# Photonics workshop instructions

**Title of the workshop:** Colours and fluorescence

**Target audience:** Young minds (10-14yrs)

**Time planning:** This workshop will take a total of 2h to complete:

Step 1: The 3-D printed mount can be loaded in Sketchup software, with printed mounts already available. The participants can see the circuit mount being printed by the 3-D printer in the workshop as a demo of the technology, introductory talk on fluorescence (30m)

Step 2: Cardboard boxs can be prepared, the participants mark out the areas on the boxes to be cut carefully, supervised and assisted at the cutting stage, safety scissor (20m)

Step 3: Electronic circuit assembly (20m) supervised by workshop leaders

Step 4: Perform color and fluorescence experiments + freebies (40m)

**Estimated cost: €10.00 per participant**

## Step 1

**Title: Colours and fluorescence**

This workshop is based on the science of colour and fluorescence. The participants will construct an experimental system, which will allow them to investigate the colour and fluorescent properties of different objects. An image of the completed device is shown in Figure 1.


Fig. 1 The finished box and mount unit.

During the workshop, the participants will perform the following tasks:

1. Assemble an electronic circuit to control an RGB LEDs.
2. 3D print a mount which will hold the electronics in place and through which the participant can look
3. Construct a box to block ambient light. The 3D printed mount sits on top of the box and the sample objects are placed in the box.
4. Examine the colour content of various objects by illuminating with different bands of the visible spectrum (a special colour chart can be printed and examined using this experiment)
5. Use an ultra violet (UV) light source or 'black light' to investigate the fluorescent properties of some materials and investigate their applications (fluorescent materials such as markers/paints, tonic water, vitamins dissolved in water)
6. Get creative by painting some artworks using regular and fluorescent paints and will look at their appearance under the various lighting conditions.
7. Using their smart phones to capture images of all of the above

Each participant will get to take home

1. The box that was assembled
2. The RGB illumination circuit and viewer
3. The handheld 'black light'

4. Their artwork
5. Pictures taken on their phones of the samples under various illumination

## Step 2: Part list

**Photonics parts:**
Hand held UV note checker/black light

**Electronic parts:**
Battery pack, AA batteries (x8), switches, wiring, LED, wire glue.

**Other parts:**
Cardboard box, colour chart (printed from 'Fig. 5 - Colour chart.tif' file), 3D printing materials, artwork materials such as colouring paper, markers and highlighter markers, duck tape, fluorescent samples (tonic water, glow-in-the-dark stickers, vitamin B dissolved in water, bank notes). Cuvettes / plastic containers (for holding liquid samples).


Fig. 2 – Images of the parts list

## Step 3

### Assembly of the electronic circuit and mount

Images of the 3D printed circuit board holder and eyepiece can be seen in Figure 3. Three switches, red green and blue

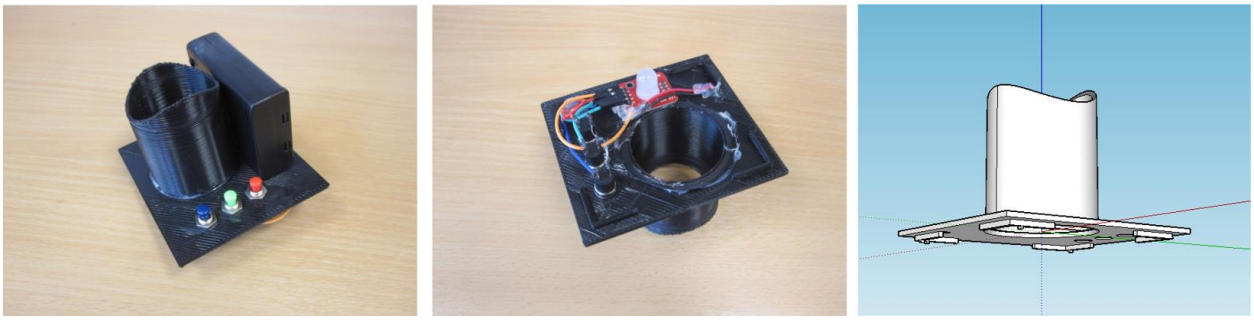


Fig. 3 The 3D printed circuit board holder and eyepiece unit as shown from above and underneath. The mount is 3D printed and the LED and switches are wired together.

### Construction of the box

The box acts as a 'dark room' and is very easy to assemble. Any cardboard box can be used. The box shown in Fig. 3 has dimensions of 420 x 380 x 360 mm (length x width x height).

Fig. 4 Image of the box which acts as a 'dark room' to block ambient light.

Three holes need to be made in the box which can be made using a scissors or blade

1. The first hole is so that the mount can sit on top of the box (as shown in Fig. 1). The dimensions of this hole are 70 x 82 mm.
2. The second hole is to place the black light for UV illumination. The dimensions are 160 x 23 mm.
3. Thirdly, the bottom of the box is completely cut off. This is so that it is easy to lift the box up and place the samples or artwork inside the box.


Fig. 5 Images of the three holes to be made in the cardboard box.

## The colour target

The colour target is shown in Figure 4. This can be printed using any printer. Note that the three white circles labelled ‘Fluorescent Yellow’, ‘Fluorescent Pink’ and ‘Fluorescent Green’ need to be coloured in after printing using highlighter markers. These act as fluorescent colour samples and will fluoresce under UV light.

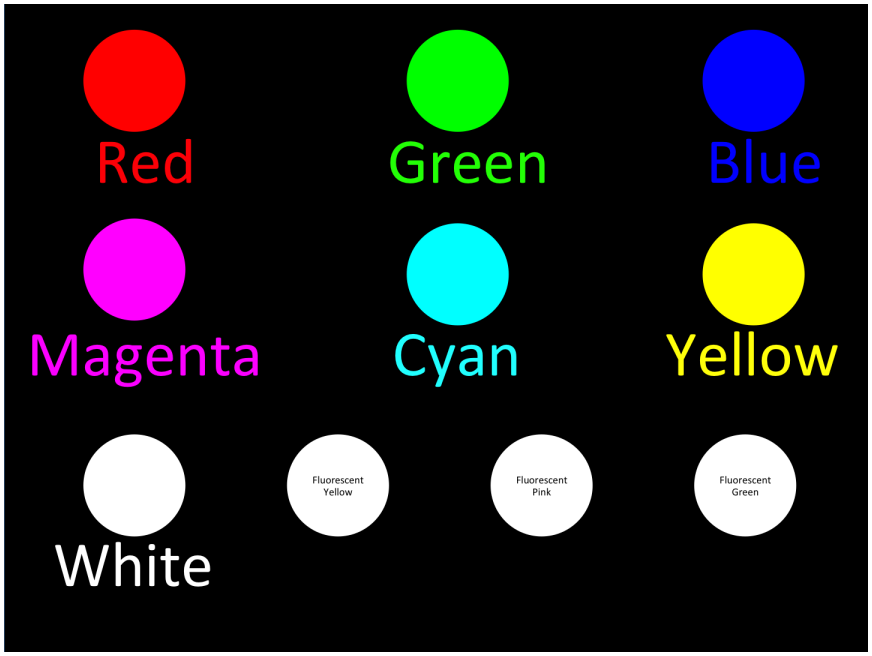



Fig. 6 The colour target which will be printed. The three circles at the bottom can be coloured in after printing using fluorescent markers using Yellow, Pink and Green highlighters pens. These are the fluorescent samples.

When the colour chart is placed in the box, and viewed under various illumination colours, each colour will appear light or dark.

## Fluorescent materials and the UV light source

Fig. 7 Image of the hand held note checker or 'black light' which is the UV light source used in this workshop. This is used for viewing fluorescent samples such as yellow highlighter ink as shown on the white page.

## Demonstration of the colour chart under various lighting conditions

Using the LED circuit, the three switches control the red, green and blue LEDs which can be used in any combination to produce white, red, green, blue, yellow, magenta or cyan coloured illumination. Examples of each of these can be seen in Figure 6. In addition, the spectra of each combination was measured using a spectrometer.

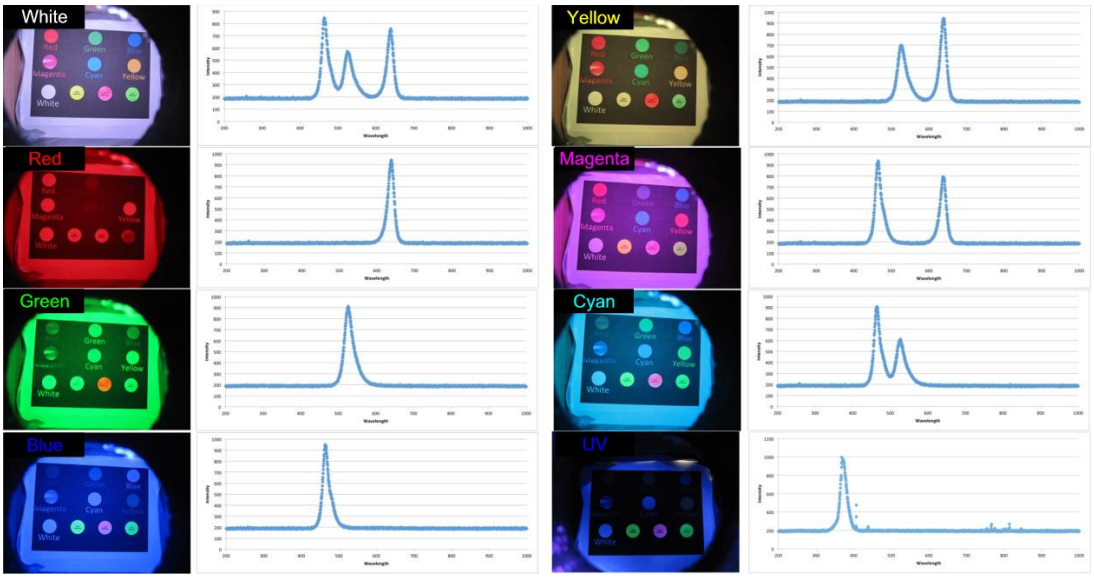



Fig. 8 The colour chart as viewed through the viewer under illumination from various combinations of red, green and blue light. Also shown, is the corresponding spectrum for each combination. The last image (labelled 'UV') shows the illumination using the black light.

## Preparation of fluorescent samples

Instructions for looking at some fluorescent samples

1. Dissolve some highlighter ink in water

2. Tonic water
3. Vitamin B dissolved in water
4. Colour pages coloured in with regular and highlighter markers

To let the participants get creative, they can either make a drawing or colour in a page from a colouring-book using standard colouring markers and fluorescent highlighters. Have them look at their drawing under the different types of illumination from the LED and the black light.

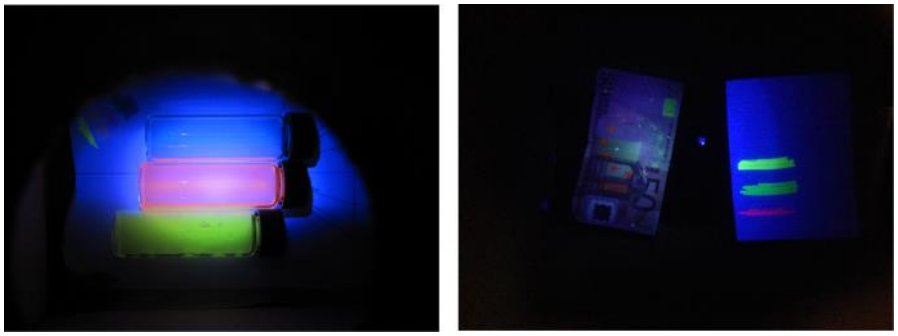


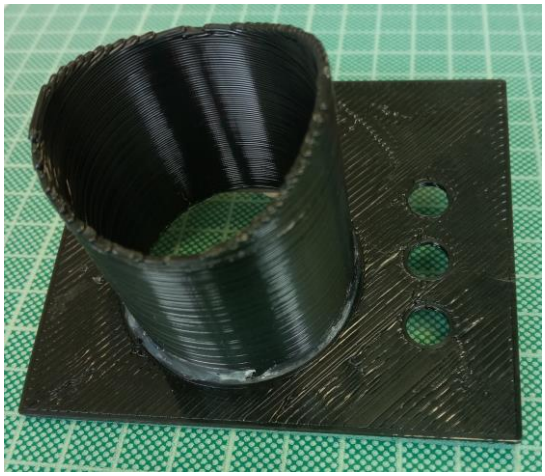
Fig. 9 Fluorescent samples showing some fluorescent paints dissolved in water, a bank note and fluorescent highlighter marker on white paper.

## Step 4 – Assembly of the LED circuit

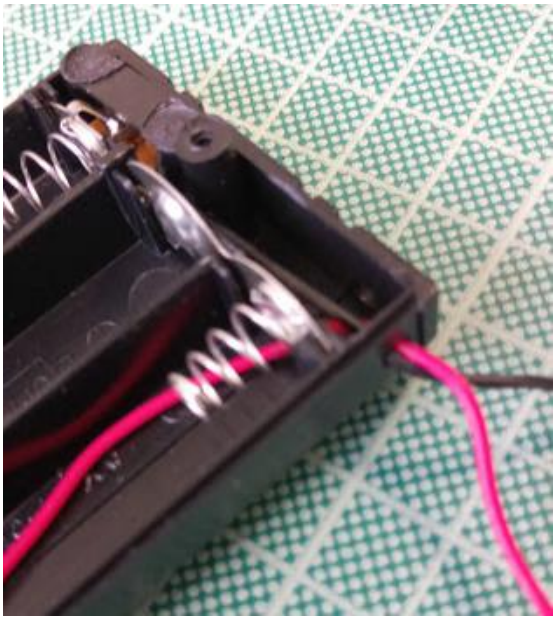
The following parts are needed to complete the LED circuit and viewer –

**3D printed components:**
Viewer eyepiece x 1
Circuit base x 1
**Electronic components:**
Push button switches x 3 (1 Red, 1 Green, 1 Blue)
Battery box for 3 AA batteries x 1
RGB led module x 1
Patch wires x 4
**Other items needed:**
Glue (hot glue works well)
Scissors or Wire Stripper
Insulation tape or some other sticky tape

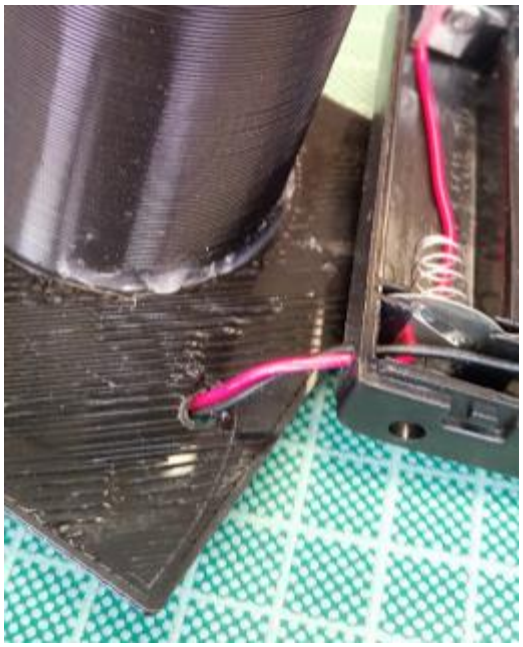
a) Insert the viewer into the large hole in the circuit base and glue in place.



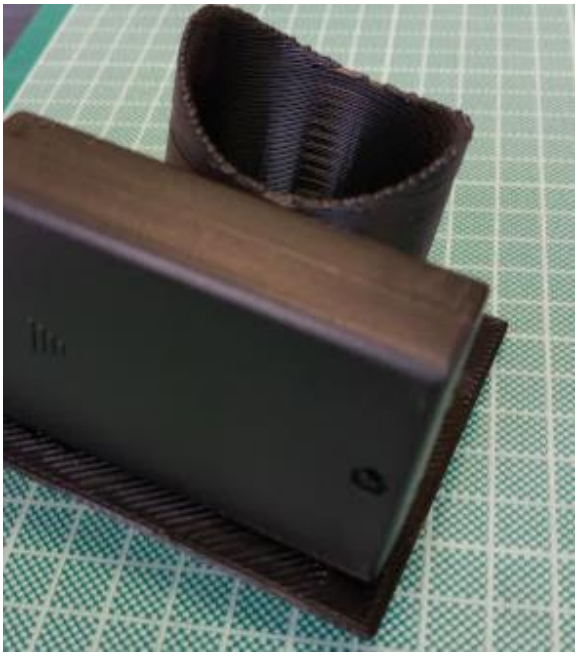
b) If your battery box has a plug attached to the black and red wires then remove it by cutting the wires close to the plug. You don't need the plug.
c) Cut a new hole in the battery box as shown and run the black and red wires through this hole.



d) Run the black and red wires from the battery box through the hole provided in the circuit base.

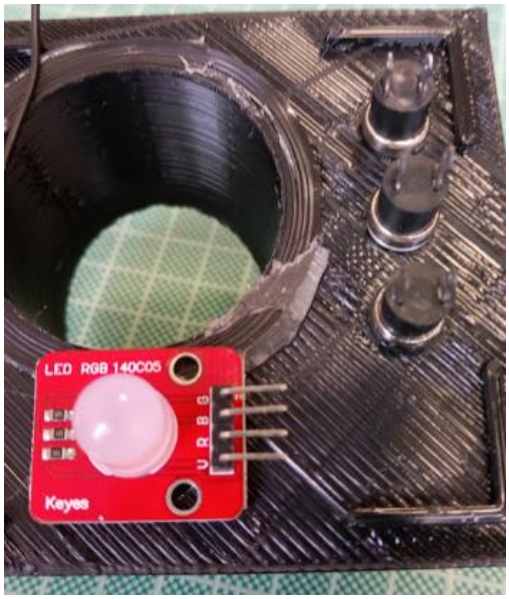


e) Glue the battery box to the front of the viewer as shown. Be careful that you put the cover to the front and the switch to the back on the eyepiece side.



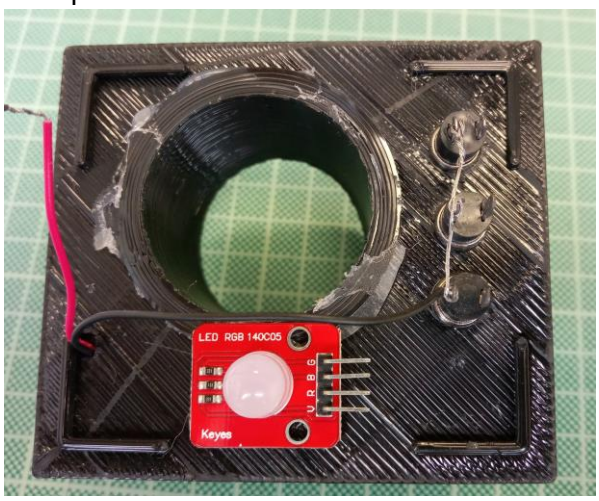
f) Mount the red, green and blue switches like this and tighten the nuts by hand. Align them so that the pins underneath look like they do in the picture.

g) Glue the RGB module to the front of the viewer so that it's underneath the battery box with the pins facing towards the switches like this.




h) Strip about 6cm of the black wires from the battery box and connect it to the same side of the three switches. You can just run it through the hole in the terminal on the switch

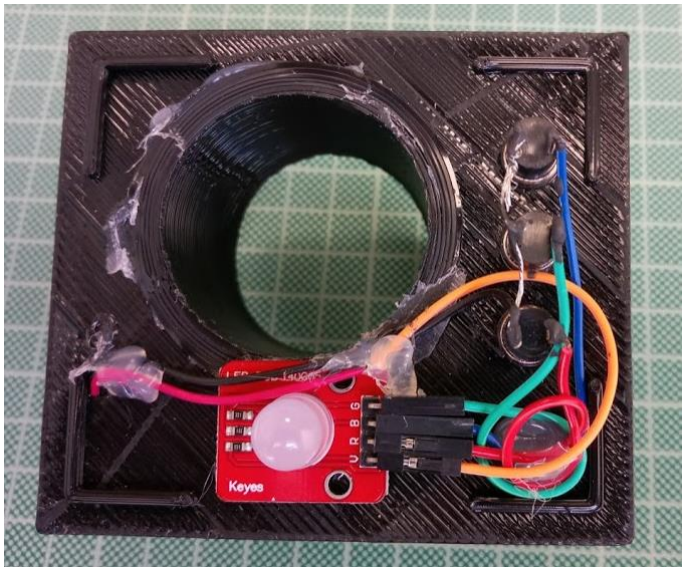
and wrap it around a couple of times. When finished it should be similar to this picture.




i) Nearly finished. Now get your other 4 wires ready by stripping about 1 cm of the end to expose the wire. Do the same on the end of the red wires coming from the battery box.

j) Twist the ends of the red wire from the battery box and one of the other 4 wires and then connect it to the V pin on the RGB led module. Wrap the exposed wire in a little tape to protect it.

k) Finally connect the second terminal of each of the red, green and blue switches to the R, G and B pins on the led module using one of the 3 wires remaining. Your final circuit should look like this from the bottom.




l) Now install the 3 x AA batteries in the battery box and turn the switch to on if there is a switch on the box. When you press each of the buttons the led module should light up with the same colour led.

## End result & conclusions

### What we learned?

By creating their own mini dark rooms and interrogating a range of different samples, students have the opportunity to learn about how colours and light are connected. They get to construct a simple electronic circuit that allows them to combine light sources and see how these combinations change what they observe in their experiments while also introducing them to electronics. The samples mentioned in this document are not meant to be limiting, and we certainly hope that further examples and samples are investigated based on the creativity of our participants when they take their components home. Although no directly 3-D printing, they can start to ask how were those components created and what else can made using this technology.

By using UV light to illustrate fluorescence and make the invisible visible on bank note, the concept of invisible information made visible by light is introduced. Using photonics to unlock secrets of our world is an exciting prospect and in some sense all scientists are detectives of the nature world, our workshop participants can take this feeling home with them!

## Concluding thoughts

The spirit of scientific enquiry can be fostered by revealing knowledge previously hidden using the power of light! White light is not itself a single entity but is composed of a combination of different colors or wavelengths. The response of different colours to different illuminations brings questions about the nature of visible light and how we perceive the world.

This workshop serves as a primer to the amazing nature of photonics and its link to our perception of our environment every day, every colour can be measured and quantified giving us information about our world. When we isolate and focus on particular colour combinations, we learn more about their true nature.

# PHABLABS 4.0

**PHABLABS 4.0** is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:
On the one hand the growing awareness of **photonics** as an important innovation driver and a **key enabling technology towards a better society**, and on the other hand the **exploding network of vibrant Fab Labs** where next-generation **practical skills-based learning** using KETs is core but where photonics is currently lacking.

www.PHABLABS.eu

This workshop was set up by the *(name Photonics Partner's Institution)* in close collaboration with *(name pilot fab lab)*.

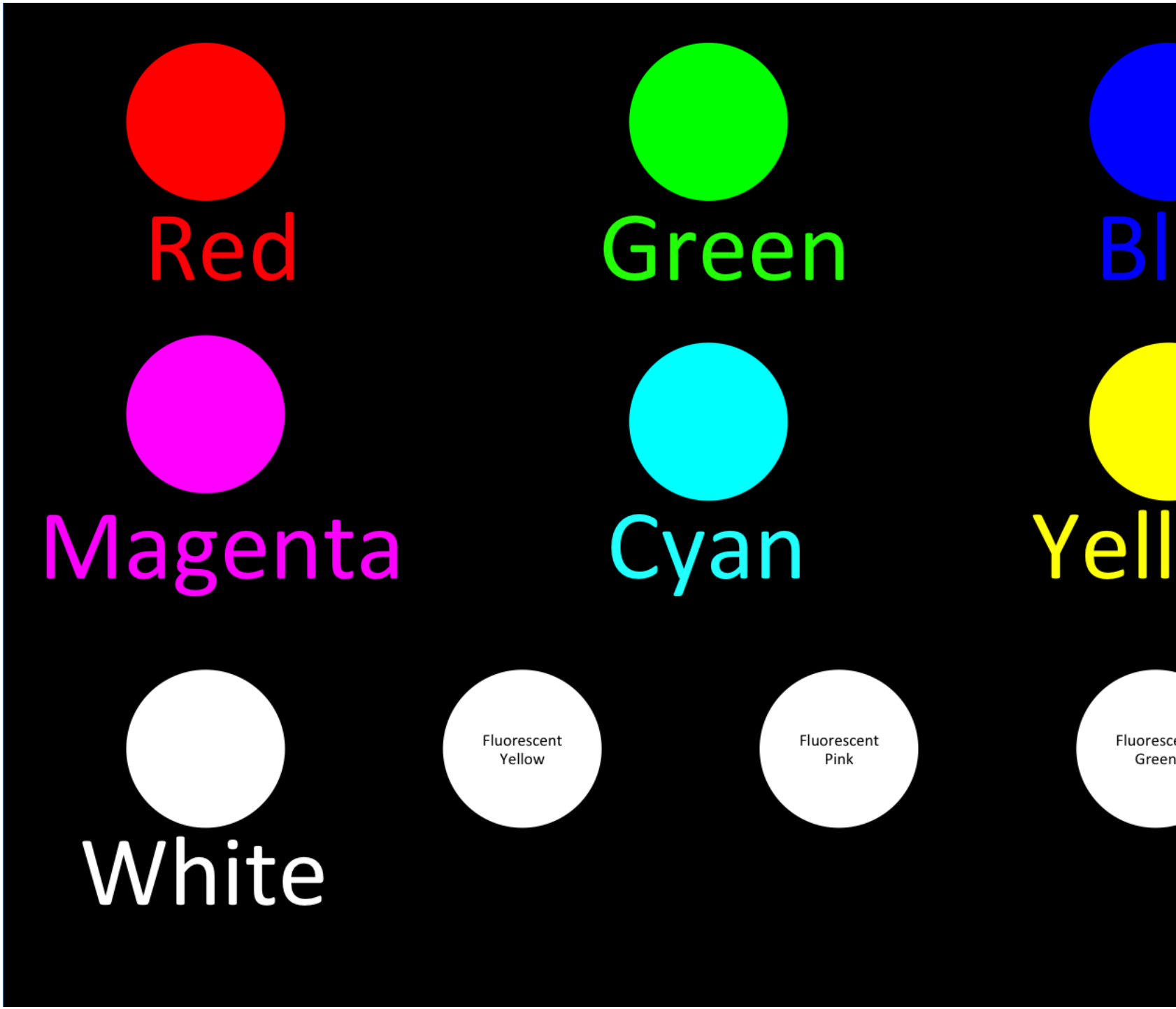
NUI Galway
OÉ Gaillimh

Maker Space

TOMI
Tissue optics & microcirculation imaging

PHOTONICS 21

PHOTONICS PUBLIC PRIVATE PARTNERSHIP


Red
Green
Bl
Magenta
Cyan
Yell
Fluorescent Yellow
Fluorescent Pink
Fluoresc Green
White