### History of known pigments and their chemical makeup.
#### 77 AD to present.

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From http://www.labthink.com/paint.htm

**ALIZARIN**

(Also known as Alizarin Crimson in modern pigments). Same as Madder, except that it was made from the European Madder root. Since the 1850s (approximately) it has been made synthetically with an identical chemical composition to Madder but with a superior clear tone and lightfastness. By manipulating these chemicals, a range of shades has been made from Scarlet to Ruby. All alizarin lake colors (see crimson lake) are permanent to light and to the gaseous atmospheres of urban areas. However, when mixed with Ochre, Sienna and Umbre, they lose their permanence. and when mixed with blacks or oxides, its permanence is not affected at all. Excellant as a glazing color over a dry surface. According to Maximillian Toch, "the medium shade of Madder Lake shows no light action after one year to the sun under glass". Purple madder, is a different pigment altogether, in that it is permanent to diffused indoor light, but not to ultra-violet light, and should therefore never be exposed sunlight.

**ALUMINA HYDRATE**

When ground in a low acid linseed oil, this pigment is as transparent as glass, and has the least hiding power of any pigments. It therefore reduces the opacity of all other pigments, and becomes inert when mixed with them. It does however add to the yellowing of pigments over time, as it takes an enormous quantity of oil to reduce it to a paste. Therefore, this pigment is extremely valuable when used for glazing techniques, and traditionally, with a more golden/yellow array of colors to mask the yellowing quality. This can also be used to advantage when creating a glaze meant to yellow a painting for the purpose of imparting age to it.

**ANTWERP BLUE**

Usually a Prussian Blue containing 25% or more of Alumina Hydrate, making it a translucent blue. When mixed with Titanium or Zinc oxides, it makes a sky-blue which is permanent to light. As a glazing medium, when mixed with Burnt Sienna, it creates a translucent dark maroon. According to Maximillian Toch, Blakelock used Antwerp Blue and Burnt Sienna for his dark glazes. It is however a fairly useless pigment as Chinese or Prussian Blue give the same, but stronger results.

**ARTIFICIAL BARIUM SULPHATE**

In France this pigment is known as Blanc Fife, meaning permanent white. It has even less covering power than zinc white, which makes it a very translucent pigment, best used as an extender or as a glazing medium.

**ASBESTINE**

A course shredded material which is used in pigments to prevent settling or hardening.

**ASPHALTUM**

(Bitumen). It’s very tempting to use asphaltum in underpainting as it allows for a sketchy brushstroke, not unlike that which is possible with graphite. It is a complete disaster in traditional uses, and can be extremely damaging as an underpaint to the more stable pigments painted upon it. However, the strange, rough quality of the material is quite interesting for more contemporary uses, and is worth experimenting with. It is however a poor dryer, Pulverized asphalt is heated in hot oil as a part of its preparation, therefore it is obviously soluble in oils, but historically boiled linseed oil would be added to improve its drying abilities. It also has a tendency to soften in higher temperatures, adding to its instability as a traditional pigment. This opens it up to experimentation in contemporary uses; it has a tendency to soften in higher temperatures, causing deep cracks in the top layers of paint, the asphaltum thus pressing through. Rembrandt used it for a glaze, where it caused no damage at all, thus opening it up to uses over other treatments/pigments. It requires 150% oil, making it an exceedingly fat paint, and is traditionally advised against for every traditional technique including fresco. Consider the modern use of asphalt: there may be possibilities available in many of the paving/industrial materials used which are not “painting” materials. Remember during all experimentation however, that the stability of the material over time might be limited, and use this toward the advantage of the work, rather than the disadvantage.

**AUREOLIN**
A nitrate of cobalt and potassium, which makes a transparent yellow color which is permanent to light. When used with sufficient oil or coated with varnish, it has the added quality of being unaffected by gaseous atmosphere, as well. It is used best as a glazing color as it has poor coverage, and yet is fairly useless as the lighter cadmium yellows give the same results.

AZURE BLUE

According to history, this name would mean "blue blue". However, in manufactured pigments it is a tone similar to Cerulean blue, and is usually a mixture of Prussian or Ultramarine blue with Zinc white. It is permanent to both light and air.

AZURITE & BLUE VERDITER

Also mountain blue, lapis armenius, azurium citramarinum (as opposed to azurium ultramarinum), and in Pliny's time called "Armenian stone" when Armenia and Spain were the chief sources of supply. Latin borrowed a Persian word for blue, lajard, which in the form of lazurium became azurium, and gave us our word azure. (This word probably meant the Persian mineral, lapis lazuli, but it came to mean the color blue in general.) It is composed of basic carbonate of copper, found in many parts of the world in the upper oxidized portions of copper ore deposits (also refer to blue copper pigments to cross reference). Azurite mineral is usually associated in nature with malachite, the green basic carbonate of copper that is far more abundant. According to Lucas (1962), azurite may have been employed as a paint pigment as early as the fourth dynasty in Egypt, but was not widely used then nor in the classical world because of the synthetic copper pigment, Egyptian blue (usually all synthetics were less expensive and more abundant). Azurite was the most important blue pigment in European painting throughout the middle ages and Renaissance by contrast, despite the more exotic and costly ultramarine having received greater acclaim. Azurite was commonly used as an underpaint to ultramarine as well. It was also the most important blue pigment in the paintings of the far east, used widely in the wall paintings of the Sung and Ming dynasties in China. It was also used in Japan, especially on paintings of the Ukiyo-e school, and is still used today. To a limited extent it was used by the pre-Columbian Indians of the American Southwest and later in Spanish mission church paintings. The invention of Prussian blue at the beginning of the eighteenth century displaced azurite from the European palette. Hungary was the principle source of Azurite in Europe until the mid-seventeenth century when the country was overthrown by Turks and supplies were cut off. This is substantiated by the fact that Hungary is a present day locality for Azurite. Other sources may have been Chessy near Lyon in France, and Sardinia, both of which remain so. There may have been others unreported to which the Germans had access, as they capitalized on the export. Azurite sometimes looks a little like lapis lazuli, and the two were often confused in the middle ages. To tell them apart with certainty the stones were heated red-hot. Azurite turns black when this is done, and true lapis is not injured. To prepare a color from it, lump azurite is ground into a powder, and sieved. Coarsely ground azurite produces dark blue, and fine grinding produces a lighter tone; however if not ground fine enough, it is too sandy and gritty to be used as a pigment. The medieval system included washing it to remove any mud and then separating the different grains by some process of levigation. If plain water is used it is a slow, laborious process, so they used solutions of soap, gum and lye. The Japanese produce three grades: coarse, medium and fine, thus all three have different tones to them. A fourteenth century text tells us that "There are some confounded tricksters who put sand into blue deliberately to increase the weight (for sales) and it is the ruin and destruction of the color." Merchants would also put all the best blue at the top of the bag, and the poorer quality at the bottom. When azurite is washed, the very fine particles are rather pale, greenish sky-blue, and not much admired for painting. Its fineness was suitable to the pen, and was chiefly used for the purpose of putting pen flourishes of blue around large letters (usually in red) in books. There was another blue still better for this purpose; turnsole, often used in conjunction with fine azurite, and the palest qualities of azurites seem not to have been in any great demand. To some extent they were used for modeling up the darker qualities in painting, so as to produce an effect in several values of blue without having to dilute the dark blues with white. Dark azurite blues in tempera on walls could be modeled up simply by roughening the surface with a stick of wood. Scratches on the dark blue looked light, but this was not very long lasting. The best grades of azurite for painting were coarse: not sandy, but so course that it was quite laborious to lay them on, especially in egg tempera. For this reason size was often used as a binder to hold them firmly in place. (Size is more easily affected by protracted dampness or by washing than egg tempera, and blues in wall paintings have therefore sometimes perished through the destruction of their binder where colors in tempera have stood.) It was necessary to apply several coats of azurite to produce a solid blue, but the result was quite beautiful. The actual thickness of the crust of blue added to the richness of the effect, and each tiny grain of the powdered crystalline mineral sparkled like a minute sapphire, especially before it was varnished. The open texture of a coat of azurite blue has often been its undoing on panels; the varnish sinks into it and surrounds the particles of blue. As the varnish yellows and darkens, the power of the azurite to reflect blue light is destroyed : strangled by the varnish. Though skilled restorers can remove surface varnishes perfectly, no means has been devised of removing that which has penetrated into the body of a film of azurite. A large number of blacks in medieval paintings were originally blues, and often is still blue at heart, only obscured by the discoloration of the varnish. Azurite was requested in medieval contracts for important paintings, unless the still more precious ultramarine was to be used. It was not as choice or expensive as ultramarine, but it was the best blue of the panel and wall painter for all ordinary purposes, and widely used in manuscripts as well. Its texture and surface quality was highly watered through the Middle ages, however in oil painting this surface quality is lost, and the pigment went out of use as the oil medium became popular. Though it has a reputation nowadays to turn black, it is incredibly permanent. It does not blacken from the effects of sulphur...
gases as some chemists have supposed, but from the action of the strong alkalis improperly used in picture cleaning, and from the purely optical effect of darkened varnish surrounding its particles. QUICKNOTES: If too finely ground it turns white; best mixed with sizing or water based binders as it turns black in oil; permanent but varnishes can destroy it; best as an underpaint, familiarly under ultramarine.

BARIUM YELLOW

Permanent yellow, yellow ultramarine, are all barium chromate. It appears to be similar to zinc yellow, but somewhat brighter, and is luminously bright under artificial light, almost white. When heated it becomes reddish, and returns to yellow when cooled. It is also slightly poisonous, and superior to zinc yellow in its permanence, and its requirement for oil being only 30% and thus leaner. It is fairly permanent in tempera, watercolor and pastel, but doubtful in fresco, though even then better than zinc yellow.

BARYTA YELLOW

Insoluble in water, this chromate of barium is similar to Zinc yellow, but is often sold under the name of Ultramarine yellow. Permanent to light and gases, but has little covering power. According to Maximillian Toch, the principal use for this chemical was in incendiary bombs.

BILE YELLOWS

In search of a color similar to orpiment, one called "Lombard gold color" was invented by chemists of the Middle ages as mentioned in the following recipe: Take the gall of a large fish and break it on a marble stone, and add a little chalk or calcined nitre and a little good vinegar, and grind it on the marble to the consistency of gum. Write whatever you please with this on parchment and let it dry. And the Greeks used to make their gilded letters in this way. Using bile for its gold color was a Greek tradition: a third century manuscript mentions a similar recipe using a tortoise’s bile in Hellenistic Thebes. Five centuries later it is reported as having been the practice in the interim. Even gallstones were sometimes used as a source of yellow color in the Middle ages. Probably the most significant substitutes for orpiment were the vegetable yellows from buckthorn and weld.

BISTRE

(French) A brown pigment made from charred wood, which as used as a chalk or an ink. In the seventeenth century if was used primarily as a wash, as can be seen in Rembrandt’s drawings, which were mostly done in this technique. Questionable however, is whether bistre’s source was done with or without the presence of air in the process, thus how unlike vine charcoal can it be? Unless a particular wood yields a brown char instead of a black one. Therefore I consider the information on bistre to be incomplete.

BLACK TONER

This color which is at present unheard of, is Nigrosine precipitated on Carbon Black. It is only partially soluble in oil, and is more useful to the leather industry than the paint industry, though I have not figured out exactly what this means yet.

BLACK: GENERAL INFO

Let me begin this list by mentioning that even though many artists have had great success with using black, that I’ve found the darkest and richest tones never came from using a black, but rather from using dark opposing tones, such as vandyke brown and Payne’s gray; Prussian blue with red or raw umber, and so on. Also, for the following; the blacker and less tinged with brown a black pigment is, the more permanent. All bone based blacks in a short time become heavy and turn a dirty gray. Therefore it is better to mix such tones from ivory black and umber, supporting some of the above theory chemically as well. All black pigments require 100% oil and cover well, but dry poorly, and therefore receive an addition of varnish (as they are light as powders, they can be inconsistent in their absorption of the oil). One preparation that helps, is to make first a thick paste by adding alcohol and allowing it to evaporate somewhat, and then adding the oil. None of them should ever discolor any liquids, and none of them is poisonous. The old masters frequently added verdigris to the black making it dry more easily and appear more even in tone. An addition of viridian brings out the same tone effect. It should also be remembered, that as it needs such a heavy amount of oil, and is so inconsistent in tone, that black should never be used in the underpainting of a picture, not to mention that its effect on the colors above over even a short time could be disastrous.

BLUE BICE

It is not easy to make satisfactory copper blues. Even in the eighteenth century (and into the nineteenth) the manufacture of blue bice (blue ashes as it was called in the middle ages) was fully understood only in England, and the French color-makers try as they did, could not equal them. It is now almost extinct in England, as there is no demand and little is known about the blues from which it descended. Blue bice is a bright, pure blue of middle register, fine grained and especially good in water mediums, but not reliably permanent nor as stable as natural azurite. IN the fourteenth century, it was an adjective meaning dark, and in the fifteenth century it became a noun that meant blue. By the; eighteenth century, bice meant a color made from copper, sometimes green but generally blue. Also by then, the copper seems to have been generally as a carbonate, while in the Middle Ages many sorts of copper salts must have figured as “blue bice.” QUICKNOTES: Best in water bases, but not permanently reliable.
**BLUE BLACK**

A permanent pigment made from calcined grape vines, and savored for its blue grey tones produced when mixed with whites. A weaker version of Lamp black, which does not deteriorate other pigments in mixtures.

**BLUE LEAD**

Not blue, but bluish grey, this pigment is a condensed sulphate of lead, tinted with carbon soot during the condensation process. A good primer coat to prevent corrosion, with a very high covering power. It is also an extremely fine pigment.

**BLUE-GREEN OXIDE**

Somewhat heavy, unnecessary and expensive colors (cobalt tin colors) which resemble cobalt green. They are however permanent and non-poisonous.

**BLUES: GENERAL NOTES**

The average medieval painting was predominantly a cool palette; taste and technique combined to make it so. And changes which perhaps improve the sixteenth century Venetians and seventeenth century Dutch and Spaniards, because they simply exaggerate a warmth which is already there, falsify a medieval painting which was intended to show a cool tonality. This is the same with impressionist painting. Nothing has suffered more from the yellowing of age than some of the cool Monets like the mornings at Argenteuil. Bear in mind as well that we must remember to imagine blues in the place of the buffs, greens, blacks and muddy grays that we see in medieval paintings. Silvery tones, which were also abundantly used, have also been affected disproportionately to the warm colors by the yellowing of varnish with age.

**BONE BLACK**

And bone black, are made from bones which have not been entirely charred, and are treasured by painters for their warm tones. They are however, the least permanent of all the black colors, require 100% oil as all blacks do, and doesn’t always dry well.

**BONE BROWN**

Like bone black, made by charring bones, but the brown is an incomplete process, therefore containing tarry matter which is non-drying and retards the drying of all other pigments it is mixed with. This matter included is also fugitive to light, therefore further reducing the value of this pigment in traditional methods. May however be of some use for contemporary materials, and thus worth some experimentation.

**BRAZILWOOD**

Just as lakes aren’t always made from lac, so grain and the sheavings of grain do not always stand in medieval recipes for the insect dyes. Sometimes so-called grain lakes were made from cloth dyed with other materials, sometimes not even made from cloth at all, and were only called grain lakes because they looked like them. The greatest source of red lakes and red colors for dyeing was a kind of wood called brazil. (So named centuries before Brazil was even discovered, so it is far more likely that the country was named after the wood as many dyewoods are found in Brazil). The root of the word is *brazier* referring to the glowing red color of the dye. In the Middle Ages, Ceylon was a great center of supply for it, imported to Europe via Alexandria in great quantities. Botanically, brazil wood is *caesalpinia*, and we have no way of knowing what kinds were available in the medieval European market. Our only clue of identification comes from several medieval texts that state the best kind of brazil wood has whitish veins in it and tastes sweet, which doesn’t identify a single wood, but rather that many were available. In its natural state, brazil wood is a light, brownish red; mahogany in appearance. It is sold nowadays in blocks or chips, and sometimes in scrapings or shavings (as of 1960s). In the Middle Ages it was always sold in blocks, and the craftsman was obliged to reduce the solid wood to powder by scraping it with a piece of glass, or filing or pounding, as the finer the powder the more easily the color can be extracted from it. When the brownish powder of brazil wood is wet it turns reddish. When steeped in a solution of lye it colors the liquid deep, purplish red, and hot solutions of alum extract the color from the wood in the form of an orange-red liquor. Most medieval brazil lakes were made either from the extract made with lye (a weak solution of potassium carbonate) or from the alum extract, as these solutions get the color out of the wood more thoroughly than plain water. Just what the shade is that is extracted depends on how acid or alkaline the mixture of solutions is made. The more alum: the warmer the color, the more lye: the colder the red. The precipitate is collected by settling and pouring off the liquid. The pasty mass is smeared on an absorbent surface such as a new brick or tile to dry. Then it is ground, and has the same degree of transparency as the alumina of which it is chiefly composed. There are many variations of this recipe for making transparent red pigments of various shades and qualities. When chalk is added to the alum, a more opaque pink rose is produced by the resulting admixture of calcium sulphate to the alumina lake. In England, instead of chalk, a chalk stone was hollowed out and holes made at the bottom of the hollow to which the hot alum brazil colored solution would be poured. The reaction would occur at the surface of the chalk stone, where a crust of semi-opaque brazil lake would form in the hollow and holes. When white lead was used, it had no other effect than to give substance to the lake and slightly less transparency, rather than to make it opaque. When marble dust and powdered egg shells were added to newly formed lakes, they further controlled the color produced by reacting chemically with any excess of alum which might give a brown cast instead of rose. In all these cases the brazil color was mordanted upon the white material, so to speak, dyed with the brazil, and the pigment...
so formed was different from a mixture of a finished lake with a white pigment. Sometimes the brazil was not made into a lake at all, but used as a red ink. It was soaked in glair with alum added to develop and fix the color. The extract of brazil in glair was used fresh, or dried and tempered for future use with water and a trace of honey. In recent times, the same red inks were made with gum arabic instead of glair. Its use in medieval books and paintings was more as a ruby stain without body. On panels, where absolute transparency was needed, this would do. The amount of brazil wood color used in the Middle Ages for painting and for dyeing was colossal. Important as the insect dyes were, this was more common and thus cheaper and easier to use, and was especially popular in the fifteenth century. Like grain and kermes, brazil was to be replaced to some extent after the Middle Ages by cochineal, and ultimately by the more permanent reds from madder. It is only used now for cheap wallpapers and marbled papers, and was used for red inks until only about 80 years ago. Brazil lakes are not very permanent, and to our eyes not particularly beautiful, but were used in enormous quantities in medieval painting and were highly esteemed by medieval painters. It has been noted by several conservationists who have studied the shroud of Turin, that the pigment used was Brazilwood in an alum base. This would naturally date the shroud to the medieval period rather than the biblical, as no instances of Brazilwood have been discovered from the period of Christ’s crucifixion. QUICKNOTES: sold today in chips, reduced to powder by scraping with glass/pounding/filing; the finer the powder, the easier to extract the color; when wet it turns red; in lye it is purplish red; in hot alum, the color is more orange; when chalk is added to the alum it makes it an opaque pink rose; when lead white is added it makes it slightly less transparent; when marble dust and powdered egg shells are added it gets a brown cast. The extract of brazil in glair is used fresh, or dried and tempered for future use with water and a trace of honey. In recent times, the same red inks were made with gum arabic instead of glair. Not permanent colors.

BRILLIANT YELLOW

A very light mixture of cadmium yellow and either lead or zinc white; it is durable but unnessssary. The old masters had only the very poisonous orpiment, yellow sulphide of arsenic, and realgar, arsenic orange to work with. It was very coarsely ground and applied with tempera. In oil painting it was used pure without admixtures between layers of varnish. In Pompeii it has frequently been discovered in ochres, but it has also been traced in present-day cadmiums.

BRONZE: SURFACE VERDIGRIS COLORS

There are certain chemical colorings for bronzes that are worth mentioning here, as there may be other applications for the formulas. They depend greatly on how the chemical ingredients are applied to the metal, and the results are therefore as different for each person as a brushstroke is on canvas. The colors for patina are within the green, brown/black families, and are applied with different types of medium sized sash brushes, fairly firm bristled, using a different one for each color applied. Wire and steel brushes are always kept on hand for equalizing areas between thin and thickly coated areas, and polishing brushes are obviously for the final rubbing of the bronze. The following formulas for patina come from a 1953 publication called " Casting a Torso in Bronze", by the Cire Perdue Process, by E.J. Parlanti.

Formula #1: Antique Green: Ammonium chloride 1/2 ounce, Copper sulphite 3 ounces, 1 quart of water. Warm the bronze slightly and apply this solution quickly all over, dabbing it with a brush and keeping the color even. After the application, the piece should be rinsed with cold water, then with hot water, and dried.

Formula #2: Yellow Green: Ammonium chloride 15 ounces, Copper acetate 8 ounces, and 1 quart of water. Apply this solution, after heating it to boiling point, with a wide stiff brush.

Formula #3: Deep Blue Black: Ammonium sulphite 2 ounces, and 1 quart of water. Apply this solution cold.

Formula #4: Apple Green: Ammonia 4 fluid ounces, sodium chloride 5 ounces, ammonium chloride 5 ounces, acetic acid 1 quart. Dab on with a stiff brush until the surface is dry.

Formula #5: Brown No. 1: Barium sulphide 1 ounce, potassium sulphide 1/4 ounce, ammonia 2 fluid ounces, and 3-5 quarts of water.

Formula #6: Brown No. 2: Hydrosulphur of potash 10 grams, and 1 pint of water. With either of formulas 5 or 6, dip the bronze into the solution and leave it in until a black tint is attained, then rinse in water and work the surface with a brass brush. When drying apply some hot water. This will deepen the color and help the drying process. After the application of any of the above colors, a thin coating of wax and turpentine may be given if a shine is required. When dry, rub the surface with a soft cloth.

BROWN MADDER

No such thing. If you bake (or calcine) Alizarin (Madder Lake), the organic matter within it toasts, causing the color to lose its brilliancy, and its permanency to ultra-violet light. Also happens when Alizarin is mixed with Burnt sienna, except that this mixture is permanent. So you may ask, “Brown madder. What is it good for. Nothing.”

BROWN OXIDE OF IRON

A permanent pigment resembling burnt sienna but without its strength

BROWN PINK

Also known as Italian pink, and in housepaints and latexes: Dutch Pink. Changes within 24 hours of exposure to direct
sunlight, which could be useful in something, but not traditional painting. It is a mustard tone which is better found in the ochres.

BROWN: GENERAL INFO

This section will take further research, as my resources are primarily medieval through high renaissance, and browns were not important to the former of the two. It wasn’t until the baroque period that brown became such a predominant color as to replace many of the brighter colors that gained popularity through the Middle Ages and the Renaissance. This is what is available at the present, to be elaborated on at a later date.

BURNT CARMINE

A mixture of carmine or carmine lake which has been heated and added to VanDyke Brown. Sounds like a lot of work for a color which could be obtained by other methods.

BURNT OCHRE

An American pigment which is a muddy terra cotta color of great permanence.

BURNT SIENNA

Prepared by calcining raw sienna which in the process undergoes a great change in hue and depth of color; in going from ferric hydrate of raw earth to ferric oxide, it turns to a warm, reddish brown. Microscopically, it becomes more even in color and the grains are reddish brown by transmitted light. Because of its transparency it is used as a fiery glazing color which requires much oil, about 180% and as an oil color is apt to jelly. This is remedied by washing, which however dilutes the intensity of the color. This like all other red and brown earths, can be used in all techniques, and was often used by the Venetians with iron oxide for flesh tones, as it increased the warmth and fire of the tones, when used with discretion. Supposedly the luminous red in the flesh tones and reflections of Rubens is not vermilion, but an especially well burnt sienna. In 1768, Martin Knoller stated that very strong heat will produce a sienna resembling vermilion that may be used in fresco out of doors. QUICKNOTES: Requires 100% oil for pigment in all techniques; by Venetians with iron oxide for flesh tones. In microscopic and chemical examination of paintings, the siennas are not usually reported under that name but are grouped under the ochres or native iron oxide pigments. According to Maximillian Toch, "American Burnt Sienna is a strong type of ochre and is neither as clear nor as brilliant as the Italian Sienna." It supposed imparts a muddy tone but is very permanent in all techniques.

BURNT UMBER

This combination of Iron oxide, oxide of manganese and clay is made by burning Raw Umber to drive off the liquid content. Completely lightfast and unaffected by gases, and makes a good glaze when thinned with oil or varnish. Can be mixed with all other pigments except for the Lakes.

BURNTGREEN EARTH

Heavier than green earth because it loses its water content when burned. It is a semi-glazing color and is permanent in all techniques.

CADMIUM RED

Regarded as the best substitute for vermilion (which is mercury based as a sulphide of Mercury), it is cadmium selenide and cadmium sulphide. As an oil color it needs a little wax and 40% oil. In tempera the color easily solidifies in the tube and is therefore better for the painter to prepare the color just before use. It is known to turn brown in outdoor frescos; with copper colors such as emerald green it turns black, as do all cadmiums. It should be noted that none of the reds the old masters used were as permanent as the cadmium range. The yellows were introduced to the public at the 1851 Exhibition, and is said to have been made first in 1846. The reds were not introduced until about 1922.

In commercially available colors, it comes in light, medium and dark. These tones vary slightly from manufacturer to manufacturer, and therefore when choosing one for a large area, be sure to have enough from the same source as to replicate the exact tone, and in many cases, the texture of the paint as well. Little is written about the abuses caused by the overgrinding and refining of commercial paint; it can often make the paint gummy in feel, and quite dense, needing extra emulsions to attempt to bring it back to the feel of “paint”. There is the opposite extreme as well, which is paint that is saturated with linseed oil. This is usually a sign of a cheaply made color, or one that has not been regarded in the sense of how much oil is needed to produce the proper texture for that tone. Therefore when purchasing paint at sometimes discounted prices, avoid those in tubes yellowing at the mouth and tail by linseed drippings, unless you are planning to use them for glazes. Even for underpainting it will not do, as the paint will be too fat from the excess oil to properly the main coat of color applied after drying. I especially stress this in the cadmium notes as they are more expensive, and sometimes we think we can avoid the price by getting them on sale or from a lesser company. The least expensive way to purchase paint, will always be to buy powdered pigments for grinding, and only make as much as is needed in a sitting; or if grinding for a larger area, some can be capped away for future use assuming it will be used over the next few days. Note: as I may have mentioned, cadmiums should never be mixed with lead white or other lead based paints, but can be mixed with the older Lithopone, Titanox and Zinc oxides, and the more contemporary Titanium whites.

CADMIUM YELLOW

Both permanent and non poisonous, this cadmium sulphide is also permanent in 1ys, but behaves oddly when heated: if
heated to red it returns to yellow, but turns to orange within a year. Cadmium lemon, is precipitated upon a white filler. Some commercial samples turned green under light, but others stood up well. The darker cadmiums have more covering power and are more permanent. A certain cadmium lemon advertised as 100% cadmium sulphide, revealed titanium white as a base. Today there is a wide range of manufacture and price; but hand made requires 40% oil, a small addition of varnish to act as a slow dryer, and 2% wax to prevent drying in the tube. Cadmium is not compatible with copper colors such as emerald green, as in mixtures with them turns them permanently black. Many cadmiums in powder form show streaks under light; the cause being cadmium salts other than sulphide. It is however useful in all techniques, except fresco, and is permanent indoors. In the open it turns brown when mixed with lime. (See Cadmium Red for history on the yellow range.)

**CALCIUM CARBONATE**

Also known as Whiting, Marble Dust, Powdered Limestone and precipitated Chalk. It is used in industrial paint manufacture, as an ingredient in grounds on canvas, and as an extender for paints. Marble Dust, which comes in a variety of degrees of grit, is used to add texture to pigments, tooth, and also as an ingredient that brings down the brightness of the color. Most calcium carbonates will do this.

**CARMINE OR CRIMSON LAKE**

Is a natural organic dyestuff made from the dried bodies of the female cochineal insect, coccus cacti, which lives on various cactus plants in Mexico and in Central and South America. It was brought to Europe shortly after the discovery of those countries, first described by mathioli in 1549. The finest quality, known as nacarat carmine, is non-poisonous and quite beautiful with the peculiarity of being more permanent in transmitted light as a transparent color, than when under direct light. According to Maximillian Toch, it is only legitimate as a food coloring, as exposure to the sunlight for three months, bleaches the pigment completely. Carmine lake does not behave much better being even weaker and less stable, is of a maroon shade, and is insoluble in water. It burns completely leaving a white ash, and smells in the process like burnt horn. Despite their rapid fading, these colors continue to be used a great deal in watercolor and oil techniques. Carmine, however, is an aluminum and calcium salt of carminic acid and carmine lake is an aluminum or aluminum-tin lake of cochineal extract, whereas Crimson lake is prepared by striking down an infusion of cochineal with a 5 per cent solution of alum and cream of tartar. Purple lake is prepared like carmine lake with the addition of lime to produce the deep purple tone.

**CASSEL BROWN**

Vandyke brown, cologne earth: is a brown coal color. Also known as Caste Earth. It is partially soluble in oil and has a slight tendency to turn gray (most apparent when used in whites). When used with resin ethereal varnish it is more permanent than when used in oil, however this is impossible in painting, and unnecessary. It requires 70% oil, and is found in the pictures of the old masters, among them Rubens, who used it mixed with gold ochre as a warm, transparent brown, which held up particularly well in resin varnish. For restoring purposes it is useful when mixed with varnish. Cassel brown is sensitive to lyes and becomes a cold gray in fresco, making it useless on a wall.

**CASSEL YELLOW**

Mineral yellow. Turner’s yellow, patent yellow, is an impermanent lead yellow not compatible with other pigments.

**CERULEAN BLUE**

This is a greenish, light, very pure and dense compound of cobaltous and tin oxides (is supposed to be a Stannate of Cobalt) which as a color, is very valuable to the landscape artist in atmospheric tones, though this color can also be made by using greenish Prussian blue with zinc oxide. It is absolutely permanent (though in the tube it needs an addition of 2% wax). A cerulean blue bound only in poppy oil becomes solid in a few weeks, “cause being perhaps gypsum”. (I don’t know what this means, and need to find more information, which so far has not become available).

**CHALK**

Calcium carbonate; is unaffected by alkalis and remains white when heated. Impure varieties discolor; when they contain iron they turn red. When strongly heated, it is converted into quicklime. Oil colors which contain chalk set quickly in tubes. It is non-poisonous and has little covering power. The whiter it is, the greater the value, therefore French chalks are the best. Gray chalks are however not useful in grounds as they develop ugly dark spots when touched by oil.

**CHINESE BLUE**

Prussian blue with a greenish tone which is not very permanent.

**CHINESE WHITE**

Zinc Oxide. Some manufacturers call Flake white, Chinese white, which is wrong, as flake white is generally the other name for lead white, which is obviously of a completely different composition.

**CHROMATE OF ZINC**
An anti-corrosive used in grounds for paintings that come in contact with steel and iron. Sometimes called Zinc yellow or Aureolin, these are confusing as this puts them in the category of pigments. They are only slightly water-soluble, and are not very useful in painting.

**CHROME GREEN**

Under this name is sold the valuable chromium oxide green as well as much less valuable mixtures of Paris blue and chrome yellow, which give heavy, earthy tones and should more properly be called chrome yellow-green.

**CHROME RED**

Similar to Chrome Yellow and also dries quickly. Is basic lead chromate, made by boiling a strong solution of potassium dichromate with white lead and a small amount of caustic soda. It is poisonous and when heated turns a reddish brown. Acetic acid changes it to yellow, whereas permanganate is unaffected. When chrome red is finely ground it becomes a considerably lighter yellowish red, so should be worked only with a spatula rather than a muller, and just before being used. Chrome red is not to be compared with vermilion for brilliancy, and when mixed with white lead, it gives cold, dull tones. It can be used in fresco, but it does not show up well. As a pigment it dates from the beginning of the 19th century; chromium was discovered in 1797, with descriptions of the preparation of properties of lead chromate published in 1809 by Vauquelain, its finder. Little else is known.

**CHROME YELLOW**

Neutral lead chromate is poisonous, and occurs in manufacture, in all the different nuances from the lightest lemon yellow through light, medium and dark, to orange. The colors are brilliant and relatively inexpensive; they cover and dry well, and as they go a long way, are often cut. The lighter tones do not stand up well under light, and even in powder form turn a dirty leather color, and in oil a dirty greenish brown. The darker shades of chrome yellow are, according to the degree of darkness, much more permanent. Chrome yellow must have 2% wax added to prevent hardening in the tube, to the 25% oil added, which should be poppy oil. When heated it turns a reddish brown, and after cooling again a dirty yellow. The darker shades can be used in both oil and tempera, and when in contact with wet lime, all tones turn quickly orange. One advantageous color change in chrome yellow occurs in Van Goghs sunflower paintings; his yellows were originally much harder and lighter, and not so mysterious as they appear today. With chrome yellow and Prussian blue are prepared mixed colors, so-called chrome greens, which are relatively more permanent than chrome yellow.

**CHROMIUM OXIDE (BRIGHT & MATTE)**

This is one of the best colors and renders all the copper greens unnecessary. Chromium oxide brilliant is transparent, not affected by alcalis or acids, is non-poisonous and dries well. It loses none of its color in alcohol, water or ammonia, and if so is adulterated with coal-tar dye. The color requires 100% oil and must stand for a few hours after grinding, when it will again absorb almost as much pigment as before. 2% wax is added, especially when preserving for tubes. It easily acquires a gelatinous character, especially in tempera, and in manufacture when mixed with fatty oils, there is a separation of a soot-like substance on top of the oil. When it dries on the palette in thick layers in oil or tempera, it looks black, but justly finds many uses, especially with Prussian blue, madder lake of cadmium. If strongly heated, the pigment loses its water content and becomes chromium oxide matte, a dense covering opaque color tone of high tinting strength. It is permanent in all techniques and only requires 30% oil. Even so, it dries no faster than its transparent variety. Because of their ability to withstand the action of acids and alkalis, the chromium oxide greens can be easily distinguished from substitutes.

**CLAY**

Or Silicate of alumina, which is the base of many of the earth colors, such as umbers, siennas and ochres. Mainly used as an additive ingredient.

**COBALT BLUE**

A modern replacement for smalt, this is also known as cobalt oxide and aluminum oxide, a non-poisonous metal color, is unaffected by acids, alkalis and heat, and therefore useful in all techniques, as well as being lightproof. It needs 100% oil but dries very quickly, with the same drying power as the metal lead. And because of this it often causes cracks in the picture when painted over layers which are not sufficiently dry. Cobalt blue is susceptible to the yellowing of oils, as all cool tones do, but yields a clear tone whereas ultramarine in thick layers, if not mixed with sufficient white, appears to be black.

**COBALT GREEN**

Also falsely called zinc green, this is a compound of cobaltous oxide and zinc oxide. It is attacked by hot acids and alkalis and becomes reddish in hot acids, but does not change when heated by itself. The color appears yellowish or bluish when manufactured, and is very permanent in all techniques, but has little coloring strength and is somewhat gritty making it not adhere well. It only requires 30% oil, and the same amount plus 2% wax when in the tube. It dries quickly as all cobalts do, and despite its poor coloring strength, its fine cool tones make it a much used color for flesh tints.

**COBALT VIOLET**

O the light variety and manufactured by the French, this is a cobaltous oxide arsenate, therefore extremely poisonous and turns dark in oil. Dark cobalt violet, a cobaltous
phosphate, is a German product and is very permanent as opposed to the French variety, but is quite expensive, and thus hardly necessary. In tempera it is not a good tube color as it hardens too easily, and in my experience, the commercial watercolors of this pigment also have an extremely short tube life.

**COBALT YELLOW**

A mineral color with covering power, which Indian yellow does not have, though in manufacture, the color is very uncertain. It is also very expensive, appearing often under the name Indian yellow as well, thus being a superfluous pigment.

**COCHINEAL**

(Also see Kermes). The discovery of Cochineal coincided with the conquest of Mexico in 1523, and was first described by Matthioli in 1549. The insect based red was then brought back to Europe, and I’m curious to know how long after or before, with the conquest of South America, that Brazilwood was also returned to Europe for trade in dyes and pigments.

**CRAP LAKE**

Also known as Krapp Lak, and is the German name for Madder Lake.

**CREMINTZ WHITE**

The same as lead white and flake white, but made by a slightly different chemical process which leaves a faint vinegar odor. Not very permanent to sulphur gases, and therefore other whites are far better to use.

**DRAGONSBLEED**

One other important vegetable source or red is an East Indian shrub known as pterocarps draco, or dradacoina draco. The sap of this shrub dries into a deep brownish-red gum resin which is known now as it was in the Middle Ages, as dragonsblood. In classical times it was called Indian cinnabar by Greeks writers, but Pliny (whose word was law in the Middle Ages) professed that it was a product of a battle between the dragon and the elephant which ended in the mingling of the blood of each. A great use of this red resin in the Middle Ages was to color metal (note: as it was not a chemical reaction that would alter the metal colors, was it more of a glaze and therefore impermanent?), improving the color of gold, and for glazing other metals to imitate gold. It was used as a pigment chiefly by book painters. Though not a lake pigment, it resembled them in transparency, but was passed out of favor by the fourteenth and fifteenth centuries, though not completely abandoned. Texts have been found with recipes for making it artificially with brazil wood as the chief coloring component. It is more likely that its value as a transparent warm red became less urgent as the manufacture of transparent yellow lakes developed, in and after the fourteenth century.

**EMERALD GREEN**

Basic copper arsenate, the most poisonous and dangerous of all pigments, therefore to conceal this fact it appears under various fantastic names. The color is luminous by itself, bluish or yellowish green, highly permanent and would be very useful except that it is incompatible with sulphur colors such as cadmium yellow, vermilion and ultramarine. It is also doubtful with white lead. On mural painting of the Romanesque period light copper greens have stood well through time, but was most likely natural mineral greens as emerald green was not known in those days. Malachite was its predecessor being basic copper carbonate, but as an oil color, emerald green requires only small amounts of oil: no more than 30%, and dries well. With sulphur colors it turns black. When verdigris and other blue and green copper colors were used by the old masters because of a lack of other pigments, they were well aware of the dangerous incompatibility and used coats of varnish between opposing layers to prevent blackening. All copper colors are easily recognizable as they turn ammonia a deep blue color. Emerald turns black when heated and smells of garlic. Potassium hydroxide discolors emerald to an ochre color, and in weak sulfuric acid it dissolves, turning the solution blue. The copper colors of the old masters look under the microscope like coarse glass splinters as compared with modern colors which have a mud-like character.

**FLORENTINE BROWN**

Otherwise known as roman brown and Hatchett’s brown, it is a copper color related to Paris blue, and is therefore impermanent. It is found in reddish-brown madder lake, such as Van Dyck red, and is poisonous.

**FOLIUM & ARCHIL**

Colors obtainable from Turnsole corresponded fairly well with the range of the ancient purple. That may conceivably be the reason why turnsole colors were sometimes called folium: that they resembled the purple of the manuscript folia. Archil, a dye made from a lichen, also had importance in medieval painting. We used to call it orchil, being derived from oricella, from the Latin name roccella, which botanists still apply to the lichen itself, Roccella tinctoria. A pigment was sometimes made from it; but its chief importance was as a dye, and perhaps its chief interest for the study of medieval art is that a Florentine family, well known as patrons of art, who are said to have made their fortune in dyeing wool with oricella, were known as the Oricellai, the dyers with archil, or in more familiar form, the Ruccellai.

**FULLER’S EARTH**
A form of Silicate of Alumina (clay) which is capable of absorbing coloring matter in oils. In the preparation of refined Linseed oil, an ounce of Fuller's earth with a pint of oil is shaken and then placed in the sun. It produces a clear, well-settled oil. As a pigment, there is less information documented even though there is proof that it was used for paint as well.

FUSTIC

From the wood of the *Rhus cotinus*, which in fifteenth century Italy at least had some importance in yellow lake-making as well as dyeing. Lily pollen and the bark of walnut-trees have been mentioned incidentally as well. An apple tree bark yellow was known in fifteenth century Germany, and there are still other minor yellows which need not be dealt with. The great medieval yellows, apart from gold, are orpiment and ochre, giallorino (probably usually massicot), mosaic gold, saffron, buckthorn, and weld.

GAMBOGE

A gum resin pigment much used in watercolor, which is neither lightproof alone or when mixed with other pigments. In thick layers it shows a gloss because of its resin content, and as an oil color it strikes through, therefore being unusable. It burns with an odor of resin, is poisonous, is not attacked by acids, and turns red in alkalis.

GIALLORINO - MASSICOT

The other medieval yellow used mostly in Italy which may have been of mineral origin, was *giallulimum*, the little yellow, a diminutive of *giallus* meaning "yellow". Some fourteenth century texts say that Mount Gilboa is green on one side and yellow on the other, a reference more likely attributed to orpiment. Cennino say that this giallorino is half natural and half artificial, found in nature as a stone in places volcanic. There is a legend that a bright yellow mineral used to be found in Naples, a product of Vesuvius, which gave its name to Naples yellow. Also a potter's color for yellow glazing compounded from lead and antimony, was known as giallulimum, which was used by painters at some point, it has been suggested was an artificial imitation of the extinct volcanic stone once found at Naples. There is a bit of confusion over all of this. Most medieval references to giallorino mean massicot, a yellow oxide of lead, prepared in the Middle ages by roasting of orange lead, the intermediate product in lead white. This pale but fairly intense yellow known in classical antiquity was too attractive to have been overlooked by medieval painters.

GRAPHITE

A form of crystalline carbon that is available naturally as a mineral in many parts of the world (modern source is Sri Lanka) and has also been made artificially by furnace process since 1891. It has been long used as a writing material, which is why the confusion with lead, hence the names "black lead" and "plumbago"; the name however is from Greek, meaning "to write". In pencils it is compressed with fine clay, and otherwise has a greasy texture and is a dull gray, being seldom used except in mural painting. It is permanent in all techniques, but has a tendency to strike through. Bocklin used in the frescos at Basel. As a further note however, I worked with graphite for many years in paintings, and found the slightly silver tone after drying quite wonderful, especially when rubbed till glowing, and the heavy, inconsistent strokes that it made on brush, wonderful for certain effects that were impossible with any other black pigment. It is however important to note that it is highly toxic, needs to be immediately wetted with varnish or linseed (not advised but I’ve had great success with it in linseed, as long as it is varnished after, or the oil is heavy enough,) and a fairly large amount in order to liquefy it. It is also best to varnish it after painting as well. It is also highly stable and very reflective, something which can be quite useful in certain techniques. There are references to graphite in fourteenth and fifteenth century texts to the use of a soft black stone, presumably graphite, a soft, smooth natural deposit of carbon, which we’re more familiar with as our so called lead for pencils. However from all evidence, in the Middle Ages, when used at all, it was chiefly for drawing.

GREEN CINNABAR

A senseless but commonly adopted name for various green mixtures, among them chrome yellow-green, also mixtures of Paris blue and Chrome yellow.

GREEN EARTHS

There is no physical resemblance between malachite and the green earths which we call Terre Verte, which is in comparison rather dull, transparent, and soapy in texture, like a clay. It is also not constant, ranging from a light bluish gray with a greenish cast to a dark, brownish olive. The name Terre Verte is applied to several different minerals, but most importantly in medieval painting is the light, cold green of celadonite, found chiefly in small deposits in rock in the area of verona, in northern Italy. The chief deposits of glauconite which yield the yellowish and olive sorts are in Czechoslovakia. No effort has been made to distinguish the characters and sources of Terre Vertes in medieval paintings; and if these distinctions were made they could teach us a great deal more. These were not the strong colors; they wouldn’t do for painting naturalistic landscape effects, and weren’t used to this effect except in wall paintings where the dull tones were in order. In manuscripts and on panels they were chiefly used to underpaint the warm flesh tones. In the fifteenth century liberties were taken with the traditional green preparation for flesh: ochre was mixed with it, or a little black, or stronger green and so on. In general, especially in works before the fifteenth century, it was quite usual to underpaint flesh with green earths mixed with whites only. They require 100% oil but dry normally. They are not poisonous, dissolve partially.
with a yellowish-green color in hydrochloric acid, but not in alkalis, and should not discolor water, alcohol or ammonia. Today the color is chiefly a durable mixture of chromium oxide, black, white and ochre, since the natural product is scarcely obtainable, though possible with effort. The color is excellent in fresco but turns much lighter when drying, and was used a great deal in Pompeii. The glazing Bohemian green earths were often used as undertones by the older Munich school for painting wet-on-wet, and is well suited to this technique as it gives to other colors painted over it a subdued tone. They darken later due to their large oil content, but this makes little difference in a picture planned in a brown key. The cheaper sorts designed for commercial purposes may show rusty discolorations when used in fresco.

**GREEN LAKE**

*Hooker’s green, leaf green, sap green* are all other names for this pigment, all of which are imperfect pigments composed of Prussian blues and yellow lakes. There also exist green coal-tar colors which are no better.

**HAEMATITITE**

A hard, compact nearly pure natural variety of anhydrous ferric oxide. Although probably this compact form of haematite was sometimes ground and used for a dark purple-red pigment, ordinarily it was for the preparation of burnishers for gold leaf.

**HANSA YELLOW**

A new coal-tar pigment, said to surpass cadmium lemon in permanence. It is durable in both lime and oil.

**HARRISON RED**

Said to have gotten its name from the artist Birge Harrison; it is a brilliant red lake color or toner which is similar to, if not identical with Toluidine red. Some other lake colors, may also be sold under that name.

**HELIO FAST RED R.B.L.**

Along with lithol fast scarlet, these are coal-tar lakes which serve as substitutes for vermillion. Helio fast red is a brilliant color which is permanent in watercolor, tempera and fresco, though with slightly better success indoors than outdoors. There is however still the question of the usefulness of coal-tar colors, as it is said that they turn brown in oil, and Helio particularly has been known to attack the metals of tubes, thus they have to be covered with a protective lacquer before filling. This is another vermillion substitute which is still somewhat questionable.

**HONEYSUCKLE AND NIGHTSHADE GREENS**

Besides the greens from buckthorn and iris, other vegetable greens were known in the fourteenth century, some seldom recorded such as one made from “the flowers of the plant called *Aquileia*,” which we think may be what we now call Columbine. Two, however, that seemed fairly important: one made from the berries of honeysuckle, the other from the leaves of most especially, nightshade. Honeysuckle green seems to have been an Arabic tradition, sometimes described as “Saracenic”, and in the recipes it is always given an Arabic name. Processes for making greens from the leaves of Solanum, Nightshade, go back to the thirteenth century and possibly earlier. Elder and mulberry leaves also yielded greens, and rightfully so as chlorophyll, the natural green color-matter of leaves, was the chief pigmentary constituent of the product.

**HYDRATED CHROME OXIDE**

Same as Green Emeraude or Veronese Green.

**INDANTHRENE BRILLIANT PINK**

Of the German “universal colors”, is a color expression between vermillion and light madder lake. The latter has an admixture of ultramarine blue to give it a cooler quality. The colors are useful in all techniques including indoor fresco. When heated, all coal-tar pigments, because they consist of organic bodies, turn black. The base and filler material remain white.

**INDIAN YELLOW**

Or, *magnesium euxanthate*, a natural organic lake, is said to have been made from the urine of cows which have been fed on mango leaves. The raw product, Monghyr purree (after a city in Bengal), in the form of yellowish brown lumps, betrays its origin by its odor. When cleaned and powdered, it is a beautiful golden yellow glazing color, which is quite permanent and can be used in all techniques but fresco. Indian yellow is slightly soluble in water, but when boiled in water with added hydrochloric acid, the yellow if genuine Indian yellow, disappears. Substitutes remain in the water. Like many organic substances, it leaves ash when burned, but a white ash which is soluble in hydrochloric acid; otherwise the product has been adulterated. The cleaner and more golden yellow, the more valuable, brownish varieties being less valuable. It requires 100% oil, and needs an addition of varnish as it is a poor dryer. There also is no substitute for this peculiar color. It is very expensive, and the expected adulterations because of that had a bad effect on its reputation. Today coal-tar colors such as napthol yellow are called Indian yellow by manufacturers.

**INDIGO**

The two great colors of medieval painting were azurite and indigo, both of which lost their importance with the inception of oil paint as neither hold up in an oil base. As a dyeing medium, indigo was imported by the ancient Egyptians (and later by the Greeks and Romans) from India, hence the name. The importation of indigo from the orient continued through the Middle Ages, and the best
qualities in the European market were known as Baghdad indigo or Gulf indigo. A by-product of this natural plant dye formed a pigment which is heavy and impermanent, therefore cumbersome to use, along with Thioindigo, a red-violet coat tar pigment which is permanent, though only in watercolor. Following is an interesting passage concerning indigo: Unknown, Cambridge, twelfth century: “Take white marble and put it into hot dung for a day and a night, and then take it out and find it on another marble strongly, and make a very fine powder. And then take the foam which is found in the cauldron in which clothes are dyed the color of indigo, and put it on this powder, and work it up for a long time. And when it is dry, add more of the foam, until it acquires a good azure color. Then after it is thoroughly dry, powder it finely and wash it with water in a basin; and then let it settle and pour off the water, and after pouring off the water let it dry. When it is dry, powder it very finely on the marble, and put it away in a little bag. And know that the foam is better before the cloths are dyed. Know too, that you can do all this with white lead as well as with the powder of marble.” (We are not sure that the source of the color in the dye van was woad and not oriental indigo.)

INFUSORIAL EARTH

Fuller’s earth.

IRGANZINE YELLOW

No information available on history or chemical make-up; seems to be a recently made color. Very acidic dark green-yellow. When mixed with linseed it becomes a very dark green with a highly acid yellow staining power. Works best as a yellow stain in zinc or titanium white. Also uses about 60% oil from my experience.

IRIS GREEN

This was the chief rival of sap green in late medieval manuscript painting, made from the juice of iris flowers, and mixed with alum and thickened like sap green, but more often prepared as a clothet. (It is the alum that causes the color to turn green.) Bits of cloth were dipped in alum solution and dried, and then dipped into the juice of the flowers and dried, over and over until they contained a sufficient quantity of color. The dark blue flowers do not appear to be a likely source of green; the purplish color that is first squeezed out is not promising; but as soon as it combines with alum, a clear and beautiful green appears. It was greatly used in the fourteenth and fifteenth centuries as far as we can tell as there is no method worked out for distinguishing it from sap green in manuscript paintings. We cannot estimate their relative importance in the works of different schools, but it is possible that iris green precedes the use of sap green and may have been more generally employed. In addition to the recipes for making greens, there are fourteenth and fifteenth century rules for making iris blues. The secret, according to a manuscript in Florence, is to take out "the yellow things in the flowers". (pollen).

IRON GALL INK

Made from tannin or gallotannic acid which is derived from oak galls. When this is combined with ferrous sulphate, ferrous gallotannate is formed (a colorless compound) which develops a black color on exposure to air because of oxidation to ferric gallotannate. 7 to 10 days are required for complete oxidation, therefore a dye or other provisional coloring matter is added to the ink to give it an immediate color. The ink ingredients are suspended in a solution of gum and water. We do not know when iron gall inks came into use, except that it was at some point in the Dark Ages or early Medieval times.

IRON OXIDE BLACK

A dependable black in fresco. When strongly heated, it turns a very dark red-brown.

IVORY BLACK

Prepared by charring bones, horns etc., in the absence of air. It is the purest and deepest black and is the best dryer. It is partially soluble in acids and can be used in all techniques. When used by itself over a smooth white ground of for example, lead or cremnitz white, it cracks, but not when slightly mixed with other colors. Ivory black was established in antiquity by the example of Apelles; but there is no evidence that it was continued in the Middle Ages. Where it picked up popularity again I have not fully established yet. Eugene Fromentin 1867: (In discussing the pigments of Rubens): "If you examine his blacks they are made of ivory-black, and serve with white to make all the imaginable combinations of heavy and light gray."

KIESELGUHR

Infusorial earth, which is Fuller’s earth. Just another name.

LAMPBLACK

In the Middle Ages it was made by allowing a flame to play on a cold surface and collecting the soot which the flame deposited; sometimes a beeswax candle, sometimes tallow. Sometimes it was the flame of a lamp burning linseed, hempseed or olive oil; or by burning pitch or incense. It does made a difference as to what the source of the flame is as the black itself is pure carbon, but there are apt to be unburnt particles which may affect the color and working properties of the pigment. It was often used for ink making as it has an extremely fine grain and doesn’t need grinding, and only needs to be mixed with a little gum water to make what we call, India ink. Our black inks made by a process which keeps the carbon permanently in suspension, was not known in the Middle Ages. Chinese stick inks are generally make with lampblack and gum; they are made for brush writing or painting on very absorbent surfaces, and often contain a larger proportion of gum than the medieval European carbon inks. It is supposed that these carbon inks, like the lampblack pigment, are absolutely permanent; we know that pure carbon black will never fade, but the material with which the ink was bound has often perished.
or become brittle, thus the writing has consequently been wholly or partially lost. The surface of parchment is so hard and close grained that even the fine grains of lampblack may fail to penetrate it if the lampblack is suspended in a strong solution of gum. Often they combined iron inks with carbon for denser black, which rendered it less permanent, however this would temper it for painting purposes. However, when mixed with water or water media, it becomes so light that the powder floats in the air and is not very manageable; tends to be a bit greasy; and though an excellent pure black, apt to muddy a bit in mixtures. Thus its value in history, was much more for ink-making than as a painting pigment.

**LEAD TIN YELLOW**

Although lead-tin yellow was used often in European painting before the eighteenth century, there is little evidence of its use from the older literature on painting techniques. The earliest recipe for a yellow pigment from lead and tin was found in a Bolognese manuscript from the first half of the fifteenth century, which mentions *giallino*, a yellow of pale color, mentioned in Italian texts as identical to *massicot* of the northern manuscripts. Although lead-tin yellow was used in European painting before 1750, it was not really used after that time. There is no reference to a yellow pigment consisting of lead-tin oxide in the whole literature on color from the nineteenth century until 1940, when it was rediscovered by Jacobi at the Doer ner Institute in Munich where he was doing investigations of samples from paintings, and subsequently it was synthesized in the laboratory.

**LEAD WHITE**

Also known as flake white, cremnitz white, kerms white, Berlin white, silver white, slate white and the list continues. The best quality is called cremnitz. As the name lead white suggests, it is a by-product of lead, and whatever the form of manufacture used, the purity of the color depends on the purity of the lead. Purifying processes greatly increase the cost of the product. White lead has always been one of the most important pigments in many painting techniques; yet chemists are still undecided as to just what our normal modern lead white is. In comparison to what the product was in the Middle Ages, that is. We have intensive recipes from that period, however the traditional method is as follows: the stack process. The “stack” consists of hundreds or thousands of earthenware pots containing vinegar and lead, embedded in fermenting tanbark or dung. They are shaped in a way that the vinegar and lead are separate, but the lead is still exposed to the vapors of the vinegar, by being coiled into a spiral which stands on a ledge inside the pot, above the well of vinegar in the bottom. It is then loosely covered with a grid of lead, which keeps the tan from falling in, allowing the carbon dioxide formed by the fermenting of the tan to enter the pot and act upon the coils and plates of lead with the vapors of vinegar and moisture. A thick layer of tan is spread out on the ground: the bottom of the pit, and the pots with lead and vinegar are arranged upon it, covered with their leaden grids. More tan is laid over them and then usually a loose flooring of boards, followed by more pots, more tan, and so on until all the pots are imbedded. The temperature process: old tan partly used up, in certain proportions will continue to maintain proper heat. The heat, moisture, acetic acid vapor and carbon dioxide do their work for a month or so, and the stacks are dismantled. The metallic lead by this point has been largely converted into a crust of white lead on the coils and grid. These are then separated from the unconverted metal and washed free of acid and soluble salts, and ground for future use in painting. This stage of the work is simple but dangerous, for lead is a poison that builds up an incurable case of lead poisoning by breathing in a little of the dust of white lead, day after day, over time. Once it gets into the human system, it stays there until the body’s tolerance level is met, and then becomes symptomatic. Medieval writers warn against the dangers of apoplexy, epilepsy, and paralysis, that come with exposure to it. What we don’t know about the process of making white lead, is whether the final product is a definite compound or an accidental mixture. Regardless, it’s importance has been unmeasurable, and is the only material that has been consistently used from ancient times until the present. The monopoly in lead white production was not broken until the nineteenth century, when zinc oxide became a competitor, and in the twentieth century, it has been almost completely replaced by titanium dioxide, which is superior to lead in some properties, and unlike zinc oxide, has the strong covering ability that lead white possesses. Since white in painting is the equivalent of light in nature, it has been essential to every aspect of painting: from flesh to skies, and so on. Because of its capacity to absorb x-rays, it is the lead white in European paintings that makes them visible through x-rays. It was also used on occasion in wall painting, tempera works on paper, and silk in early periods in China and Japan, even though lime white reproduced from calcination of the shells of mollusks had a wide use there. Leonardo Da Vinci, 1493:

"Put the white into an earthen pot, and lay it no thicker than a string, and let it stand in the sun undisturbed for 2 days; and in the morning when the sun has dried off the night dew."

**LITHARGE**

This pigment is Massicot; the monoxide of lead described by Leonardo da Vinci. It is the heaviest pigment, slightly orange in color, and forms a cement which is impervious to water when mixed with Linseed oil. To form an actual cement, it is mixed with glycerine. It makes a drier known as lead drier when cooked at over 500 degrees F and mixed with Linseed (this is the lowest temperature in which it becomes soluble).

**LITHOL RED**

A similar color to Para red which does not bleed quite as much. It can’t compare in permanence to many of the other reds such as Cadmium Vermilion, so therefore it is not terribly useful.

**LITHOPHONE**
Considered to be a very important pigment in the earlier part of this century; it is 30% Zinc sulphide and 70% precipitated Barium Sulphate, and was the basis of most wall paints from the turn of the century until the 1940s. Until the 30s it was not considered safe, as it turned dark in sunlight, and then turned white again at night. This quality was rectified by using pure chemicals in its manufacture, though I wonder today how these faults could be manipulated if the fugitive chemicals could be duplicated?

**Madder Lake**

This came in to use in the Middle ages as mostly a dye, and then went out again, returning in the fourteenth century as a pigment. A Parisian author at the beginning of the fifteenth century writes, "warantia is a color, or raw material of color, because if it is cooked in water with lac or ivy gum it made a red color called cynople." Warantia is garance in modern French, and that means madder: a field plant which grows wild in Italy and was cultivated in France as a dyestuff in the end of the thirteenth century. As an extract of the root of the madder plant, which was allowed to grow for two years in the ground, the root is not red itself. But it contains alizarine, which can be made to produce red lakes of several shades and precipitated on a clay base, it is a beautiful transparent red, but impermanent. In the trade it is available as rose, light, medium to dark, and violet. Rose madder bleaches out in a few months, but the darker tones are more permanent. Rubens' madder, Rembrandt madder and Van Dyck red are doubtful color mixtures of fantastic nature, and in fresco, lime destroys madder completely. Alizarin madder lake (artificial color made from synthetic alizarine, now known as alizarin crimson) is a coal-tar color, and in permanence exceeds the natural product, which in contrast ages more gracefully than the artificial. The permanence of Alizarin madder has been fixed as a standard for other coal-tar colors. In the original root there is a second coloring agent called purpurin, which when removed creates a superior permanence. The pigment was at one time sold in cakes which contained starch to insure their solidity. They were broken up into powder, whereas crystallized madder lakes could not be used due to the difficulty in grinding. Madder lake requires about 70% oil, dries poorly and should therefore be first mixed with linseed oil and ground with an addition of varnish (damar). Alizarin madder lake can be used with oil, tempera or watercolors, but not with wet lime, as vegetable based pigments can never be used in fresco. It is however reliable on wet plaster interior walls. It has been observed over time that madder lake bleeds, and when so it has been an indication that it has not been used properly, perhaps too thickly in underpainting, or that it has been mixed with impermanent coal-tar dyes.

**Malachite Green and Green Verditer**

Malachite is more abundant in nature, and large deposits have been found in the Ural mountain region of the former USSR, and in the Katanga district of Zaire; also in Zimbabwe and in Chile. By grinding and washing it was one of the very popular greens of medieval painting, in Asia as well as Europe, though its sources are not well known, with sparse mention of copper mines in Hungary being a probable source of both Azurite and Malachite, with an added possibility at Chessy, near Lyon. Like Azurite, it is not at its best in oil, and has therefore largely gone out of use in the West since the introduction of oil painting. It is still much used in the Orient, particularly in Japan, though modern color dealers in Japan now get their malachite from Africa and Chile. The green mineral used in present day as a decorative stone for furniture or wood objects. It has a grain rather like that of wood, and is easily inlaid with skillful carving; but none of it has nay great intrinsic value. It occurs in several modifications: pale to bright green, but is generally found in conjunction with Azurite, often merging imperceptibly into the blue color. Geologically, Azurite is the parent, and malachite: a changed form of the original blue deposit. Malachite was used in Egypt for eye-paint as early as pre-dynastic times and has been found on tomb paintings since the fourth dynasty; it occurs on Sinai and in the eastern desert. Though it was abundant and widely used in the middle ages, we find very few recipes for its preparation as a color, and few references to its use. Cennino calls it Verde Azzurro, "Blue-Green", and its close association with the blue probably made it unnecessary to treat it separately in the cookbooks, just as rules for handling silver are lumped under those for handling gold. It is also possible that we are wrong in supposing all the bright, pale, crusty, bluish greens in medieval manuscript and panel painting to be malachite; but it matches it so closely that we believe in the identification. Another possible reason was that to be useful as a bright green it must be ground coarse, as finely ground renders it too pale. Early examples of artificial malachite found on easel paintings, have been generally in egg tempera medium. In European paintings a common device for obtaining a green of increased saturation was to glaze with transparent copper resinate over malachite. The Japanese painters, had no such problem, as they employed coarsely ground malachite to represent the deep green of foliage and a more finely ground pigment for the bright green of costumes. In European easel painting, malachite seems to have been of importance mainly in the fifteenth and sixteenth centuries in both egg tempera and oil medium, undergoing some minor revival in the nineteenth century. It is quite suitable for the technique of true fresco. It is moderately permanent and unaffected by strong light; even though theoretically subject to blackening when mixed with sulfide pigments, in practice, darkening from this cause has not been reported. The malachite areas on medieval Italian frescoes are often still fairly bright green. Vanoccio Biringuccio, fifteenth century Italy: (On Malachite): "This is more or less green or blue according to the quantity of mixture and more or less abundant according to the powerful exhalation of the ore. It is also gathered with care from the colored stones and is cleaned and made fine by washing and grinding. That which is the finest and of the loveliest color is the most highly esteemed by the master painters."
MANGANESE BLACK

A strongly heated manganese brown which has a good reputation in lime, hence excellent in fresco.

MANGANESE VIOLET

This is a Nuremberg violet, a mineral violet and is permanent, heat proof and non poisonous. However as a manufactured product, it is not a beautiful tone, tinting use occasionally in fresco and mineral painting. The new manganese violets of German manufacture are powerful, fast colors furnished in several tones. It covers and dries well in oil and tempera, and works well in tempera, pastel, and watercolor, but not in fresco. When heated it fuses into a hard white substance.

MARBLE DUST

This was used in Pompeii as a filler material for paints, or as additions to colors for texture and the damping of bright colors. This was also the purpose for it in the Renaissance. However today it is used primarily in the preparations of grounds and in fresco plaster.

MARS YELLOW

More transparent than the natural ochres as they contain less clay, and are disproportionately expensive. They must be well washed, but are very strong and permanent artificial ochres

MAZARINE

Robert Henderson, a mid-late 19th century English miniaturist makes reference to this color in a book on English miniatures: "...There is a new red brought out which is warranted to be thoroughly permanent; it is a useful color, called mazarine, and comes in for everything. There have been suspicions cast upon rose madder, but I have found it stand well enough in ordinary miniature painting." This is all the information I have ever found on this pigment, so it seems it wasn’t nearly so useful as once thought. This quote it should be noted was found in a book published in 1908, where it referred to him as the “late” Robert Henderson, thus we can assume that this pigment was a Victorian invention.

MICA, MUSOCOVITE MICA

Though many micaceous minerals are recognized in mineralogy, the name of mica is mostly applied to that of muscovite which is hydrous potassium aluminum silicate, and is found in nature in thinly layered laminae, in small deposits worldwide. When it is ground, it is used as a lubricating agent and as a reinforcing pigment in paints, which raises the question to me, if it’s effect is similar to that of adding ground aluminum. In the Far East it was occasionally used in painted designs where the shiny surface it left gave a similar effect to that of metal. In contemporary work, I have seen it used to add luminosity and pearlescence to paint, which aluminum powder also does, but needs to be used in cautious amounts as it makes the paint extremely gummy in texture and dries it more quickly. When reading about other metal powders, some accounts mention their use as that of a drying agent to the pigment.

MINERAL BLACK

A carbonaceous slate, which is permanent, but does not cover as well as Ivory black.

MINIMUM

Red oxide of lead, not to be confused with iron oxide, and commercially sold as Saturn red. It is produced by heating white lead in the presence of air (for a more detailed explanation of the process, refer to lead white). It is highly poisonous, sensitive to hydrogen sulphide, attacked by hydrochloric acid but indifferent to alkalies. Red lead also should not discolor alcohol; if it does it has been adulterated with coal tar dye (most likely a test of the color upon purchase from the chemists at that time); also, when doctored with coal tar it has a tendency to bleed when painted over with white lead. Dilute nitric acid turns red lead into brown lead peroxide: the last stage to which white lead may be oxidized. Under great heat red lead becomes a light violet, and when cooled again, a yellowish red. As a pigment, it quickly turns dark in the light, but when mixed with oil (and it requires only 15% oil), it is fairly permanent. When mixed in oil with white lead, it tends to fade rather than turn dark, and stands up better than white lead with vermilion. Red lead can only be used as an oil color; as a powder and in fresco it eventually turns black. Freshly ground red lead is best (thus why it is no longer used as paints are most widely available pre-prepared through manufacturers), and when red lead is produced under insufficient heat, red-yellow oxide forms, which is not sufficiently permanent. This can be eliminated by washing with sugar-water. When it is ground in oil, a little wax should be added to guard against its hardening too quickly. Red lead ground in oil dries the quickest of all pigments. This pigment was very common all through the Middle Ages in manuscript embellishments and painting. It was not used on walls, and rarely on panels, but in manuscripts it was used in conjunction with the more expensive cinnabar and vermilion as one of the chief elements of colored decoration. It was cheap, and easy to make, and wasn’t dependent on the supply of any rare material. As long as cinnabar was hard to get, and before vermilion became common, this form of minium known as orange minium was the nearest approach to a bright red color that a painter could manage for his everyday work. Pliny called it color flammous (flame color), and was at times called cinnabar as well as stupium. The confusion of medieval terminology in regard to red colors is immense, so it is difficult to trace all the facts behind these colors before the 15th century. In Medieval times, miniare meant to work with minium, so one who worked in it was called a miniator, and the things that he was to miniate were called miniatura. So miniatures
were originally the sections of a manuscript that were to be painted in red. Over time, as manuscripts were small and incidental, the word *miniature* came to mean diminutive.

**MIXED GREENS**

These are greens made simply by mixing other pigments; Cennino mentions that Terre Verte mixed with white makes a sage green, and to be lightened and still kept properly green, add yellow and not white. Mixtures of blue with yellow would combine naturally to make a wide variety of greens, however, let’s say indigo with orpiment was so admired that a compound of this sort almost took on the character of an independent pigment. (Bearing in mind the limitation of ultramarine, which made a somewhat more intense green than that made with indigo. Saffron was also mixed with blues to bestow them with certain green qualities, but as the yellow was not reliably permanent, these colors have sometimes faded out. (The phenomenon of blue left by the fading of the yellow element of a mixed green is not unusual in manuscripts, but is most familiar in tapestries.) Sometimes the yellow was used to glaze over a blue in which case binding medium remains alone to show at the edges where these colors once were. They were however, mixed greens, not the basis of most work, as most painters would not tend to possibly lose the individuality of their hand-trogen colors in such complicated mixtures; there was in medieval manuscripts a decided preference for single pigments displayed to their best advantage.

**MIXED PURPLES**

Except for folium and archil, and to some extent whelk reds, the Middle Ages seem to have depended for their purples largely upon mixtures of red and blue colors. There were a great number of purplish red lakes (notably the naturally violet lac lake), and the medieval eye favored blues with a violet cast. Mixed purples were therefore readily made as needed. For walls, hematite and the dark red ochres served well alone or mixed with black. Colors which we now call purple were not common in medieval painting, partly because of fading or being neutralized through the yellowing of varnish, or perhaps they were not particularly fashionable. "Royal purple" could have been easily mixed by medieval painters but seem not to have been used, and more often in any case as shading upon other colors than as an independent tone.

**MIXED WHITE**

This is an oil tube color which is a mixture of creaemitz and zinc whites, and is said to have all the good qualities of the two, without any of the bad. It naturally dried more slowly than lead white, as an addition of zinc white would cause that, and without knowing first hand, I would assume would have slightly less coverage than lead white alone, as zinc white is somewhat transparent.

**MOLYBDATE ORANGE**

A bright, scarlet pigment known chemically as Lead Molybdate. It contains chromate and sulphate, and owing to its lead content, has great coverage but is not stable when exposed to sulphur gases, and is only somewhat lightfast. As an industrial pigment it is valuable when mixed with 25% Toluidine Toner, which forms a brilliant vermilion. When this is ground in Stand oil and thinned, it at one point was ideal for painting the smokestacks on steamships. The stand oil prevented sulphur gases from acting upon it.

**MONASTRAL BLUE**

See Phthalocyanine.

**MOSAIC GOLD**

One of the most esteemed imitations of gold was a yellow sulphide of tin, made by a difficult and elaborate process, and to modern eyes not a very convincing alternative to the ruddy metal. This color was known as *aurum musicum*, or in English, "mosaic gold"; why it is called mosaic we don’t know. The recipes for it are common in texts from all parts of Europe after the fourteenth century. The Portuguese tell how to make this "gold with which you may illuminate, or paint, or make capitals, or write." In the fourteenth century a new name was applied to mosaic gold being *color purpurinus*, and from that the word Cennino uses, porporina, coming perhaps from the association between purple and gold. A color purpurinus may have been thought of as resembling the sort of color used for gold writing in a *codex purpureus*, and if so, the idea of these magnificent volumes from the earlier Middle ages must have been impressive in the fourteenth and fifteenth centuries to cause the word "mosaic" to give way to the word "purpurine". We do not know when it was invented but that it may not have been known in Europe before the thirteenth century. It became well known in the fourteenth, and has been ever since. It’s a sulphide of tin, made by mixing tin with sulphur under special conditions including the presence of sal ammoniac and mercury, and long and carefully regulated heating. Ordinarily the tin was made into an amalgam with mercury, and ground to powder. This powder was then ground and mixed with sal ammoniac and sulphur, to produce a black compound consisting chiefly of sulfides of tin and mercury. The mixture was heated for hours in stages, increasing the strength of the fire until at the end of nine hours or so, little sparkles of "gold" could be seen on the end of a stick plunged into the vessel.

Mosaic gold made this way looks a bit like bronze powder. However on inspecting it in person, it is so little golden that it might be mistaken for orpiment or ever for an ochre, therefore it takes a trained eye to recognize it in medieval works. Without the multitude of recipes written to signify the importance of its existence, we may not have known to look for it to begin with. Cennino spoke of it as being primarily a manuscript painters pigment with some use in panels, and warns against using it in conjunction with real gold, as the little mercury it contains will ruin the effect of gold-leaf gilding.
NAPLES YELLOW

Principally lead antimoniate, one of the colors already known to the old masters, that is said to have been found on the tiles of Babylon. It is very heavy and dense, and therefor of exceptional covering power; moreover as a lead color it is a good dryer, but poisonous as all leads are. Manufacturers distinguish between Naples yellow and dark Naples yellow; both are very permanent. The reddish Naples yellow however, is an impermanent mixture recolored with coal-tar dyes, chrome red, minium, or similar pigments, which is quite superbulous, but strangely favored by artists. In oil, tempera and even fresco, excellent use can be made of Naples yellow as it is compatible with all other colors. It is a much more compact compound of lead than is lead white, requiring only 15% oil, and it is totally unaffected by light. It seldom cracks, and in varnished tempera is invaluable because of its covering power. One claim on record is that it should never come into contact with a steel spatula as it turns grayish green, though this has never been proven to be the case. More likely the alleged discoloration is via an optical process when a thin layer lies over a dark background at which point it would appear this way. Also, that Naples yellow cannot be mixed with iron colors such as ochre is also erroneous. Discoloration has however been proven in tempera colors from the tube, where the metal of the tube was attacked by disinfectants contained in the tempera medium, which creates a dirty gray. Naples yellow needs little grinding; only a brief working with the spatula, and if too finely ground becomes heavier and earthy in texture, therefore best when made by hand, and not previously manufactured.

NATURAL & ARTIFICIAL BLUE COPPER PIGMENTS

Natural, coming under the title of; Mountain blue, Bremen blue, blue verditer, cendres blues, all of which are impermanent, highly poisonous and incompatible with many other colors including lead white and vermilion. Combined with sulphur colors such as cadmiums, all copper colors turn black. Though copperers were used by necessity in old paintings, they were isolated by layers of varnish and applied pure with egg tempera. In medieval times, the artificial copper blues were the answer for use in woodwork, sky blue ceilings etc., where the pigment couldn’t cost more than the building; the poorer market could not supply the artist with azurite or ultramarine, thus these colors were probably more significant than all the rest. IN all of Cennino’s accounts he never mentions these pigments at all. A standard of judgment on permanence also was not developed until later on, and pounds of copper blue were used to each ounce of ultramarine, and they were as mentioned, quite impermanent. There were also copper blues which depended upon the property of copper and ammonia to combine, in order to make the color required. A solution of copper sulphate, weak enough to look pale greenish blue, turns to a very dark blue if spirits of ammonia are added. The cuprammonium salt is formed which is dark blue; however, it is again, not durable, as the ammonia evaporates when not used quickly enough, leaving nothing but copper sulphate. With lime, it stabilizes instead, making it more durable for fresco. The many variations were all designed to produce cheap blues from common materials for everyday purposes. The weakness of these blues however, is their tendency to revert to green through loss of ammonia content, explaining the patches of bright green which appear in the blues of medieval wall paintings. One conspicuous example being in the values of the upper church of San Francisco at Assisi, which as of this entry, probably sustained damage in the recent earthquake there. This color change is usually attributed to a change of azurite into malachite, but it is more likely the result of the employment of a cuprammonium-lime blue.

NEW BLUE

Another name for artificial ultramarine blue.

ORGANIC YELLOWS

Manuscript painters had two other sources of bright organic yellows like saffron: buckthorn and weld. Weld pigments were used to some extent by panel painters, and buckthorn was reserved exclusively for books. There were largely excluded from the palettes of other painters because of their lack of durability.

ORPIMENT

Orpiment is a sulphide of arsenic, found in nature as a stone, a golden hued yellow that was used by painters of books in the middle ages. Chieflly imported into Europe from Asia Minor, it was this resemblance to gold that tantalized the ancients and medieval alchemists. Pliny reports that a prince named Caius had an enormous quantity of it cooked up to extract the gold, making an excellent gold which was however, too light in weight. Painters used it only as a paint, and not as a precious metal, and was used especially for writing in imitation of gold. Its color is a light, vivid yellow, sometimes pure yellow but often inclined toward orange. In its natural state, it has a mica-like sparkle which recalls the luster of metallic gold. Orpiment was not compatible for other colors, and could not be used to modify green tones containing verdigris, as the sulphur of the orpiment attacked the copper; and for the same reason was not compatible with lead white. It also had a corrosive action on binding materials, and has quite often decayed and come away from panels and parchment. During the late Middle ages they gladly turned to substitutes, though it was not completely abandoned until the end of the nineteenth century. When mixed with zinc or titanium white, it loses its yellow tones becoming a pale brown/beige.

PAYNE’S GREY

A mixture of Ultramarine blue, raw sienna, black and white. Does however come from manufacturer’s pre-mixed under this name.

PERMALBA
A titauium pigment, manufactured by F. Weber Co. of Philadelphia in 1921. Was at one time, the best known white pigment used by artists. It was 78% pigment with 22% oil, (which must have prevented it from yellowing.) It’s hiding power was greater than that of flake white, and had no chemical reactions to other pigments. It was completely permanent and worked in all techniques. Today it is not nearly so well-known: it would be interesting to find out why.

PERMANENT BLUE

Artificial ultramarine blue.

PERMANENT GREEN

A minor sort of chromium oxide brilliant which has been strongly adulterated with barite and in mixtures is naturally less high in coloring strength. Also a name that often applies to mixtures of Viridian with a yellow pigment such as cadmium yellow or zinc yellow. It may also contain zinc oxide.

PERMANENT GREEN LIGHT

A much used mixture of chromium oxide brilliant with cadmium, lemon or light, and in this case is absolutely reliable. But here as with all mixtures, the composition often differs.

PHTHALOCYANINE BLUE

Also known as monastral blue, phthalo blue or copper phthalocyanine, is an organic blue dyestuff that was developed by chemists under the trade name, "monastral blue" and presented as a pigment in London, November 1935, claiming that it was the most important blue discovery since Prussian blue in 1704, and artificial ultramarine, in 1824, and was a superior pigment to both. It is prepared by fusing together phthalic anhydride and urea to copper chloride, first washing it in dilute caustic soda and then in dilute hydrochloric acid. It then becomes copper phthalocyanine, but is not conditioned as a pigment until it is dissolved in concentrated sulfuric acid and carefully washed in excess water and filtered, the resulting paste being used thus directly in the preparation of lakes by adsorption on aluminum hydrate, or dried for incorporation into non-aqueous mediums. It is a highly complex organic synthesis. Pure copper phthalocyanine in crystalline form is a deep blue with a strong bronze reflection, but when dry in pigment form is bright blue without any bronzniness. They’re lightfast, and an ideal pure blue for it absorbs light almost completely except for the green and blue bands. There are other phthalocyanine colors as well, which are equally lightfast. However when photographed, this line of colors tends to turn brown in the camera lens, being logically attributed to the fact that though it absorbs all other colors of light, there must be some refractive or reflective bounce of the initial bronze tone of the mineral in crystal that is not evident to the eye. There is evidence of this in the work of Brice Marden, who uses Phthalo colors, all of which photograph brownish in all variety of light and film stocks.

PRUSSIAN BROWN

Prepared by heating Prussian blue. This color when well washed and dried is permanent.

PRUSSIAN, PARIS OR BERLIN BLUE

The pre pigment is called Paris blue, has a coppery reddish sheen, and is a compound of iron and cyanogen. Antwerp blue and Milori blue are adulterated products which, because of their intense chromatic power, are often met with. Paris blue is non-poisonous, uncommonly strong in coloring power and very permanent in all techniques except fresco, where it loses intensity and leaves rust colored spots. It can also in very light mixtures be known to bleach out. It is instantly discolored by potassium hydroxide, and is sensitive to all alakls, therefore useless in fresco, where indanthrene blue is a better substitute. Paris blue dries well but takes up 80% oil, of which poppy or nut oil is preferable, as linseed becomes granular. Paris blue in paintings is splendid when used with oxide of chromium brilliant or in shadows when mixed with madder lake; being sparing in its use, because as an oil color, it tends to give the picture a darker, heavier character than cobalt blue or ultramarine. It can be used in tempera and watercolors, where when mixed with zinc white, it has the peculiar characteristic of fading when exposed to light, but completely regaining its chromatic strength in the dark.

PURPLE MADDER

Same as Purple Lake: is permanent to diffused indoor light, but not to ultra-violet light. Never use on work that will be exposed to direct sunlight.

RAW UMBER

An ochre containing manganese oxide and iron hydroxide. Because of the manganese content it is an excellent dryer. It can be used in all techniques but requires 80% oil, with an additional 2% wax when in tubes to prevent hardening. The best variety is sold under the name of Cyprus umber, which comes chiefly from the Harz mountains. Many umbers have a greennish tinge, and in acids it dissolves in part leaving a yellow solution; hydrochloric acid gives it an odor of chlorine. In alkalis it discolors a little and when heated, becomes a reddish brown. Burnt umber has the same properties as natural umber. In oil both tend to turn dark later on, especially if the underlayers were not thoroughly dried, but this darkening may also occur in alla prima painting. Burnt umber turns especially dark, surprisingly as the burnt tones are usually more reliable in this respect. Here again, the tendency to darken is increased by the modern practice of grinding the tube colors too finely. Its best not to use the color in fresco, as in the open it tends to decompose and the produces a burnt heavy tone.
REALGAR

The first cousin of orpiment, both being a sulphide of arsenic; realgar being an orange-scarlet, to orpiments yellow. Realgar however, was not common in medieval paintings, with references limited largely to preservation of glair, and only sometimes used as a pigment. Cennino mentions it without any real enthusiasm, it is not mentioned often concerning book paintings, and it has not been identified on any panels.

RED AND LAC LAKES

The work "Lake" in pigments derives from a material known as Lacca from which they were prepared. We don’t know what was meant by lacca but have supposed that was the material we now call Lac, the gum lac of India, a dark-red encrustation of resin which is produced on certain kinds of trees by the sting of certain insects. This gum, or rather resin, is the source of our shellac. If the crude material is boiled with water and a little alkali, the coloring matter dissolves in the water; it is dried and sold (rarely now) as "lac dye". This is used for painting, or a lake can be colored with it. The one pigment still made with it now, is called Indian Lake. The colors that lac dye produces are generally violet, and not very brilliant. Cennino advised beginners "for their great pleasure, always to start by doing draperies with lac". This was primarily a panel painting color; too dark and dull for books, and not stable enough for walls. Lakes in general were not highly regarded as other colors could make the same dark, purplish earth reds with much more stability. Cennino 1400: "A color known as lac is red. And I have various receipts for it; but I advise you, for the sake of your works, to get the color ready made for your money. But take care to recognize the good kind, because there are several types of it... Get the lac which is made from gum. And it is dry, lean, granular, and looks almost black, and it has a sanguine color. This kind cannot be other than good and perfect... It is good on panel; and it is also used on the wall with a tempera; but the air is its undoing".

RED LEAD

Also known as minium

RED OCHRE

A version of iron oxide which contains clay in varying quantities, and silica. It is an important natural pigments which has been widely used; mostly known as the red paint of the American Indian, and Sinopia of classical antiquity (see sinopia for more information). The best examples of the pigment contain as much as 95% ferric oxide.

RHAMNUS YELLOW

The berries of buckthorn known as rhamnus, were gathered when they were ripe, yielding the color now known as sap green. When gathered before ripening, they yielded a yellow color; the compound of their unripe juice with alum was not much used, but was recorded in the sixteenth century under the name berry yellow. The fourteenth century method was to use the verjuice alone in its natural state to enrich mixed greens. In the course of that century in Italy, yellow lakes began to be made from the unripe berries, and they were popular in the fifteenth century under the name of giallo santo, or holy yellow. Their popularity increased in later centuries despite their lack of permanence, and were very much in vogue in eighteenth century France and England. rhamnus berries are still sold, dried, under the name of grains d’Avinon, or Persian berries.

RHODAMINE

Discovered by Berthsen in 1892, this is one of the more stable synthetic dyestuffs used for making red lake pigments, and is the ethyl ester of diethylamino-o-carboxy-phenyl-xantheryl chloride.

ROSE CARTHAME

The French name for Rose Madder.

ROSE DORE

A weaker and less stable Madder Lake.

SAFFRON

This was the indispensable element in compounds made for imitating gold. Saffron though attributed to the dried stigmas of the autumn flowering crocus sativus, may have also been meant to include other kinds of crocus yielding this yellow, the "Oriental" variety most favored in antiquity. For use in illuminating, the painter put a pinch of dry saffron into a dish, covered it with glair, and allowed it to infuse. The resulting extract or tincture, was a perfectly transparent strong yellow. In this preparation it was also used for writing, and mostly painting and glazing over other colors. It enriched greens throughout the Middle Ages, and in the fourteenth and fifteenth centuries was added to vermilion, especially in Germany. Greens for books were compounded with saffron and azures, as well as with verdigris and saffron. The glossy saffron alone was used also for ornamental pen flourishes around colored initials, for gold-like frameworks of illuminated panels in books, and for golden glazes and touches in lines of writing in red and black. It was primarily a manuscript color, and in medieval books it has sometimes faded, though not always. It was not used much in tempera on panels, and not at all on walls because of its fugitive character. From my experiences with it, you need a large amount of it to have the tinting quality it describes, but add a little at a time, as quantities are subjective and vary with pigments.

SALT GREEN & ROUEN GREEN

Two variations on verdigris, popular in the middle ages, were salt green and Rouen green was used from the twelfth century onward. Salt green was made like verdigris, but the...
plates of copper were coated with honey and salt. And some copper chloride may have been formed along with the acetates. The use of honey with verdigris was fairly usual probably to keep it slightly moist after its application; for verdigris loses some of its richness if it becomes too dry. An excess of honey is suspect as contributing to the tendency of verdigris to spread in manuscript parchment. Rouen green won quite a reputation in France and England in the fourteenth century. Though it was known before and after. It was made by coating the copper with soap before it was exposed to the action of the vinegar; the result presumably, a mixture of verdigris with some copper salts of the fatty acids from which the soap was made, and some glycerin. These and many other medieval painting materials have still to be more fully investigated synthetically before their importance can be estimated.

**SAP GREEN**

The most important substitutes for verdigris were sap green and iris green. Sap green is made from the juice of the ripened berries or buckthorn, or rhamnus. Though there are many varieties of green which could be prepared, it is evident from laboratory experiments that some varieties yield inferior colors. We cannot suppose that medieval colorists possessed botanical knowledge which would have enabled them to pick the right kind of buckthorn; but where it grew well, was where it became known, and the best quality available. Its preparation was the squeezing out of the juice, mixed with a little alum, then allowed to thicken by evaporation. The result was a gummy green color, generally rather olive, transparent and rich. As the juice of these berries was used early on without preparation to temper and enrich verdigris, its probable use as an independent pigment came about as a development of its accessory function. Cennino suggests putting a bit of it into a mixed juice, the verjuice as he calls it, but warns that the effect won’t last. The color made with alum is more durable, though not permanent in the modern sense. Some of it has however lasted in many manuscripts. It is different from many pigments in that it was not dried nor mixed with a binding medium, as the thickened juice was already sticky. In early times it was sold in bladders as a dense syrup rather than dried. It is still used though somewhat more as a watercolor, and in oil paints now sold under this name they usually contain coal tar lakes.

**SCHEELE’S GREEN**

An acid copper arsenite; the first artificial green pigment in which copper and arsenic were the essential constituents. First prepared in 1778 by Swedish chemist, Carl Wilhelm Scheele, it was usually made by dissolving white arsenic in a solution of soda ash or potash, and adding the hot arsenite solution of a solution of copper sulphate. The precipitate needed only washing and drying. It is said that the pigment consisted of small and large irregularly shaped green flakes which were only slightly transparent. Since this green is an inferior pigment it was quickly displaced by Emerald Green, which is a copper aceto-arsenite, introduced in 1814. Scheele’s green is blackened by lead and is decomposed by acids. It is a yellowish green when made but jades rapidly and is blackened by sulphur-bearing air and sulphide pigments, and is also extremely poisonous, obviously. It can be found in paintings of the late 18th and early 19th centuries.

**SEPIA**

A pigment from the ink bag of the cuttlefish, is only reasonably lightproof, and is soluble in ammonia, and only good in watercolor. Colored sepia "beautified" with madder lake, sienna, etc., is permanent.

**SILVER WHITE**

Pure Zinc Oxide, though the name in the past has been used for lead white.

**SINOPIA**

The choicest source for red ochre in classical antiquity was known as Pontus Euxinus, from the Pontine city of Sinope, according to Pliny in the first century A.D. A much lighter version of the same could be found in Asia Minor, and as of the 1950s, no source of supply was known of, even though there is a version sold in Italy, which is supposedly of Italian origin. In antiquity, to guard against the sale of imitations, the cakes of color were sealed and stamped, thus known as "sealed siniope." In the Middle Ages this name came to refer to all red ochre colors; an English derivative of the word, Sinoper, means earth red. Within the title of Red Ochres, there are many variations used to describe the many variations of color; a light and warn tone is known as Venetian Red, or Mars Red. Darker, more cool toned purple versions are called Indian Red, Mars Violet or Caput Mortuum. Terra Rosa from Pozzuoli near Naples has a salmon pink color which is easily recognizable in some medieval Italian wall paintings, whereas the dark wine red of ground hematite is more common on the wall paintings of Florence. Some versions are clear and strong toned, whereas others are tinged by admixtures made up of other minerals besides iron oxides. The Red Iron Oxides, are artificial pigments made from iron ore or the waste material of chemical industries, though they are closely related to the red earths and have very similar properties. However, with these colors, if ground too finely in oil, they have a tendency to bleed, whereas versions of sinopia will not.. English red, which is a light red, is often cut with gypsum when in the powder form, though I have not discovered why yet. This however makes it too dangerous to use in fresco. All of these pigments need 40-60% oil, possess good covering power, and dry fairly well. When mixed with whites, they yield cool tones, and can be used for all purposes in all techniques. (Mars Red and Mars Yellow also belong here.) I have discovered that sinopias work well as an underpainting when thinned with a reasonable amount of rectified turpentine, whereas the iron oxides are not as useful as they need more oil than is recommended so close to the canvas, and do indeed bleed into the above colors. To return to the yellow ochres for a moment, when they are heated they turn red, losing their chemically bound water content to become
thick and dense. Under moderate heat, yellowish-red colors are produced, however, the stronger the heat, the more rich and saturated the color produced, which if mixed with white create colder tones than one would expect. The coloring agent again, is of an iron oxide. One of my sources claimed that the useful light yellow-reds that could be created through these methods, were not at the time sold as tube colors, but warned that the ochres had to be pure and free from adulterant admixtures such as chalk, because this would create quick-lime if heated, and gyspum should also never be present especially if intended for fresco use. None of these colors however, is in any way poisonous. Natural burnt ochres and red ochres often occur in volcanic regions as decomposition products, and also as natural products finely washed on the banks of rivers. The warmer tones are also called burnt light ochre, burnt gold ochre, and flesh ochre, and the cooler tones often have names such as terra rosa, terra di treviso and Naples Red, which is especially strong and beautiful.

SMALT, OR STARCH BLUE

First described by Borghini in 1584. A moderately fine to coarsely ground potassium glass of blue color, due to the small but variable amounts of cobalt added as cobalt oxide during manufacture. The principal source of cobalt used in this preparation in Europe during the Middle Ages appearing to be the mineral smaltite, one of the skutterudite mineral series. In the seventeenth and eighteenth centuries other associated cobalt minerals were probably used as well (erythrite and cobaltite). The cobalt ore was roasted and the cobalt oxide obtained was melted together with quartz and potash or added to molten glass. When poured into cold water, the blue melt disintegrated into particles, and there were ground in water mills and elutriated. Several grades of smalt were made according to cobalt content and grain size. The quality of color was marked by F(fine), M(ordinary), and O(ordinary), and the coarse grades receive the label H(high), and were called in Saxony, Streublau, which means literally blue to be strewn. There were other grades they were given as well. In the complex ores in Saxony, as they were first roasted, much of the arsenic was volatilized. The oxides of cobalt, nickel and iron were then melted together with siliceous sand, and the resulting product called Zaffre or Zaffera were, in part, sold to potters and glassmakers. The rest of the product was used instead of potash. A violet tint was obtained. Smalt was a European invention, credited to Christoph Schurer, a Bohemian glassmaker in the mid sixteenth century, though it was available a century before as it has been traced to two paintings from the fifteenth century, and is also suspected to have been used much earlier in the Near East. Also, cobalt ores were used for coloring glass in Egyptian and classical times. The origin or cobalt tinted glass probably coincided with the development of vitreous enamel techniques; near east in origin, as enamels were made from easily fusible powdered and colored materials similar to glass. And it is understandable that a stable blue enamel powder should be used as pigment for painting. As smalt is a glass, its particles are transparent, and its hiding power is lower, even than that of cobalt blue. Therefore it must be coarsely ground for use as a pigment. When used in oil medium, it has a tendency to settle and streak down perpendicular surfaces. Like all glass based pigments, it is stable unless improperly made, and is better in aqueous media and lime for fresco. In oil, only a dull color is obtained because the refractive index of smalt is so close to that of dried oil. It has been observed to have partially or completely discolored in oil, except when mixed with lead white which helps prevent the loss. Smalt was rarely used for European easel painting after the discovery of Prussian blue in the early eighteenth century, and the discovery of synthetic ultramarine and cobalt aluminite blue (Thénard’s blue) in the early nineteenth century. The last manufacture of smalt was reported in England in 1952 by Reckitts Ltd., a firm that no longer exists.

SPANISH WHITE

Calcium carbonate, or another name for whiting.

STRONTIAN YELLOW

Somewhat richer in color than barium yellow, but otherwise has the same properties and reputation to being better than zinc yellow. Partially soluble in water, and when heated becomes yellow ochre, returning to yellow when cooled, but is like zinc yellow in its discoloration to green when in oil. It is used therefore in green mixtures and with darker tones. Mixtures with all three in white are fairly durable.

TERRA DI POZZUOLI

A natural cement which was known to the ancients as rich in silicic acid and useful with lime in Pompeii. In fresco it prevents superimposed layers of color from setting, while itself, sets quickly and is quite stable. Other volcanic earths act in the same way, such as Santorin Earth from Greece, (an island in the Aegean Sea.) The burnt ochres and red earths, as mentioned earlier are reliable in all techniques and are resistant to acids and lyes. They require only 40% oil, and for painting purposes, only unadulterated and unimproved colors should be used. They bleed if ground too finely, and like asphaltum, will penetrate into superimposed layers of oil colors. This was not the case however, when they were ground by hand.

TITANIUM DIOXIDE WHITE

A non-poisonous, good covering paint which is useful in all techniques and a 20th century invention. There is certain dispute about its drying abilities, but does remain even in mixtures. It also however yellows easily, especially in tube paints which have been mixed with heavy oil. Avoid any tubes of titanium that have oil residue at the top of the tube when opening, as these will surely yellow, and within a very short time. Titaniuims are however, sometimes cut with large quantities of zinc white to improve their drying time and cohesion with the oil.

TOLUIDINE RED

History of Known Pigments and Their Chemical Makeup — 77 AD to present
A synthetic, yellowish red, organic dyestuff; one of the most permanent of its kind, and widely used for outdoor purposes where a permanent bright red paint is needed. It can take strong sunlight for some months without fading. It is unaltered by heat up to 150 degrees centigrade, and by alkalies; is insoluble in water but soluble in boiling alcohol. Was first made by the Badische Company in Germany, and patented in 1905, but has not generally been offered to the artists trade by this name. It is occasionally found in cheaper colors as a toner or as a substitute. David Davis art supplies sold me a red pigment under this name in 1989. Whether it was the same pigment or a version of it, I do not know, but it is worth investigating if you are interested enough.

TURNSOLE

The name indigo was attached to all sorts of blue vegetable coloring matters in the Middle Ages, except for turnsole which possessed a rival identity of its own. Like indigo, it lent its name to many poorer substitutes. Both were the great medieval organic blues, yet each name was equally applied to colors made from elderberries, mulberries, bilberries and centaureas, and all manner of other vegetable sources. Where indigo and woad indigo were used for all purposes, turnsole was almost entirely reserved for painting, writing and flourishing in books. There are several other names for turnsole, not of which was used long enough to have any consequence, but there are abundant indications that it was also known as folium, and in several fourteenth century texts we find that "Morella is a kind of plant which grows in the land of St. Gijes. Out of this plant three grains are formed in the seed; and cloths are especially stained with these grains so that they yield a splendid color; and this is called folium." Medieval accounts of folium tell us that it is red when acid, violet when neutral, and blue when alkaline, thus Morella as a plant has seeds that contain a coloring agent which exhibits these characteristics. It is a three seeded plant native to southern France; in Lyte's English botany of 1578, we read that the seed of the small turnsole dies and stains old linen clothes and rags into a purple color. In Holme's armoury of 1688, he states that the leaves have three berries which have a juice or moisture of a purple color from which turnsole is made. All these documents prove that turnsole or folium is the plant now called, Crozophora tinctoria. Extraction of the color from the seeds was done by saturating bits of cloth with the juice of the seed of capsules, that were gathered in the summer. The juice was extracted by squeezing gently so that the kernels were not broken; when a good supply was collected the cloths were dipped into it, dried, and re-dipped and re-dried over and over until they had soaked up substantial color. For red, plain linen cloth would work, for violet, they were first soaked in lime water and dried so the lime would neutralize the acidity; for blue the cloths were used to soak up the color and then exposed to ammonia to increase the alkaline content. As a blue it was impermanent and would revert to violet, but this was not considered a flaw, and large quantities of turnsole were used in the later Middle Ages. The turnsole violet was highly esteemed in fourteenth century Italy, as a common and universal shading for all colors. Why turnsole would have been called folium is a bit of a mystery, except that the bits of cloth were kept between the leaves of a book, the "falia", and took their name from those. The clothlets were the most convenient form of colors for illuminators, as it was placed in a dish, wetted with a little glair or gum water, and the color would dissolve out of the cloth and into the medium, forming a transparent stain. Turnsole, as far as we can tell was a medieval invention with a fairly late introduction; as early as the twelfth century perhaps; but was not prominent until the fourteenth. It paved the way for labor saving methods, clothlet colors and technical degradation of manuscript painting. (Clothlet colors needed no grinding or washing). Fourteenth century manuscript painters found that a touch of turnsole in their azure enriched the blue. In the fifteenth century transparency in the colors was much over-emphasized; thus the popularity of clothlets is related to the stylistic trend. Manuscript painting was turning into a luxury trade with elaboration, richness and succulence of color becoming prime considerations. With the tendency of book painting in the later middle ages to cater to a wealthy, secular clientele, the use of transparent colors to the detriment of form and significance was inevitable; as was the smart handling, the emphasis on costume, genre, gaiety and luxurious fantasy of all sorts.

TUSCAN RED

A red iron oxide brightened with one of the more permanent organic pigments like alizarin red.

TYRIAN PURPLE

From the Murex: first mentioned by Pliny in the first century, as a pigment prepared by Irish monks from Carpillus Purpura. Also from this period were the vegetable purples, which included indigos, along with the red lakes and Dragonsblood.

ULTRAMARINE BLUE OR ULTRAMARINE AZURE

There is some evidence that a blue was extracted from Lapis Lazuli found in Persia in early times; used in Europe long before any of the recipes for extracting it were written, and that the name ultramarine refers to the color and not the actual stone. It was therefore an adjective which was applied to other important commodities as well. It served to distinguish the genuine lapis lazuli ultramarine from other tube pigments, in particular the blue copper mineral pigment, azurite. As a pigment name, it has been traced to Italy at the beginning of the fourteenth century. Archeological evidence and accounts by Pliny and Theophrastus show that lapis lazuli was used as a semi-precious stone and decorative building stone from early Egyptian times. There is no evidence that it was used as a pigment by them or the Greeks and Romans, all of whom had a very satisfactory blue in the synthetic copper silicate pigment Egyptian blue, of which the secret of manufacture has been lost. The earliest occurrence was in the sixth and seventh century wall paintings in cave temples at Bamiyan in Afghanistan. It has been identified to Persian miniatures of the thirteenth and fourteenth centuries; on Chinese paintings of the tenth to eleventh centuries, and Indian
murals and paintings of the eleventh, twelfth and seventeenth centuries. When it was used in Italy, its most extensive use was in illuminated manuscripts and panel paintings, complementing the use of vermilion and gold, and was as expensive as gold to work in. Many contracts for paintings specified the use of ultramarine, and the patron would have to agree to buy it, just as he would for the addition of gold leaf. The highest quality and most intensely blue-colored ultramarine was often reserved for the robes of Christ and the Virgin. The size of the picture and the status of both artists and commission seem also likely to have influenced the use. Azurite was often used as the underpainting as it was more economical, though other traditional blue tones would have been used as well. (It is important to note that the use of such expensive paints would add as much status to the piece as the piece itself, and that the bourgeois middle class became more and more important in time, it was a bit like the modern nouveau riche purchasing the objects of status from Chanel and BMW; these things became important as markers in themselves). Chemically, the mineral lapis lazuli from which the pigment is made, is an extremely hard and complex rock mixture: a mineralized limestone containing grains of the blue cubic mineral called lazurite, which is the essential constituent of the pigment. Present however are two isomorphous minerals, one containing sulphate and the other, chloride, both of which sometimes occur in a blue form, as well as other colors. There are other silicates which may also be present, creating variables in the quality and appearance of the stone. The best are of a uniform deep blue, but can be paler as there is a great deal of white calcite and iron pyrites in it that sparkle like gold; there is also the possible intermingling with white crystalline materials. As it is such a hard stone, it is difficult to separate the pigment from the other constituents. The aforementioned mining quarries of Badakshan (now in Afghanistan) were described by Marco Polo in conjunction with a journey he made in 1271, where he specifically states that the mineral was used for the extraction of blue pigment. These quarries supposedly provided almost all the lapis lazuli to Europe. In the mid 1800s they were somewhat out of use, but as of the 1960s, mining had been resumed. It was most likely imported into Europe via Venice, the principal port for trade with the east, thus it was referred to in texts as coming from "across the seas". There were however other blues that were imported this way that are now obsolete and we have very little information on, such as Yemen alum or Armenian Bole. Nicholas Hilliard, the sixteenth century miniaturist remarked that the darkest and highest ultramarine blue was the ultramarine of Venice and that its prohibitive price compelled painters to use other blues such as smalt and blue bice (artificial azurite). Lapis lazuli is a somewhat rare material, and the only other sizable deposits are near lake Baikal in Siberia and in the Chilean Andes, neither of which was mined until the nineteenth century. There are smaller deposits in Argentina, Burma, Canada and the USA. There are nineteenth century accounts which speak of deposits in Italy, but of insufficient quantity or quality to have been useful in providing a supply of pigment. The blue cannot be separated from the impurities by washing with water, as noted in Byzantine texts, as doing so would create a gray powder. By the twelfth century they began to invent more complicated measures of extraction, but there is no evidence as to what these early recipes were. The Arabian alchemist Geber in the thirteenth century mixed the powdered lapis with powdered resin and then washed it with water. There was also a practice in fourteenth century Italy which may have been a product of Moorish ingenuity, which consists of mixing the powdered lapis with a paste of wax, oil and resin, and kneading the mixture under water or lye until the blue came out in the water, largely free of the uncolored parts of the mineral. The fullest account was Cennino’s, written at the close of the fourteenth century: CENNINO: "To begin with, get some lapis lazuli... pound it in a bronze mortar covered up so that it may not go off in dust; then put it on your porphyry slab and work it up without water. Then take a covered sieve such as the druggists use for sifting drugs, and sift it, and pound it over again as you find necessary. And bear in mind that the more finely you work it up, the finer the blue will come out, but not so beautifully violet in color... When you have got this powder all ready, get six ounces of pine turpentine from the druggists, three ounces of mastic and three ounces of new wax, for each pound (i.e. 12 ounces) of lapis lazuli. Put all these things into a new pipkin, and melt them up together. Then take a white linen cloth, and strain these things into a glazed basin. Then take a pound of this lapis lazuli powder, and mix it all up thoroughly and make a plastic of it, all incorporated together. And have some linseed oil and always keep your hands well greased with this oil, so as to be able to handle the plastic... When you want to extract the blue from it, adopt this method. Make two sticks... and then have your plastic in the glazed basin in which you have been keeping it, and put into it about a porringerg of lye fairly warm; and with these two sticks, one in each hand, turn over and squeeze and knead this plastic, this way and that... When you have done this until you see that the lye is saturated with blue, draw it off into a glazed porringer. Then take as much lye again and put it on the plastic... and go on doing this for several days in the same way, until the plastic will no longer color the lye, and then throw it away, for it is no longer any good... If you have eighteen porringers full of the yields, and you wish to make three grades of blue, you take six of the porringers and mix them together and reduce it to one porringer; and that will be one grade, and in the same way with the others. But bear in mind that if you have good lapis lazuli, the blue from the first two yields will be worth eight ducats an ounce. The last two yields are worse than ashes; therefore be prudent in your observation, not to spoil the fine blues for the poor ones... and keep this to yourself: for it is an unusual ability to know how to make it properly. k Know, too, that making it is an occupation for pretty girls rather than for men; for they are always at home, and reliable, and they have more dainty hands. Just beware of old women." As it was expensive enough to have become an instrument of luxury, Cennino’s advice was to exhibit this color in conjunction with metallic gold, thus reaching the peak of highest elegance and intrinsic worth. This intrinsic worth has gone out of painting now entirely. But in the middle ages they lavished costly materials and unlimited service upon their churches; and in the Renaissance, the society of Europe looked kindly upon the exaltation of wealthy individuals, the function of art therefore to provide the marks of individual distinction. Slowly, the ruling classes began to use the artists to point the distinction that their wealth and power made between them and their fellows, thus paying hefty fees for blues and golds. In manuals of painting of all periods, there are warnings against counterfeit and
adulterated natural ultramarine, its costliness making it an obvious subject for such practices. Very few could detect flaws in gems, or even know real from the false. Therefore, in market or from dealers, often the powder would be cut with whites which were undetectable at first, or the gems themselves would be small veins of blue rather than saturated areas. Over time, these additives have shown up on the work, as veins of white around the edges of cracks, and in many other forms. The natural ultramarine however, has a high stability to light as is proven by the fact that examples on paintings as much as five hundred years old have as intense and pure a blue color as either the freshly extracted pigment or the best synthetic. Even heating to redness has no visible effect, and early in the history of the pigment this was the only way to truly distinguish the general article from other substances or adulterations. There is a disorder known as "ultramarine sickness" which has occasionally been noted on paintings as a grayish or yellowish gray mottled discoloration of the paint surface which also occurs from time to time with artificial ultramarine used industrially, which is brought about by the action of atmospheric sulphur dioxide and moisture. An alternative cause may be the acidity of an oil or oleo-resinous paint medium: the slow drying of the oil during which time water may have been absorbed to cause swelling, opacity of the medium and therefore whitening of the paint film. As it has also occurred when mixed with smalt, this sickness cannot be assigned to a single cause. Also, artificial ultramarines have been known to fade when in contact with lime; for instance if it is used took color concrete or plaster. This has lead us to speculate that possible fading of the natural mineral pigment may possibly be the result of its contact with the lime plaster of fresco paintings. On Dutch pictures of the seventeenth century, ultramarine natural was used over a white ground as a local color for air and draperies; done in tempera no doubt, as Van Dyck did this as well. A difference in color tone and value was achieved by glazing with other colors, such as ochre and white, particularly in skies, over the ultramarine. This was made necessary by the cost of the pigment, which would be largely lost in mixtures. The graduations were easily achieved and quite beautiful, but the cost eventually drove it into obsolescence with the invention of artificial ultramarine. Ultramarine is imitated nowadays by a process which was invented in France in the eighteenth century as a result of a prize offered by the French government. The raw materials of ultramarine manufacture are soda and china clay and coal and sulphur, all common and inexpensive materials. The process requires skill, is inexpensive, and the product is many thousand times less costly than genuine ultramarine prepared from lapis lazuli. It is known as French ultramarine, French blue, Guimet’s blue, permanent blue and synthetic ultramarine. The first observance of the substance was made by Goethe in 1787, when he noticed blue deposits on the walls of lime kilns near Palermo. He mentioned that the glassy blue masses were cut and used locally as a substitute for lapis in decorative work. He didn’t mention whether the idea had arisen of grinding the material for use as a pigment. Tassaert, who found the blue masses in soda kilns of the glass factory at Saint Gobin in France, submitted samples for analysis in 1814 to Vauquelin, and to the French Government on the basis that a method for synthesizing ultramarine might be investigated. IN 1824 when the Societe offered a prize of 6,000 francs for this discovery, whereby it would be manufactured at a cost of not more than 300 francs per kilogram, there were many submitted imitations based on cobalt or Prussian blues, with no regard to the analyses of natural ultramarine. 4 years later it was awarded to Jean Baptiste Guimet, and hotly contested by Tassaert for many years. Guimet’s right to the prize was upheld in France, and he started a factory for the commercial production of the pigment in 1830. Chemically the artificial ultramarines are not distinguishable from the blue particles of genuine lapis; you can only tell by the percentage of colorless optically active crystals, whereas the artificial is pre blue and free from diluting elements. If the two are mixed, the results cannot be distinguished with certainly from finely ground genuine ultramarine of good quality. The importance of the intrinsic value of this pigment in medieval painting has little to do with its appearance; but a great deal to do with an understanding of the Middle Ages and their osmosis into the renaissance. Ultramarine was in some ways less important to Medieval painting than azure, as it did not become common until the fourteenth century, and was less used in He middle ages than has been supposed. It was attached more to the centers of wealth and luxury, but fifteenth century German texts seldom know it except by name, and mention very inadequate substitutes for the fine azure as they make it across the sea.” IN 1549, Valentin Boltz said that “Ultramarine is prized as the choicest of all, but in German lands is seen seldom and in small quantity”. In fifteenth century Italy it was the standard of quality (all French recipes being of Italian descent, it was a choice somewhat there as well). The popularity of this blue in early renaissance Italy and its comparative rarity elsewhere are probably due to the higher development of that personal luxury of which it was in Italy so often the obvious material expression in painting. Rich wares go to rich markets. We should also note, that artificial ultramarine became a common component of the impressionist and post impressionist palette, as opposed to natural ultramarine. And that even though Turner has been attributed as the first painter to popularize its use, that chemical testing has shown use of other colors which were thought to be ultramarine, and therefore this is now in question. Also, catalogues of color merchants from the 1850s list several shades of artificial ultramarine blue, but none list the green, red or violet varieties, although they are still available as industrial pigments. Apart from the disadvantage of their rather low tinting strength, the lack of popularity of these other ultramarines as artists’ pigments may be because, whereas there is absolutely no substitute for the distinctive hue of blue ultramarine, there were available to the artist by the second half of the nineteenth century excellent pigments such as cobalt green, violets, and chromium oxide greens.

Cennino, late fourteenth century: "Ultramarine blue is a noble, beautiful color, perfect beyond any other; one could not say anything about it, or do anything with it, that its quality would not still surpass. And, because of its excellence, I want to discuss it at length, and to show you in detail how it is made. And pay close attention to this, for you will gain great honor and profit from it. And let some of that color, combined with gold, which will grace any work of our art, whether on wall or on panel, shine forth in every picture."
URANIUM YELLOW

Or Uranium oxide, light and dark, is regarded as a fast color in mineral painting [stereochromy], but is otherwise used only for china painting.

VERDIGRIS

Verdigris is mentioned in Greek and roman literature, using the word aeuca to denote various blue-green and green corrosion products formed at the surface of copper, copper alloys and copper ores. Pliny for example mentioned that aeuca can be scraped from natural copper ore. Theophilus described a viride hispanicum and a viride salsum, the latter formed when copper covered with honey and slat is exposed to the vapors of urine or acetic acid. Its manufacture creates many acetates of copper, each differing in color, solubility and general behavior, all being verdigris. Pliny mentions that verdigris was often used as a pigment in antiquity, and though copper was found in numerous green and grayish green paint samples from Rome and Pompeii it was not established whether they contained verdigris or malachite. It was used to an enormous extent in the middle ages, made through formation on copper; by burying copper sheets in fermenting marc; grinding copper filings with vinegar, and so on. If there was lead in the copper, some white lead may have been produced along with the verdigris. If bronze or brass was used instead, no doubt the product was somewhat different as well. The apple vinegar used in England would have also altered the product bringing into it organic salts (this was a passing vogue however). In the fifteenth century, the milky juice of Euphorbia, a spurge, was used most likely to make the soluble green a little waterproof. There is a modern copper salt that we call verdigris, but we cannot assume that the medieval verdigris was the same thing. With all the different preparations, we find variations in its solubility (sometimes it was completely insoluble in water), and its stability, having spread into parchment and stained, corroded or eaten it away so that the painted parts actually drop out of the page; other times it has stayed in place over time and kept its transparent blue-green color without distress. In medieval recipes, to make the color richer, sap green was sometimes mixed in it. In all periods, to make it warmer and more grass green, saffron was blended in, which over time generally faded out or has been lost in the darkening of the verdigris, with the exception of especially well preserved manuscripts. In early Italian, Netherlandish and German paintings, is was widely used to produce the green tones for landscapes and drapery, because neither mixtures of blue and yellow pigments nor malachite and green earth possessed as strong a color. It was common to glaze over an opaque body color of lead white combined with verdigris, or verdigris with lead tin yellow, with a copper resinate layer to produce a deep saturated green. By the eighteenth and nineteenth centuries, it was rarely found. Emerald green and viridian were available as early as the nineteenth century: hardly surpassable in brightness, but verdigris as an oil medium in tube color was available in France by the LeFranc brand as late as 1928. It does not last except under favorable conditions. It is susceptible to the action of prolonged moisture, readily blackened by alkalis (often used in cleaning pictures), reacts unfavorably with other pigments often aiding in their deterioration as well, and may be darkened by gases in the atmosphere. As hinted at earlier, it is also terribly destructive to paper. Much of the darkened verdigris areas in medieval and Renaissance painting is constantly misleading to art historians. As a note: verdigris was the cause of the blackening of the shadows in the canvases of later masters such as Rubens, who used it in oil instead of tempera and without protective varnishes. As popular and beautiful it may have been in the fifteenth century to Italian painters, the damages and discolorations have left us with little evidence of the colors their writings rave about. Time effects no other color so badly, and tempera samples are mostly what has survived, though they too are badly stained with brown marks. There is reason to believe however, that these changes in color occurred rather slowly through time, having remained green for two to three hundred years before the damage took effect. Another great difficulty with using verdigris was its incompatibility with white lead and orpiment. It was therefore desirable for the painter to have substitute greens and yellows, to avoid the inconvenience of having to replace his white lead with bone white or another inert substitute. Alternatives to verdigris and orpiment began to make their appearance a bit before the fourteenth century, and during the century they developed rapidly. By the fifteenth century, there was no reason for painters, easel or manuscript, to use either of these two incompatible colors, unless if by choice. Leonardo DaVinci: ”To make a fine green take green and mix it with bitumen (asphaltum) and you will make the shadows darker. Then for lighter green with yellow ochre, and for still lighter green with yellow, and for the highlights pure yellow; then mix green and turmeric together and glance everything with it. Verdigris with aloes, or gall or turmeric makes a fine green and so it does with saffron or burnt orpiment; but I doubt whether in a short time they will not turn black. Ultramarine blue and glass yellow mixed together make a beautiful green for fresco, that is wall-painting. Lac and verdigris make a good shadow for blue in oil painting. Grind verdigris many times colored with lemon juice and keep it away from yellow.”

VERMILION AND CINNABAR

Vermilion: This is now the standard name given to red artists’ pigment based on artificially made mercuric sulfide (mercury and sulphur). The common red crystalline form of mercuric sulfide is called cinnabar, a name reserved only for the natural mineral. The natural product found chiefly in Almaden and Idria has been eliminated for practical purposes (including that it is slightly poisonous). The properties of both natural and artificially prepared are practically identical. Cinnabar, a dense red mineral, is the principal ore of mercury or quicksilver. It is widely found but not abundant, and from theophrastus we discover that cinnabar was known in Greece as early as the sixth century BC and perhaps Asia Minor long before that. It was not however, used in Dynastic Egypt or Mesopotamia. The best cinnabar came from Spain, but there were deposits of it in Italy at Monte Amiata, not far from Siena, and elsewhere in Europe (A version known as Monte Amiata, from that area is available in very small quantities from Kremer fine art, on Elizabeth Street in New York). There are deposits of
Cinnabar which would not make good pigment, but which can be used as a source of Mercury. We don’t know when scientists first discovered how to make mercury from cinnabar by depriving it of its sulphur content; but we do know that this was understood in the third century A.D. as described in the writings of the alchemist Zosimus. Mercury was a source of great interest to medieval alchemists as its appearance and chemical behavior were the basis of a very large part of alchemical theory and practice. They were regarded as the parents of all metals, and the marrying of mercury to sulphur, the manufacture of vermilion, the re-synthesis of these elements into the likeness of cinnabar from which the mercury was extracted, was a consummation greatly admired and devoutly practiced. To do so it is necessary to mix mercury with sulphur and heat them together; if simply mixed and ground together, a black sulphide of mercury is formed, but at the proper temperature this vaporizes and recondenses in the top of the flask in which it is heated. The flask is then broken and the vermilion is removed and ground. Upon grinding the red color begins to appear, and the longer it is ground, the finer the color becomes. This evidence first appeared in the eighth century A.D. We are not sure if the invention of vermilion was known in Hellenistic times, or whether it was a product of Syrian or Arabic alchemy, or Byzantine or European, but we’ve safely assumed that the knowledge of it was popularized in Europe under the influence of Moorish science after the twelfth century. Although the late eighth century recipes prove that the making of vermilion was understood before the year 800. However, vermilion (and in early reports we use this term loosely as it is possible that in terminology it may have still been called cinnabar, even though the process of extraction was reversed), is not generally considered today to be a permanent pigment. It has been known since roman times, and that specimens of vermilion darken when exposed to light. (In the 1920s samples were observed to withstand exposure to sunlight for at least ten years. In other tests it has been discovered that impurities in the alkaline polysulphides used to “digest” the pigment, led to the instability of the red. This catalyzes the transition of the red to black). Also, we’ve found that the darkening of vermilion occurs mainly in paintings in egg tempera but it is not unknown in oil paintings. As the ancients knew this there were attempts to counteract its natural darkening; i.e. the vermilion wallpaintings in Pompeii were covered in wax as an attempt to preserve them. Naturally this greatly altered their appearance. It is however fairly unreactive to other colors’ chemical makeups, therefore when mixed with lead white to produce flesh tones (as was common) it did not produce the black sulfides. The traditional use of red glazes of madder, kermes, and cochineal lakes over vermilion underpaint not only increases the purity of the color but has been shown to reduce the tendency to darken as well. It is also known that the farther light can penetrate into the binding medium., the more quickly the vermilion will darken, thus again the use of varnishes and glazes to protect the color. Because of its cost and the poor lightfastness of some varieties, vermilion has long been substituted and sophisticated with the addition of red lead, chrome orange and organic colorants. Carmine vermilion was often a mixture of red iron oxide and vermilion. Under the name American Vermilion, chrome orange pigment and mixtures of red lead and lakes have been sold, toned or dyed with a permanent red called Para red, and for lighter shades with Lithol or Toluidine. Before the discovery of the permanent Aniline Reds, American Vermillion was sold under the name of VanDyke Red, and was composed of a very deep lead chromate. Little is known of the composition of these reds, but when composed of lead and a permanent dye, it is permanent to light, but not to gases. Antimony vermilion was introduced in England in 1847, but never gained widespread use. The lakes alone, based on monolite red, lithol reds, eosin and other synthetic dyes of appropriate hue were once called vermilionettes. Two such reds, one based on Toluidine red and the other a mixture of eosin and naphthol struck on barytes have been found on early Chinese ceramic objects. From the 1950s, a range of dark red to bright orange colors, based on mixed crystalline compounds of mercuric sulfide and cadmium sulfide were introduced by an American Manufacturer as Mercadmium pigments. To give vermilion an agreeable luster in manuscript decoration, the use of egg yolk along with the glair was how the color was normally toned in books. In tempora painting on panel, vermilion was tempered with egg yolk alone, or whole egg. In the fourteenth and fifteenth centuries, in the northern countries of England, France and Germany, they would add warmth to the color by adding saffron. In fourteenth century England, a decoction of walnut bark was sometimes used to enrich the color. In Italy and France only, illuminators used to blend it with Minium to make it brighter and warmer, especially if the vermilion which had been tempered and washed repeatedly had become dingy in the process. End result is that there are too many questions about the stability of vermilion to use it in any traditional sense, thus the enormous number of other reds available on the market today. This however should not prevent someone from capitalizing on its instabilities for their own purposes. Following are several quotations about the pigment which should be of interest: Leonardo Da Vinci, 1493: To make a fine red take cinnabar or red chalk or burnt ochre for the dark shadows and for the lighter ones red chalk and vermilion and for the lights pure vermilion and then glaze with fine lake. Church, 1890: Vermilion was formerly known as vermículus, cinnabaris, cenobrium, and minium; the last name is now appropriated to red lead. Vermilion and vermiculus are derived from the Latin vermes, a name originally designating the kermes insect found in the ilex or evergreen oak and used for the preparation of a red dye. From kermes, in its turn, the words crimson and carmine are derived. The name cinnabar is supposed to be of Indian origin, and was sometimes used to designate Dragon’s blood, a red resin. Theophrastus informs us that two kinds of cinnabar were known to the Greeks. One of these was undoubtedly real cinnabar (chiefly from Spain), the other was red lead. Pliny’s cinnabar or Minium was true vermilion; so was the Minium of Vitruvius. Theophilus called it Cenobrium. Harley, 1982: In English two names, cinnabar and vermilion, have been used interchangeably in the past to describe either the natural or the manufactured product, but by the seventeenth century, vermilion was used more frequently. Pliny, 77A.D.: Almost the entire Roman supply of cinnabar came from Sisapu (Sisipo) in Spain. (A reference most likely to the famous mines of Almaden, which are still the most important source of Mercury in the world). “Nothing is more carefully guarded. It is forbidden
to break up or refine the cinnabar on the spot. They send it to Rome in its natural condition, under seal, to the extent of some ten thousand pounds a year. The sales price is fixed by law to keep it from becoming impossibly expensive, and the price fixed is seventy sisters a pound". (This is supposedly a colossal price, and therefore it must have been of a very high quality.). Brelich, 1904: Cinnabar was mined at the turn of this century in the province of Kweichow, and produced quicksilver from it in Iron and clay retorts. It was exported to different parts of China "Where it is used for the manufacture of vermilion, for which there is great demand throughout the Chinese empire. Vitruvius, 1st century A.D.: "When the lumps of ore are dry, they are crushed in iron mortars and repeatedly washed and heated until impurities are gone and the colors come." He refers to the use of cinnabar in coloring the polished stucco finish of interior walls where it is only stable if not exposed to the sun. Cennino, 1400: By the fifteenth century, almost everyone who had any interest in making vermilion knew how to do it. "If you want to take the trouble, you will find plenty of receipts for it, and especially by asking of the friars. But I advise you rather to get some of that which you find at the druggists for your money, so as not to lose time in the many variations of procedure." Eugene Fromentin 1876: "None of Ruben’s tones is very rare in itself. If you take a red - his red - you can easily dictate its prescription; it is vermilion and ochre - not very finely crushed, and used just as they are after the first mixing."

VERTE ANTIQUE

Artificial Malachite.

VICTORIA GREEN

A bright color tone made from light permanent green and zinc yellow, but also often from cheap, much adulterated pigments like Paris blue and zinc yellow. There is much confusion about this color.

VINE BLACK

Charcoal made from young shoots of grape vines were referred to in medieval times as the best of blacks. It is now referred to as more of a blue-black, considering the coolness of the grays that it produces in mixtures. It was important that the vine sprigs be thoroughly burnt and reduced to carbon, otherwise the color was brownish and an unpleasant consistency; but they must not be burnt in the air or they might reduce to ashes instead of to carbon. So they had to be packed tightly in little bundles in casseroles, covered and sealed, and baked in a slow oven. The resulting charcoal was used in sticks for drawing; or for painting it was first powdered and ground up dry, and then mixed with water and ground for a long time between two hard stones.

VIOLET CARMINE

Same as Purple Madder, with a fair amount of permanence.

WELD LAKES AND ARZICA

Yellow lakes made from weld were possibly a slightly earlier development than those from rhamnus; but they seem first to have become significant in the fourteenth century. Weld is a tall growing relative of the garden mignonette. It used to be called "dyer’s herb" or "fuller’s herb." It has a very long history as a yellow dye, for welds (as the crop is called in the trade) is still grown commercially in Normandy and used in dyeing silk. No synthetic dye has been able to replace it in this function. The whole plant, flowers, stems and all, is dried and sold in bundles, and for dyeing and color-making it is broken up and stewed in water or a weak solution of alum. Medieval color-makers considered weld lakes with high esteem when opaque, and preferred buckthorn for transparency. Weld lakes were often precipitated out of the decoction of the plant in alum solution by the addition of chalk, which gave a mixture of an alumina lake with calcium sulphate, only partially transparent. Sometimes weld lakes were precipitated on a base of egg-shells, sometimes on white lead. When white lead was used, the color was a pure, light yellow, as brilliant as orpiment. The weld lakes were sometimes in Italian called arzica, probably a corruption of the old word for orpiment, arsenicon; and it seems quite certain that these colors were specifically thought of as substitutes for orpiment free from its chemical and physiological disabilities.

WHELK REDS

The whelk shellfish are more familiarly known as murex; "murex purple" thus loosely meaning purples of antiquity. Though a good many mollusks yield the porphyry dye.

WOAD & WOAD INDIGO

A substitute for the imported Indian indigo (even in classic times) was known in the native European weed called in Latin, Glastum or Isatic, and in English, Woad a shrubby herb with broad, green leaves which contain the raw material of a blue dyestuff. Simply gathering the leaves produces a deep and lasting blue-black stain on the hands. Chemically there is little difference between this blue, and that of indigo. As to a difference in their appearance in medieval art, this we can not judge. Both indigos were a very dark, purplish, even blackish color, and less attractive than when it is mixed with a material to lighten it. Even the ancients used to stain white substances with indigo, and in the Middle Ages certain compounds of indigo with whites assumed the character of independent pigments. Color was also sometimes made with a lime made from eggshells. Many medieval recipes claim to produce a blue "better than that which is extracted from the mineral" A whole family of indigo or woad pigments consisting of mixtures of indigo with powdered marble, natural and calcined, calcined gypsum, calcined eggshells and white lead we now regard as pigments in themselves, independent of the indigo from which they were made. However, considering the extra cost of indigo, naturally it was largely replaced in the middle ages by domestic indigo from woad. Woad was grown commercially in England until the early 1950s as an adjunct.
to dyeing with true indigo. Its known as a “gross feeder” that exhausts the land its grown on unless the salts it extracts are constantly replaced. This property was capitalized on as no source of potash was more esteemed in medieval England than the ashes of woad. (Potash, from pot ash, meaning the ashes which were made of potassium carbonate). The solutions of this potash were made immediately into dyes, soaps, and other products. But the earth left behind was agriculturally desolate, and the large profits they yielded for a time left the landowners in ruin. Thus they kept moving and using new land, leaving constant wasteland behind them. Even with the efforts of governments to control these agricultural activities, they never fully solved the problems. Therefore the Middle Ages paid heavily for the privilege of wearing blue cloth. Woad leaves were stripped from the plants, crushed, made up into balls forming the common raw material of commerce in domestic indigo; for use in dyeing they were powdered, spread out, and allowed to ferment. They were then made up into a dye bath with water and bran (other materials were used as well) and subjected to further fermentation, all of which took great skill. In the course of dyeing a scum collects on the surface of the vat. Called “Florey” or the flower of the woad, This was skinned off, dried and used alone or in elaborate compounds under the name of indigo in the Middle Ages. The stench of ammonia and other smells produced by the fermentation isolated the factories from residential and business quarters (in an age where they were not as sensitive to foul odors); the waste from the dyeworks contaminated water supplies, and yet this process went on. Woad indigo wreaked havoc in order to be produced.

**YELLOW OCHRES**

Earth colors which owe their hues to the iron hydroxide that they contain. Many painters are firmly convinced that there is no better earth or natural color, yet they are impure, often with admixtures of humus or bituminous organic matter, or clay, etc. For panels and walls in medieval painting they were widely used though substandard at times; it was the opacity of the product they was so admired. The beauty of these colors are due to such impurities, and if washed often lose their color, even though this washing is necessary to freeing them from harmful iron sulphate compounds. It was so common a product in the middle ages that they left no recipes for preparation as I suppose this was a given to all painters. Ochre colors are found everywhere in nature, the purest coming from France, but additionally from the Harz mountains and upper Palatinate. An “Amberg Yellow” from these areas was prized for fresco painting, but is no longer available. Ochres are ground and washed. Old masters worked hard in preparing them, often doing this procedure themselves. They were distinguished by the degree of brightness: light ochre, medium ochre, gold ochre, dark ochre, Italian earth, Roman ochre, brown ochre, etc. Gray varieties such as stone ochre and greenish ochre are best avoided. They have a medium covering power and must be pure. Because of their clay content they are apt to decompose, having a bad effect on the superimposed coats of varnish, and also require 60% oil, but again, permanent when free of impurities, and useful in all techniques. On badly preserved paintings, the ochre can be wiped off like dust however, and if impure, will turn brown and later dark as the impurities are soluble in oil. The artificial varieties have the advantage of being reliable in color and purity, which is not the case in the natural product, and are known as Mars yellow. According to Maximillian Toch (1940s), there are many varieties of American yellow ochre which are primarily found in Georgia and Pennsylvania. The Ochres found in the rest of the States are not good enough to be used as pigments. The two formerly mentioned however, are some as strong as the French ochres, but “their shade is not quite as clear”. I am unsure if this refers to inequities from batch to batch, or within the pigment itself.

**YELLOW: GENERAL NOTES**

Most important yellow in medieval painting is the metal gold. Yellow played an important role however in terms of their techniques, and most often, as the imitation of gold, along with modification of greens and to a lesser extent, reds. Perhaps the least important use was that of the representation of yellow things. Nothing disturbs the balance of decorative painting more than large areas of strong yellow as they tend to be obvious and conspicuous, most of all in glass painting, where they add nothing to the interiors they illuminate. This wariness followed through to all forms of medieval painting therefore, admiring the golden, but abhorring the bilious. The greater freedom of yellow is one of the marks of the approach of the Renaissance, when many new forms of yellow pigment were introduced in the course of the fourteenth and fifteenth centuries.

**ZINC WHITE**

First introduced in 1840, this white is colder in appearance than lead white, and doesn’t cover nearly as well, yet it is far less expensive. It is also non-poisonous, is permanent and doesn’t yellow, though all these positive factors are true only with pure zinc white, as something less chemically pure, evidently will prove. If you heat zinc white, it turns to lemon yellow, but will revert to white when cooled. It differs from lead white in this respect. It also disintegrates quickly out of doors, increases in volume thus causing massive crackling, so it is not useful in fresco at all. Ground in oil it dries slowly, especially in poppy oil, where the retarded drying time is needed. It does not dry as solid as lead white, due to some transparency in the pigment. A small addition of damar or mastic varnish speeds up the drying time. As it is very fine in powder form, it can be sufficiently mixed with only a spatula, requiring 30% oil and an addition of 2% wax in the tube to prevent hardening. It is compatible with all other pigments, including copper based, but in watercolor it is destructive to the permanency of coal-tar colors and accelerates the process of fading (though it definitely doesn’t do this in oil.)

**ZINC YELLOW**

Zinc chromate is a slightly poisonous, light lemon-colored pigment, which is obtainable only in this one tone, although richer tones can be produced without difficulty. It requires
40% oil, dries well, but fatally turns green when used pure as an oil color. It is not absolutely waterproof; the powder partially dissolves when shaken with water, and if moisture condenses on the surface, a yellow sheen will spread over the affected parts. In fresco, it can dissolve from the spot it is applied to, and reappear nearby where it has longer remained wet. Because of its tendency to turn green, it should not be used in sensitive areas such as atmospheric tones. When mixed with chrome oxide, permanent green, as a half tone, it is very useful.

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