

## Teachers' Card



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## Teachers' Card

# General Introduction

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Raw materials is a term used for natural resources that are essential in our everyday life. Whether it is a regular paper, wall paint or even batteries used in cell phones or cars, those resources are needed for their manufacturing.

One of the goals of the EIT RawMaterials Consortium financed under Horizon 2020 is to increase awareness of European population on necessity of production of the aforementioned materials in Europe. The purpose of this toolkit is to familiarize students with how even the seemingly ordinary and mundane occurrences surrounding us can be used for a much more concrete activities, such as creating colours needed for making art works. The history behind the pigments usage is described within the toolkit, including descriptions and origins of the ores required for different colours. In the end, students will be able to make their own colours from scratch and paint their own artwork.

### Key words:

*Raw materials, minerals, pigments, colouring*

## Extended background information

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Any objects colour is a result of the interaction of its surface with light. Light itself is a form of electromagnetic radiation perceivable by human eye. The colour of an object is the wavelength that is reflected off a surface of an observed object but it is also in the eye of the observer, as each individual can perceive it differently.

Pigments are materials that reflect certain wavelengths of visible light and therefore have unique colour. Their other properties include high tinting strength and the ability to form a stable solid at ambient temperatures. Generally, not all pigments are stable during a longer period of time. These short-term pigments that are not stable in the long term are called fugitive.

Earliest known pigments were directly used minerals. Iron oxides were used in many Paleolithic and Neolithic paintings for red and brown colours, as well as the coal or charred bones.

In later times, with the development of art and other activities, red, brown and yellow pigment ochre as well as black, were readily available. One of the most expensive pigments was ultramarine which was the only one that could be used for achieving the "deep blue" colour. This pigment was derived from grinding semi-precious mineral lapis lazuli which was mined in Asia. For instance, the artists without wealthy patrons had to use cheaper sources of blue colour which was either another, more available mineral (azurite) or from biological origin pigment (plant of indigofera genus).

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Today, pigments are mostly synthesized and this large industry has a global market value of 30 billion USD per year.

### Pigments from minerals

#### ***Yellow, red and brown ochre***

Yellow ochre is produced for many thousands of years from various iron oxides. These colours are mainly derived from iron oxyhydroxides which are composed of  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ , O and H. It should be noted that even though some minerals appear to have one colour, when crushed into small particles their colour changes. This is mostly the case when hematite with crystals appears to have grey to metallic colour while in fact it is red when crushed. These minerals also serve as or for producing iron. Raw materials are relatively abundant in Europe (Sweden, Norway, Germany, Slovakia...) and the rest of the World.

#### ***Yellow***

Yellow color in the ancient times was sometimes derived from a mineral orpiment which is arsenic sulfide ( $\text{As}_2\text{S}_3$ ). This mineral is highly toxic and chemically incompatible with other mineral colours which therefore resulted in its insignificant usage for pigment extraction.

#### ***Blue***

There is a variety of different blue colours of which most famous one was ultramarine. It was derived from a rock called lapis lazuli, mostly mined in Afghanistan and very hard to procure in Europe. The cheaper variant was deriving blue colour from grinded mineral azurite. Azurite is a copper carbonate ( $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$ ). Azurite derived blue was not nearly as valued as lapis lazuli derived blue due to the lack of "depth" and long-term chemical instability to its potential reactivity in normal conditions. Lapis lazuli as a more stabile variant of blue was also used but as the ore itself was scarce at the time of middle ages it was very valued as a pigment. Lapis lazuli is composed of several minerals but two are dominant – tectosilicate lazurite and feldspathoid silicate. Largest occurrence of lapis lazuli is in Afghanistan. Both minerals are silicates with complex formulae, e.g.  $(\text{Na,Ca})_8(\text{AlSiO}_4)_6(\text{SO}_4,\text{S},\text{Cl})_2$  for lazurite and  $(\text{Na,Ca})_8(\text{AlSiO}_4)_6(\text{S},\text{SO}_4,\text{Cl})_{1-2}$  for feldspathoid silicate.

#### ***Vermilion red***

Vermilion red colour was derived from a mercury sulfide cinnabar ( $\text{HgS}$ ). The first usage of this pigment was dated to approximately 7000-8000 BC in Roman culture and in China. The pigment itself is highly toxic but due to its bright colour and lack of knowledge of its toxicity, it was extensively used at the time. Cinnabar was used for the production of Mercury. One of the great, and now closed mines, is located in Idria, Slovenia.

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### **Green**

Malachite was one of the sources for producing vibrant green color. It's composition is similar to azurite ( $\text{Cu}_2(\text{CO}_3)(\text{OH})_2$ ) and was mined as a copper ore in the ancient times. Today it is mostly used for making gemstones and sculptures. Malachite can be used for extracting copper. It can be found in Germany and Austria in larger quantities while in the world there are many deposits (e.g. Brazil, Congo...)

### **Black**

Black pigment was one of the easiest to acquire as it was derived from materials that were readily available. Most common sources of black pigment were either charred wood, bone or crushed coal. Occurrence is frequent while the main usage is for producing electricity in power plants and steel industry. It can also be regarded as a Raw material if it is adequate in purity and composition for medical usage (active charcoal).

## Glossary

**Mineral** – a well defined solid chemical compound which present building blocks of rocks

**Ore** – a rock or a sediment which contains one or more valuable minerals out of which useful compounds can be extracted (e.g. metals, rare earth elements)

**Pigment** – a colored material that is mostly or totally insoluble in water

**Color** – a visual perception property of a material based on its light absorption

## Learning Outcomes

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By the end of the lesson the students will be able to:

- Distinguish different Raw materials/minerals/ore which can be used for pigment preparation
- Summarize the procedure of making paint from Raw materials
- Point out potential usages of Raw materials in every day life
- Relate the abundance of the Raw materials on Earth in contrast to current exploitation in Europe

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# Key Competence European Framework

<b>Literacy competence</b>
S2. Ability to express concepts, feelings, facts or opinion in written and oral form.
S3. Ability to interpret the world and relate to others.
S4. Ability to interact in an appropriate and creative way in any situation.
<b>Personal, social and learning to learn competence</b>
S1. Ability to pursue and persist in different kinds of learning.
S2. Identifying available opportunities.
S3. Ability to gain process and assimilate new knowledge, skills and qualification required for career goals.
<b>Citizen competence</b>
S1. Ability to effective interaction with other people
S2. Ability to adapt to the changing situation, being flexible and work under pressure
S3. Ability to work effectively and collaborate with other team members
<b>Cultural awareness and expression competence</b>
S1. Ability to turn idea into action
S2. Creativity/innovation
S4. Independence, Motivation and Determination

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# United Nations' Sustainable Development Goals

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.

		Enable access to basic services		Equal access to global expertise
		Safe medical devices		Sustainable urbanization
		Access to education		Responsible consumption and production
		Less hardship, more opportunities		Strengthen resilience, reduce disaster impact
		Safe and affordable water		Reduce marine pollution
		Energy — the golden thread		Sustainable use of terrestrial ecosystems
		Safety of workers and economic growth		Promote peaceful and inclusive societies
		Resilient infrastructure and sustainable industrialization		Better access to technology and innovation



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# Contents – Theoretical principles

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Minerals and ores are a key driving mechanism for technological advancement and are needed for everyday usage. From them we acquire a variety of products, from precious metals for electronic industry, elements for car batteries to clays for production of paper.

One of the earliest applications of these raw materials was an art long before any car or mobile phone existed.

Modern humans were not the first species that have used the pigments in their drawings. In fact, the first known applications of pigments date as far back as 250,000 years BC.

Contents of the toolkit is comprised of mortar and pestle for grinding softer pigments, pigments, mineral/rock samples, containers and the description of the activity. The medium (base) for painting is partially supplied (linseed oil) while other part has to be supplied by teacher/student (egg yolk).

## Lab Procedure

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The experiment is comprised of a following module:

### Module 1 – Coloring with minerals

“Egg tempera” is one of the oldest medium for making paintings which made its peak in popularity during the renaissance. It was later substituted with oil-based paints but a few artists even to this day embrace this procedure of making paint.

Egg tempera is comprised of three main components:

- Egg yolk
- Powder pigment
- Water (preferred distilled but not crucial)

The procedure for making egg tempera is pretty straight forward.

1. Pigment preparation (grinding if needed)
2. Separating egg yoke from the egg white
3. Mixing the water with egg yolk with  $\frac{1}{2}$  to 1 teaspoon of water
4. Add water to the pigment in a separate container to achieve paste like medium
5. Mix equal amounts of egg yolk with prepared pigment
6. Stir until colour is homogenised

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Within this toolkit mineral pigments that are supplied are:

- Red (hematite)
- Yellow ochre (limonite)
- Blue (lapis lazuli)
- Green (malachite)
- Black (coal)

Painting motive is selected by the teacher.

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## Learning Pathway

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**Step 1- Introduction (Earth and raw materials):** 10 - 15 minutes - Teachers do a short introduction with a prepared PowerPoint presentation.

**Step 2 – Grinding minerals:** 5 - 10 minutes- Students are divided into groups (preferably the number of students in one group is 3-4). Each group takes few samples of minerals and grinds them to a powder.

**Step 3 – Mixing colours:** 10 minutes- Students of each group are taking containers from the toolkit and are mixing mineral powder (pigment) with linseed oil, water and egg (if possible).

**Step 4 – Painting with minerals:** 60 minutes- Each student is getting a canvas or paper and are drawing a picture on a given theme (If the theme requires, few students can draw on a same but bigger canvas)



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### Evaluation



Mentimeter or Kahoot quiz will be organized for students which will cover the general Raw materials applications as well as thematic topic regarding pigments from minerals and their usage.

E.g. Malachite as an or mineral can be used for extracting which metal

- Iron
- Aluminium
- **Copper**
- Lithium

Further examples of questions are as follows:

- Which of the following pigments is harmful to human health?
  - Yellow ochre
  - **Vermillion red**
  - Green
  - Blue
- Where in the world can lapis lazuli be found?
  - China
  - **Afghanistan**
  - Brazil
  - India
- Orpiment, in addition to being used as a yellow pigment, in ancient times served as an ore of which element?
  - Cadmium
  - Molybdenum
  - **Arsenic**
  - Copper
- The first use of coloring pigments can be tracked to how many years B.C.?
  - 10 000
  - 70 000
  - 135 000
  - **250 000**

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# Description of Student's Cards

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### Student's Card 1 – Colouring with minerals

In this card the experimental activity is described in detail with instructions how to use the toolkit. Almost all material is supplied within the toolkit.

## Sources

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- <https://rmschools.isof.cnr.it>
- [https://www.youtube.com/watch?v=384TYLQaM\\_o](https://www.youtube.com/watch?v=384TYLQaM_o)

## Acknowledgement

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