# How important is light to the human vision?

Bárbara Moiteiro
Agrupamento de Escolas José Belchior Viegas
Escola E. B. 2,3 Poeta Bernardo Passos


NUCLIO
Núcleo Interativo de Astronomia e Inovação em Educação

**July 2022**

# Metadata

## *General Info*

Title: How important is light to the human vision?

### Short description:

In this activity, students will learn about light and color through exploration of hands-on activities and virtual labs that lead them to exploration:
- of the sun as a star (luminous object)
- of the moon as an illuminated object
- the color of the stars
- the color of objects
- light emitted by the sun
- of the electromagnetic spectrum

Students will have the opportunity, for example:
- to explore the color of different objects when illuminated by lights of different colors
- to build a simple spectrometer
- to explore the overlap of two of the three primary color lights red, green and blue
- to build a Newton disk
- detecting infrared light in a TV remote control

Students will also have the opportunity to share their knowledge with the community.

### Keywords:

Light, color, luminous object, illuminated object, visible light, electromagnetic spectrum, spectrometer, human eye, light- reflection and light- dispersion.

## *Educational Context*

### Age: 12 / 14 years old

### Prerequisites:

- Recognize that light carries energy and that it is a wave (electromagnetic) that does not need a material medium to propagate.
- Recognize that light travels in a straight line.
- wavelength

- Frequency
- Refraction
- Reflection

Duration: 6 hours but can be extended

Lv. of difficulty: medium

Aggregation Level: 8th grade of primary school

## *Educational Objectives*

### Cognitive Objectives:

- Distinguish luminous from illuminated objects, concretizing with examples from astronomy and everyday life.
- Know the electromagnetic spectrum.
- Order the main regions of the electromagnetic spectrum, taking into account the frequency, and identify some applications of radiation from these regions.
- Explain the formation of images in the human eye.
- Experimentally distinguish between monochromatic and polychromatic light, associating the rainbow with light scattering and justifying the phenomenon of scattering in a glass prism based on refraction.

### Affective:

- To understand the importance of cooperation in Astronomy and science in general
- To understand the importance of the evolution of technology in science
- To understand the importance of communicating the results of laboratory and research activities using scientific vocabulary

Psychomotor

- be able to use the computer.
- Know and comply with laboratory work safety standards
- be able to use Stellarium software
- be able to use Salsa J software

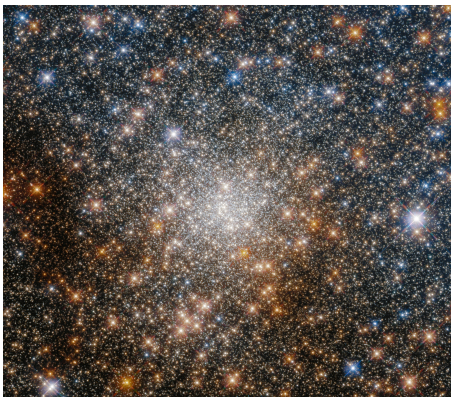
## *Connection to the curricula*

Domain: Light

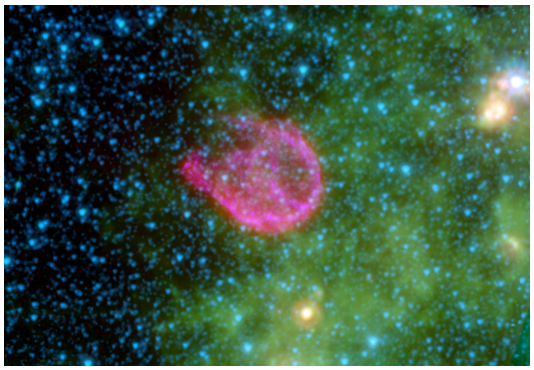
Subdomain: Light and vision

## Orienting & Asking Questions

➢ **The teacher projects some images of the universe**



Credit: NASA Image of the Day /A Sea of Stars Like Sequins



Credit: NASA Image of the Day /A Supernova's Shockwaves

Credit: NASA Image of the Day /Behold: The Carina Nebula's 'Mystic Mountain'

- **Students are invited to view what Italian journalist Piero Angela once said:**

**https://www.youtube.com/watch?v=ux9za-5o5rg**

"[…] the universe is dark, and black. The stars don't shine and the Sun is not bright. Everything is frighteningly dark in the universe.

Why? "Because the universe lights up only when there are a set of eyes and a brain able to detect the electromagnetic radiation and understand it as light and colors."

- **Students are invited to enter a completely dark room. In this room there are several objects on a table with different colors (blue, yellow, red, green, white, orange and black)**

**Can you see what's in this room?**
**Why can't you see objects in total darkness?**
**What do you need to observe what is in this room?**

Possible Student Answer: Light

Afterwards, the room is lit successively with red light, blue light, black light and finally white light.

**What do you see in room lit with red light?**

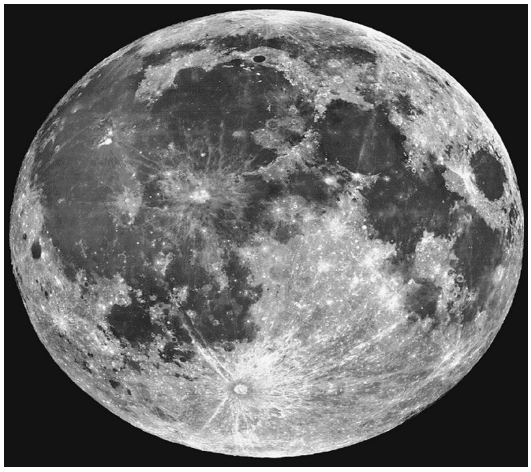
**What do you see in the room lit with blue light?**

**What do you see in the room lit with black light?**

**What do you see in the room lit with white light?**

Throughout this activity we will explore light and human vision.

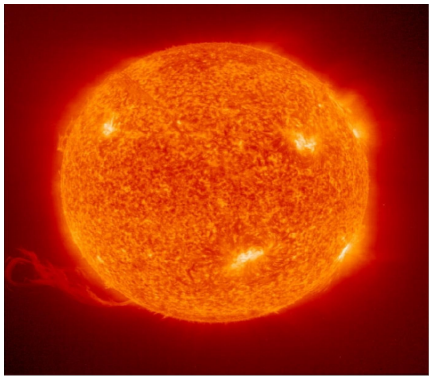
- **Students observe a set of photographs (Moon, Sun and planets)**



Credito: NASA Image of the Day, solar system

Credit: NASA, editor Mark Garcia

Credit: NASA Ames



Credit: ESA, NASA

**What are the sources of Light represented in the photographs?**

Possible Student Answer: Sun, the stars

**Why is the Sun a Source of Light?**

Possible student response: Because it produces its own Light.

**Investigate: how does the Sun manage to produce its own light?**

**What are Light Sources?**

In this set of images we can distinguish two groups: the objects that produce Light and the objects that do not produce light.

Objects that emit visible light, such as stars, are called luminous objects, so they are sources of light. Objects that do not produce light, such as the Moon and planets, are called illuminated objects.

**Why can't you see an object in total darkness?**

When there is no light source, the human eye does not receive light, so vision does not occur. When light from a light source falls on an illuminated objects, it becomes visible. For example, when sunlight strikes the moon, the moon becomes visible, because the reflected light reaches our eyes.

If we represent through light rays, the path of light between the source, the receiver and the light detector, the so-called vision triangle is formed, which represents the three fundamental aspects to see an illuminated object.


Credit: CFQ, Miguel Oliveira

**Fig. 1**- viewing triangle

- **Does the human eye detect all sources of light?**

**Materials:** TV remote control, Smartphone
**Procedure:**

1. Look at the remote control led and press the remote control keys.
2. Turn on the smartphone camera.
3. Press the keys on the remote control and now observe the remote control led through the mobile phone screen.

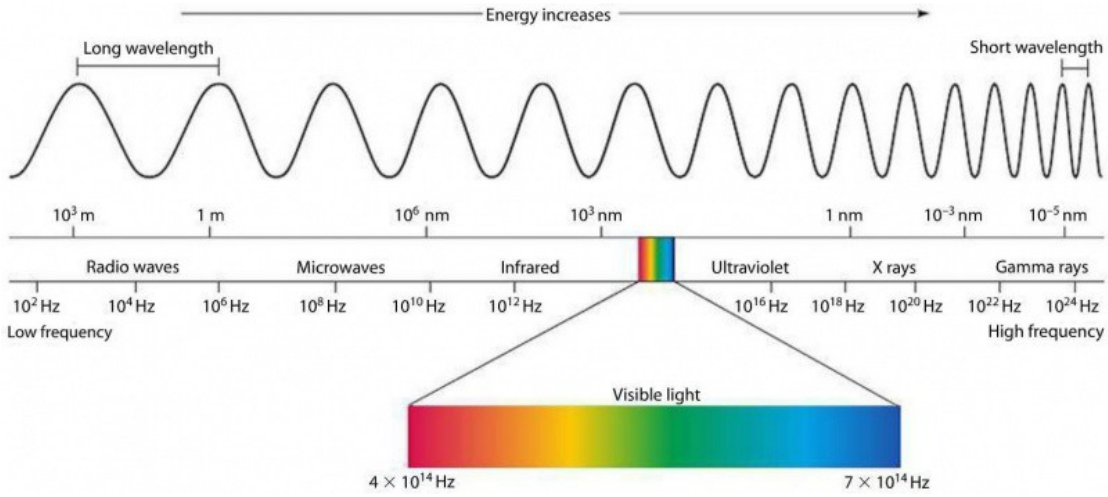
**Record of Observations:**

**Results analysis:**

Light is electromagnetic radiation formed by electromagnetic waves. That do not need a material medium to propagate. Sunlight traveled through space until it reached Earth.

Visible light (commonly known as white light) was for a long time the only known component of the electromagnetic spectrum. However, electromagnetic radiation, commonly called light, encompasses radiation visible to the human eye and not visible.

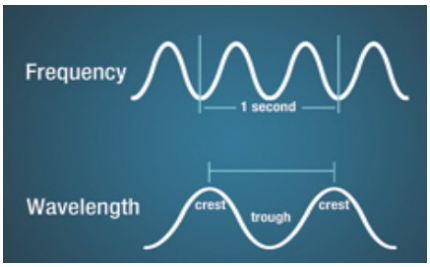
The various forms of electromagnetic radiation are distinguished by their frequency and it is customary to organize them into different bands, in ascending or descending order of frequency in a scheme called the electromagnetic spectrum (fig. 2).

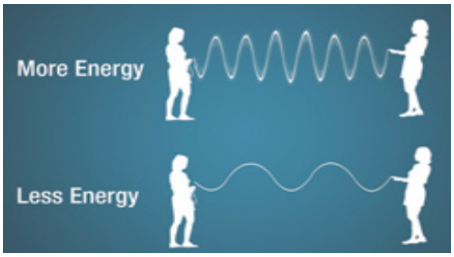



crédit: https://wiki.travellerrpg.com/Electromagnetic_Spectrum

**Fig. 2-** Electromagnetic Spectrum

Associated with each frequency we can also refer to a wavelength and a defined energy. The higher the energy of the radiation, the higher the frequency and the shorter the wavelength. Thus, radio waves are the lowest in energy and gamma rays are the most energetic.



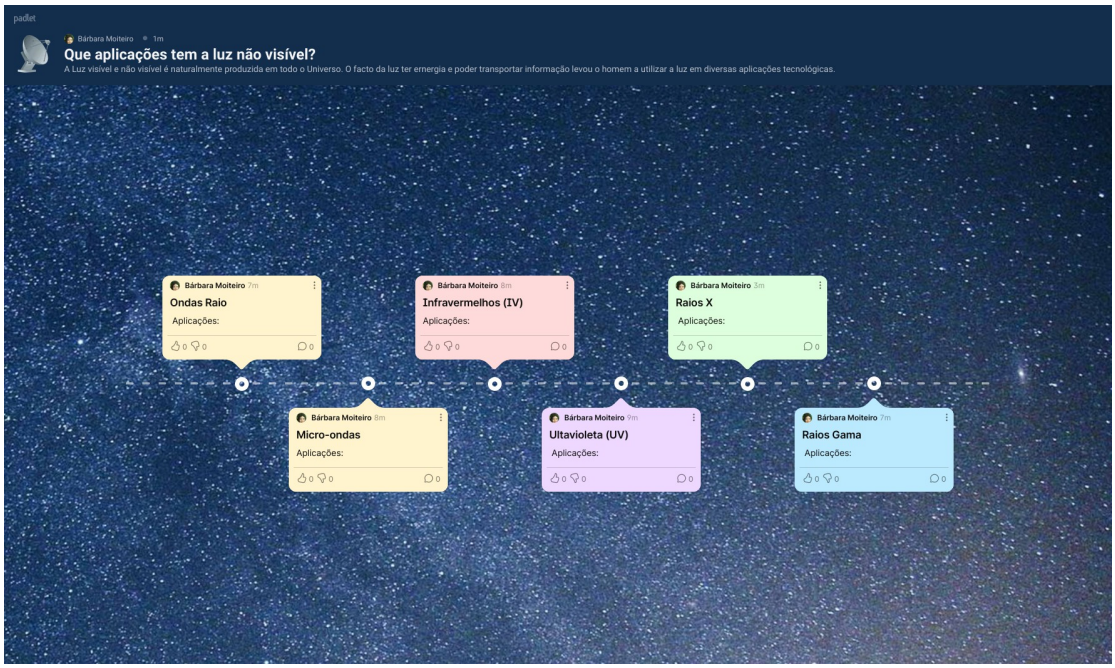
**Conclusion:** Visible light is only a small part of the electromagnetic spectrum. Most electromagnetic radiation is not visible to the human eye.

The visible light accounts for only 0.0035% of the entire electromagnetic spectrum. When we look at the universe, we are basically blind.

- **What applications does non-visible light have?**

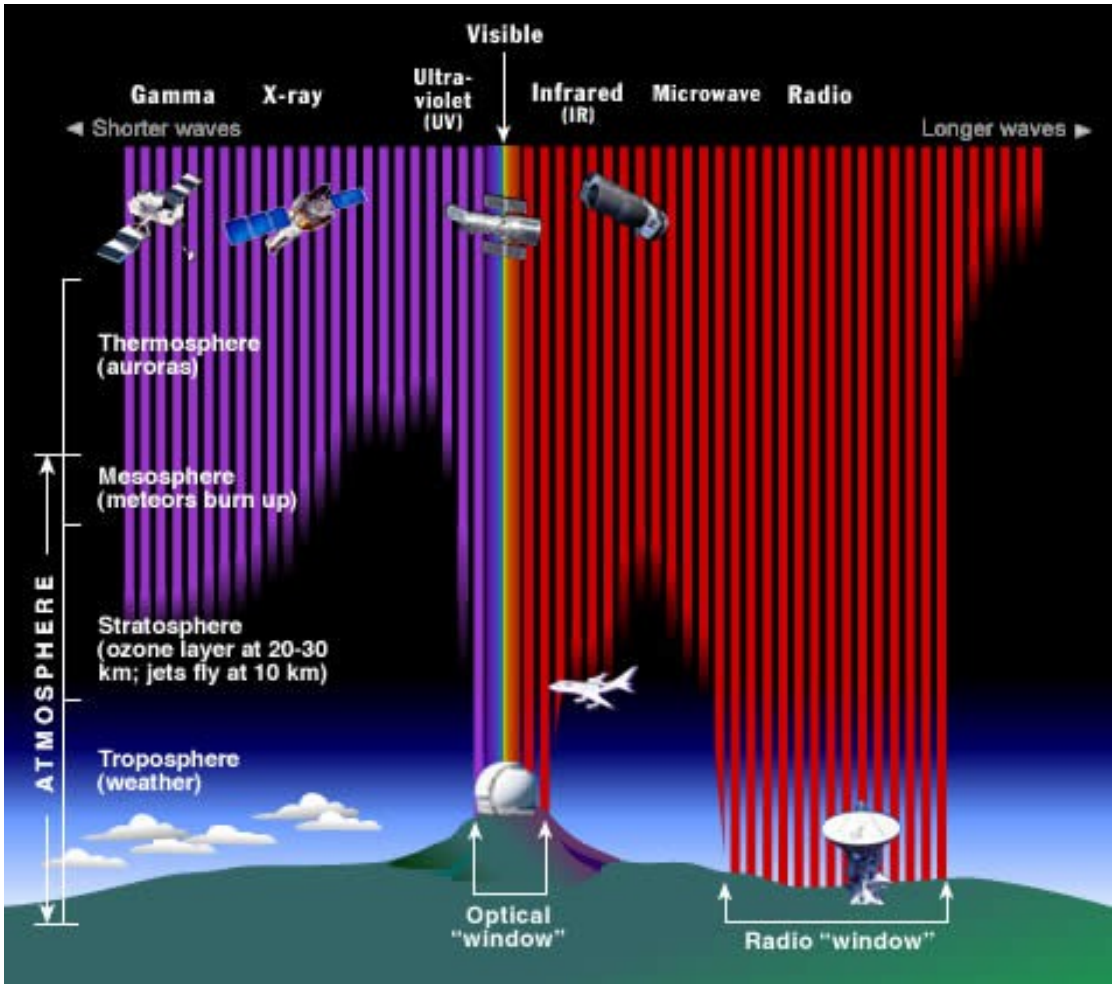
Visible and non-visible Light is naturally produced throughout the Universe. The fact that light has energy and can transport information has led man to use light in various technological applications.

**Research:** the different applications of non-visible light and record your research in the padlet https://padlet.com/bcmoiteiro/qx5l008sf16odtkr



➢ **What is the electromagnetic radiation emitted by the Sun?**

Although the Sun emits all the radiation in the electromagnetic spectrum, the Earth's atmosphere causes only a part of this radiation to reach the Earth's surface.




**Credit:** Image courtesy STCI/JHU/NASA

**Fig. 3 -** Solar Radiation Penetration into Earth's Atmosphere

Various wavelengths of solar radiation penetrate Earth's atmosphere to various depths. Fortunately for us, all of the high energy X-rays and most UV is filtered out long before it reaches the ground. Much of the infrared radiation is also absorbed by our atmosphere far above our heads. Most radio waves do make it to the ground, along with a narrow "window" of IR, UV, and visible light frequencies.

- **What materials allow light (visible light) to pass through?**

Reflect as a group on the problem question and make your hypotheses.

**Part I**

As a group, plan an experiment that proves your hypotheses to the problem question.

Share the planned experience between groups.

Run the experiment and record the observations in a table.

Share the recorded observations between groups.

Example of practical activity that students can plan:

Materials: acetate sheet, tracing paper, glass, frosted glass, black cardboard, white cotton fabric, black cotton fabric, denim fabric and lamp.

Procedure:

1. Light the lamp and place the lamp at one end of the workbench;
2. Move to the other end of the workbench and observe the flame of the lamp with your eyes aligned at the level of the flame.
3. Place an acetate sheet in front of the eyes (between the eyes and the lamp).
4. The observations are recorded.
5. Repeat steps 3 and 4, replacing the acetate sheet with the other materials.

Record of Observations:

**tabela 1:** Record of Observations

| Material | Clear image of the lamp | Blurred image of the lamp | The lamp is not visible |
|---|---|---|---|
| acetate sheet | | | |
| parchment paper sheet | | | |
| glass | | | |
| frosted glass | | | |
| black cardboard | | | |
| white cotton fabric | | | |
| black cotton fabric | | | |
| denim fabric | | | |

**Analyze your results:** Which materials were allowed to pass through the light?

**Part II**

Measurement of the amount of light (illuminance) using the Phyphox mobile app.

Procedure:

1. The Phyphox application is installed on the mobile phone.
2. Open the application and select the light sensor.
3. A new column is added to table 1 – illuminance
4. Select the button ( ►) to start the activity
5. Wait about 10 s and place the acetate sheet on the cell phone.
6. Wait another 10s and replace the acetate sheet with the tracing paper sheet.
7. Repeat procedure 5 for the remaining materials.

8. Save the registration made: select the button ( ⋮ ) and choose the option “Save experience” and “Save to Collection”.
9. Observe the obtained illuminance graph.
10. The illuminance values of the different materials are recorded in table 1.

**Analyze your results:** Which materials were allowed to pass through the light?

**Conclusions:** Search the dictionary and record the definitions of the following terms: Transparent, translucent and opaque.

Reflect on the problem question again and work out the conclusion of your experience.

**Opaque materials** do not allow visible light to pass through. But there are some materials that allow visible light to pass through. **Transparent** materials let visible light completely through and **translucent** materials partially let visible light through.

- **Did you know that the English physicist, mathematician and astronomer Isaac Newton, has inscribed in his tomb the following sentence: “the first to demonstrate the diversity of light rays and the properties of colors caused by them, which no one suspected or explored.”**

**Part I**

**What experiments and discoveries did Isaac Newton make that led to the inscription of this phrase on his tomb?**

Research Isaac Newton's experiments on this subject and plan your experiments that replicate his findings.

**Part II**

**Why does the rainbow sometimes appear?**

Did Isaac Newton's discoveries answer this question? Write a short text that explains the formation of the rainbow.

(In case the students in your previous research didn't build a Newton disk, share the following link: https://www.youtube.com/watch?v=LlKeTEzYrjo )

**Part III**

**What happens to sunlight when it passes through a glass prism?**

**What happens to the light of a flashlight when it passes through a glass prism?**

**What happens to the red light of a laser when it passes through a glass prism?**

Reflect in a group on the problem questions and elaborate your hypothesis(s).

As a group, plan the experience that proves your hypotheses to the problem questions.

Share the planned experience between groups.

Run the experiment and record the observations

Share the observations recorded and the conclusions between groups.

Example of practical activity that students can plan:

**Materials:** Glass Prism, Flashlight and Red Laser

**Procedure:**

1. Bring the prism closer to the living room window and position the prism so that sunlight passes through the prism.
2. The observations are recorded;
3. Close the windows of the room and now shine the light from the flashlight on the glass prism;

4. The observations are recorded;
5. Turn off the flashlight and now shine the red laser light on the prism.
6. The observations are recorded;

**observations:**

| Sun light | flashlight light | red laser |
|---|---|---|
| | | |

**Analysis of results:** Why does the white light (from the sun and the flashlight) when it falls on the prism give rise to different colors and the laser light does not?

**Conclusion:**
Search and record the definitions of the following terms: Monochromatic and polychromatic light. and work out the conclusion of your experience.

- **Is it possible, from a beam of white light, to obtain a beam of colored light?**
- **Is it possible, from a beam of monochromatic yellow light, to obtain a beam of blue light?**

Reflect in a group on the problem questions and elaborate your hypothesis. Use the phET vision and color simulator to prove your hypothesis.

Simulator:

https://phet.colorado.edu/sims/html/color-vision/latest/color-vision_pt_BR.html

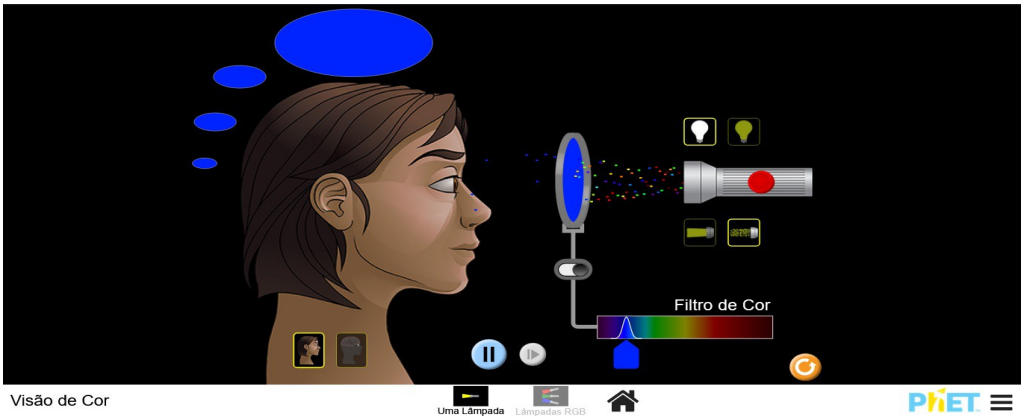



**Fig. 4 a –** Simulator phET Light and Vision - White light with color filter

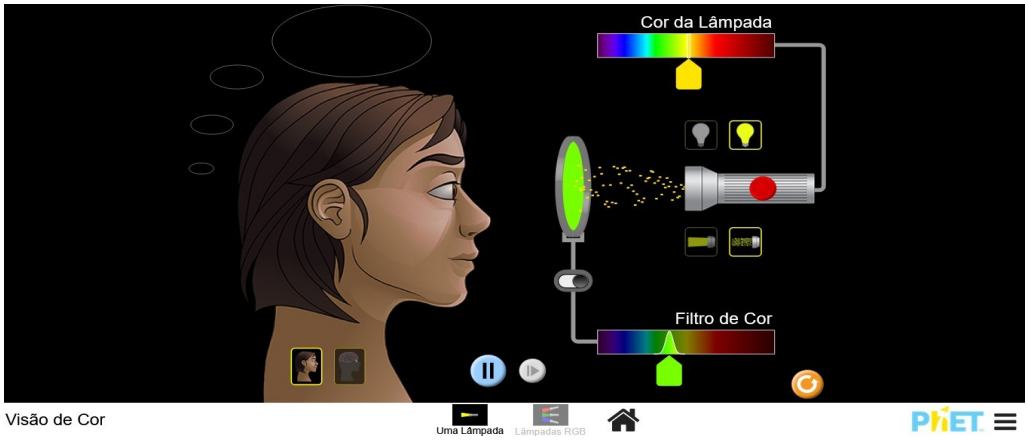
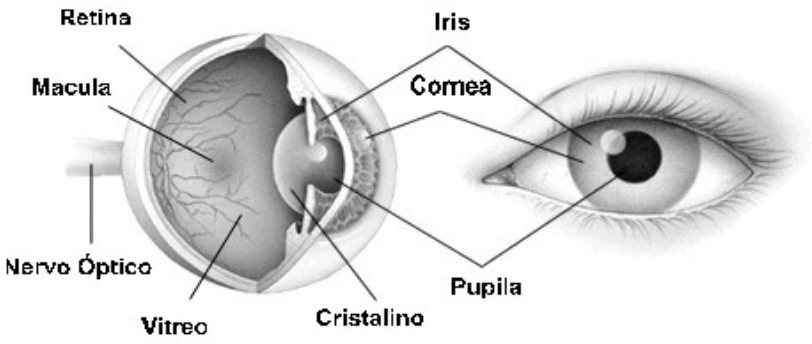



**Fig. 4 b –** Simulator phET Light and vision - Monochromatic light of different color to the filter

- **How do we see objects and colors?**




**Crédit:** [https://retinaportugal.org.pt/wordpress/funcionamento-do-olho/](https://retinaportugal.org.pt/wordpress/funcionamento-do-olho/)

**Part I**

**What is the effect of light on the iris and pupil of your eye?**

reflect in a group on the problem-questions and elaborate your hypothesis(s).

As a group, plan the experience that proves your hypotheses to the problem questions.

Share the planned experience between groups.

Run the experiment and record the observations.

Share the observations recorded and the conclusions between groups.

Example of practical activity that students can plan:

**Procedure:**

1. In a dimly lit room, look at your eyes in the mirror;
2. Turn on the room light and look into your eyes again.

**Record your observations:**

| Pupil in the presence of too much luminosity | Pupil in the presence of low luminosity |
|---|---|
| | |

**Conclusions:**
In low light environments the Iris contracts and forces the pupil to expand.

In bright environments, the iris expands and forces the pupil to count.

Watch the video and discover how the human eye works:
https://www.youtube.com/watch?v=axpCN6Vj9p0

## Part II

## How do we see colors?

Reflect in a group on the problem questions and elaborate your hypothesis.

Use the phET vision and color simulator to prove your hypothesis.

Simulator:

https://phet.colorado.edu/sims/html/color-vision/latest/color-vision_pt_BR.html

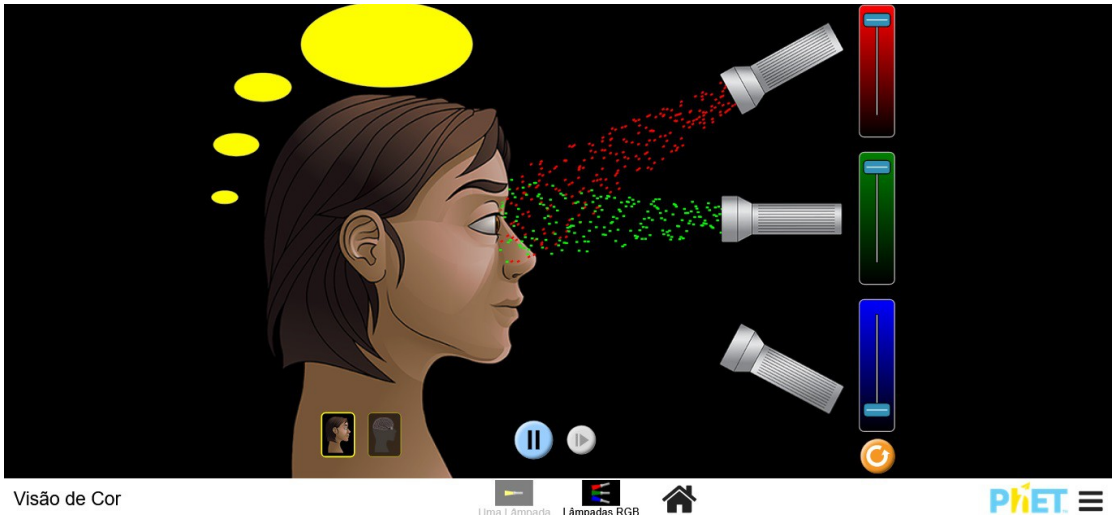



**Fig. 5 –** Simulator  phET Light and Vision – Monochromatic Light overlay

- **Using the Robotic Telescope**

Finally, students are invited to use a **robotic telescope** to photograph a part of the sky.

To prepare the observation session with the robotic telescope, the students will use the **Stellarium software** and to process the photographs the students will use the **SalsaJ software**.