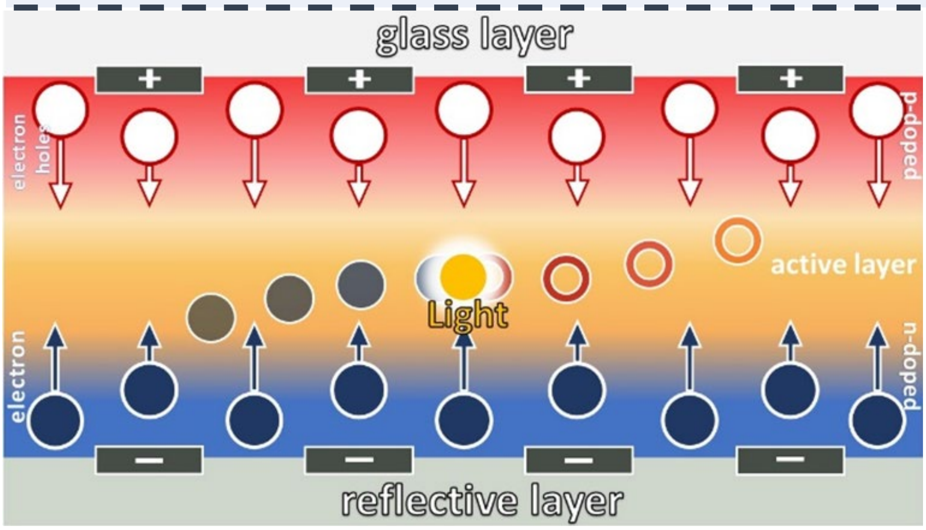
Worksheet 7

LEDs

The firs **l**ight-**e**mitting **d**iode (LED) was developed by Nick Holonyak in the 1960s. From the first red glowing LED, to the many colours available today, the luminous efficiency and general efficiency of this technology have increased. In everyday life, there are numerous uses of LEDs: room lighting, monitors, or torches. An LED's luminous efficiency is about 30%, making them much more efficient than conventional light bulbs or halogen lamps. LEDs need less energy for the same light output: for 450 lumens, an incandescent conventional light bulb needs 40 W, a halogen lamp 29 W, and an LED only 7 W.

The LED's light-generating layer is a silicon semiconductor. Pure silicon is barely conductive due to a lack of charge carriers. However, when a silicon crystal is doped with atoms that have more than four valence electrons, free charge carriers are available (n-doping). Doping the silicon crystal with atoms that have less than four valence electrons leads to a shortage of electrons (p-doping). When the two materials are layered, their charges reach an equilibrium at the contact surface. This process is called recombination. Through this process, a high-energy electron reaches a lower energy level by combining with an atom lacking an electron. Surplus energy is emitted as light.

Through applying a voltage, this process occurs continuously, causing the LED to glow. This process is called electroluminescence. The LED's light-generating layer is covered by a layer of glass. The optical properties of this layer have an effect on the luminous efficiency. A reflector layer is located right below the light-generating layer.



Schematic overview of an LED's light-generating layer

Task:

1) How could the LED's luminous efficiency be increased? Think about the photocytes and how they are structured. What can we learn from nature? Note down your ideas.

____

____

LEDs & FIREFLIES

In fireflies, light generated in the photocytes has to pass through the transparent chitin layer become visible in the surrounding environment. Due to the optical properties of chitin, only part of light passes through. If the angle with which the generated light hits the chitin layer is too steep, all light is reflected. Using a scanning electron microscope, scale-like structures can be observed on the chitin layer. Due to these scales, generated light is scattered, which, in turn, increases the luminous efficiency. When comparing the structure of an LED and that of a firefly's photophore, structural similarities become apparent. Both have a light-generating layer covered with a transparent material.

Activity 4 – LEDs

I) Preparation

List of materials:

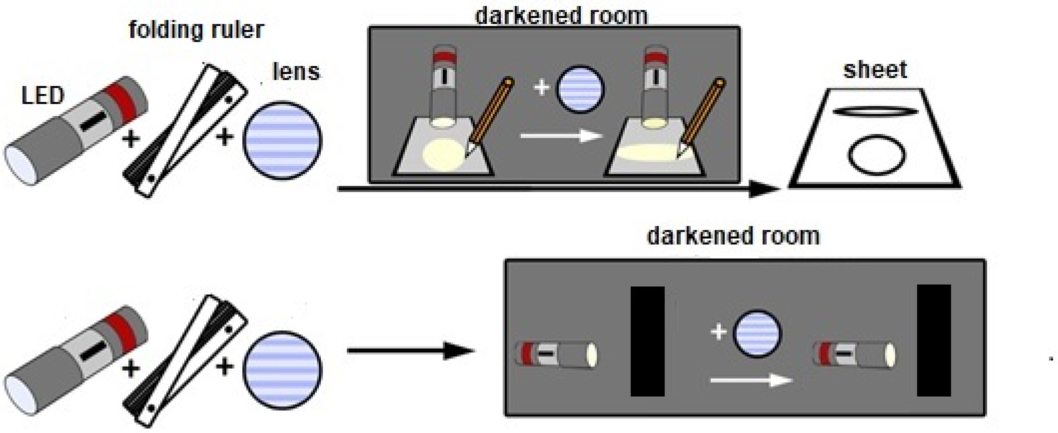
- An LED torch
- A lens
- Two sheets of paper
- A folding ruler
- A pen

II) Setup & procedure

1) An LED torch is pointed at a sheet of paper (30 cm distance) in a darkened room. The illuminated area is then circled with a pen.

2) A lens is put in front of the LED torch and the illuminated area is circled again on the paper.

3) The LED torch is then pointed at a wall with and without the lens (3 m distance).



III) Observation

1) How does the lens influence the light beam's size?

____

____

2) Can you spot a change in light intensity?

____

____

3) Draw the shapes of the light beams you observe:

Without lens	With lens

IV) Interpretation

1) Which kind of lens did you use?
(**Tip:** How does the lens change the light beam? What has to happen to the light for this to occur?**)**

____

____

2) How can the change in light intensity be explained?

____

____

3) How are the lens and the firefly's lantern connected?

____

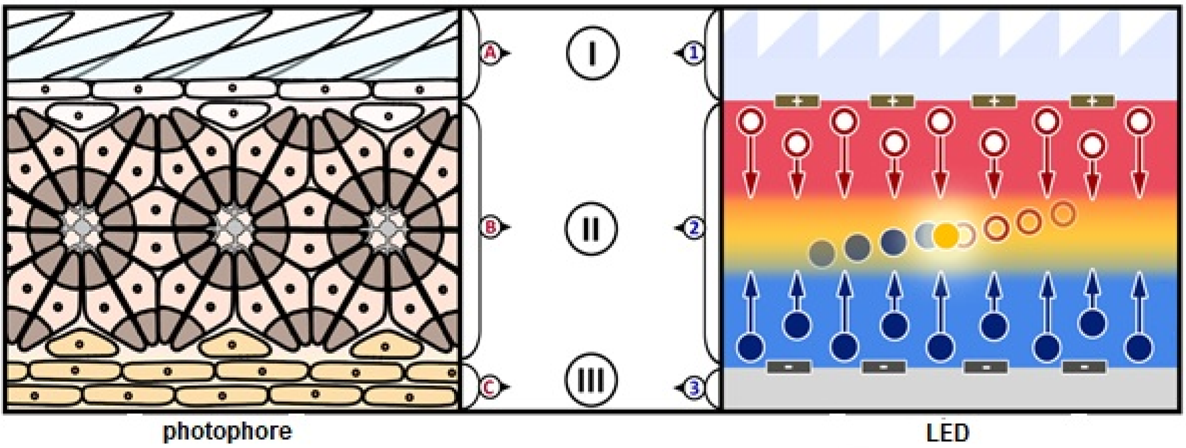
____

____

Task:

1) Try to name the layers of the LED and the photophore based on their function.

2) Compare the functions of the three layers. Use the schematic overview below.



Photophore	LED
I) Name:	
Function of A:	**Function of 1:**
II) Name:	
Function of B:	**Function of 2:**
III) Name:	
Function of C:	**Function of 3:**