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LIGHT AND THE COLOURS WE SEE

COLOURS AND SHADOWS

3 to 5 years

SCIENTIFIC CONTENT

Light and the colours (Physics)

CONCEPTS

Light, colours, shadows.

TARGET AGE-GROUP

3 to 5 year-old

DURATION

3 hours

OBJECTIVES

Understanding that:

- "White" light is composed of light of all colours;
- Not only mirrors reflect light;
- The colour of objects is the colour which they reflect;
- The colours we see depend on the light we use.

SUMMARY

This activity aims to demonstrate that white light is composed of light of all colours and that the colours which we see depend on the objects but also on the light under which they are seen. Three independent experiments are proposed, each lasting around one hour. Experiments can be pursued in sequence or in three stand-alone sessions of one hour each.

1. Using a prism or a CD we can break light up into its constituent spectral colours. Light is not all the same: we obtain different results depending on the source of light we use. (experiment 1).
2. With three lamps, each with a different-coloured light bulb (red, blue and green), we may obtain light that is white, yellow, magenta or light-blue (experiment 2).
3. Not only mirrors reflect light: all the objects we see reflect some light. White reflects much light, whereas black reflects none. The colour of an object is the colour of the light reflected by that object. If we illuminate an object with red light, we will not be able to see the colours yellow, green or blue in it very clearly (experiment 3).

Experiment 1: Decomposition of light

The room must be darkened. A little beam of light is allowed to come in through one of the windows. A CD is turned toward the light coming in from the window, and the results of the decomposition of light can be observed. Closing the window completely, so as to remove all natural light from the room, we may proceed to observe the spectrum of the light emitted by different light bulbs (incandescent bulbs, fluorescent bulbs, LEDs, or coloured light bulbs).

Experiment 2: Mixing light of different colours

Three bulbs are used – red, green blue – alongside a desk lamp with a regular transparent bulb. Before beginning the experiment, the four sources of light are simultaneously pointed at the same spot on a blank, smooth and non-polished wall, in such a way that the resulting light is white in all the illuminated area. As a first step, the white light bulb is switched on, and the children are asked to project

shadows onto the wall with their hands. This is repeated separately with each bulb. Then, all three bulbs are switched on and directed at the wall simultaneously; shades are again projected, and children are asked to write down all the colours observed. The exercise is repeated with only a pair of bulbs at a time. Attention is paid to the colour of the light bulbs being used, and to the colours observed in each situation.

Experiment 3: The colours we see

This experiment takes place in a darkened room, using a potent source of light (strong light bulb or overhead projector) pointed at a blank wall.

A few "targets" are placed in the room, in strategic positions. A child is asked to direct the light issuing from the projector by means of a mirror, so as to hit one of the target objects (targets must be distributed is such a way that it is possible to illuminate them using only the mirror, with no need to adjust or move the projector itself).

The target is chosen that is close to the source of light. The mirror is oriented so as to make the target object well-lit. In this position, the mirror is covered with a white pasteboard sheet, and the effects that this has on the target are observed. The operation is repeated with white and black pasteboard sheets.

The projector is then itself adapted with coloured filters (if possible, three filters are used, blue, red and green; a red filter and white light are otherwise sufficient).

Coloured pasteboard squares are attached to the wall (pasteboard must not be glossy).

The projector is switched on using one of the coloured filters, and children are asked to notice the colours visible on the wall. The exercise is repeated with each available filter. Finally, the exercise is repeated using no filters on the projector, and children notice the colours visible in the unfiltered light.

EXPERIMENT

WHAT'S THE COLOUR OF SUNLIGHT?

LIGHT AND THE COLOURS WE SEE

TEACHER'S NOTES

Topic:	Light – the colours of "white" light.
Concept:	Natural "white" light is composed of light of all colours, encompassing the full colour spectrum, spanning from red to violet.
Problem:	What is the colour of sunlight?

INTRODUCTION

The visible light emitted by the sun contains the full and continuous colour spectrum, spanning from red to violet and encompassing all intermediate colours. These colours are not simply three, five or seven – there is an infinite number of intermediate colours, each differing gradually from the ones before and after it, in a continuous span. Using an optic prism or a simple CD we can break up natural or artificial light. Many "white" light bulbs which pretend to reproduce natural light do not contain the continuous spectrum; the spectrum of each light bulb varies depending on the process/material used for generating light (in some cases, only three colours are present – blue, green and red.

Our eyes and brain are only sensitive to three of the colours of light (red, green, blue). When the three are combined (with equal intensity) we see/perceive "white light". If we combine light of these colours in different proportions we perceive mixes like orange, pink, purple, turquoise, etc. The composition of colours can easily be assessed with resort to any drawing or painting software – all available colours correspond to different proportional variations of blue, red and green. To each available colour corresponds a three-number code – the RGB code – in which each number corresponds to the fraction (from 0 to 255) with which each colour - red (*R*), green (*G*) and blue (*B*) – contributes to the final colour.

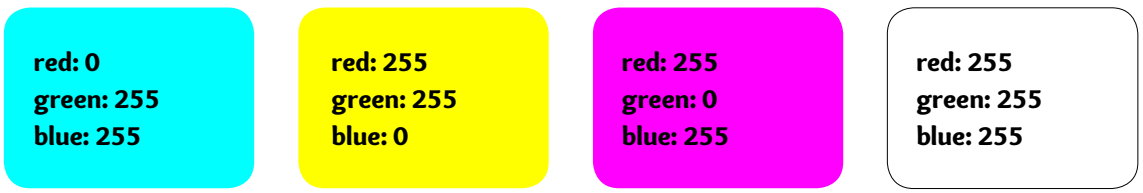


Fig. 1: RGB code of the three colours.

EXECUTION OF THE EXPERIMENT

Necessary materials

- A room which can be darkened
- CDs (these can be old/used, one for each groups of children)

Conducting the experiment

1. Children are divided into groups. Each group receives a CD.
2. The room must be darkened. A little beam of light is allowed to come in through one of the windows.
3. Children are asked to turn the CD to the beam of light, and to observe the effects produced by this.
4. Natural light is sealed off completely – or as much as possible – and a source of artificial light is switched on; the exercise in step 3 is repeated.
5. The previous lamp is switched off and a lamp with a red light bulb is switched on; the exercise in step 3 is repeated.
6. The experiment can be repeated with different sources of light. (Note: before the experiment, the teacher must have selected three sources of artificial light – light bulbs of different types, coloured light bulbs – capable of producing spectrums in which are clearly visible.

Experiment guidelines

7. Before the experiment, the teacher should introduce the children to the topic of sunlight ("How is a rainbow formed?", "Has anyone here seen a rainbow in a place other than the sky?" "Where do the rainbow's colours come from?" "What colour is sunlight?", "Is the liht of the sun the same as the light of our lamps at home?"...
8. During the different stages of the experiment, the teacher should also ask some questions: what colours can children see on the CD? Do they see the continuous spectrum of colours? Do they see well-defined stripes of certain colours? What do they see when a coloured light bulb is used?
9. These guidelines include a "Record of experiment" sheet with three components: (1) Before the experiment, (2) During the experiment, and (3) after the experiment.

The chief purpose of this record sheet is to remind children throughout the experiment of the problem at hand, and to weave their ongoing observations with the matters introduced in the preliminary conversation. Before the class, three larger boards may be prepared (printed, or drawn on pasteboard) based on these record sheets, so that the children may register their answers with stickers or stamps.

Through this experiment, children should be able to realise that:

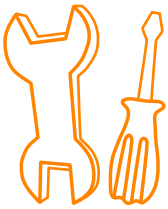
- White light is formed by light of all colours.
- With a CD we can break light up.
- Light is not all the same (but our eyes cannot always perceive these differences).
- Coloured light is only a part of white light.

1. PREPARING THE EXPERIMENT

RECORD
EXP. 1

- What colour is sunlight?
- Where do the colours of the rainbow come from?

WHAT WILL YOU NEED?



- A CD

WHAT DO WE INTEND TO DISCOVER THROUGH THIS EXPERIMENT?

What size is	the sun
What colour is	the wind
What's the use of	the sea
What is the smell	sunlight

What colour is sunlight?

- ☐ Purple
- ☐ Light-blue
- ☐ Dark-blue
- ☐ Red
- ☐ Colourless
- ☐ Yellow
- ☐ Orange
- ☐ Pink
- ☐ Green
- ☐ Multicoloured

Why do you think that?

_____

_____

_____

_____.

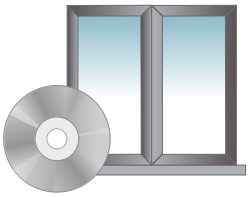
2. LET'S DO THE EXPERIMENT

HOW TO DO IT?

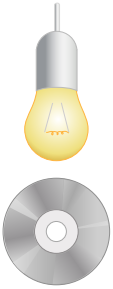
1. Darken the room, allowing only a little beam of outside light into the room.
2. Turn the CD toward the natural light. Observe the colours that appear on the surface of the CD.
3. Close the window completely and switch the main lights on. Turn the CD toward the light. Observe the colours that appear on the surface of the CD.
4. Switch the main lights off and turn on a single desk lamp. Observe the colours that appear on the surface of the CD.

WHAT DO WE SEE?

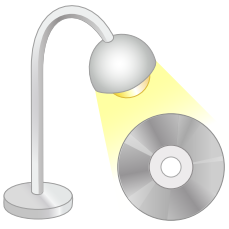
When you turn the CD to the light coming in from the window, what colours do you see on the surface of the CD?



When you turn the CD to the ceiling lights, what colours do you see on the surface of the CD?



When you turn the CD to the desk lamp, what colours do you see on the surface of the CD?



3. AFTER THE EXPERIMENT

THIS WHAT HAVE YOU LEARNED FROM EXPERIMENT?

(you can tick more than one box)

Sunlight is...

- ☐ Purple
- ☐ Light-blue
- ☐ Dark-blue
- ☐ Red
- ☐ Colourless
- ☐ Yellow
- ☐ Orange
- ☐ Pink
- ☐ Green
- ☐ Composed of all colours

Turn back to page 2 and check if your answer was correct:

- ☐ Yes
- ☐ No

EXPERIMENT

MULTICOLOURED SHADOWS

LIGHT AND THE COLOURS WE SEE

TEACHER'S NOTES

Topic:	Light – multicoloured shadows.
Concept:	The light we call white results of the sum of each and every colour, as seen in the previous experiment. But our eyes are sensitive only to three colours – red, green and blue. When we mix light of these three colours we obtain white light. If we mix only two, we may obtain magenta, yellow or cyan.
Problem:	What happens when we mix red, blue and green light?

INTRODUCTION

When we shine red, blue and green light simultaneously on a blank wall, the wall reflects the mixture of the three colours. The three types of sensors in our eyes are simulated all at once, and our brain detects and interprets the mixture as white light.

If on the wall we project only light of two colours, only two kinds of sensors and our brain will, depending on the colours in question, perceive magenta, cyan or yellow.

If on the wall we project only light of two colours, only two kinds of sensors and our brain will, depending on the colours in question, perceive magenta, cyan or yellow.

During this experiment, red, blue and green light bulbs are switched on and directed to the same area in a blank wall, and white light is perceived. When an object is introduced between the lamps and the wall, some of the light will be prevented from reaching the wall. Depending on the respective positions of lamps and the intervening object, a given area of the wall will remain illuminated by all three colours, while other patches will be lit only by one or two of the light bulbs – causing yellow, green, red, blue yellow, magenta and cyan patches to become visible on the wall.

EXECUTION OF THE EXPERIMENT

Necessary materials

- A room which can be easily darkened.
- A smooth, blank wall, the surface of which cannot be glossy (if such a wall is unavailable, a large white sheet will have to be used, as a screen).
- A desk lamp with a white' light bulb, and three others equipped with red, blue and green light bulbs.

Conducting the experiment

1. Before starting the experiment itself, all lamps must be simultaneously directed toward the same area on a smooth, blank, so that the resulting light is white across all of the illuminated area. The coloured bulbs are then switched off.
2. With the white' bulb on, children are asked to project shadows on the wall using their hands. The children are asked what causes the white and dark patches on the wall.
3. The procedure is repeated with each individual coloured light bulb. Before switching on each lamp, children must be asked what they expect to happen, and what they think will be the colour of the shadows. At the end, a record is made of the colours observed.
4. After this, all three coloured light bulbs are switch on simultaneously, and step 3 is repeated.
5. The procedure is repeated with two coloured light bulbs at a time. A record is made of the colours observed, and this is correlated to the colour of the light bulbs in use in each occasion.

Notes:

- For the experiment to be fully viable, it is necessary that the natural light can be completely sealed off from the room.
- The three coloured bulbs must be reasonably strong and of similar intensities (if there are disparities, stronger bulbs must necessarily be placed farther away from the wall).
- Sometimes coloured light bulbs are not "pure". This is most often the case with blue and green bulbs. To prevent this, light bulbs should be tested beforehand.

Experiment guidelines

- Before each step of the experiment, ask children what they expect to observe. Before switching on the coloured bulbs, let children know which colours you are about to use, and ask them what they expect to observe. Before introducing and object between the source of light and the wall, ask children what they think the shadow will be like.
- During the experiment, ask children to describe what they are observing, and compare their answers with what their preliminary expectations or guesses.

During the course of this experiment, children should be able to realise that:

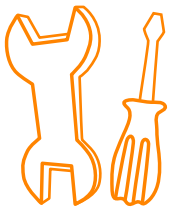
- White light results from the sum of all colours.
- When an "ordinary" light bulb is used, the shadow projected by an intervening object is dark because the object in question bars the passage of light.
- Yellow-, magenta- and cyan-coloured lights can be obtained through the mixture of other two colours.

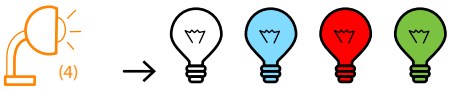
1. PREPARING THE EXPERIMENT

RECORD
EXP. 2

- What happens when we mix red, green and blue light?
- What is a shadow?

WHAT WILL YOU NEED?





- An ordinary desk lamp and three lamps equipped with red, green and blue light bulbs

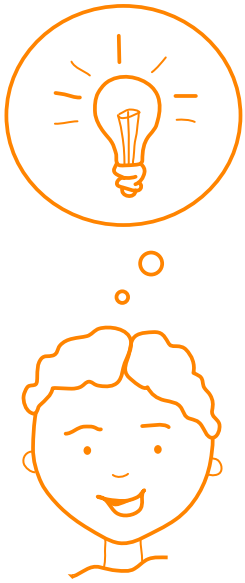
WHAT DO WE INTEND TO DISCOVER WITH THIS EXPERIMENT?

What happens when

we mix

- three ice-cream flavours.
- three-coloured light.
- hot and cold water.
- the sound of three musical instruments.

What's the colour of the shadows?



Why do you think this is?

_____

_____

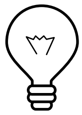
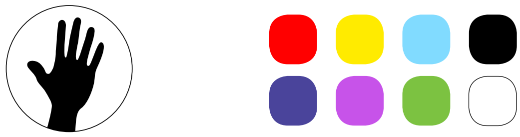
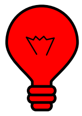
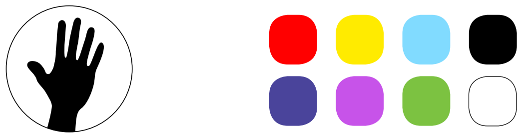
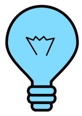
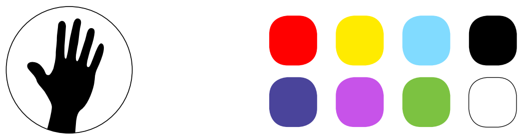
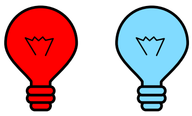
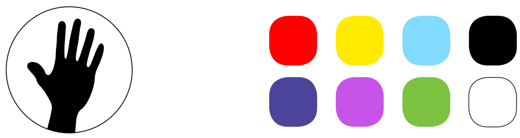
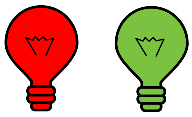
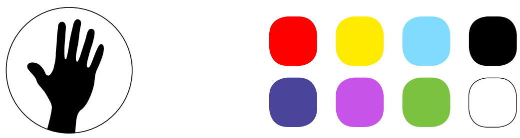
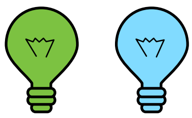
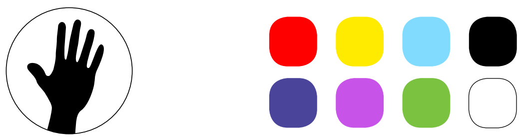
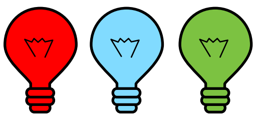
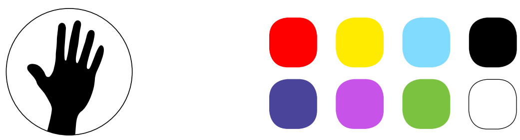
_____

_____.

2. LET’S DO THE EXPERIMENT

WHAT DO WE OBSERVE?

See which lamps are on and what are the colours you can see on the wall.

LAMPS USED	COLOUR OF THE SHADOWS
	
	
	
	
	
	
	

3. AFTER THE EXPERIMENT

WHAT HAVE YOU LEARNED FROM THIS EXPERIMENT?

(you can tick more than one box)

- ☐ If we mix blue, red and green light, we see white light.
- ☐ If we mix blue, red and green light, we see black light.
- ☐ If we mix blue, red and green light, we see the rainbow.
- ☐ If we mix blue, red and green light, we see shadows of many colours.
- ☐ When the red light bulb is on, we see only black and red shadows.
- ☐ When the red light bulb is on, we only see black and green shadows.

Turn back to page 2 and check if your answers was correct:

- ☐ All correct.
- ☐ All wrong.
- ☐ Some correct and some wrong.

EXPERIMENT

THE COLOURS WE SEE

LIGHT AND THE COLOURS WE SEE

TEACHER'S NOTES

Topic:	Light – The colours we see.
Concept:	All objects that we see reflect some of the light - we see objects because light reflected by them reach our eyes. A mirror reflects light but also a cardboard reflects some light. In cardboard reflection is "diffuse" (the light is reflected wildly in all directions), as in a mirror reflection is "speculate" (the light is reflected in an "organized" manner). When we illuminate a cardboard with sunlight or white light (mixture of light of all colors) it, will reflect more or less light, depending on its colour. The colour we see is the colour of light reflected from the cardboard. A red cardboard illuminated with the same light reflects only red light.

PART 1

- Place some "targets" in strategic positions in the room. It is required for a child to reflect the projector light with a mirror to achieve a target (the target must be placed so that it is possible to illuminate them using only the mirror, with no need to adjust or move the projector itself).
- Pick up a target that is closer to the focus. The mirror is oriented so as to illuminate the target well. Cover the mirror with a white cardboard and observe the target. Repeat with a cardboard with a red and black cardstock.

PART 2

- The same projector and color filters are used. The ideal is to use three filters: one blue, one red and one green, but you can do only with a red filter and white light. (note: the projector and filters can be replaced by lamps with colored bulbs.)
- On the wall is pasted squares of white cardboard, black, blue, green and red (the cards should not be shiny).

- Lights up the wall with one of the filters placed in projector and asked the children to record the colors observed. Repeat the procedure with each other filters. Remove out the filters from the projector asked the children again to record the colors they observe

INTRODUCTION

PART 1

The mirror reflects almost all the light from the projector. When the light is reflected by the mirror, the target is illuminated by a beam of light well focused- well we can distinguish every detail of the design. The white cardstock also reflects much of the light focus, but the reflection is "disorderly", the light is spread over a larger region, but the target is also illuminated. If the cardboard is black, does not reflect almost no light - the target is difficult to see. If the cardboard is red reflects only part of that focus light is red - the spot light is reddish and less intense than that observed with white cardstock. (note the distance of the cardboard target has to be small, and the positions of the focus, cardboards and target should be tested by the teacher in advance).

PART 2

When white light strikes the cardboard pieces of different colors, each piece reflects only part of the light: red cardboard reflects some of the red light, the green cardboard reflects green light, white cardboard reflects all light and black reflect almost no light.

When the pieces of cardboard are illuminated with red light, the cards can only reflect red light. So the red cardboard continues to reflect red light, white cardboard, as reflects all colors, reflects red light. The green, blue or black cardboards do not reflect red light, and therefore do not reflect any color - seem very dark, almost black.

EXECUTION OF THE EXPERIMENT

Necessary materials

- A room that can be easily darkened.
- A desk lamp or a projector and coloured filters (green, blue and red). The experiment can be done using only the red filter.
- A smooth, blank wall, the surface of which cannot be glossy (if such a wall is unavailable, a large white sheet will have to be used, as a screen).
- A mirror, three squares of cardboard with about 25 cm across, a white, one red and one black.
- Small pieces (squares, circles, triangles) of colored matte cardboard (blue, green, red, black, white.

Conducting the experiment

PART 1

1. Place the focus oriented so that the light beam is parallel to the wall, one meter from a white wall. The focus position should be such that will be easy to bend light to the white wall using only the mirror.
2. Stick a puppet on the wall - can be a simple small drawing (10cm) that will serve as a "target."
3. Turn on the light focus and asked a child to "bend" the light with the mirror so that it reaches the "target" (it is usually necessary for the teacher to give a helping hand in the beginning).
4. Repeat the procedure, replacing the mirror by large squares (25 cm) of white, red and black cardboard.

PART 2

5. Place the focus oriented so that the light beam is parallel to the wall, one meter from a white wall. The focus position should be such that will be easy to bend light to the white wall using only the mirror.
6. Stick a puppet on the wall - can be a simple small drawing (10cm) that will serve as a "target."

7. Turn on the light focus and asked a child to “bend” the light with the mirror so that it reaches the “target” (it is usually necessary for the teacher to give a helping hand in the beginning).
8. Repeat the procedure, replacing the mirror by large squares (25 cm) of white, red and black cardboard.

Experiment guidelines

PART 1

- Before each step of the experiment, ask children what they expect to observe.
- Before using the mirror and cardboards, ask them what they expect to observe.
- During the experiment, ask children to describe what they are observing, and compare their answers with what their preliminary expectations or guesses.

PART 2

- It is important that children do not see the cards colour before they are illuminated with coloured light.
- You should only use white light (without filters) at the end.

Through those experiments, children should be able to realise that:

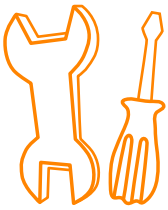
- Mirrors are not only ones that reflect light.
- The colour of objects is the colour of light reflected by them.
- The colours we see depend on light we use.

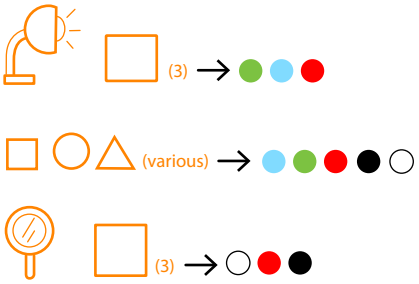
1. PREPARING THE EXPERIMENT

RECORD
EXP. 3

- What is the color of objects?
- The color of an object is always the same?

WHAT WILL YOU NEED?





- A mirror, three squares of cardboard with about 25 cm across, a white, one red and one black
- Small pieces (squares, circles, triangles) of colored matte cardboard (blue, green, red, black, white)
- A desk lamp or a projector and coloured filters (green, blue and red). The experiment can be done using only the red filter

WHAT DO WE INTEND TO DISCOVER WITH THIS EXPERIMENT?

The colours of the objects

change

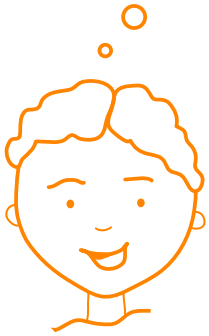
With air

With water

With the light colour

Never changes

What is the colour of a blue object when illuminated by a red light



Why do you think that?

_____

_____

_____

_____.

2. LET'S DO THE EXPERIMENT

WHAT DO WE SEE?

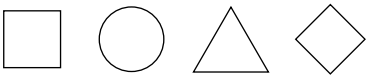
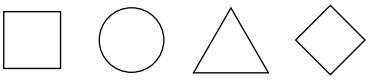
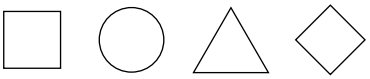
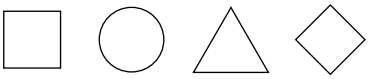
PART 1

The object is best seen when illuminated with light reflected by the:

- ☐ Black cardboard.
- ☐ White cardboard.
- ☐ Mirror.
- ☐ Red cardboard.

PART 2

See which spotlights are lit and paint the color of cardboard when illuminated with this light.

LIGHT COLOUR	CARDBOARD COLOUR (paint each figure with the respective color)
	
	
	
	

3. AFTER THE EXPERIMENT

WHAT HAVE YOU LEARNED FROM THIS EXPERIMENT?

(you can tick more than one box)

- ☐ The objects have always the same colour.
- ☐ A white object when illuminated with red light turns yellow.
- ☐ A white object when illuminated with green light turns green.
- ☐ The colour of objects depends on the light that illuminates them.

Turn back to page 2 and check if your answers was correct:

- ☐ All correct.
- ☐ All wrong.
- ☐ Some correct and some wrong.

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