnish.

In practice the last three mediums, if used pure, will be found to be too sticky to lend themselves to a successful use.

[1] Dieterich on Analysis of Resins, Balsams, and Gum Resins.

Or we may paint our picture with gum, egg, or glue, and then protect the surface afterwards by varnishing with any of the above substances. The sticky nature of the varnishes will not prevent their use for this purpose, though making them unsuitable as painting mediums (see Appendix I.).

There is still, however, another substance which has not been mentioned, and which will serve to protect the pigment, and that is beeswax.

Beeswax is easily melted and forms semi-fluid semi-solutions, with turpentine and oil, and dissolves in fused resins. It is not transparent, but in thin coats is so nearly transparent as to make it quite suitable for solid painting.

While a fused resin is quite unsuitable for a varnish, as it is impossible to lay it on in smooth coats, and it cracks all over on cooling, the dissolving of a little beeswax in it only diminishes its transparency a little, and makes it quite suitable for use as a varnish. The melting point is considerably lowered, and the varnished surface does not crack.

After these preliminary explanations we are in a position to consider intelligently the information available as to the mediums and methods used by painters in the time of Pliny.

In the first place we shall begin by stating what knowledge they had of the various substances mentioned in the above statement.

In Pliny's account of remedies derived from eggs, he states that a cement for glass can be made of white of egg and lime.[1] He says that white of egg (ovi candidum) is suitable for laying gold leaf on marble.[2] He also mentions egg as suitable for a painting medium in a particular case in the following words:[3] —'Pingentes sandyce sublita, mox ex ovo inducentes purpurissum fulgorem minii faciunt. Si purpurae facere malunt, caeruleum sublinunt, mox purpurissum ex ovo inducunt.' 'Painters put on sandyx as a ground colour; thereafter, laying on purpurissum with egg they produce the brilliance of vermilion. If they prefer to produce the brilliance of purple they put on caeruleum as the ground colour, and then lay on purpurissum with egg.' If we now proceed to consider this statement of Pliny's, it is evident, in the first place, that he does not state whether he means the whole egg or the white or the yolk to be used. Formerly, when describing how to lay on gold leaf, he states definitely that 'candidum ovi' is to be used. It seems therefore probable that the medium in this case is intended to be the whole of the egg. In the second place, he only directs the purpurissum to be mixed with the egg, and fails to mention what medium the other pigments are mixed with.

If the medium for these other pigments was not also egg, it certainly could not be wax, as the paint-

[1] xxix. 11. [2] xxxiii. 20. [3] xxxv. 26.

ing over it with the egg medium could not be successfully carried out. Probably, therefore, it was a water medium, that is egg, gum, or glue.

There is also another possibility, and that is that the passage refers to fresco painting. Purpurissum, he tells us later, was one of the pigments that could not stand the action of wet lime, and therefore it may have been customary to paint it on the dry surface with egg. Similar directions for touching up true fresco with pigment mixed with egg are to be found in Cennino Cennini.[1]

It is also not clear from the statement whether it is the process of glazing with purpurissum to which he wishes to direct attention, or the use of egg.

There are other passages with which we shall have to deal later, in which a process is stated either to be peculiar to a particular painter, or only to be used in a special case. In such cases we are justified in stating that such processes were not universally used.

In this passage it is impossible to say from the context, whether or not we are to understand that the use of egg is exceptional, and whether only for this special purpose.

The passage at any rate proves conclusively that the use of egg as a medium was a familiar idea to Pliny for this special purpose, and there is certainly

[1] Cennino Cennini, translation by Mrs. Herringham.

no evidence to be drawn from the text that he intends egg to be used *only* in this case, and therefore there is no evidence that egg was not the ordinary accepted medium for other purposes.

Pliny mentions the preparation of glue from hides of oxen,[1] and the preparation of fish glue[2] and the use of glue by carpenters.[3]

He also mentions glue in connection with pigments in his description of the preparation of black pigments.[4] The actual words used are as follows:—

'Omne autem atramentum sole perficitur, librarium cumme, tectorium glutino admixto.' 'The preparation of every sort of atramentum is completed by exposure to the sun, that used for writing having an admixture of gum, that for use on plaster-work an admixture of glue.'

With this statement the following statement made by Vitruvius can be compared:—

'Inde collecta partim componitur ex cummi subacta ad usum atramenti librarii, reliqua tectores glutinum admiscentes in parietibus utuntur. Sin autem hae copiae non fuerint paratae, ita necessitatibus erit administrandum, ne expectatione morae res retineatur. Sarmenta aut taedae schidiae comburantur, cum erunt carbones extinguantur, deinde in

[1] xi. 94. [2] xxxii. 24. [3] xvi. 82, 83.
[4] xxxv. 25.

mortario cum glutino terantur. Ita erit atramentum tectoribus non invenustum.'[1] 'When it has been collected thence' (*i.e.* when the soot arising from the combustion of resin has been collected from the walls of a specially constructed furnace), 'part of it is blended with beaten up gum for use as writing ink, the rest is used on walls by plasterers, who mix it with glue. Should such material not be at hand, the necessities of the case must be so dealt with as to prevent undue delay in carrying out the work. Twigs or pine-shavings are to be burnt, when converted into charcoal they are to be extinguished, and then powdered in a mortar with glue. This will provide plasterers with a quite pleasing black.'

It has been assumed that these passages prove the use of glue for painting on walls. They are, however, capable of another explanation. Lamp black is of such a light powdery nature that it is very unmanageable as a pigment, being both bulky to handle and difficult to moisten with water. It has long, therefore, been the custom of the trade to grind it with water and a little glue, press it into convenient shapes, and sell it in such a form as 'drop black.' The pigment in this form can readily be mixed with oil or any other medium, the amount of glue being just sufficient to bind it together. Charcoal is also very unmanageable, and would

[1] Vitruvius, vii. 10.

require fine grinding and similar treatment. It is therefore quite possible that this method of preparing black for use was equally familiar in the time of Vitruvius, and that the passages quoted have no reference to the actual medium used for painting.

Glue was used for preparing gesso grounds on coffins in Egypt, and possibly also as the painter's medium.[1]

Pliny mentions various kinds of gum, including gum Arabic, which he states to be the best, and he also describes the use of gum for medicinal purposes.[2]

The references to the use of gum for making ink have already been quoted. There is a passage in his description of gums in the thirteenth book to which more attention might well have been given. In speaking of a gum which he calls sarcocolla, he says:—'Fit et e sarcocolla—ita vocatur arbor et cummis—*utilissima pictoribus* et medicis, similis pollini turis, et ideo candida quam rufa melior.' (A gum) 'is also obtained from sarcocolla—both tree and gum are so named—which is very useful to painters and physicians. It resembles the dust of frankincense, and for that reason the white is better than the red.'

This is supposed to be the Penaea Sarcocolla of Linnæus, the gum of which is brought from Abys-

[1] See Appendix II.

[2] xiii. 19; xiii. 20; xxiv. 64, 65, 67.

sinia. Pliny mentions its medicinal uses later on,[1] and it is also described by Dioscorides.[2] It would be of great interest to follow up this reference, and if the gum can really be identified, carefully examine its properties.

In conclusion, the artistic possibilities of these three media, glue, gum, and egg, require no demonstration. Glue is the medium of the scene-painter, gum is the medium of the painter in water-colour, and egg was the medium of the early Italian painters.

Nor can there be any doubt that all these substances, being familiarly known, would be tried as media by artists, though they might ultimately select one in preference to another.[3]

We shall now proceed to examine carefully the statements made by Pliny about oils, resins, and beeswax.

A very large number of resinous bodies are mentioned by Pliny, including those used for perfumes, such as balm of Gilead and frankincense, and the various sources from which they are obtained are described.

It is unnecessary to include all these in our present

[1] xxiv. 78. [2] B. iii. c. 99.

[3] A medium of egg and gum mixed, with the addition of bile to make the colour flow easily, is mentioned in a Papyrus found at Thebes of the third or fourth century. *Papyri Graeci Musei Antiquarii publici Lugduni Batavi*, edited by C. Leemans: tom. ii. papyrus x.

inquiry, but it is sufficient to give the names and sources of some of them. In the 22nd chapter of the twenty-fourth book, he mentions resins extracted from the pine, the pitch-tree, and the larch, the terebinth, the lentisk, and the cypress. He distinguishes in this chapter between the dry and the liquid resins, speaking, for instance, of the resin of the pitch-tree as unctuous and of the larch as thin like honey. It is a matter of some difficulty to identify the various kinds of pine referred to by Pliny. The terebinth, which he says comes from Syria, is supposed to be the pistacia terebinthus, while the lentisk yields the resin known as mastic.[1]

An exhaustive inquiry into all the resins mentioned by Pliny, and an attempt to conclusively identify the various trees described by him would involve a long and laborious research, and would be of no value for our present purpose. It is sufficient that such balsams or natural varnishes were well known, and were obtained from many sources.

A clear distinction is drawn by Pliny between resin and pitch.[2] The 'resin' is the natural product of the tree, 'pix' is the result of a special process, namely, heating the broken up timber of the tree, when a tar flows out and is collected. Such a tar

[1] xxiv. 22.

[2] Dioscorides mentions the trees pitch is obtained from, but not the method of preparation. B. i. 94.

or pitch is still known and used to-day, and is of a rich brown colour. It differs in its behaviour and properties from the natural balsam or resin, and from the hard resin obtained when the turpentine has been distilled. The preparation of this pitch will be found described in the 21st chapter of the sixteenth book. This pitch, Pliny informs us, was used for tarring ships. There is also another artificial preparation described by him called zopissa, which was apparently used in medicine, and was scraped from the bottoms of ships. This he states to have been a mixture of pitch and beeswax. The beeswax would doubtless be introduced to toughen the pitch. A description of this substance is given in the 23rd chapter of book sixteen. The resins already referred to were used, either to add to wine, or to paint the inside of the wine vessels. They were also, of course, used in medicine. There is no hint or suggestion in Pliny of their being used to varnish pictures or other objects. Below will be found the references to the chapters where resins are mentioned, with the exclusion of those used as perfumes, such as frankincense.[1]

He tells us that all resins are soluble in oil,[2] describes the extraction of a resin by oil,[3] and de-

[1] xii. 36; xiii. 11; xiii. 12; xiv. 25; xvi. 16-23; xvi. 76; xxiv. 11; xxiv. 22, 23, 24, 25, 26, 28.

[2] xiv. 25.

[3] xxiv. 1.

scribes the preparation of liniments by dissolving resins in oil.[1] When the nature of the oil is not specially mentioned, no doubt olive oil is intended. We are not justified, therefore, in supposing that the preparation of an oil varnish by dissolving the resin in a 'drying' oil was understood, on the evidence merely of these receipts for medical preparations by the use of olive oil.

A large number of oils were also known in the time of Pliny, though no distinction was made between fixed oils like olive oil and essential oils. A list of these oils will be found[2] in the 7th chapter of the fifteenth book, and some account of their method of extraction. They are either extracted by pressing, or by boiling the substance containing the oil with water, or by mixing the substance first with olive oil and then pressing, by which a solution of the required oil in olive oil would be obtained.

It is in this chapter that the preparation of walnut oil is mentioned. There are two other references to walnut oil. It is mentioned as a remedy for certain complaints,[3] and a receipt for bird lime consists of walnut oil mixed with the juice of the mistletoe berry.[4] This receipt is very interesting, as no doubt the drying properties of the oil would make the mixture stickier on exposure to the air.

[1] xxiv. 22.
[2] xv. 7.
[3] xxiii. 45.
[4] xvi. 94.

The preparation of linseed oil and poppy oil are not given, but the preparation of poppy oil is given by Dioscorides.[1]

Several other interesting oils are mentioned, such as castor oil.

It is evident from this account of the oils and resins known in the time of Pliny that the *materials* for oil painting and for making oil varnishes were known. We shall next consider whether the materials for making spirit varnishes were also available. These are spirits of turpentine, alcohol, and petroleum.

There are several references to petroleum in Pliny. It is mentioned in the 109th chapter of the second book, in the 39th chapter of the thirty-first book, and, under the name of liquid bitumen, in the 51st chapter of the thirty-fifth book. He distinguishes between different kinds, and states that it is used for burning in lamps. Some writers have therefore assumed, on the strength of these references, that it was used in classical times as a painting medium and in the preparation of varnishes. Natural petroleum is quite unsuitable for such a purpose, and requires to be most carefully rectified by distillation before it can be used. So that we may dismiss this hypothesis, as the true art of distillation was apparently unknown at the time of Pliny, the first descriptions

[1] Dioscorides, B. iv. 65.

occurring at a later date.[1] For this same reason alcohol was not available.

A description of a crude method of distillation is, however, to be found in Pliny in his chapter on oils,[2] where he states that, by boiling pitch and covering the boiling pot with fleeces and then wringing them out, a yellow oil is obtained which he calls pissinum. This oil is again referred to as pisselaeon.[3] It has been assumed that this statement in Pliny justifies us in stating that in classical times spirits of turpentine was known and doubtless used in painting. It has not been noticed apparently that this oil was not distilled from the pine balsam or oleo resin, but from the pitch, the method of preparing which has already been described. Such an oil would be very different from spirits of turpentine, and of very doubtful value as a medium, or for the preparation of varnishes.

Finally, it may be pointed out that the assumption that the art of distillation was *not* known in the time of Pliny, because it is *not* mentioned, is strengthened by the description given by him of the process for obtaining an oil from pitch. This crude process no doubt represents the first attempt at distillation before the idea of a closed-in vessel, and a descending pipe leading from it, had occurred to any one.

It is evident then that spirit varnishes artificially prepared were not known in the time of Pliny,

[1] See Appendix III. [2] xv. 7. [3] xxiv. 24.

though natural spirit varnishes or balsams were available. Such varnishes were used in Egypt in the 19th dynasty for varnishing coffins, and the varnish is still in good condition,[1] and therefore there is no reason why they should not have been used by classical painters. The evidence provided by Pliny is, however, against their having been generally used, for, speaking of Apelles Pliny says, 'Inventa ejus et ceteris profuere in arte; unum imitari nemo potuit, quod absoluta opera atramento inlinebat ita tenui, ut id ipsum, cum repercussum claritatis colorum omnium excitaret, custodiretque a pulvere et sordibus, ad manum intuenti demum appareret, sed et *lum*inum ratione magna, ne claritas colorum aciem offenderet veluti per lapidem specularem intuentibus et e longinquo eadem res nimis floridis coloribus austeritatem occulte daret.'[2] 'His innovations in the art of painting have also been useful to others; but one of them nobody has been able to imitate. He used to cover his pictures after their completion with a layer of atramentum so thin, that while it created a reflexion of the brightness of all the colours and protected them from dust and dirt, it was itself visible only to one examining very closely. But the chief purpose was to prevent the brightness of the colours from offending the eye (they were as if looked at through talc), also that when seen from a distance

[1] Appendix II.

[2] XXXV. 36.

the too florid colours might be imperceptibly chastened.'

The general impression made by this description is that of the result of varnishing a picture painted in some medium like tempera, by which the dead dull look of the colours is at once removed.

The use of the word atramentum, and the remarks about the softening effect, suggest, however, that the artist covered his picture with a thin glaze of bitumen. Some of the more fluid bitumens could probably be used for such a purpose. The beautiful effects which bitumen is capable of giving were only too well known to the early painters of the nineteenth century as their pictures now testify.

Atramentum properly means black, and is confined by Vitruvius[1] to lamp black and charcoal black. On the other hand Pliny, in speaking of atramentum,[2] mentions an atramentum which exudes from the earth like the brine of salt pits. This must surely be some form of bitumen, in which case the use of the word atramentum, in speaking of the process used by Apelles, would be justified. It is evident that Pliny himself did not understand the process, and that it was some method of varnishing, though possibly with a bituminous or semi-bituminous varnish. A varnish, for instance, in which bitumen was dissolved in a pine balsam like

[1] vii. x., Vitruvius. [2] xxxv. 25, Pliny.

Venice turpentine, would fulfil all the conditions laid down in Pliny's description.

It was also a process peculiar to Apelles, for Pliny speaks of it as having been used only by him, stating that in this no one could imitate him.

The evidence, therefore, of this passage is in favour of the conclusion that the varnishing of pictures was not practised by classical painters, with this one exception. On the other hand it is difficult to understand, since they had natural varnishes in abundance, and since the use of them was so well understood in Egypt, why they were not used by classical painters. This is one of the cases where we have to decide between the facts derived from the actual examination of contemporaneous objects, and the authority of our author. While it is difficult to imagine that Pliny was not familiar with the artists' studios of his time, or that the special significance of the passage lies in the use of the word atramentum, the dark glazing being the special invention of Apelles, yet it is not easy to see why other artists should have had any difficulty in repeating his process. On the whole I am disposed to think that the classical painters were probably quite familiar with the advantage of varnishing their pictures with the natural balsams, and that Pliny is speaking in ignorance of the traditions of the studios.

Whether the pictures were varnished or not, we

have so far identified three possible media for painting, gum, glue, and egg. For pictures that did not require to be waterproof these media would be sufficient, but as soon as a demand came for a medium which should be waterproof, and at the same time pliable in handling and not too brittle when dry, it is evident that we have a choice between two, a drying oil, like nut or linseed oil, and beeswax.

We have found no evidence of a knowledge of the properties of drying oil, and therefore we are bound to assume, as a working hypothesis, that such knowledge was absent. If we find definite proof of the use of beeswax, it is a further confirmation of the absence of, at any rate, a practical working knowledge of drying oils, as no one would use beeswax if he knew of something more convenient, and any one who has worked in both media will unhesitatingly prefer oil.

The problem of obtaining a waterproof medium would probably arise, in the first instance, in connection with ships. The substance already described, zopissa, the mixture of beeswax and pitch which was used for coating the sides of ships, would be a translucent brownish yellow body. If a desire arose for decorating ships it could be easily done by mixing pigments with this substance and laying them on with the tar brush in bold designs, as the colour of the mixture would not affect the colour of

the pigments more than a dark varnish would do. Experience in this rough decorative treatment might well lead to a more refined use of wax mixed with pigments, as a medium, without the sticky dark coloured tar, both for ship decoration, and for painting on panels.

At this point, however, the technique derived from the practice with the tar brush would meet another technique, namely that of modelling in coloured waxes, and from the two combined a special kind of pictorial art would develop. We shall see how far this conjectural view agrees with the information at our disposal. We shall begin by considering the statements made by Pliny about the preparation and properties of beeswax itself, by quoting in full chapter 49 of the twenty-first book :—

'Cera fit expressis favis, sed ante purificatis aqua ac triduo in tenebris siccatis, quarto die liquatis igni in novo fictili, aqua favos tegente, tunc sporta colatis. Rursus in eadem olla coquitur cera cum eadem aqua excipiturque alia frigida, vasis melle circumlitis. Optima quæ Punica vocatur, proxima quam maxime fulva odorisque mellei, pura, natione autem Pontica, quod constare equidem miror inter venenata mella: dein Cretica, plurimum enim ex propoli habet, de qua diximus in natura apium. Post has Corsica, quoniam ex buxo fit, habere quandam vim medicaminis putatur. Punica fit hoc modo: ven-

tilatur sub diu saepius cera fulva, dein fervet in aqua marina ex alto petita, addito nitro. Inde lingulis hauriunt florem, id est candidissima quaeque, transfunduntque in vas, quod exiguum frigidae habeat, et rursus marina decocunt separatim, dein vas ipsum aut aquam refrigerant. Et cum hoc ter fecere, juncea crate sub diu siccant sole lunaque. Haec enim candorem facit, sol siccat, et, ne liquefaciat, protegunt tenui linteo. Candidissima vero fit post insolationem etiamnum recocta. Punica medicinis utilissima. Nigrescit cera addito chartarum cinere, sicut anchusa admixta rubet, variosque in colores pigmentis trahitur ad reddendas similitudines, et innumeros mortalium usus parietumque etiam et armorum tutelam. Cetera de melle apibusque in natura earum dicta sunt.'[1] 'Wax is made from honeycombs out of which the honey has been pressed. Having been first cleaned with water and dried for three days in the shade, the combs are on the fourth day melted on the fire in a new earthen vessel with water enough to cover them, and then strained off in a wicker basket. The wax is again boiled in the same pot with the same water, and is poured into cold water contained in vessels the interior of which has been smeared all over with honey. The best wax is that called Punic, the next that of a very yellow colour with the smell of honey,

[1] xxi. 49.

which, though of Pontic origin, is unaffected, I am surprised to find, by its poisonous honey. Next best is the Cretan, for it has a large proportion of propolis of which we spoke when treating of bees. Next to these is the Corsican, which, as it comes from the box-tree, is believed to have medicinal qualities. Punic wax is prepared as follows: Yellow wax is exposed to the outside air for some time, then boiled in sea-water taken from the open sea, with nitrum added. Then the flower, that is, the whitest part, is skimmed off and poured into a vessel containing a little cold water. Again it is boiled in sea-water by itself, then the vessel, or at least the water, cooled. When this has been done three times the wax is dried in the open air on a mat of rushes in the light of the sun and the moon. For the latter makes it white, the sun dries it, and lest it should melt it is covered with a thin linen cloth. It will become exceedingly white if it is boiled again after the exposure to the sun. Punic wax is the most useful for medicines. Wax becomes black when papyrus ash is added to it. It becomes red when mixed with alkanet; with pigments it is made to assume various colours in order to represent true likenesses of objects. It is useful to men in numberless ways, even serving as a protection for walls and weapons. Other particulars concerning bees and honey we have stated when speaking of the nature of these insects.'

It is evident from this passage that it was customary to mix pigments with wax, and the coloured mass was used for modelling portraits, and wax was used as a protective coating for walls and armour. It is necessary here, however, to make a somewhat long digression in order to consider the statements made by Pliny about Punic wax and the method of purifying it with nitrum. A description of nitrum is given by Pliny in xxxi. 46. The description is obscure, and he may well be referring to more than one substance, but we are on the whole justified in identifying it with a natural efflorescence found in some of the desert regions on the Mediterranean, and proving to be a double salt of carbonate and bi-carbonate of soda. For experimental purposes, therefore, we can replace it by ordinary sodium carbonate, which will, however, be the more powerful alkali of the two.

Fée[1] and John[2] both rightly concluded that the treatment with soda and salt water would have no effect on the purification of the wax, and the matter might be left here if Herr Berger had not revived an old idea in a new form, namely, that a special medium of wax and soda was used in classical times, consisting of a wax-soda soap or emulsion, an idea which he bases largely on this passage in Pliny.[3]

[1] Fée: *Sur la Matière Médicale et la Botanique de Pline.*

[2] John: *Malerei der Alten*, Berlin, 1836, p. 204.

[3] 'Der Zusatz von Nitrum bezweckt die Verseifung oder nur Emulgierung des Wachses,' etc. *Die Maltechnik des Alterthums*, vol. i. p. 100.

It is impossible to give all the references in Berger dealing with this subject, as the principal object of the whole book is to prove that this medium alone, or in combination, was used for panel and wall painting.

In the first place, therefore, it is necessary to consider whether the process described by Pliny would result in the saponification of the wax. Beeswax consists principally of myricyl palmitate with about ten per cent. of cerotic acid. Myricylic alcohol is insoluble in water, and the soda salts of cerotic acid are also insoluble. While, therefore, beeswax readily saponifies in an alcoholic solution of soda, it is not probable that it would be saponified by a solution of soda in water. Moreover, in the British Pharmacopœia the test for the purity of beeswax is to heat it with a solution of soda in water. If any soap is formed this shows the presence of adulteration with fats. This test might be regarded as conclusive, but the question as to saponification is so important that I determined to test the matter further. I therefore took some beeswax of undoubted purity, of which I knew the history, and boiled it under an inverted condenser with a saturated solution of carbonate of soda for twelve hours. At the end the whole mass was treated with ether, and both the water solution and the solution in ether examined. Neither contained the slightest indication of a soap having been formed. The question

of saponification may be considered therefore as finally settled.

We shall next consider the question of the formation of an emulsion. Herr Berger states quite correctly that when beeswax is melted in pure water and then shaken up, no emulsion is formed, but that the introduction of a small quantity of soda at once makes it possible to form an emulsion in this way. The question therefore is whether Punic wax, prepared in the way described by Pliny, can be considered to be an emulsion of beeswax and soda solution. If the beeswax is merely boiled with the soda without shaking up, it collects on the top and very little emulsion is formed. If the emulsion is formed by shaking up, prolonged warming in a water bath causes the wax to separate again and float on the top. If, then, we suppose a considerable quantity of wax to be boiled in this way with soda, we should expect to find the bulk of it collecting on the top, just as when it is boiled with water.

Following the description by Pliny, we find that he states that the whitest part of the wax is skimmed off, is poured into cold water, and is bleached in the open air upon a mat of rushes. It is quite evident that this bleaching could only be applied to dry, solid beeswax, which could not possibly therefore be an emulsion as supposed by Berger. It might certainly accidentally contain a little soda mechanically caught

in the wax. But the boiling with sea water alone would serve to remove this accidental impurity, and as I have shown no soda is chemically combined with it. The resulting product will therefore simply be bleached beeswax, and will not differ from the wax prepared with water alone.

In order to strengthen the view that Punic wax was something quite different from ordinary wax, and was specially used for treating walls, Berger points out that when talking of ordinary encaustic Pliny speaks of wax, but, when discussing wall painting, he speaks of Punic wax,[1] and that similarly Vitruvius, in speaking of the treatment of walls with wax, speaks of Punic wax.[2]

In Mayhoff's edition of Pliny the word is given as *punica*. But in the corresponding passage in Vitruvius (vii. 9) we find that Rose, in his later edition alters the *punica* of his former edition to *pontica*. From a note to the text we find that in the oldest MSS. (see below, p. 78, note) the word appears, not as *punica*, but as *pumica*. Rose refers us further to his edition of the works of the physician Theodorus Priscianus, where we find the following note: 'pontice fere legitur ut pomice, unde ponice, punice, quod delendum.' In another note on 'cera pontica': 'falsa lectio punica' (in certain MSS. of Theod. Prisc.) 'ut etiam apud Plinium alibi.'

[1] Pliny, xxxiii. 40. [2] Vit. vii. 9.

It is evident that whether Rose is right in his reading or not, no argument can be based on the use of a word which a commentator of the authority of Rose does not consider to be a correct reading.

It will also be noted that Pliny states that Punic wax is best for medicinal uses, yet when discussing the medicinal use of wax[1] he speaks simply of wax without the word Punic. If he regarded Punic wax as something quite distinct from ordinary wax, and used the word Punic whenever he wishes it and not ordinary wax to be used, it is difficult to understand why he does not do so in the chapter on the use of wax for medicinal purposes.

If we inquire further from what source this idea of the use of an emulsion of wax and soda comes, we find two sources.[2]

In the *Hermeneia*, obtained by Didron from the Monastery of Mount Athos, and supposed to be written in the sixteenth century, claiming to be the teaching of a painter of the eleventh or twelfth century, a receipt is given for a medium consisting of equal quantities of potash lye, wax, and size melted on the fire. While this medium is mentioned, the evidence to be drawn from the *Hermeneia* as a whole is in favour of egg being the customary medium.[3]

[1] xxii. 55.

[2] Berger's receipt for what he calls Punic wax will be found on page 100 of the *Maltechnik des Alterthums*, vol. i.

[3] Didron: *The Hermeneia*, a MS. found by him at Mount Athos.

A similar receipt exists in the MS. of Jehan Le Bègue,[1] which begins thus: 'Prenez une livre de chaux et douze de Flandres puis prenez eaue boulant,' etc. This receipt refers to the presence of potash, only if we accept Mrs. Merrifield's emendation of 'Cendres' for 'Flandres.'

Such a medium would in reality be a glue medium with wax intermixed. It is hardly necessary to point out that a medium containing free soda or potash is very objectionable, and would probably soon result in the destruction of the picture.

But it is not necessary for us to discuss the merits or demerits of this medium. It is sufficient for our purpose that it appears for the first time in MSS. which are not earlier than the end of the fourteenth or beginning of the fifteenth century, and that therefore they have no bearing on the subject we are discussing, namely, the medium used before and up to the end of the first century of the Christian era.

Sufficient has been said to show that Pliny clearly does not describe such a preparation, and that we may dismiss it as one of the ingenious fictions that have so long obscured the scientific investigation of the classical methods of painting. I shall have to refer to it again, however, when discussing Herr Berger's theories about methods of wall painting.

[1] Mrs. Merrifield, *Ancient Practice of Painting*, vol. i. p. 307.

Having now cleared the way we can proceed to consider the actual information given by Pliny about pictures on panel, linen, or parchment, leaving the question of wall painting for later consideration.

In the first place, it is necessary to consider the evidence in favour of two mediums having been used, one by painters 'with the brush,' and the other, wax, 'with the cauterium and the brush.'

In the 34th chapter of the thirty-fifth book. Pliny begins by stating that he is going to enumerate as briefly as possible the more eminent among painters, 'Nunc celebres in ea arte quam maxima brevitate percurram,' etc. After discussing in this chapter the early beginnings of painting, and in the next chapter the institution of pictorial contests at Corinth and Delphi, he begins to describe the great painters in detail in the 36th chapter, and speaking of Apollodorus of Athens, says:—'Hic primus species exprimere instituit primusque gloriam penicillo jure contulit.' 'He was the first to depict objects as they really appeared, and he first conferred a just glory on the brush.' And again further on, speaking of Zeuxis of Heraclea, he says: 'Ab hoc artis fores apertas Zeuxis Heracleotis intravit olympiadis LXXXXV anno quarto, audentemque jam aliquid penicillum—de hoc enim adhuc loquamur—ad magnam gloriam perduxit,' etc. 'Through the gates of art thrown open' (by Apollodorus), 'Zeuxis of Heraclea

passed in the fourth year of the 95th Olympiad, and brought the brush—for it is of the brush we are still speaking—to the great glory at which it was already aiming.'

He is evidently speaking here of artists who painted with the brush. This, however, is not conclusive evidence that they were not painters in wax, as we shall find that he tells us that one method of painting in wax was with the brush. But we shall find, as we follow up the quotations, that he is evidently referring to a school of painters who used a different medium from the wax medium. These pictures with this medium were evidently painted on panels, as frequent references to panel, one of which has already been quoted, are made in this chapter.

The pigment mixed with this medium could be easily removed from the picture with a sponge, because he tells us that Protogenes, not satisfied with his success in painting the foam on the mouth of a dog, frequently removed the paint with a sponge, and at last threw the sponge at the picture, when the wet colour on the sponge was thus replaced on the picture and gave the required effect.

This story certainly suggests the use of a medium soluble in or mixed with water, though it might equally happen in the case of oil painting. It could not have happened with a wax medium, except in

a very hot climate like that of Egypt during the summer months. We also know from this chapter that the pictures of this school of painting were destroyed by damp.

In chapter 37, Pliny proceeds to discourse on painters of an inferior rank, who, however, were 'painters with the brush.' He says, 'Namque subtexi par est minoris picturae celebres in penicillo:' 'It is well to add some mention of those who won fame by the brush in a minor kind of painting.'

In this chapter he mentions the painting of stage scenery and the painting of walls, so that there is clearly no distinction in his mind between the method used for these three purposes, namely panel pictures, stage scenery, and wall decoration: they are all 'painters with the brush.'

It is also in this chapter that the method of varnishing pictures invented by Apelles is mentioned.

In chapter 38 a method of frightening birds by picture of a dragon painted on parchment is described.

In chapter 39 he discusses who was the inventor of painting in wax, and then[1] proceeds to give an account of famous painters in this medium. Speaking of Pausias, who had been taught encaustic painting, he says that he retouched 'with the brush' some walls at Thespiae, but was not successful, as this kind of painting was evidently not in his line.

[1] Pliny, xxxv. 40.

'Pinxit et ipse penicillo parietes Thespiis, cum reficerentur quondam a Polygnoto picti, multumque comparatione superatus existimabatur, quoniam non suo genere certasset.' 'He also painted with the brush some walls at Thespiae when they were being repaired. They had been previously painted by Polygnotus, and the work of Pausias was considered to suffer much by comparison, for he was contending in a style not his own,' thus apparently indicating that wax painting was not the method usually used for painting on walls.

The next sentence, however, throws some doubt on this conclusion, as Pliny says:—'Idem et lacunaria primus pingere instituit, nec camaras ante eum taliter adornari mos fuit; parvas pingebat tabellas, maximeque pueros.' 'He first started painting coffer-ceilings, nor had it been the custom before him to decorate arched roofs in this way. He usually painted small pictures, chiefly of children.' Unless we are intended to draw a distinction between instituo and pingo, and to understand that while he introduced the decoration of ceilings, not necessarily *executed* by his own hand, he *painted*, with his own hand, on panel small pictures of children.

Further light is thrown on the process of painting in wax by the following quotation:—'Hoc aemuli interpretabantur facere eum quoniam tarda picturae ratio esset illa. Quam ob rem daturus ei celeritatis

famam absolvit uno die tabellam, quae vocata est hemeresios, puero picto.' 'This his rivals interpreted as due to the slowness of that manner of painting. Wherefore wishing to gain the reputation of celerity he completed a picture in one day. It was a portrait of a boy, and was called "a day's work."'

So tedious a process, in which the execution of a picture, it is to be presumed of small size, in a single day was regarded as a remarkable feat, is, apart from other reasons to be considered later, further evidence that the wax technique was not convenient for large surfaces of walls.

Further on in this chapter, after mentioning various painters and their principal works, Pliny says:—'Hactenus indicatis proceribus in utroque genere non silebuntur et primis proximi: Aristoclides, qui pinxit aedem Apollinis Delphis.' 'Though I have so far mentioned only the leading painters in each branch, I will not pass over in silence those of the second rank: Aristoclides who painted the temple of Apollo at Delphi.'

We have here a further proof that there were two schools of painters, those who painted 'with the brush,' and those who painted in wax.

It is not clear, however, whether in the remainder of the chapter Pliny is speaking still only of the wax painters or including both schools.

In confirmation, in the table of contents we find as follows:—

'Qui penicillo pinxerint
De avium cantu compescendo
Qui encausto cauterio vel cestro vel penicillo pinxerint.'

'Those who painted with the brush
On silencing the singing of birds
Those who painted in encaustic with the cauterium, the cestrum, and the brush.'[1]

These three methods of encaustic painting will next have to be considered, but the distinction is clear between those who painted with the brush, and those who painted in encaustic with the brush. The story about the birds divides for us the part of the book dealing with the one kind from the part dealing with the other kind of painting.

In the 41st chapter the different kinds of wax painting are described, and in the 42nd chapter a special method of painting or dyeing cloth used in Egypt, and so the chapters on painting end.

It is, I think, clearly established by these quota-

[1] I have adopted the reading 'encausto cauterio' restored by Mayhoff on the authority of the Codex Bambergensis, the most ancient extant. It was Sillig who altered 'cauterio' into 'aut ceris,' wishing to harmonise the Index with the Text xxxv. 41, where it runs '*cera* et in ebore cestro.' For Mayhoff's proposed emendation of xxxv. 41, see below, p. 60.

tions that the painters in classical times painted on panel as well as on walls, and that there were two quite different methods of painting panel pictures, the one defined by Pliny as 'painting with the brush,' and the other painting with wax.

While the evidence is not conclusive, it is on the whole in favour of the view that Pliny regarded 'painting with the brush' as equally suitable for panels, large canvas pictures, scenery, and wall painting, while the painting in wax was confined to panels, probably of small size, and that the process was recognised as a tedious one unsuitable for large surfaces.

The medium used for 'painting with the brush' is nowhere described, but the story of the use of the sponge certainly suggests that it was a medium which could be mixed with water.[1] The fact that the medium is not mentioned is strongly in favour

[1] If the following simile of Plutarch's may be pressed so far, I would suggest that we find in it strong evidence of the use of a water medium for panel pictures, and that it agrees with Pliny's statements as to the destruction of paintings. It is unlikely that Plutarch is alluding to buon fresco, which is extremely durable: *ἡ γὰρ ὄψις ἔοικε τὰς μὲν ἄλλας φαντασίας ἐφ' ὑγροῖς ζωγραφεῖν, ταχὺ μαραινομένας καὶ ἀπολειπούσας τὴν διάνοιαν, αἱ δὲ τῶν ἐρωμένων εἰκόνες ὑπ' αὐτῆς οἷον ἐν ἐγκαύμασι γραφόμεναι διὰ πυρὸς εἴδωλα ταῖς μνήμαις ἐναπολείπουσι κινούμενα καὶ ζῶντα καὶ φθεγγόμενα καὶ παραμένοντα τὸν ἄλλον χρόνον.* 'For, indeed, sight seems to paint all other fancies on a wet ground, so swiftly do they fade and leave the mind, but the images of those beloved, painted by it as it were in encaustic by means of fire, leave behind in the memory shapes which move and live and speak and remain for ever.'—*Amatorius*, 759 C.

of the conclusion that it was either egg, gum, or glue, or any one of these according to the fancy of the artist. These mediums are so obvious that it might well never occur to a writer to mention them. The same omissions are to be found in later MSS., where the special methods and materials for laying on gold, etc. etc., are mentioned, but it does not occur to the writer to say with what he mixed his colours.

Of the three mediums mentioned, the early and almost universal use of egg as a medium in Italy and elsewhere, and the Byzantine traditions, point to this being most probably the medium used in classical times.

There is no need, however, to imagine that there is any mystery in the matter. These substances were known, just as they were known in the fifteenth century, and were used probably one for one purpose and one for another, just as they were used in later times.

We find, for instance, that in order to prepare a proper painting surface the Egyptian of the nineteenth dynasty covered the wood of the coffin with a gesso of chalk and glue, and we find Cennino Cennini, in the fifteenth century, directing panels to be prepared in exactly the same manner, while the directions given by Pliny for using white of egg in gilding agree with the directions given by Cennino Cennini. It is surely

reasonable, therefore, to suppose that before the revolution produced in painting by the introduction of the use of drying oils, artists made use of the three obvious mediums at their command—egg, glue, and gum, and that probably just as egg was found to be the most suitable in the fifteenth century, so it was found to be the most suitable in the first century.

At any rate, until we have further information, there can be no justification for devising mediums, made of mixtures of wax and soda, for which there is not a particle of historical evidence, and for exercising our ingenuity in getting away as far as possible from the obvious.[1]

We have next to consider what information can be derived from Pliny about painting in wax.

Some writers have suggested that the wax medium was the wax soda emulsion, others have suggested that the wax medium used by Greek painters was an emulsion of wax in turpentine, or of wax in a mixture of drying oil and turpentine, or of a drying oil, varnish, and turpentine. Such mediums, on the purely negative evidence which we have obtained from a study of Pliny, are quite inadmissible.

We shall have to consider three different chapters of the thirty-fifth book in order to understand clearly

[1] Herr Berger believes this medium to have been a wax soda or potash emulsion.

what Pliny has to say about encaustic painting. In the 31st chapter, after discussing the various pigments, he says: 'Ex omnibus coloribus cretulam amant, udoque inlini recusant purpurissum, Indicum, caeruleum, Melinum, auripigmentum, Appianum, cerussa. Cerae tinguntur isdem his coloribus ad eas picturas, quae inuruntur, alieno parietibus genere, sed classibus familiari, jam vero et onerariis navibus, quoniam et pericula expingimus, ne quis miretur et rogos pingi, juvatque pugnaturos ad mortem aut certe caedem speciose vehi.' 'Of all colours those which love a chalk ground and refuse to be laid on a damp surface are purpurissum, indigo, caeruleum, Melian white, orpiment, Appianum, and white lead. Waxes are stained with these same colours for pictures in encaustic, a kind of painting unsuitable for walls, but commonly used for ships of war, and now also for merchant ships. Since we paint even those vehicles of danger, no one should be surprised if we also paint our funeral piles, and like to have gladiators conveyed in splendid carriages to death or at least to carnage.'

The first part of this chapter dealing with the pigments which cannot stand a wet surface we shall consider later.

We have it here clearly stated that all these pigments were used for colouring wax for encaustic painting, and that the process was not suitable for

walls, but was used to decorate ships. As we know from the chapters already quoted, encaustic painting was not confined to ship decoration. We have here a confirmation of the former probable conclusions that encaustic was seldom used, at any rate in the time of Pliny, for wall decoration, but we know from the 64th chapter of the thirty-sixth book that Agrippa had the potter's work in the baths painted in encaustic (figlinum opus encausto pinxit in calidis, reliqua albario adornavit). This must have been an ornamental terra-cotta work introduced as part of a scheme of wall decoration and painted either before or after it was put in position. Evidently Pliny regarded this as a proof that he would have spared no expense, and would therefore have used mosaic if it had been invented in his time. This is a close approach to treating the whole wall with encaustic, if the terra-cotta was painted after erection. It will be evident, as we proceed to consider in more detail the nature of the process, that while not impossible to apply to walls, the process would be difficult.[1]

[1] In the inscription from Athens, which records the building accounts of the Erechtheion, occurs the entry of a sum paid to the encaustic painters for having painted the cymatium on the epistylium of the interior: ἐγκαυσταῖς τὸ κυμάτιον ἐγκέαντι τὸ ἐπὶ τῷ ἐπιστυλίῳ τῷ ἐντός (Cecil Smith, article 'Pictura' in Smith's *Ant.*). That encaustic was used at a later date for ceiling decoration seems clear from the statement in Procopius that Justinian, on restoring the imperial palace, had the ceilings decorated, not with paintings in melted wax, τῷ κηρῷ ἐντακέντι τε καὶ διαχυθέντι, but with mosaic.

After discussing the artists who painted 'with the brush,' he speaks as follows in chapter 39 :—

'Ceris pingere ac picturam inurere quis primus excogitaverit, non constat. Quidam Aristidis inventum putant, postea consummatum a Praxitele; sed aliquanto vetustiores encaustae picturae exstitere, ut Polygnoti et Nicanoris, Mnesilai Pariorum. Elasippus quoque Aeginae picturae suae inscripsit *ἐνέκαεν*, quod profecto non fecisset, nisi encaustica inventa.' 'It is not agreed who first thought of painting with wax colours and making a picture by heat. Some think the art was invented by Aristides and afterwards brought to perfection by Praxiteles. But there are in existence encaustic pictures of a date somewhat earlier than theirs, such as those by Polygnotus, and by the Parians Nicanor and Mnesilaus. Elasippus also wrote on his pictures at Aegina *ἐνέκαεν*, which he certainly would not have done unless encaustic painting had been invented.'

In the former chapter we have had the coloured wax associated with the verb *inurere*. In this chapter *inurere* is brought into association with encaustic, and *ἐγκαίειν*, so that there can be no doubt of their being used to describe the same process of painting.

The opening sentence of this chapter, 'Ceris pingere ac picturam inurere,' has given rise to serious

misconception as to the probable nature of the process. It has been assumed by many writers on this subject, of whom Eastlake and Donner are examples,[1] that this means that the painting process was done first, and the heating of the surface done afterwards. They have therefore tried to devise mediums which would on the one hand be fluid under the brush when cold, and could be subsequently fused by heating without injuring the picture. I do not like to say that to produce a picture under such conditions is impossible, but the experiments I have made with wax dissolved in turpentine, and the attempts I have afterwards made to fuse the surface, do not encourage me to believe that anything can be done in this way. Unless the wax is in great excess the fusing process is quite useless as a method of attaching more firmly the comparatively easily removed wax turpentine painting, and if it is in sufficient excess to fuse, the picture itself is inevitably injured. Such wax turpentine painting, even after subsequent heating, does not make nearly so durable a job as starting with the fused wax right away. The introduction of oil instead of turpentine increases the difficulties of the operation.

There is no need, however, to translate this sentence as if the 'inurere picturam' *followed* the

[1] Eastlake, *Materials for History of Oil Painting*, p. 152. Donner, *Mitteil. des archäol. Inst. Rom.*, Abtheil. xiv., 119.

process of 'ceris pingere,' as Mayhoff[1] has correctly pointed out. Without entering into the subtilties of the various uses of *ac*, it is sufficient for our purpose to state that *ac* denotes a closer connection than that implied by *et*, and can be used therefore to represent the same idea in a slightly different form. This sentence may be therefore regarded as an attempt to give a complete description of the process of encaustic painting, by mentioning that it was a process for painting, it involved the use of wax, and it also involved the heating of the wax during the painting process.

Moreover, Mayhoff points out that if Donner's view be accepted the passage should run, 'Ceris pingere pictaque inurere.'

The correct translation of *ἐγκαίω*, and therefore of *inuro* is difficult. Mayhoff, in the communication to Herr Berger, which has been already referred to, considers that the correct translation is not 'einbrennen,' but rather 'aufbrennen'—*i.e.* heiss auf den Malgrund auftragen.[2]

At the end of the section dealing with encaustic painters, the following chapter occurs[3]:—'Encausto

[1] Communication to Ernst Berger, printed in *Die Maltechnik des Alterthums*, vol. i. p. 189.

[2] This view is confirmed by the following allusion to the process in Plutarch: *εἰκόνες ἐν ἐγκαύμασι γραφόμεναι διὰ πυρός*—'images painted in encaustic by means of fire.'—*Amatorius*, 759 C.

[3] Pliny, xxxv. 41.

pingendi duo fuere antiquitus genera, cera et in ebore cestro, id est, vericulo, donec classes pingi coepere. Hoc tertium accessit resolutis igni ceris penicillo utendi, quae pictura navibus nec sole nec sale ventisve corrumpitur.' 'In ancient times there were [only] two methods of encaustic painting, with wax and on ivory with the cestrum, that is with a sharp pointed tool, until it became the custom to paint ships of war. Then the third method was added, that of melting the wax colours with fire and laying them on with a brush. This kind of painting applied to ships is not injured by sun, wind, or salt water.'

If we include along with this chapter the statement made in the contents, 'qui encausto cauterio vel cestro vel penicillo pinxerint,' we have evidently here three methods of encaustic painting—with wax, using the cauterium, on ivory, using the cestrum, and again with wax, using the brush.

Professor Mayhoff has suggested an amended reading of this chapter, replacing the word 'cera' with the word 'cauterio,' thus making the passage run, that there were two ancient methods, 'one with the cauterium, and the other with the cestrum on ivory.'

Whether we accept this amended reading or not, there is no dispute as to what one of the three methods was. The cauterium is the name used for the branding-iron for cattle, and for the instru-

ment used in surgery for performing cauteries. It is therefore a hot metal instrument, with which the coloured sticks of wax could be moulded and modelled on the panel into the required picture. The only other instrument mentioned in this connection is the *ῥαβδίον*, which Mayhoff, with great probability, identifies with the cauterium.

The painting on ivory with the cestrum remains up to this day an unexplained process. Many ingenious suggestions have been made, but they are merely suggestions unsupported by evidence. A very complete discussion of possible explanations is to be found in Herr Berger's *Maltechnik*, for which the reference is given.[1]

Leaving then the painting on ivory with the cestrum unexplained, we come to the third process, namely, painting with the brush.

Pliny's description of this process is perfectly clear and definite—'hoc tertium accessit, resolutis igni ceris penicello utendi'—and yet most of the writers on this subject have refused to accept the process as described by Pliny. Eastlake, for instance, at once dismisses it by saying that it is impossible to paint with melted wax alone, as it cools too rapidly on the panel.

The discovery, however, of actual wax portraits by Flinders Petrie at Hawara, painted apparently in the

[1] Vol. i. p. 223.

second century, and very little later than the time we are considering, threw fresh light on the matter.[1] Many similar pictures have since been discovered, and they are remarkable for the fact that in many both the modelling process with the cauterium and work with the brush can be seen side by side.

Flinders Petrie was, I believe, the first to point out that in Egypt, for many months, wax remains melted in the sun, and that therefore far from presenting difficulties from too rapid cooling on the canvas, the difficulty would be the other way, and he mentions a particular case where the eye of a portrait has got smudged by a careless finger.[2]

The ease, therefore, with which melted wax can be used as a medium for the brush is a question of temperature; as we move from Egypt to Greece, from Greece to Rome, and from Rome to France, the difficulty would increase, and special methods would have to be adopted.

The experiments on wax-painting made by Herr Berger are of great interest, and he has doubtless correctly identified the spoon-like instruments found at St. Médard, with the cauterium, but on this question of brush work with melted wax his account of his experiments is not clear. He seems

[1] *Hawara, Biahmu, Arsinoe*, Flinders Petrie. The Leadenhall Press, 1889.

[2] *Ibid.*, p. 19.

DIRECT PHOTOGRAPH FROM ORIGINAL IN NATIONAL GALLERY OF PORTRAIT FROM HAWARA (FLINDERS PETRIE).

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to have used a medium of wax, resin, and nut oil, and to have varied the proportion, and he does not state what these proportions were. The introduction of a drying oil is, in the light of the information we have derived from Pliny, quite illegitimate. The introduction of a very small quantity of olive oil, especially if counteracted by hardening the wax with a resin, produces a mixture which is firm when cold, but the addition of an appreciable quantity of olive oil results in a soft mess which will not harden. If the olive oil is replaced by a drying oil, then the ultimate hardening of the surface depends on the oxidation of the oil, and to all intents and purposes we are merely painting an oil picture with the superfluous introduction of wax and resin.

Pliny says the picture is to be painted with the brush with wax melted over the fire, and speaks of no other admixture. What we wish to know, is whether this process is practicable in more temperate climes. We have seen that in Egypt there would be no difficulty. I determined therefore to experiment upon this point with the assistance of Mr. Thomson, a young art student.

The beeswax mixed with the pigments were kept melted in little pots resting on a hot plate. The hot plate also served for mixing tints. Ordinary artists' brushes were used, and the painting done on wooden panels. The secret of success proved to be

the warming of the panel. This can be done either by holding near the surface a lump of hot metal, such as a soldering bolt, and then painting on the surface thus warmed, or better, by warming the panel over a gas flame or in front of a fire. The painting must be executed rapidly and with certainty. There is no difficulty in over-painting or in keeping the panel just warm enough to enable the colour to be freely laid on without fusing what has already hardened.

Probably no such warming of the panel is necessary during the summer either in Greece or Rome.

Just when about to commence these experiments I found that Mr. Burns had many years before devoted a year to experimenting on painting with melted wax. The powdered pigments mixed with the wax were kept in front of a fire in bottles, and the picture was painted on a canvas which was kept sufficiently warm by placing it so that the back was exposed to the warmth from the fire.

The following photographs of one of the experiments made by Mr. Thomson and myself, and the beautiful work by Mr. Burns,[1] prove conclusively that there is no difficulty in painting with melted wax with the brush even in northern countries. The process does not lend itself to glazing, but if the finished work is polished with a piece of linen, it has all the appearance of an oil picture, while either thin washes or

[1] See Frontispiece.

PAINTING IN MELTED WAX BY MR. THOMSON.

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impasto painting are at the command of the artist.

The remains found at St. Médard throw further light on this question. For a detailed description of them the reader is referred to Berger's *Maltechnik* vol. i. page 211.

Among the contents of the vessels was found beeswax, and a mixture of beeswax and resin.[1] Some long thin metal rods, with a shallow spoon at one end and a flattened portion at the other, have been supposed by Herr Berger, with every probability, to be specimens of the cauteria used at that time. There was also a bronze box, measuring 12 cm. by 20 cm. and 10 cm. deep, and divided into compartments which are covered with silver lids, stamped full of square holes, and thus forming a silver grid over the top of the box.

Herr Berger suggests, with every probability of truth, that this box was filled with glowing charcoal to melt the wax colours and warm the cauteria. It would, however, serve another purpose still better, with its large hot surface covered with the silver grid, namely, the warming of the panel at intervals during the process of painting.

[1] The fatty acids found in one vessel by Chevreul are doubtless due to the oxidation of the beeswax. Herr Berger's *Maltechnik*, vol. i. p. 268, and again the experiments by Georg Buchner, Munich, p. 273, which explain Chevreul's results.

In conclusion, the significance of the resin mixed with the wax does not seem to have been completely grasped. By dissolving a dry resin in the wax we raise the melting point, and make it much more difficult to manipulate.

But by mixing it with the semifluid pine balsam existing in quantities in the surrounding forests, the painter of St. Médard would lower the melting point of the wax, and make it easier to manipulate. The resulting medium would also be more translucent, and ultimately harder than the wax alone, though taking longer to become firm.

Experiments I have tried with beeswax and Canada balsam have clearly demonstrated the statements made above. In the course of time the volatile turpentine of this balsam would evaporate, and the final result would be the mixture of wax and resin, free from the original turpentine found at St. Médard.

It seems a very natural development of the technique in more northern lands, where pine balsams were plentiful, and where the high melting point of the wax seriously increased the difficulties, to use this mixture. The wax removes the stickiness which the balsam would have if an attempt were made to use it alone.

To sum up, the statements made by Pliny, the

discoveries of wax pictures at Hawara, the materials found in the grave at St. Médard, and Herr Berger's experiments and my own combine to give us a complete picture of this old technical process about which so much speculation has been indulged in.

The origin of the technique from two sources, modelling in wax and tarring ships, is clearly shown in Pliny's account of the process; the two resulting methods of painting with the cauterium and the brush are also correctly and clearly described by Pliny, and the two methods are found side by side in the pictures from Hawara.

Finally, the difficulties that have been supposed to exist are completely removed when we allow for the climate of the region where wax painting originated, and when we find how easy it is to overcome the difficulties by warming the panel. The introduction of pine balsam and the bronze box, with the painting and modelling tools found at St. Médard, complete the picture, and show us a modification due to northern climes of the pure and simple wax medium. Large panels could of course only be painted in warm weather, or by heating them with a hot bolt or brazier. Wall surfaces could probably be directly painted in a warm climate, but in a colder climate would require to be heated with a brazier. Vitruvius describes the use of such a brazier for heating walls which were being varnished with

beeswax. Varnishing is a simpler matter than painting, and I am disposed to agree with Pliny that the process was not suitable for wall painting in Rome, though possibly in Egypt and in Greece.

We shall now proceed to consider the methods used for painting on walls.

Before looking at the information to be obtained from Pliny and Vitruvius, we must first shortly consider the possibilities in the use of mediums for wall painting which the information already collected brings before us.

In the first place we have the possibility that the pigments mixed with water were painted on to the wet plaster. This is the process known as Buon Fresco, and is probably the simplest and most obvious form of wall painting.

Or before being laid on the wet plaster the pigments might be mixed with gum, glue, or egg; or again, the plaster might be allowed to get dry, and then the medium might be used to attach the pigments to the dry surface.

In addition to these water mediums there is another possible one, namely, milk. The caseine in milk forms a very strong and durable cement with lime, and consequently milk[1] is a very suitable medium for wall painting.

Besides these water mediums the wall might be

[1] Pliny, xxxvi. 55; xxxv. 56.

painted in encaustic, though this would evidently be a troublesome process, and finally the wall surface, painted by any of these methods, might be varnished with wax to preserve and polish the surface.

There is evidently no reason why only one of these methods should be used, or why more than one method should not be combined with another, just as we find Cennino Cennini directing work to be painted in buon fresco, but also directing it to be finally finished, when dry, with egg tempera.

A wall, for instance, might well be begun in buon fresco, painted with a size or egg medium, and finally varnished with wax.

There is no reason to suppose that only one of these methods was selected and always used, and therefore it is not surprising that authorities should differ or that the results of analysis should vary.

The question, however, that has recently been reopened by Herr Berger is whether the process known as buon fresco was ever used, and whether the process which is called stucco lustro was not the universal process.

I have not included stucco lustro among the possible processes which I have suggested above, but we shall have to consider it in due course.

The principal authority whom we shall have to consult in this matter is Vitruvius, but before

doing so we shall consider first the statements made by Pliny which throw light on the subject. We have already noted one of these, in which he says definitely that encaustic painting is not suitable for walls. In the opening of the same chapter, which I here requote, he mentions certain pigments as not suitable for painting on a wet surface.

'Ex omnibus coloribus cretulam amant udoque inlini recusant purpurissum, Indicum, caeruleum, Melinum, auripigmentum, Appianum, cerussa.' This sentence is quite meaningless if it is intended to apply to water only, but if it means a wet surface of lime it becomes intelligible, as many of these pigments would be destroyed by wet lime. The reference to wall painting in the next sentence makes this meaning all the more probable.

But this chapter must be considered in conjunction with another chapter, xxxiii. 56, where he is describing different varieties of ochre. One variety he calls marmorosum sil, and then goes on to say, 'Hoc autem et Attico ad lumina utuntur, ad abacos non nisi marmoroso, quoniam marmor in eo resistit amaritudini calcis.' 'This and the Attic sort they use for high lights; for panelled spaces none but the marmorean kind, because the marble in it resists the acridity of the lime.'

If this mention of a special ochre which resists lime be read along with the mention of the special

colours which do not resist a wet surface, I think the combined evidence shows clearly that he is speaking in both cases of the action of wet lime, and therefore is familiar with the process of painting on wet plaster. There is, however, another interesting point to be noticed in the last quotation. One of the arguments against the use of buon fresco in classical times is the large area covered at one time by many of their wall paintings, as it is held that buon fresco involves the treatment of limited areas at a time, and therefore joins should be visible. We shall have to consider these matters presently at greater length, but in this chapter Pliny distinctly suggests, by the use of the word *abacus*, that limited spaces or panels only are painted on the wet plaster, and that consequently a pigment which could resist wet lime was selected for the painting of such limited areas. It may well have been that, while this wet painting was used for important decorative pictures, the cheaper decorative colouring round the margins was painted on dry plaster in a less durable manner.[1] We shall find some remarks of Vitruvius bearing on this point. In the meantime the evidence is clear and unmistakable from Pliny that he was familiar with the operation of painting on wet plaster. This does not, however, exclude the possibility of some medium

[1] Wiegmann holds this view : *Die Malerei der Alten.*

like size being mixed with the pigments laid on this wet surface.

We shall next consider the information to be obtained from Vitruvius.

In the seventh book of his work on Architecture, after describing the making of concrete floors and the preparation of lime, and the plastering of arches and cornices, he proceeds as follows, in the middle of the 3rd chapter :—

'Coronis explicatis parietes quam asperrime trullissentur, postea autem supra, trullissatione subarescente, deformentur directiones harenati, uti longitudines ad regulam et ad lineam, altitudines ad perpendiculum, anguli ad normam respondentes exigantur. Namque sic emendata tectoriorum in picturis erit species. Subarescente, iterum et tertio inducatur. Ita cum fundatior erit ex harenato directura, eo firmior erit ad vetustatem soliditas tectorii. Cum ab harena praeter trullissationem non minus tribus coriis fuerit deformatum, tunc e marmore graneo directiones sunt subigendae, dum ita materies temperetur uti cum subigatur non haereat ad rutrum, sed purum ferrum e mortario liberetur. Graneo inducto et inarescente, alterum corium mediocre dirigatur. Id cum subactum fuerit et bene fricatum, subtilius inducatur. Ita cum tribus coriis harenae et item marmoris solidati parietes fuerint, neque rimas neque aliud vitium in se recipere poterunt.

Sed et liaculorum subactionibus fundata soliditate marmorisque candore firmo levigata, coloribus cum politionibus inductis nitidos expriment splendores. Colores autem, udo tectorio cum diligenter sunt inducti, ideo non remittunt sed sunt perpetuo permanentes, quod calx in fornacibus excocto liquore facta raritatibus evanida, ieiunitate coacta corripit in se quae res forte contigerunt, mixtionibusque ex aliis potestatibus conlatis seminibus seu principiis una solidescendo, in quibuscumque membris est formata cum fit arida redigitur uti sui generis proprias videatur habere qualitates. Itaque tectoria quae recte sunt facta neque vetustatibus fiunt horrida, neque cum extergentur remittunt colores, nisi si parum diligenter et in arido fuerint inducti. Cum ergo ita in parietibus tectoria facta fuerint uti supra scriptum est, et firmitatem et splendorem et ad vetustatem permanentem virtutem poterunt habere. Cum vero unum corium harenae et unum minuti marmoris erit inductum, tenuitas eius minus valendo faciliter rumpitur nec splendorem politionibus propter imbecillitatem crassitudinis proprium obtinebit. Quemadmodum enim speculum argenteum tenui lamella ductum incertas et sine viribus habet remissiones splendoris, quod autem e solida temperatura fuerit factum, recipiens in se firmis viribus politionem fulgentes in aspectu certasque considerantibus imagines reddit, sic tectoria quae ex tenui sunt

ducta materia non modo sunt rimosa, sed etiam celeriter evanescunt, quae autem fundata harenationis et marmoris soliditate sunt crassitudine spissa, cum sunt politionibus crebris subacta, non modo sunt nitentia, sed etiam imagines expressas aspicientibus ex eo opere remittunt. Graecorum vero tectores non solum his rationibus utendo faciunt opera firma, sed etiam mortario conlocato, calce et harena ibi confusa, decuria hominum inducta, ligneis vectibus pisunt materiam, et ita ad certamen subacta tunc utuntur. Itaque veteribus parietibus nonnulli crustas excidentes pro abacis utuntur, ipsaque tectoria abacorum et speculorum divisionibus circa se prominentes habent expressiones.'

There are so many difficult and doubtful points involved in the translation of this chapter that I now give a rendering into English which has been done with the greatest possible care, and after consultation with more than one classical scholar. This will enable us to discuss more easily the difficult passages.

'When the cornices are finished, the walls are to be trowelled as roughly as possible, and thereafter, when the trowelling is somewhat dry, over it the directions of the sand-mortar are to be so traced out, that in length it must be true by the rule, in height by the plumb-line, and the angles by the square. For thus the surface of the plaster will be faultless for pictures. When this (first coat) is slightly dry,

a second is to be laid on, and then a third. The firmer and sounder the laying on of the sand-mortar, the more solid and durable will the plaster-work be. When besides the trowelling not less than three coats of sand have been set out, applications of marble-dust[1] are to be used. This stuff is to be so tempered that in the spreading it does not stick to the trowel, but the iron comes out of the mortar clean. A coat of marble-dust[1] having been laid on and getting dry, another rather thin coat is to be applied. When this has been beaten and well rubbed, another still finer is to be put on. Thus with three coats of sand and as many of marble, the walls are so firm that they cannot crack or become defective in any way. And moreover, solidity being secured by rubbing with planes, and smoothness from the hardness and sheen of the marble, the walls will give out with great brilliance colours applied with polishings. For colours, when they are carefully laid on damp plaster, do not get loose, but are for ever permanent, for this reason, that the lime, losing all its moisture in the kiln, is so dry and porous that it readily imbibes whatever chances to touch it, and solidification taking place from the mixtures of the various potentialities whose elements or first principles are brought together, the resulting substance, of whatever it is composed, when it

[1] *i.e.* marble-dust mortar.

becomes dry, is such that it seems to have special qualities peculiar to itself. Thus plaster-work which is well executed neither becomes rough from age nor when it is washed does it give up the colours unless they have been laid on carelessly and on a dry surface. If, therefore, plaster-work on walls is carried out as above described, it will be firm, lustrous, and very durable. But when only one coat of sand and one of marble-dust are used, its thinness renders it liable to be easily broken, nor can it take on a proper brilliance from the polishings owing to its lack of substance. For just as a silver mirror when made from a thin plate gives back a wavering and uncertain image, but if made from a plate of solid temper takes on a high polish and reflects to the spectators bright and faultless images, so plastering, when its substance is thin, is not only full of cracks but also quickly decays, while that which is firmly compacted of sand-mortar and marble, when it has been rubbed with many polishings, is not only glistening but also clearly reflects to the spectators the images falling on it. Greek plasterers, indeed, use not only the above methods to make their work firm, but also putting the lime and sand together in a mortar, they have it thoroughly pounded with wooden staves by a number of men, and use it after it is so prepared. Hence from their old walls people cut out slabs and use them as panels, and those plaster slabs so cut out

for panels and mirrors have fillets in relief round them.'

Before considering this chapter as a whole, there are one or two points in the text and translation to be considered.

In the earlier edition by Rose, in speaking of the finishing processes of plastering, the word *baculorum* is used, which in the later edition is replaced by *liaculorum*, that is 'smoothing planes' instead of 'beaters.' These smoothing planes would probably not differ from the modern plasterer's trowel. Though beating the surface might be part of the earlier stages of preparation, smoothing planes would obviously be necessary for the final process.

In line 3, p. 73, the words 'cum politionibus' have been rendered 'with polishings.' This translation is justified by the repeated use of this word in this chapter and elsewhere by Vitruvius in a sense which can only be translated by the word polishings, and by its agreeing with the whole description of the nature of the process used. Herr Degering suggests that here the word refers to the material used in the mortar. The view adopted by Herr Reber[1] is that the correct translation is the colour laid on at the same time with the plaster. On the other hand Rode and Donner interpret the passage as we do. It is difficult

[1] Reber, *Des Vitruvius Zehn Bücher über Architektur*, Stuttgart, 1865.

to reconcile Reber's translation with the fact that in the very next line Vitruvius directs the colour to be laid *on* the plaster. It is true that Vitruvius sometimes uses the verb 'polire' in the sense of 'to plaster.' But when we take into account the use of the substantive in its plural form here, its undoubted signification elsewhere in the chapter, and the statement made in the next line that the pigments were laid on the wet plaster, we are, I think, justified in our translation.

Herr Berger suggests as an alternative translation that in this passage 'coloribus cum politionibus inductis' should be translated the 'colours mixed with polishing substances.'

In line 4, p. 73, we find the words 'udo tectorio.'

In the four MSS. mentioned in the note,[1] this word is not *udo* but *nudo*, and the emendation was made by Jocundus in the sixteenth century. As this sentence contains the most direct and important statement to be found in either Pliny or Vitruvius in favour of the use in their time of buon fresco, it is curious that the opponents of buon fresco have not made more use of this fact that *udo* is an emendation on *nudo*. If, however, the whole passage

[1] *Harleian* MS. Brit. Mus., 2767 (about ninth century). *Scletstatensis*, 1153 (tenth century). *Wolfenbuttelensis Gudianus*, 69 (eleventh century). *Epitomati Vitruvii*, *Wolfenb. Gudian.*, 132 (tenth century). These four are regarded by Rose as the most reliable authority for the original text.

is read, and especially the remarks lower down, contrasting the dry with the wet method, this correction is justified. Possibly the copiers of the ninth and eleventh centuries, unfamiliar with buon fresco, put in the *n* to make sense of the passage, while Jocundus, familiar in his time with buon fresco, did not hesitate to strike it out again.

Herr Berger also proposes to translate 'colores autem udo tectorio cum diligenter sunt inducti,' 'when the colours are laid on *with* the wet plaster' ('udo tectorio als Ablativ, nicht als Dativ gefasst') 'wenn sie *mit* dem feuchten Tectorium aufgetragen sind,' p. 94. This is quite inadmissible. Whatever doubt there may be about the translation of the line above, the only possible translation of this passage is the colour laid, or smeared, *on* the wet plaster.

In line 10, p. 73, the phrase 'in quibuscumque membris est formata,' gives rise to considerable difficulty. If it had been 'quibuscumque membris' the translation we have given would be justified. The Rev. G. C. Richards suggests, 'whatever be the shapings of the divisions of the plaster,' and Herr Degering that it refers to markings. Reber translates it as we have. I confess I am unable to understand either of these suggestions, or to make sense of them when introduced into the passage. We are here dealing with the chemical union of the lime, water, and pigments into a homogeneous whole on the smooth plaster

surface. Another translation which has been suggested is, 'in whatever shape or form.' The phrase, however, is not necessary to the meaning of the passage as a whole.

We shall now consider the information to be derived from this passage.

In the first place, the instructions for preparing the plaster surface are perfectly clear and definite.

In the second place, whatever doubt there may be about the translation of line 3, line 4 can only be translated as meaning that the pigments are to be laid on the wet lime.

In the passages after line 4 there is a most interesting attempt to explain the way in which the lime and pigments ultimately form a homogeneous whole. If, instead of speaking of the lime losing its moisture, Vitruvius had said losing its carbonic acid, the passage might with this emendation have been written by a modern chemist describing the scientific basis of buon fresco. I do not understand why this most interesting passage has been condemned as obscure.

In the next place, it is to be noted that Vitruvius does not speak of this as the *only* method of wall painting, but as the most *durable* method, and contrasts it with the results obtained by painting on a dry surface.

We have here definite evidence that painting on dry walls was also customary, in which case some medium like glue would doubtless be used, and this

goes a long way to explain the conflicting conclusions of investigators and chemists.

Vitruvius in effect tells us that he is familiar with painting on dry walls, necessarily with some binding medium, and with painting on wet lime, and he regards the wet lime painting as the more permanent. He would not have come to this conclusion without a wide experience of both methods.

We have next to consider whether, in painting on wet plaster, any medium such as glue was introduced. No such medium is mentioned by Vitruvius, and we are therefore bound to conclude that it was absent, until chemical analysis or carefully conducted experiments prove the contrary. There is no necessity for its introduction in buon fresco. As I have already pointed out, no conclusive evidence is to be derived on this point from Pliny.

I have already discussed the references in Pliny and Vitruvius to the mixing of glue with black, and have shown that they do not prove the use of glue as a medium, as they are capable of quite a different and equally plausible explanation.

Herr Berger suggests that the whole of this passage applies to the preparation of coloured grounds by mixing pigment with the last layer of plaster, and has nothing to do with the decoration by painting on the wall, which might be carried out on the top of this coloured ground. He claims to have

found such coloured grounds in Pompeii, and states that the thickness amounts to ·01 mm. (page 96). So thin a coat as this can hardly be described as a final coat of plaster and pigment laid on with a trowel. But Chevreul seems to have found cases of pigment mixed with the last layer of plaster.[1] There is no reason why, if they wished, the decorators should not prepare such coloured grounds in certain cases, and it is quite probable they did so. In reply, however, to the statement that this description applies *only* to the preparation of such coloured grounds, I have to say that, in the first place, it is impossible, without making a distorted translation, to translate 'udo tectorio cum diligenter sunt inducti' in any other way than laid *on* the wet plaster. In the second place, Vitruvius is in this book discoursing of wall painting, and gives no other method than this for carrying it out.

It is true that there is an obvious hiatus in the MSS. about the 6th chapter of this book, but this does not justify the assumption that other methods of painting on walls were here described and have been lost.

To sum up, then, the information which we have so far derived from Pliny and Vitruvius, it is clearly demonstrated that both painting on dry plaster, with a suitable medium, and painting on wet plaster in buon fresco was practised.

[1] Hittorf, *l'Architecture Polychrome.*

A further study of this chapter shows clearly that this method of fresco painting was very different from the method used in the time of the Renaissance, or to-day, as there are frequent references to the *polishing* of the surface during the process. Herr Berger was, I believe, the first to point out the significance of these polishing processes. In order to understand the meaning of these passages, we shall have to consider more clearly the nature of buon fresco itself.

When the pigment is flooded over the wet surface of the plaster, the particles settle into the hollows of the surface, bathed in a solution of lime. As this solution of lime becomes carbonated and precipitated by the carbonic acid of the air, the particles of pigment are packed round with the precipitated carbonate, so that the holding of the pigment to the plaster is more of the nature of a mechanical than a chemical process.

Moreover, lime is so slightly soluble in water, and the carbonating of the lime is so slow a process, that each time the surface is flooded with water, fresh unaltered lime is dissolved and brought to the surface of the plaster, for many days.

There is no need, therefore, for the *immediate* painting of a surface as soon as the last layer of plaster is put on, though, on the other hand, it is as well that the plaster should be kept damp, in order to keep a soft bed beneath the pigments, into which

they can become more or less incorporated. If this is done there is no reason why a large surface should not receive its final coat of plaster and then be painted on in a leisurely manner, as long as, by means of damp cloths or occasional sprinkling over with water, it is prevented from getting too hard. The particular technique, therefore, adopted by the Renaissance painters, a small portion at a time receiving its final coat of plaster and then being painted on, is not of the essence of the buon fresco process.

The Roman plaster was not only very thick, but the numerous coats were to be put on before the last coats were completely dry.

Such a mass would hold the contained water for some time, and could easily be kept damp if necessary, while the painting could be proceeded with in a leisurely manner.

It is next necessary to consider carefully the statements made in Vitruvius about polished surfaces. As he does not direct the addition of any foreign substances, we must first try whether such a polished surface can be produced by the methods he describes.

In order to test this I had a series of shallow wooden trays made, into which I introduced first a layer of lime and sand, and then laid on this, when partially dry, two layers of marble dust and lime, in the proportion of two of marble dust to one of lime.

While the final coat was quite wet it was subjected

to the process familiar to plasterers of 'closing in.' That is to say, it was worked repeatedly on the surface with the long, straight, slightly rounded steel edge of the plasterer's trowel, the trowel being held at an angle to the surface of about forty-five degrees. This closed in surface, although inside a building, took several days to dry. As it got drier and firmer the working of the surface with the rounded edge of the trowel was repeated, by drawing it across with quick firm strokes. Ultimately we obtained a dry, hard, compact surface with the appearance of polished marble. This satisfied me that, in so far as uniform plaster surfaces are concerned, the polished surface described by Vitruvius can be got without the introduction of any material beyond lime, marble dust, and water, although great technical skill is doubtless wanted, and great expenditure of time and patience to produce a satisfactory result. It is, however, evident from his account that such polished plaster surfaces were highly prized, and were not the work of the every-day plasterer.

The next experiments were made with pigments.

I had had the opportunity of examining some portions of Roman fresco obtained some years ago by a friend from the Palatine. One of these was coated with vermilion,[1] another with red oxide of

[1] The plaster immediately below the vermilion was stained yellow, as if some wax and oil had been used. This appearance was absent in the other examples.

iron, and a third with the blue Egyptian frit. In the case of the vermilion, and to a great extent in the case of the oxide of iron, the coating of pigment appeared homogeneous under the microscope. But in the case of the coarse particles of the copper frit, which had to some extent weathered off, it was evident that the particles were imbedded in the plaster and flush with the particles of marble dust. In order to try to reproduce this appearance another panel of plaster was prepared and closed in. It was then allowed to dry for a day before being painted on, and then it was painted with a thin coat of cobalt blue, in one part,—laid on so as to show the brush-marks and different depths of work,—with a thick uniform coat of vermilion in another part, and with yellow ochre in a third part. It was then left for another twenty-four hours, and the whole surface then pressed firmly with the flat of the plasterer's trowel. This could be done without any disturbance to the painted surface, but with an evident improvement in the vividness of the colouring. On examining under the microscope the whole surface appeared uniform, and the pigments flush with the plaster, the edge of the vermilion and the edge of the plaster being in focus at the same time, and the particles of cobalt blue imbedded among and flush with the particles of marble dust. (This pigment was selected because it is of a comparatively coarse grain, and corresponds most nearly

MICROPHOTOGRAPH IN THREE COLOURS
OF PORTION OF FRESCO, SHOWING
EGYPTIAN FRIT IMBEDDED INTO
LIME AND FRAGMENTS OF
MARBLE DUST.

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therefore to the old Egyptian blue.) The surface was allowed to dry further, and then the attempt was made to polish it with the edge of the trowel. This was only partially successful; in some places a polish was obtained, in others the pigment was disturbed, owing to a want of perfect smoothness in the edge of the trowel. Such a process of polishing does not seem, however, to be impossible, even in the case of a painted surface, if the right tools were devised and sufficient practice attained. But even the first stage of the process produces a smooth surface with some degree of shine about it, and compacts the whole mass together. When dry it can be washed with water or rubbed up with beeswax and turpentine.

If, then, we are to accept the account given by Vitruvius, the Roman method of buon fresco differed very widely from the one at present practised, involving, in the first place, the 'closing in' of the plaster, and in the second place the partial or complete smoothing and polishing of the surface after the colour had been laid on. This is probably the most durable method of painting ever devised. While this polishing process might be facilitated by the introduction of glue,[1] or, judging by the results

[1] Wiegmann, as a result of his experiments, came to the conclusion that some size was present. *Die Malerei der Alten*, Hanover, 1836.

of Herr Berger, still more by the introduction of soap, it is not necessary to introduce any such substances in order to carry out successfully the process as described by Vitruvius, and the durability would be diminished. It is also evident, that even if it were found preferable to plaster only a small portion at a time, as is suggested by Pliny, such divisions would disappear in the subsequent treatment, though they might, as was found by Donner,[1] reappear in course of time as cracks running along the lines of the former joins.

We shall next consider the special treatment to which the plaster surface was subjected in order to protect vermilion, according to the statements of Pliny and Vitruvius.

In the 40th chapter of the thirty-third book, speaking of native vermilion, Pliny says 'Inlito solis atque lunae contactus inimicus. Remedium, ut parieti siccato cera Punica cum oleo liquefacta candens setis inducatur iterumque admotis gallæ carbonibus inuratur ad sudorem usque, postea candelis subigatur ac deinde linteis puris, sicut et marmora nitescunt.' 'When laid on, the exposure to sun and moon is harmful. The remedy is: when the wall is dry spread on it with a brush melted Punic wax mixed with oil and glowing hot, and again heat it to sweating point by

[1] *Die erhaltenen antiken Wandmalereien in technischer Beziehung*, 1869.

placing charred gall-apples near it, afterwards rub it with candles and then with clean linen cloths as marble is made to shine.' And Vitruvius, also speaking of vermilion, says in the 9th chapter of the seventh book, 'apertis vero id est peristylis aut exhedris aut ceteris eiusdem modi locis, quo sol et luna possit splendores et radios inmittere, cum ab his locus tangitur, vitiatur et amissa virtute coloris denigratur. itaque cum et alii multi tum etiam Faberius scriba cum in Aventino voluisset habere domum eleganter expolitam, peristylis parietes omnes induxit minio, qui post dies xxx facti sunt invenusto varioque colore. itaque pro minio locavit inducendos alios colores. At si qui subtilior fuerit et voluerit expolitionem miniaceam suum colorem retinere, cum paries expolitus et aridus fuerit, ceram ponticam igni liquefactum paulo oleo temperatam saeta inducat, deinde postea carbonibus in ferreo vase compositis eam ceram a proximo cum pariete calefaciundo sudare cogat, atque ut peraequetur deinde tunc candela linteisque puris subigat, uti signa marmorea nuda curantur. haec autem *γάνωσις* graece dicitur. ita obstans cerae ponticae lorica non patitur nec lunae splendorem nec solis radios lambendo eripere ex his politionibus colorem.' 'But in open places, that is, in peristyles and loggias and the like, into which sun and moon can dart their bright rays, the [painted] part when touched by these is marred, and

the quality of its colour being destroyed it turns black. Thus it was that when Faberius the notary wished, like many others, to have his house on the Aventine hill richly decorated, he covered all the walls in the peristyles with vermilion. After a month they became ugly and uneven, and accordingly he bargained with the contractors to lay on other colours instead of vermilion. But a more discerning person, who wishes his vermilion decoration to keep its colour, should, when the wall is well polished and dry, lay on with a stiff brush Pontic wax melted in the fire and tempered with a little oil, then bringing an iron pan of glowing coals near to the wall, he must heat both it and the wall and make the wax sweat, and thereafter, to make the surface even, he must rub it with a candle and clean linen cloths, as nude marble statues are treated. This process is called γάνωσις by the Greeks. The coat of Pontic wax being in front does not allow the play of the sun's rays or the sheen of the moon to take away the colour from such decorations.'

In the first place, it is evident that this is a process for varnishing a surface already painted, and not for painting a surface. There is no inconsistency therefore, as some have held, in Pliny's saying in xxxv. 31 'alieno parietibus genere,' where he is discussing the use of wax as a medium for painting, and on the other hand recommending it for varnishing an

already painted surface. Mastic varnish, for instance, is quite suitable for varnishing pictures, but would make a very inconvenient and unsatisfactory medium to paint with. In the second place, both Vitruvius and Pliny confine the use of this process to a special purpose, namely, the protection of vermilion, and only when exposed to direct sunlight. Vitruvius states definitely that it is not necessary where vermilion is used for interior decoration.

This is a conclusive proof that this process was not a universal one. If the process had not been mentioned at all, it might have been omitted by accident and still have been used. But to mention a process and at the same time confine it to a particular purpose, shows quite clearly that it was not the general method of treating all wall surfaces. It will also be noted that Vitruvius says the varnish is to be applied 'cum paries expolitus et aridus,' clearly indicating that the decorative treatment with vermilion has been executed on the wet surface, which, after drying, is then varnished with wax.

In Pliny's statement the wax mentioned is Punic wax.

As has been already explained (p. 43), in the older edition of Vitruvius by Rose, *punicam* is given as the word, but in the four MSS. already referred to, the word is written *pumicam* (sometimes written *pomicam*), which Rose has come to the conclusion is

a corruption of the word *ponticam* (the short *t* and the *n* being perhaps mistaken for *m* by the transcribers).

It will be remembered that Pliny, in his chapter on beeswax, mentions both these waxes, and I there pointed out that Herr Berger lays great stress on *punicam* being the word used both by Pliny and by Vitruvius in this connection.

After the correction by Rose, it is at any rate open to doubt whether *punicam* was the word used by Vitruvius, and therefore it is unsafe to base any argument on the presence of this word.

The use of the word *candela* has given rise to some difficulty. Some have suggested that it means that a lighted candle was used to warm the surface, others that a roller shaped like a candle is meant. Candles seem to have been known, made both of wax and tallow, and therefore others have said that the meaning is that the surface was finally rubbed with a wax candle and a linen cloth. Another possible view is that a tallow candle was used for the final polishing.

It will be noticed also, on examining the context, that it is not at all clear whether the statement about the polishing of marble applies to the whole process, or merely to the rubbing with candelae and linen cloths. Either view would satisfy the translation.

I tried the experiment of polishing marble with tallow, with wax melted with olive oil, and then strongly heated after being applied, and with a lump of solid wax alone and a linen cloth.

I failed to obtain a polish either by rubbing up with tallow or rubbing up after treatment with hot melted wax and oil. But I found that if the marble was very lightly rubbed over with a lump of solid beeswax, and then rubbed hard with a hard rough linen cloth, a beautiful polish was at once obtained. The only precaution necessary is to avoid putting on too much wax when rubbing with the lump of beeswax. The layer is so thin that the marble is not in the slightest discoloured, but gets at once a glossy surface, which gives it depth and translucency. The marble used had already, of course, been smoothed and polished as far as was possible by merely treating the surface of the stone itself.

A piece of wax, already shaped as a candle, would be very convenient for this purpose, being readily held in the hand while the end would be rubbed over the marble.

The rubbing with wax candles is thus completely explained, and it is evident, that while in the case of a porous plaster surface it is necessary to fill up the pores with hot wax to begin with, before polishing with wax candles and linen, in the case of marble this process is not necessary, the process called

γάνωσις being the rubbing with wax candles and linen alone.[1]

In conclusion, vermilion, when exposed to direct sunlight, does change colour in the way described, and is to some extent protected by being covered with a glossy surface either by varnishing or in the way described by Vitruvius.[2]

We shall next proceed to consider the evidence supplied by chemical analysis. But before doing so it is necessary to state clearly two propositions.

In the first place, the presence of organic matter is not a proof that an organic medium like glue or egg has been used. Such organic matter may be present accidentally in the original material, may form part of one of the pigments, as for instance a pigment prepared from murex or madder, or may have soaked into the buried plaster surface.

If we can extract the organic substance and identify it as glue, gum, beeswax, or what not, that is another matter altogether.

In the second place, if organic matter is absent, and at the same time the pigment is firmly adhering

[1] Pliny uses the word 'nitescunt,' therefore the process must give a shine. No doubt armour, to which he refers, would be polished the same way.

[2] ἡ δὲ γάνωσις τοῦ ἀγάλματος ἀναγκαία· ταχὺ γὰρ ἐξανθεῖ τὸ μίλτινον ᾧ τὰ παλαιὰ τῶν ἀγαλμάτων ἔχρωζον. 'The "Ganosis" of the statue is necessary, for the vermilion with which the ancient statues are painted soon loses its colour.'—Plutarch, *Quaest. Rom.*, 287 D.

to the plaster, this may be taken as proof positive that the use of an organic medium was not of the essence of the original painting process.

For it is inconceivable that if the binding material has been removed by the action of fire, or of water, the pigment would still remain firmly adhering to the plaster, though of course it might be found lying on the plaster in a loose powdery condition.

Therefore the presence of a firm adhering coat with no organic matter, or merely traces of organic matter, may be taken as a proof that buon fresco was the process used. Herr Berger's experiments with portions of fresco painted with wax colours and then treated with hot ashes are quite inconclusive, as after the baking he did not analyse the pigments to see if the wax, all or in part, was not still there, though driven in by the heat (p. 148).[1] Such hot ashes might suck up some, but not *all* the wax, and some would still be present.

Those who believe the Roman frescoes at Pompeii to have been painted with wax are on the horns of a dilemma.

Sir Humphry Davy, John, and Chevreul, all agree that wax is absent. If this absence is due to the action of hot ashes, then how is it that the pigments adhere?

How can any one explain the miraculous process

[1] The test with acid for effervescence is quite inconclusive.

by which the binding material has been removed and the pigments left firmly adhering?

A very interesting statement by Presuhn is noted by Herr Berger in this connection (p. 149). He finds that monochrome washes on walls in Pompeii dust off, but in wall pictures the pigments are firmly adhering. This clearly points to the use, for cheap colour work, of an organic material, such as glue, on the dry plaster, which has dissolved and therefore left the pigment loosely adhering, while the more important frescoes were executed in the more reliable method of buon fresco as directed by Vitruvius.

The determination of the actual organic substances is a difficult matter; the amount of binding medium necessary to fix a pigment to a surface is very small, and as a rule chemists can only get small fragments to examine, as they cannot be allowed to destroy large surfaces; and such organic substances, even if they remain *in situ*, change their character in course of time from the chemical actions of moisture and oxygen, and therefore it becomes more and more difficult to decide definitely what they were originally composed of.

The earliest experiments were made by Sir Humphry Davy and Chaptal. Chaptal's experiments were, however, confined to pots of pigment found in Pompeii, and therefore throw no light on the question of the employment of a medium, as it

may well be that the medium was to be subsequently added. Sir Humphry Davy, however, examined actual pieces of fresco, and as it has been stated by Herr Berger that he only examined minute fragments taken from the Aldobrandini wedding, I proceed to quote the whole of the sentence from his paper dealing with this matter.

'I have examined *several pieces* of the painted stucco found in the different ruins, and likewise the Aldobrandini picture, with a view of ascertaining if any application had been made to fix the colour, but neither by the test of alcohol, nor by heat, nor by the action of water, could I detect the presence of any wax varnish, or animal or vegetable gluten.' (*Phil. Trans.*, vol. 105, p. 119.) He then suggests that the lightness of vegetable blacks might require the use of glue in their case, as stated by Pliny and Vitruvius, though not for heavier pigments. This is very much the explanation I have already suggested for these passages.

It is to be regretted that Sir Humphry Davy does not enter into greater detail, but while the identification of a particular organic medium and the determination of the amount of it present is difficult, the absence of organic substances is not difficult to settle, even though very small fragments are available.

This statement of Sir Humphry Davy's may

be taken, therefore, as conclusive evidence that no binding medium was present in the samples examined by him. As, however, he does not describe the condition of these samples, this is not conclusive evidence that a binding medium had not once been present.

J. F. John (*Die Malerei der Alten*, Berlin, 1836, p. 155), in examining a piece of red tectorium from Pompeii, found no binding material or organic matter beyond a trace of fatty matter extracted by ether. Ether, unless very carefully purified and rectified, always leaves, on evaporation, a slight greasy residue, and therefore, considering the early date of John's researches, I think it quite possible that the fatty matter was contained in the ether and not in the pigment.

At any rate, such a trace of fatty matter is quite rightly neglected by the chemist.

We now come to Chevreul's results.[1]

(1) In a red-coloured plaster, which was polished hard and shining, distillation yielded ammonia, 'showing a very appreciable quantity of an organic substance to be present,' evidently of a nitrogenous nature.

A water solution residue also yielded an ammoniacal distillation, and alcohol extracted a trace of fat.

[1] *Memoirs of the Academy of Science*, xxii. 1880. Reprinted in Hittorf's *l'Architecture Polychrome*, p. 912.

The greater part of the organic substance was not dissolved by the water or the alcohol.

It is evident that here an organic substance is present, either forming a constituent of the pigment, or forming a binding medium, as Chevreul comes to the conclusion later on that there is more of it present than can be accounted for by accidental impurities.

The experiments would agree either with the presence of egg or glue or milk, all nitrogenous bodies yielding ammonia, and all containing oils or fatty matter. Such fatty matter is present as an impurity even in the glues of to-day, and would be sure to be present in the glues made in ancient times, when the methods for completely separating fatty matter were not fully understood.

It is also possible that an organic pigment or lake had been mixed with the red oxide of iron, which was found to be present.

(2) The next piece examined was a black colour, and had been painted over a pink plaster, of 1 mm. thickness.

It proved to be an organic black, and yielded ammonia, and resinous bodies were extracted from it by alcohol.

The presence of such resinous bodies was to be expected in an impure vegetable black. The presence of ammonia suggests that some animal black had

also been mixed with it, or that the ammonia was due to the glue, which we know was introduced into these blacks as a matter of course.

This analysis, therefore, cannot be held to throw light on the question as to whether a medium was present or not.

(3) was coated with yellow ochre. Boiling water separated an organic substance, and boiling alcohol a 'wax or resin like matter.' It seems improbable that any organic pigment would be present in this case.

(4) This was a fragment containing various colours on white plaster.

The white plaster contained an organic material of a nitrogenous character, partially soluble in water, and a trace of fatty substance soluble in alcohol.

The mortar underneath contained very little organic matter.

(5) In this fragment the red ground was over-painted with yellow, and the yellow with white and brown lines.

The red ground contained organic matter, but the yellow colour mere traces of organic matter.

This is a very remarkable case, as at first sight the painting over of one colour by another seems almost to necessitate a binding medium, and yet if it had been present it had disappeared from the over-painting. We have no information in this case

of the condition of attachment of the surface pigments. It is not impossible, I believe, to execute over-painting in buon fresco if carried out in the manner described by Vitruvius. The partially dried and pressed under painting could quite well receive an over-painting, which could then again be pressed and polished. The final white over-painting softened very much with water.

This completes the Pompeian fragments. The next analysis was of a portion of Roman fresco found in the Palais de Justice, Paris.

Only a trace of organic matter was found, but the red plaster was firm, shining, and very compact. In this case the essence of the process cannot have been the introduction of an organic binding material.

Next we have the examination of two examples from St. Médard des Prés. In this case there were two or three over-paintings, yet alcohol only extracted a trace of fatty matter, and there were only traces of ammonia set free, and in dissolving the fragment in acid so as to decompose any soap present, and then treating with alcohol, no fatty matter was obtained. In this case, therefore, the evidence is in favour of no medium having been used, and the pigments were adhering firmly enough for one layer to be removed above another, revealing those underneath. The probable explanation is that the painting was done in the way suggested below.

The second fragment from St. Médard had over-paintings, but was also free from organic binding material. In the case, therefore, of the fragments from Paris and St. Médard, Chevreul comes to the conclusion that no organic binding material was used, and possibly milk of lime was used as the medium. This method of painting on a dry wall with milk of lime is described by Theophilus.

In the case of this second fragment from St. Médard, the layers of pigment could be lifted off one from another, and each layer contained carbonate of lime, which may well have been originally milk of lime.

In the Pompeian fragments the quantity of organic matter Chevreul concludes is too great for us to suppose its presence accidental.

To sum up, in all Chevreul examined nine samples.

Of these four contained only traces of organic matter, three contained nitrogenous organic matter and traces of fatty matter, and two contained nitrogenous organic matter and resinous or waxy bodies.

One of these two would necessarily contain resinous bodies, so that of these one only contains unexplained resinous or waxy bodies. The suggestion that the organic medium had disappeared through time will not account for its absence in the samples from Paris and St. Médard, certainly not in the case of the Paris sample, where the firm hard nature of the

coating is specially mentioned, as the removal of the medium would destroy the adherence of the coating.

In the St. Médard samples, the layers of colour are found one on the top of the other, as if laid on a dry surface, and can be split off from each other.

This would hardly be the case if each coat had been pressed home after being painted on the still damp plaster; and at the same time the description of these layers of pigment, which can be split off from each other, is not consistent with the presence of a binding material which has perished. The presence of carbonate of lime in each layer explains the whole matter as Chevreul points out. In this case the layer of pigment was mixed with milk of lime as a medium.

From what I have said before of the probability that organic binding mediums were sometimes used, it is evident that there is no inconsistency between the results obtained by Chevreul and Sir Humphry Davy.

We can draw the following probable conclusions from these results.

That many wall paintings were executed in buon fresco without the use of organic binding material, and that in some cases a modified buon fresco was used in which the pigments laid on the dry surface were mixed with milk of lime.

That in many cases an organic medium was used which is present in the under plaster, and which was of a nitrogenous character and contained traces of fatty matter, and which might therefore be egg, milk, or glue. If glue, it had become considerably modified, or originally contained insoluble matter, as it was only partially soluble in water.

That the fatty matter present had evidently not become saponified by the enormous excess of lime present.

That in one instance Chevreul searches for the presence of soaps and finds none.

That there is no evidence to support the view that wax, or any preparation of wax, was used except in one doubtful instance, where a 'waxy or resinous' substance is found.

That there is no evidence to show whether the medium used in the Pompeian fragments mentioned was utilised to paint on a dry surface, or was used to paint on wet lime as a form of modified buon fresco.

The results obtained by the chemist Geiger (*Chemische Untersuchungen*, 1826) are unfortunately open to doubt, as the fragments examined by him had apparently been treated for preservation after discovery, and therefore I do not propose to discuss them.

Before concluding I have a few suggestions to make about the painting of marble walls and statues in

Greece. The problem in this case is quite different from that of painting on heavily plastered walls. The colour is laid on a smooth marble surface, or a very thin coat of plaster, and we have no information, either in Pliny or Vitruvius, as to how this was carried out. Faraday, Landerer, and Semper[1] have analysed some of the Greek decorations and find in all cases organic matter, and in most cases identify the presence of beeswax. It is not, however, clear from their results whether beeswax was the only binding material present. Having identified beeswax they seem to have been satisfied and looked no further.

I have experimented in the painting of smooth marble surfaces with the following results.

In the first place, if the marble is warmed the pigments can be applied with melted wax. This, as has been already pointed out, would be a very inconvenient process on large wall surfaces, unless the wall was warmed to a suitable temperature by the sun.

I have tried to paint surfaces with Herr Berger's 'Punic wax,' but have never succeeded in doing so, the wax collecting in sticky particles, even with the addition of soap as well as soda.

[1] Faraday's Analyses, Hittorf, p. 547. Landerer's Analyses, *Antiquités Helléniques*, by A. R. Ramsgate, i. p. 63. Semper's Analyses, Hittorf, p. 489.

I have also tried the Mount Athos receipt. Size alone emulsifies roughly with wax, but not in a very satisfactory manner. The Mount Athos receipt gives a perfectly workable medium, and the resulting surface can, as stated in the receipt, be polished with a cloth. There is another way, however, in which I have obtained a better result.

As I have already pointed out, the statements as to the polishing of marble with beeswax made by Pliny and Vitruvius (Ganosis) may well refer simply to the rubbing of the surface with wax candles and polishing with a cloth, a process which is the best I have found for polishing marble.

It occurred to me that this process was capable of further application.

I therefore painted a piece of marble with a pigment mixed with a little glue, allowed it to dry, and then rubbed it lightly all over with a lump of beeswax, taking care not to scratch off the pigment until the whole surface had been passed over with the beeswax, and then began rubbing with a linen cloth, at first lightly, then with hard rubbing, and finally lightly again. In this way a beautiful polish was obtained, which was carried on to the bare unpainted marble as well.

The result is to give the whole surface a uniform shining coating, the pigment appearing like a dark stone let into the marble, and the aesthetic effect being

therefore quite different from any other method of painting the marble which I have tried. Such a pigment, if analysed, would show the presence of wax.

Further analyses are required of Greek paintings on marble before the question, as to whether this was the method, can be settled, but the process is very simple, beautiful in its results, and quite in agreement with the scanty information given by Pliny and Vitruvius.

The information to be obtained about Egyptian wall painting is very confusing and not satisfactory. In samples I have examined the pigment is easily sponged off, and therefore is probably put on with size or gum. In other cases apparently the paintings resist water, and probably wax has been used, possibly in the way described above.

Herr Berger quotes John as saying that 'wax soap' is present, but giving no demonstration of the evidence for this impossible conclusion. Evidently further research is required.

In conclusion, it is necessary to refer briefly to the theory developed by Herr Berger in his *Maltechnik des Alterthums*. There is a modern process known as stucco lustro, used in Italy for making an artificial marble, in which a plaster of marble dust and lime is polished by treating it with an emulsion of lime and olive oil soap, and polishing with hot iron. Herr Berger holds that this was the method of wall paint-

ing used in classical times, the medium being an emulsion of wax in soda or potash, which he calls 'Punic wax,' mixed with oil, which would be saponified by the soda, and then applied to the walls. He also believes other organic mediums were used, along with this stucco lustro process.

He has developed this ingenious theory at great length, and those who wish to study the evidence he brings together must be referred to his book.

In the first place, the attempt to connect the modern stucco lustro process with the ancient technique through Pliny's description of the preparation of Punic wax breaks down at the outset, as it is quite obvious that Pliny's description does not refer to an emulsion of wax and soda. Yet the presence of a watery mixture containing soda is necessary to Herr Berger's theory, because he depends on the solution of soda to saponify the subsequently added oil. In fact the wax is superfluous and unnecessary.

In the second place, in the account given by Pliny and Vitruvius of the application of wax mixed with a little oil to walls, we are directed to melt the wax, not to boil a watery emulsion.

In the third place, the process described by Pliny and Vitruvius is meant for only limited application to special cases.

In the fourth place, the results of chemical analysis have proved the absence of wax from Roman frescoes.

Therefore the proof is complete that the wax soda oil lime medium, suggested by Berger, is not mentioned by classical writers, and is disproved by analysis. The most that can be said for his theory is, that in those cases where an organic medium has been found, the use as one constituent of the medium of a lime olive oil soap *without wax* has not been disproved, as it has not been looked for.

To sum up our conclusions, we have found that when painting panel pictures the ancients either painted with a medium which was probably egg, glue, or gum (of these egg being the most likely), or with wax, and when painting in encaustic, made use either of the cauterium to model the wax surface, or the brush using melted wax. That the difficulties supposed to underlie this process have proved to be imaginary, when climatic conditions are allowed for, or the panel is artificially warmed.

That they were accustomed to use more than one method of painting on walls. That the best method of painting on plaster was considered to be buon fresco, the pigments being laid on the wet lime, though it is not absolutely clear that they did not sometimes modify this by mixing the pigments laid on the wet surface with glue, milk, or egg, this modification not affecting the essential nature of the process.

That they in certain cases painted either on the

wet or the dry surface with one of these three mediums.

That they also sometimes painted on the dry surface with milk of lime.

That an essential part of their best work was the polishing during and after the preparation and painting of the plaster.

That this polishing process is quite possible on marble plaster without the addition of any organic medium.

That such a treatment, even if only carried a little way, increases the durability of the painting, and gives a smooth surface capable of being washed or varnished or polished with wax.

That in the case of vermilion painting exposed to direct sunlight they varnished with wax.

That the process known as Ganosis among the Greeks consisted, in all probability, in simply rubbing the surface over with a beeswax candle and a linen cloth.

That the easiest way to paint on marble is to lay on the pigment mixed with glue, and then polish the surface when dry with a lump of beeswax and a linen cloth, and that this is the simplest possible explanation of the presence of wax in Greek paintings on marble walls and statues.

That in order to get further light on the extent to which organic mediums were used in painting on

plaster, not only should a systematic analysis be made of existing remains, but plaster painted in different ways should then be subjected to analysis, in order that we may have some indication of what sort of results to expect.

And, finally, that the more faithfully we examine the writings of these authors, without allowing ourselves to be carried away by plausible hypotheses or later inventions, the more we are convinced of the completeness and accuracy of their statements.

Note.—While in making this inquiry I have as far as possible avoided referring to any information of a later date than Pliny, yet there is a passage in the famous MS. in the library of the cathedral at Lucca, of the eighth century, which bears so directly on later practice that it is worth quoting:—

'Ita memoramus omnium operationes quae in parietibus simplice in ligno cere commixtis coloribus in pellibus ictiocollon commixtum.'

'Thus we mention operations with all of them, on walls unmixed, on wood the colours being mixed with wax, on skins fish-glue being mixed.'

This quotation I take from Mrs. Herringham (*Cennino Cennini*, p. xxiv.), who copies it from a photograph of the original, and which I find is exactly the same in Muratori's work on *Italian Antiquities*, vol. ii. p. 377, except for an error in

spelling and a comma. It is the more necessary to introduce this quotation as it is incorrectly quoted by Herr Berger (*Beiträge*, Part III. p. 18), the 'in' between 'simplice' and 'ligno' being omitted, and the whole sense thus altered, 'cere' being thus made to apply to painting both on wood and walls, and 'simplice,' which means 'unmixed,' becoming meaningless.

APPENDIX I

Professor Baldwin Brown supplied me some time ago with a portion of an Egyptian mummy case, of about the time of the nineteenth dynasty, which he had obtained from Flinders Petrie.

The wood, which was much decayed, was covered with a layer of gesso, on this was laid a black pigment, and on the black ground a yellow pattern had been painted, the whole being covered with a varnish of a warm colour.

In many places the varnish had powdered off, but in other places it was intact. It was smooth, shining, with straight cracks running through it, brittle, and broke up under the needle point, with a conchoidal fracture. In fact it had all the characteristics of a spirit varnish, either artificial by dissolving a resin in a volatile medium, or natural, that is, a liquid balsam or natural turpentine. I have discussed this matter at some length in the text.

On treating with alcohol in the cold it readily dissolved, showing it to be neither an oil varnish nor one of the more insoluble resins, but rather behaving like a pine balsam or some similar balsam. To identify it further would require an examination of the balsams from Syria mentioned by Pliny, such as terebinth and mastic, and from other possible sources. The quantity present was not sufficient to make anything but solubility tests. The varnish had a distinct orange colour which was imparted to the alcohol.

By treatment with alcohol the varnish could be removed without affecting the painting underneath, which was evidently executed with a medium insoluble in alcohol.

The black pigment proved to be coarsely powdered charcoal, and the yellow pigment was a yellow ochre, which had, however, not been floated according to the modern practice, as it contained coarse white particles apparently of quartz. The gesso was carbonate of lime.

On boiling with water the painting and gesso were completely disintegrated, and the water solution, on filtration and evaporation, left a residue of translucent brown flakes, which on heating with soda lime gave off quantities of ammonia. The solution was precipitated by tannic acid, but did not give the xanthoproteic reaction. It was examined for me by Dr. Jerdan, of Cox's gelatine and glue works, and he came to the conclusion that it was slightly altered glue, which, very probably owing to slow oxidation, failed to give all the characteristic reactions. This fact that Egyptian glue does not give all the characteristic reactions of fresh-made glue has been noted by other chemists.

The medium used to lay the pigments on the ground could not be separately identified, as the painted surface could not be removed in sufficient quantity from the glue underneath. The question of most interest raised by this fragment is the source of supply of the natural balsam with which it has apparently been varnished.

The varnish itself was too glossy and transparent to have been made by diluting a hard resin with wax.

APPENDIX II

The possibility of using natural pine balsams as painting media is of considerable interest.

The receipts for lakes given in the MSS. from the twelfth to the sixteenth century are nearly all for their preparation from dye wood or from kermes, or cochineal, madder being very rarely if ever referred to.

Such lakes are very fugitive.

Moreover, the only really brilliant green in the receipts is verdigris, which has the reputation of turning black in oil.

It is therefore difficult to understand how the pigments used for glazing by Van Eyck, for instance, have stood the test of time so remarkably well. It is usually assumed that oil, and still more oil varnishes, protect pigments from moisture, and amber varnish has been treated with a special superstitious reverence. Some experiments I made in 1891,[1] and which are published in the *Proceedings of the Society of Arts*, have evidently escaped the attention of recent continental writers. By using ignited sulphate of copper with various mediums, and exposing the painted surfaces when dry to moist air, I found that oil and oil varnishes, including amber, are readily permeated by moisture and the pigment attacked.

On the other hand spirit varnishes and natural pine balsams protect the pigment from attack.

The question therefore arises whether the Van Eyck mediums were not more of the nature of a balsam than an oil.

De Mayerne gives a receipt for making from verdigris a green which will never change by dissolving the verdigris in a pine balsam. This receipt gives a most beautiful green, and it is the only green, either used as a glazing colour or mixed with yellow, with which I have been able to match the magnificent greens to be found in Van Eyck's pictures, when confining myself to the palette available for him.

The whole question has been carried further by the Hon. Neville Lytton, who has been painting for some time with a medium of Canada balsam and mastic varnish, containing spike oil, and a little amber varnish (copal oil varnish would do just as well) to give it toughness and elasticity. He prefers to emulsify this medium

[1] *Pigments and Vehicles of the Old Masters.* Cantor Lectures, Society of Arts, 1891.

with water. Though it is not so easy to manipulate as an oil medium, the surfaces painted with it are sufficiently pliable, and tests which I have made with it show it to be capable of protecting pigments from both moisture and pernicious gases. White lead, for instance, in this medium is not affected by sulphuretted hydrogen. Unfortunately the possibility of using it with sufficient facility for fine painting has not been completely demonstrated, as Mr. Lytton has been mixing it with pigments ground in oil, thus introducing an excessive amount of oil into the picture, instead of grinding the dry pigment in the medium itself. A little oil or oil varnish can be added with impunity, but the amount must be small.

In my own experiments I have found an emulsion of Canada balsam, turpentine, and white of egg quite nice to paint with, though of course drying rather rapidly. Curiously enough this emulsion, if the white of egg is not in excess, dries to form a hard transparent layer, the egg merely serving to make it easier to manipulate under the brush. A picture painted on panel with this medium would resist chemical change, but would be brittle and easily injured mechanically.

The problem is, therefore, how much drying oil can be safely introduced to give toughness without spoiling the protecting value of the balsam.

The whole subject is deserving of further investigation, but it is, I think, at any rate possible that the Van Eyck medium was principally a natural pine balsam, like Venice turpentine, toughened with a little oil, and perhaps emulsified with white of egg.

The solid painting might be pure egg, while the upper glazings would be nearly pure balsam with a little oil. The green would be prepared by dissolving verdigris in Venice turpentine by heat, and then probably adding a little oil.

APPENDIX III

Distillation

Its history in ancient times and during the Middle Ages. Extracted from the account by M. Berthelot in *La Grande Encyclopédie*, by kind permission of the publishers.

'The operation of distillation does not appear in the history of the sciences before the Christian era, although the industrial practices relative to the preparation of mercury are certainly more ancient. But towards the first centuries the concordant texts of Pliny and Dioscorides prove that it was in use. They explain that cinnabar being placed in an iron cup which is itself enclosed in an earthen vessel with a head (ἄμβιξ) carefully luted all round, and the whole heated on a coal fire, the mercury sublimates and condenses by cooling on the head, whence it is collected by scraping. It is a real sublimation which is thus described. These authors describe also a preparation of essence of turpentine carried out by heating resin in a pot and condensing the vapour in wool spread on the orifice, this wool being afterwards squeezed in order to extract the volatile oil. To the same order of ideas might also be referred the preparation of pompholyx, or oxide of zinc, described by Pliny, the ore (calamine) being thrown into a furnace and the vapour condensing into smoke in the midst of a second chamber superposed.

'More exact indications as to the results of distillation are to be met with in a writer who lived in the third century, Alexander of Aphrodisias, a commentator on the

"Meteorologica," which is a writing of the Aristotelian school. It is said there that sea-water can be rendered drinkable by heating it in a boiler and collecting the vapour in covers placed above. Wine and other liquids, it is added, furnish water in the same way.

'Besides these documents drawn from classical sources we find others, more detailed, and accompanied by drawings of the distilling apparatus in the writings of the Greek alchemists of the same epoch. The most ancient are derived from a treatise, now lost, written by Cleopatra, a learned Egyptian lady who lived some time in the early centuries of the Christian era, and who also wrote on weights and measures. Along with the mystic figures of her "Chrysopeé" we find a distilling apparatus consisting of a mattrass surmounted by a large tube which debouches into an upper receiver provided with two inclined bent side tubes by which the condensed liquid flows. The whole is placed on a furnace.

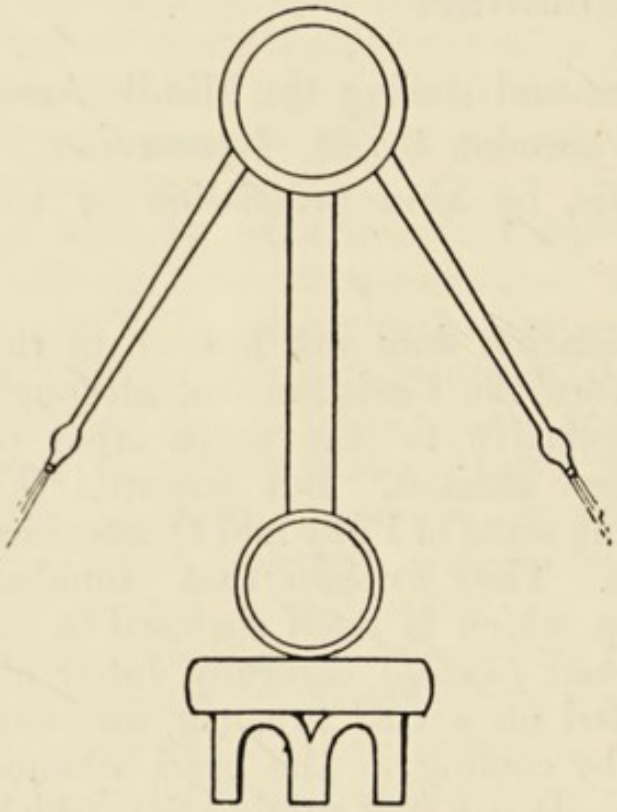
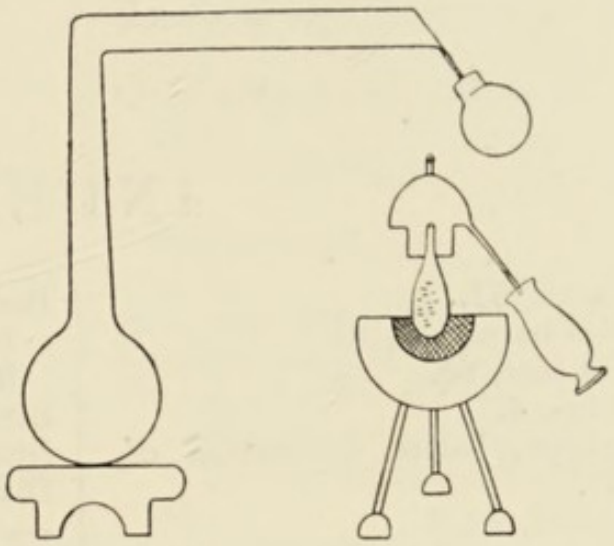


Figure from a MS. in St. Mark's, Venice.

'Similar figures more detailed are found in the works of Zosimus, the oldest writer on alchemy whose authentic writings we possess. He seems to belong to the epoch of Clement of Alexandria and of Tertullian (about 200 A.D.). Some of his figures have two or three lateral tubes, the upper receiver being called *βῆκος*.

'We shall give only the accompanying figure (1) from Zosimus. It is that of a true alembic.

'An apparatus (2) still more analogous to our alembics is described and pictured in Synesius, an author who lived at the end of the fourth and beginning of the fifth century. In Synesius we have a boiler heated over a bain-marie, or a bath of cinders.



1 2

The MSS. containing these figures were copied in the 11th and 15th centuries, but they reproduce more ancient MSS., and the figures correspond exactly to descriptions in the text.

'The agreement between the MSS. containing the figures here given, and the indications in the "Meteorologica" by Alexander of Aphrodisias leaves no doubt as to the existence of distilling apparatuses founded on the same principles as our own, in the time of the Roman empire, particularly towards the third and fourth centuries of our era. It is to be observed that the covers, heads, condensing vessels then bore the names of ἄμβιξ and of βῆκος. This is doubtless the origin of the word alembic, modified only by the addition of *al*, the Arabic article.'

It is clear from this account that there is no evidence of distillation with covered vessel and descending tube so early as the time of Pliny, though apparently invented shortly after. It is still more improbable that such inventions were used at this early time for the preparation of turpentine, alcohol, or rectified petroleum in considerable quantities.

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