

Pigments and Dyes: Lab 3
Pigments, Binders, and Color Theory
Guests: Lynne Vogel (pigment grinding) and Bob Askew (water color painting)

The goal of this lab is to prepare a green paint and measure its color characteristics. You will use the blue, yellow, and white pigments that you prepared in Pigments/Dyes Lab 1. You will use two binders: egg yolks to make egg tempera and gum arabic to make watercolors.

Teams will prepare the binders, and then mix the binders and pigments to prepare the paints.

You should have looked at Wilcox, Michael *Blue and yellow don't make green* ND1488 .W54 1994 (reserve) in preparation for this lab

SAFETY

Handle all of the dry powdery pigments with extra caution—the dusts are hazardous to breath. Wear a dust mask while working with these very fine powders (and while those around you are working with them). Place a sheet of white paper or one of the glass mirror squares under the container you are using for grinding to make it possible to see and collect any stray powder. See the instructor before cleaning up any spills. Wash everything well immediately after completing work with the dry pigments.

There are several designated areas where your work should be performed. Please minimize the amount of waste we need to dispose of! Put all waste in the designated containers in the hood.

Preparation of Pigments in Binding Media

From *The Molecular Basis of Color and Form: Chemistry in Art—Laboratory Manual*, Patricia S. Hill, Department of Chemistry, Millersville University, Millersville, PA:

"Introduction. In order to prepare a **paint** or an ink which can be used for protective or decorative purposes, a dry **pigment** must be mixed with some sort of **vehicle** which will enable it to be spread evenly and smoothly. The vehicle contains a **binder** and a **diluent**. The binder anchors the pigment to the surface and prevents flaking. A binder may be a film or an adhesive. Film binders also protect the colorant and supply gloss. Binders must be tough, flexible, durable, and they must form the film quickly. The diluent increases the fluidity of the paint to improve spreadability. ... With a few notable exceptions, the same pigments can be used in almost any type of paint formulation. Therefore, the real difference between types of paints lies in the binder used in the formula. The binder type in turn dictates what solvent system will be appropriate. The common property of most paint binders is that they contain either macromolecules (polymers) or else they contain smaller molecules which will form macromolecules (polymers) upon exposure to air and moisture."

Grinding the pigments

We will grind each pigment with a mortar and pestle and/or a muller (The instructor will give you the specifics for each pigment). After the proper amount of grinding, take half of the pigment to be mixed into egg tempera. The other half will have gum arabic solution added with continued grinding.

Watercolor: Gum arabic has been used as a binding material since Egyptian times.

The 'prepared' gum arabic binder needs to be mixed in lab. Place 40 drops (approximately 2 mL) of the gum arabic solution into a small beaker. (This solution was made using 1 gram of gum arabic for every 2 mL of boiling water, it is time consuming to grind and dissolve it). Add several drops of strained honey (plasticizer), 2 drops of glycerin (plasticizer and moisturizer) and 0.02 grams of benzoate of soda (preservative) (Note: these quantities may be "eyeballed" from the examples prepared by the instructor). Mix well. For larger quantities, keep these same proportions. 10 mL of the prepared gum arabic will be about enough for 10-12 people.

Be sure you have saved half of the pigment to be made into egg tempera! Then take some of the pigment you will be working with (for the Prussian Blue take a rather small amount of blue pigment—you can always add more later—at this point is better to have a rather dilute blue paint) continue grinding the pigment while adding the prepared gum arabic binder (with the additives!) dropwise. COUNT the number of drops used. Record the volume (number of drops) of solution used. Use a metal spatula to form the resulting thick paste into a small patty.

To test if the proportion of binder to pigment is correct, dip a brush in water and then pick up some of the pigment mixture on the paint brush, just as you would with commercially prepared watercolors. Paint a strip on a glass plate. Allow the strip to dry. Rub the completely dried surface of the painted area with a white tissue. If the paint crumbles and becomes powdery there is not enough binder. It is acceptable if only a small quantity of color adheres to the tissue. If no color is removed, then less binder may be used in the future.

In previous years we found it helpful to add water as the watercolor paint dries. The paint should have a glossy appearance. We do not want grit.

To clean up, rinse the mortar and pestle and/or muller and spatula with a little hot water into the appropriate waste beaker, then wash with soapy water and rinse well and dry.

To paint, dip a brush in water and then pick up some of the pigment mixture on the paint brush, as you did to prepare the test strip.

Egg tempera: Egg tempera was used extensively during the 14th and 15th centuries as a binding medium for paintings. During some periods of history, the whole egg (yolk and white) was used; during other times only the yolk. We will use just the yolk.

Break an egg into a bottle and separate the yolk from the white and just use the yolk. The technique calls for passing the yolk from palm to palm until the yolk sac becomes fairly dry. You might try using a paper towel. When the yolk is dry, puncture the yolk with a pin and drain the yolk into a graduated cylinder. Note the volume of egg yolk. Transfer the yolk to a beaker and add an equal volume of water. Stir to prepare a pale emulsion. Keep the emulsion covered with plastic wrap so it will not dry out.

Take the portion of pigment that was ground with the mortar and pestle and/or muller and put it in a large plastic weighing boat. [NB! In previous years we found it helpful to add some water to the pigment before adding the yolk emulsion] Adding the yolk emulsion to the pigment as needed, use a pestle to grind the pigment and emulsion to form a paste. Cover the weighing boat with some plastic wrap so that the egg emulsion will not dry out. Rinse the mortar and pestle and/or muller and spatula with a little hot water into the appropriate waste beaker, then wash with soapy water and rinse well and dry.

To paint with the egg tempera mix approximately equal quantities of pigment paste and the egg emulsion. To test if the proportion of binder to pigment is appropriate spread a sample on glass and allow to dry. If a sharp knife will peel the paint layer up in a continuous strip then sufficient binder is present. If it flakes, powders and crumbles then more egg is required. Refrigeration of tightly covered egg tempera (add one drop of oil of cloves to the egg emulsion as a preservative if it or the paints are to be stored) will permit its storage for a few days.

[*Enhancement*: you might want to try a couple different proportions of pigment paste and egg emulsion. Record all particulars.]

Preparation of Painted Samples

The class will be divided into groups to prepare color samples for each binding medium. We will use watercolor paper; use one piece of paper for each binder. When mixing paints, use a ceramic or glass spot plate or a flat glass plate. Make a sequence of color strips, from just yellow to just blue, with several steps in the middle. Since the blue tends to overpower the yellow, always add blue paint to yellow. Remember we are trying to make a satisfactory and satisfying green. Do the sequence for each of the binders. Make a strip of just the binder, too.

When working with the watercolor paints, put the watercolor paper on a slant. When the paint is applied, a puddle forms. Add paint to the puddle and draw the puddle down.

[*Enhancement* As a group, design the process for studying both saturation and lightness. For the watercolor, try layering washes to study the lightness idea. For the egg tempera, mix in the white pigment. Time permitting, you might want to try some of the white watercolor, though I believe watercolorists usually use the layering-of-washes idea.]

[*Enhancement* There are some other blue and other yellow pigments available in the lab. To produce a **better green**, choose a different yellow to mix with our blue, a different blue to mix with our yellow, or a new blue and a new yellow. Comment on why you chose the new pigment(s) you did. How successful were you? See Color Studies below.]

Color Studies

1. After recording your observations in your laboratory notebook, write a paragraph about the green(s) you produced in each of the binding media.
2. [*Enhancement* Use the colorimeter to measure the colors of your sequence of paint strips—in egg tempera and gum. Write a paragraph answering the following questions:
 - a. Are the values the same or different?
 - b. [*Further Enhancement*: What is the experimental error in each measurement? (Hint: measure the same area three times (lift up the monitoring head between each measurement). How much deviation is there?]
 - c. [*Further Enhancement* Why are the values the same or different?]
3. [*Enhancement* Make a painting with the paints made from one of the binders. This could be on the same piece of watercolor paper that you put your tests on, or you could do a separate painting. For the water color paints, demonstrate the techniques demonstrated by Bob Askew.]
4. [*Enhancement*: Use the colorimeter to measure the test strips of just the dry binder. What effect does the color of the binder have on the color and appearance of the paint?]
5. [*Enhancement* Preparation of slides for examination with Olympus microscope. Prepare several slides with cover slips: pure yellow, pure blue, and several of your greens. Look at the slides through the microscope. Can you see the individual pigment particles in the mixtures?]