Student Sheet

In this practical I will be:

- Creating egg tempera paints and oil paints from different types of minerals.
- Evaluating the different paints, looking at various aspects, including:
    - what colours different minerals make;
    - how easy the different types of paint are to use;
    - and which paints give the highest quality finish on different surfaces.

Introduction:

Whilst polishing your spear with plant oil, you accidentally drop a couple drops onto some powdered charcoal by the fire pit. You notice that an interesting solution is made with the charcoal, and you wonder if you can paint with this solution.

And if you can make paint using the **mineral** charcoal**,** then maybe you can make paints from other different **minerals, binders** and **extenders**. You decide to investigate further…

Equipment:

- Spatula
- Linseed oil
- 1 egg
- Ethanol
- Water
- 2 plastic pipettes
- 2 paintbrushes
- 250 ml beaker
- A4 paper
- Piece of MDF (or white tile)
- Small prepared canvas 5 cm by 5 cm (or similar)

Access to:

Copper(II) carbonate
Calcium carbonate
Iron(III) oxide
Carbon powder
Ethanol
Disposable plastic cups or Petri dish
Washing up liquid
Paper towelling
Disposable apron
Disposable gloves
Newspapers to cover the work area

Pestle and mortar (if using lumps of minerals)

Hazard Warnings:

Wear safety glasses.
Wear disposable gloves.
Wear dust masks (if using lumps of minerals)
Ethanol – Highly flammable and harmful
Copper(II) carbonate – Toxic if swallowed and irritant
Calcium carbonate – Low hazard
Iron(III) oxide – Low hazard
Carbon powder – Irritant

Method:

Preparation of the pigment

1. If the pigment is already finely ground skip to the questions. If you have large lumps of pigment carefully measure out your pigment into the mortar. Cover the mortar with a sheet of paper or put it inside a plastic bag and grind very gently until you have a fine powder. (You don't want to raise too much dust, as the dust is harmful.)

   Use the spatula to bring the fine pigment powder into a small pile. Leave it in the mortar.

   - Why is the pigment ground to a fine powder?
   - What is the chemical difference between carbon and the other pigments?
   - Describe and compare the appearance of the lump of pigment and the fine powder pigment.
   - What are the differences?
   - Why do think there is a difference?

Making the paint from fine pigment particles

2. Separate the yolk of an egg from the white. Break the egg. Use the egg into an egg yolk separator to separate the yolk of the egg from white. Alternatively, break the egg and carefully hold all the egg liquid in one half of the shell, then pass the yolk between the two halves of the shell letting the thick transparent 'white' flow off into a 100 cm^3 beaker or plastic cup. This should leave the yolk in one half of the eggshell.
3. Drop the yolk into another 100 cm^3 beaker or plastic cup; add about 5 cm^3 of water, and mix thoroughly with the yolk to form a paste.

4. Using the spatula take about 20 g of the pigment from the mortar and place in a pile in a Petri dish. Put 3 spatulas of copper(II) carbonate (or any of the pigments provided) into each of two disposable plastic cups.
5. Repeat step 4 using the same pigment but put into a second Petri dish or pair of plastic cups.
6. Push a small dent in each pile of pigment.
7. Using an eyedropper or plastic pipette drop a small quantity of yolk and water mixture into the dent in one pigment pile.
8. Repeat the above step but this time drop a small quantity of oil into the same colour pigment in the other Petri dish or plastic cup.
9. Use the cotton bud or spatula to very gently thoroughly mix the binder with the pigment to form a thick paste.
10. If the pigment is too stiff, add more of the egg binder or some of the distilled water as the extender to thin it. If you are using oil as the binder add more oil or alcohol as the extender. (Plant sap or saliva was used by early artists because it would mix easily with oils or fats and would be stickier.)

    Ideally you want a not-too-thick paste. Too much thinning can make the pigment harder to paint with, and it may run off the slab.
11. It may be that certain pigments just will not wet. If this happens add a drop or two of ethanol (care, ethanol is inflammable) to the pigment to help the water moisten it
12. Stir round in small circles, and every now and then scrape the pigment back together into a heap.
13. When the pigment is smooth, cover it.
14. When all the groups have finished making their paint sample then move onto the next step.
    - Describe the appearance of the egg yolk and the egg white.
    - Was making the paint paste easy?
    - Did adding more binder make a difference to the colour and was it different from the addition of the extender. What was the difference?
    - Compare the colour of your paints with the lump and powder pigment. Is there any difference?
    - What are the differences?
    - What do you think has caused the differences if there are any?

Using the paint

15. Now use a paintbrush and the paints to paint a shape on to a piece of white paper.
16. Repeat using the MDF board and the prepared canvas.
17. Rinse the paintbrushes before repeating with the other paints that you have made.

- Describe the appearance of the paint before painting.
- Was it easy to paint on each surface?
- Describe the appearance of the dry paint on your painting.
- Was it glossy, dull, bright, smooth, or rough?

Evaluate the paints by completing the following table.

Criteria/ Pigment						
Malachite + **Water or** **Egg Yolk**						
or **Linseed oil**						
Haematite + **Water or** **Egg Yolk**						
or **Linseed oil**						
Carbon + **Water or** **Egg Yolk**						
or **Linseed oil**						

Going further:

- Using a paintbrush, paint with each different paint type and colour a design on to a piece of MDF or cloth. Note how easy or difficult the paint is to spread. Does it cover easily, does it smear or does it require a second coat?
- Note how it dries, quickly or slowly? Think about the implications for time to paint.
- Make an evaluation of which binder you think is best.
- Identify your criteria for your judgement.
- Can the criteria be standard if the surfaces are different materials and have different dimensions? Explain your answer.
- Explain why paint seems to have had such a complex history.

Theory:

In the fifteenth and sixteenth centuries, there was a gradual movement from **tempera paints** to **oil paints** as the primary medium. This movement began in northern Europe for the following reasons:

- **Egg tempera paints**: dried quickly, less colour saturation, and low transparency;
- **Oil paints**: dried more slowly (easier to work with), greater colour saturation, and increased transparency.

Egg tempera paint is made by mixing pigments with an egg yolk binder. This mixture is thinned with water, acting as the extender. Egg yolk dries fast and forms a hard film and that is one of the keys to a good paint. The other is the choice of mineral pigment, its depth and permanence of colour. The problem is that drying time is variable and is affected by environmental conditions.

Water and egg yolk mix with each other due to the presence of lecithin which allows an emulsion to be formed. This is due to the formation of weak hydrogen bonds which makes the yolk water soluble. The oil substances in the egg yolk make the paint flexible. When the egg tempera paint dries the water first evaporates leaving the pigment - yolk mixture glued to the surface and protected by a protein skin. Overtime this mixture cures or hardens.

Olive oil and linseed oil became the oil medium during the Renaissance. Oil paintings do not really dry hence the ‘drying’ time for olive oil is excessively long. The oil is generally mixed with the pigment and an extender such as alcohol, white spirit or turpentine. These allow the paint to be used easily and they will evaporate as the paint is applied. This leaves an oily pigment paste on the surface.

Then a different process takes over. The oily pigment paste begins to react with the oxygen in the air. This reaction is known as oxidation and it causes the oily pigment paste to harden. At the same time some of the oil molecules form cross links or weak bonds resulting in a

plastic. These sets of reactions continue over time leading to some changes in the depth of colour on some paintings.

Oil painting as we know it today emerged from much experimentation with egg-oil tempera painting media by Northern European artists during the 15th century. Flemish painter Jan van Eyck is credited with developing a stable medium based on linseed oil and his painting *Giovanni Arnolfini and his Wife*, which hangs in the National Gallery in London, is considered one of the first to employ a linseed oil paint preparation method that is still used today.