Tunable Light Source
Tuned LEDs and their Applications

ECE 480
Team 13

Lab Coordinator……..Ruben Alejandro
Manager……...Isaac Davila
Presentation prep……...John Foxworth
Web Designer……..Haosheng Liu
Document Prep……...Cynthia Patrick

Sponsor: Dr. Chahal

Facilitator: Dr. Ayres

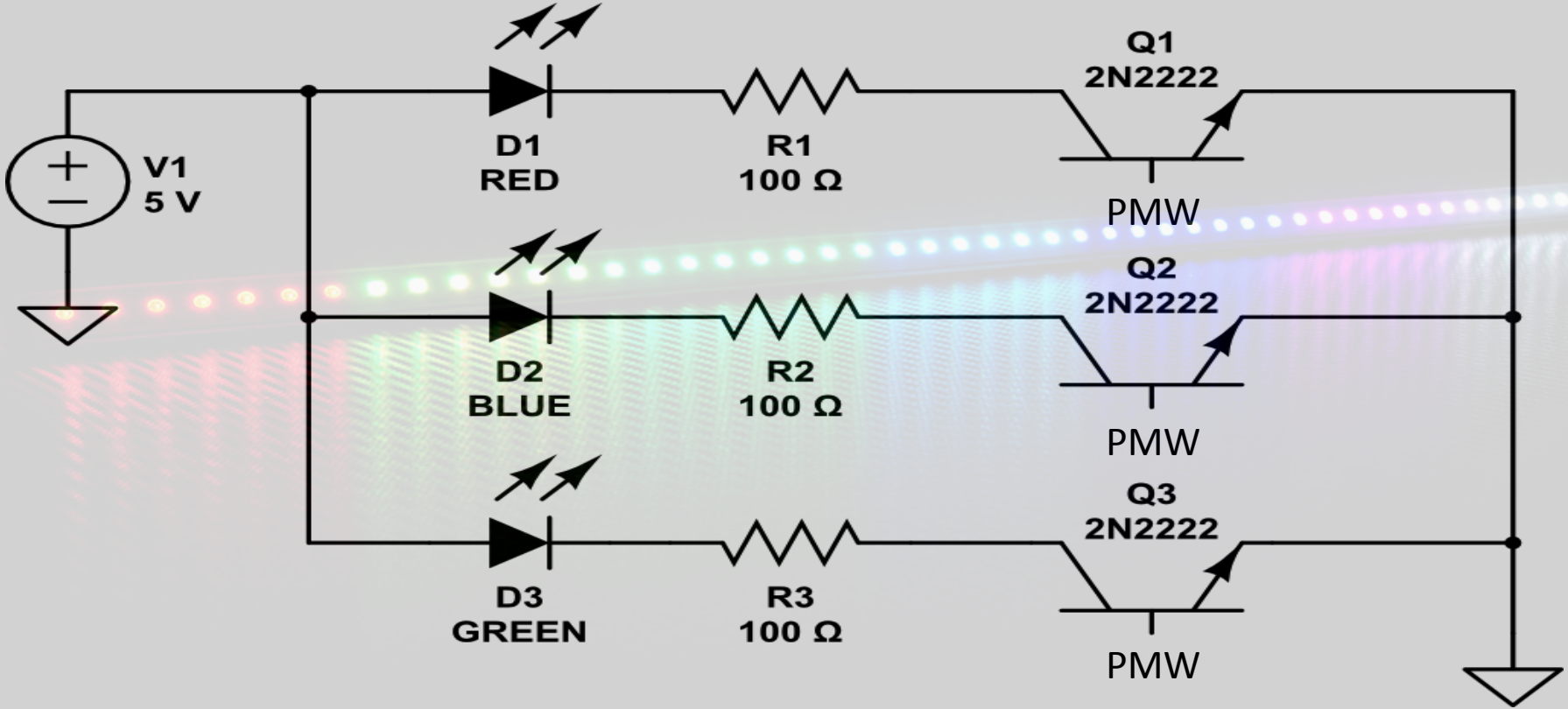
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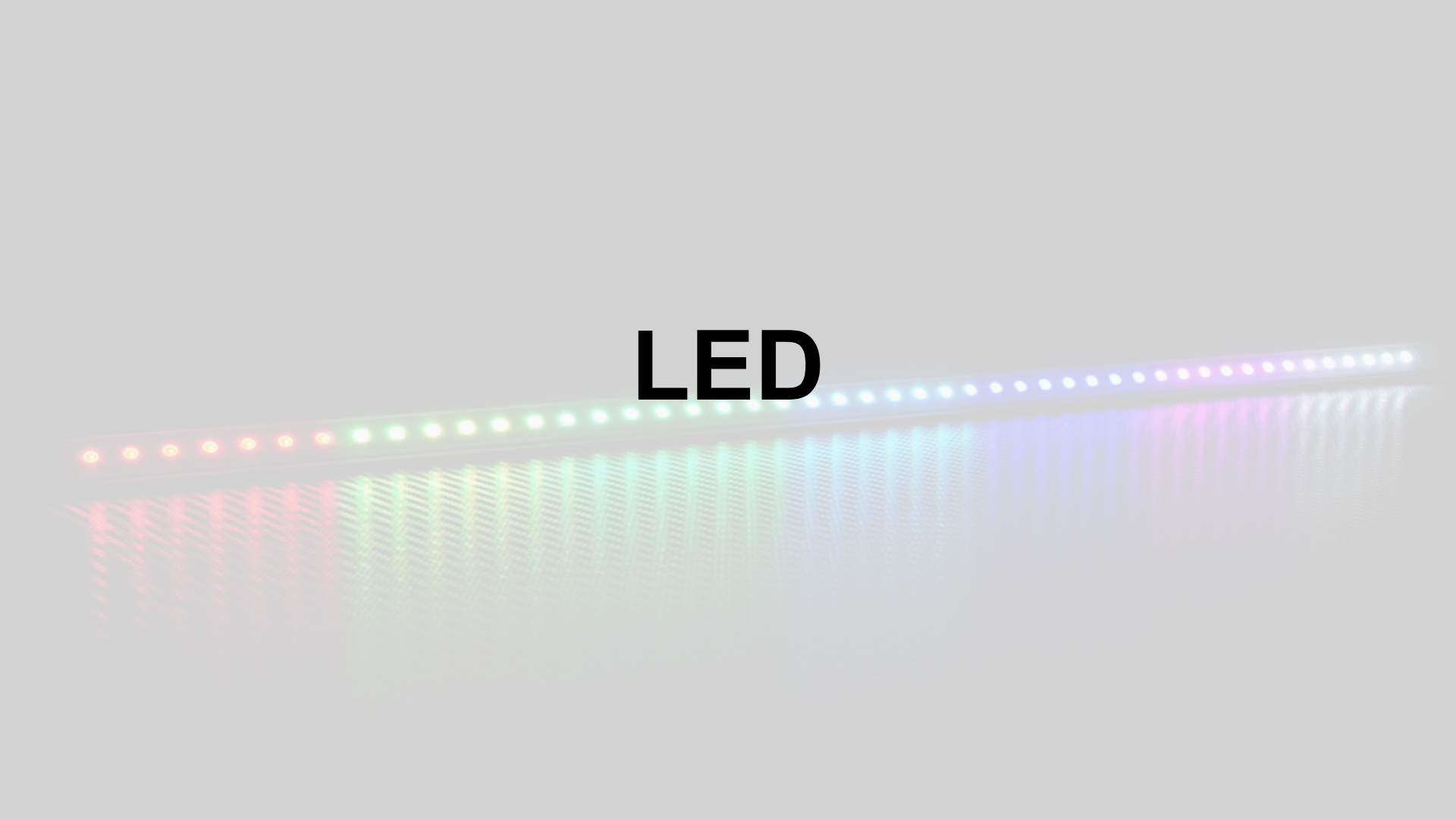
Project Goals

- Create a tunable light source that emulates the black body radiation curve of the sun.
- To be used in solar cell testing, and has potential to be used in a variety of other applications.
- Design is to be low cost, adaptable, and user friendly.

Final Schematic

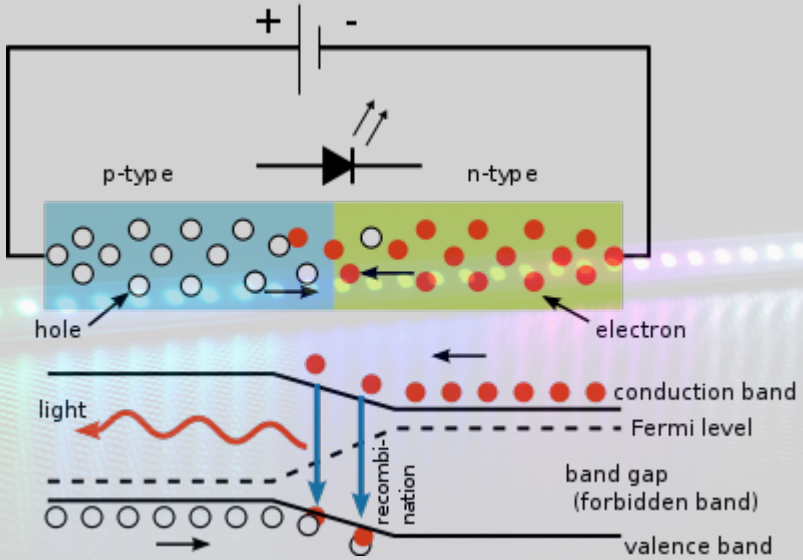


LED



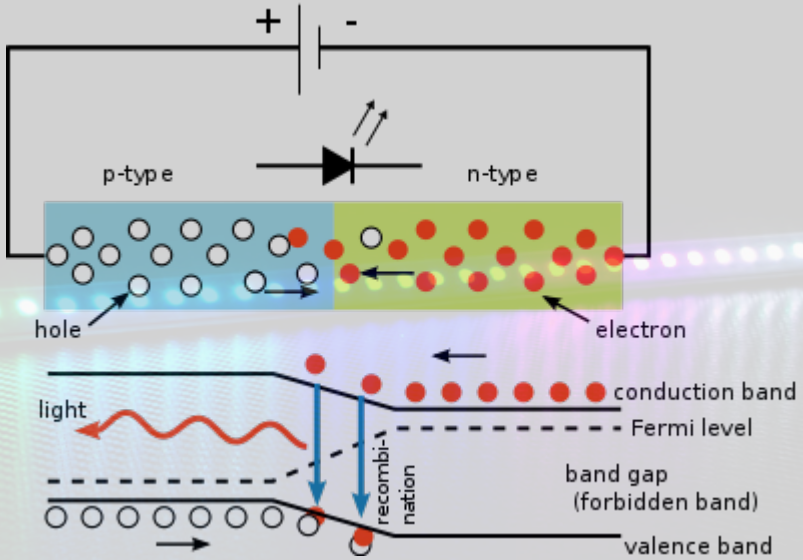
What is an LED?

- Light-emitting diode
  - Semiconducting material
  - Impurities
  - P-N junction
    - p-type
    - n-type



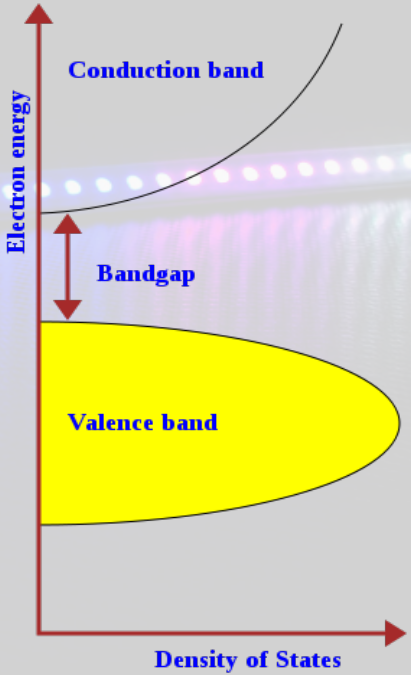
How LED works?

- P-type semiconductor
- N-type semiconductor
- Electron
- Hole
- Photon

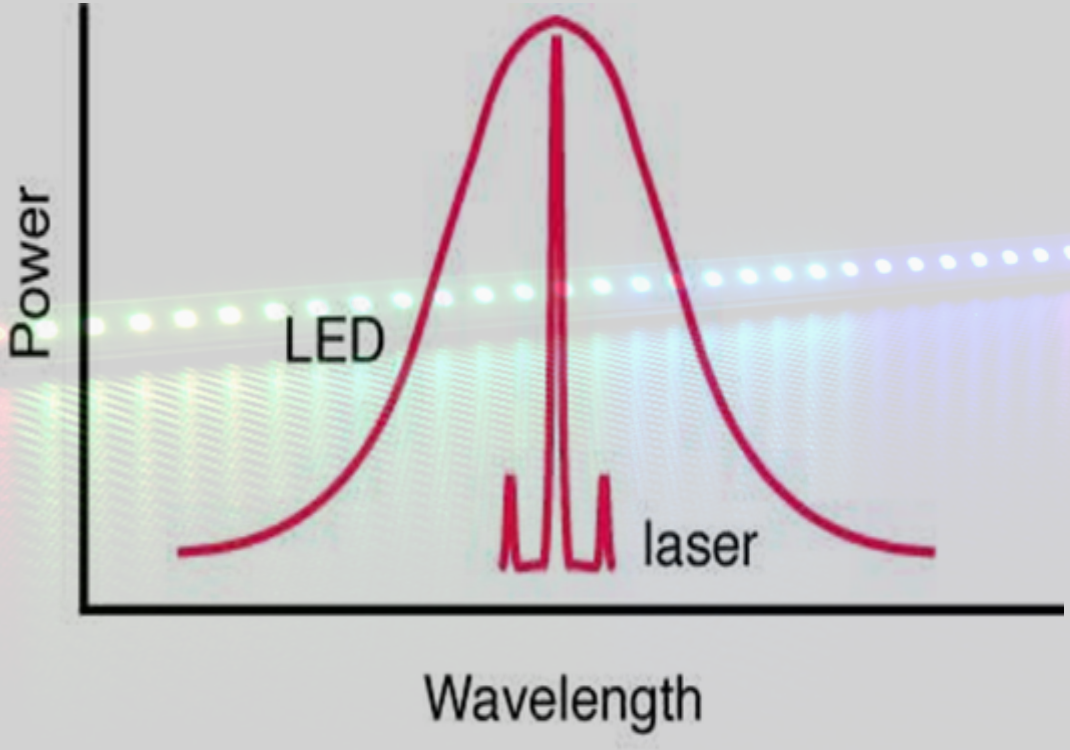


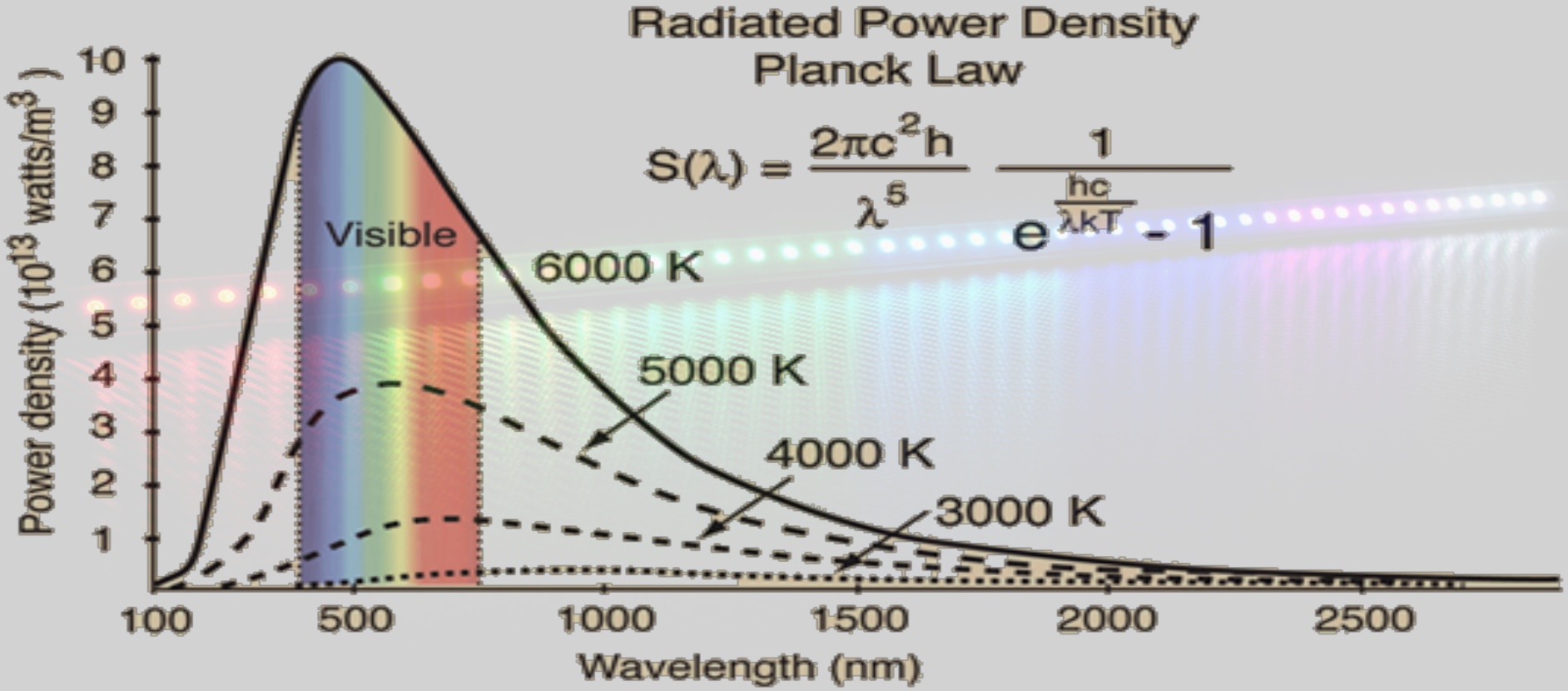
What determine the color of light?

- Frequency
- Band gap energy
  - conduction band
  - Valence band
- Photon energy released

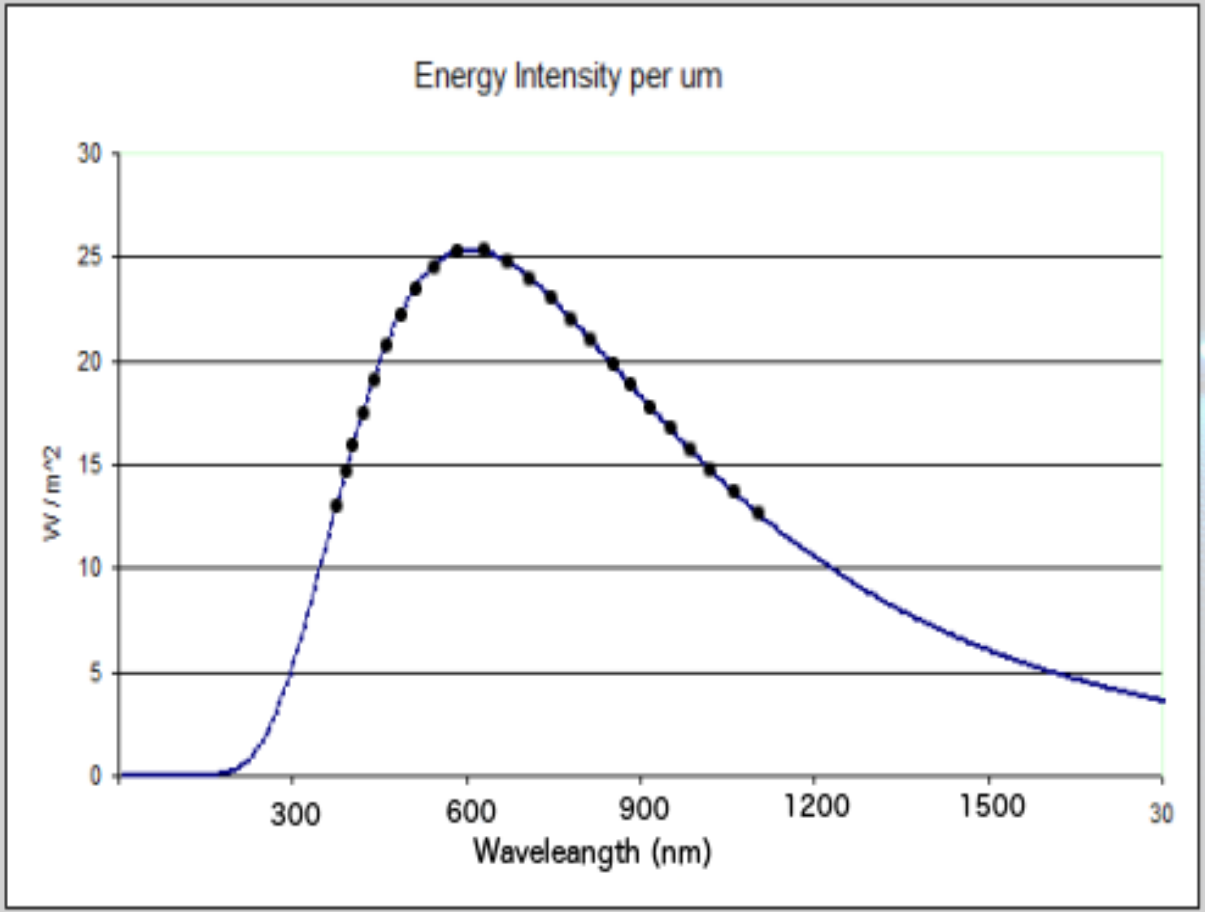


LED Spectrum



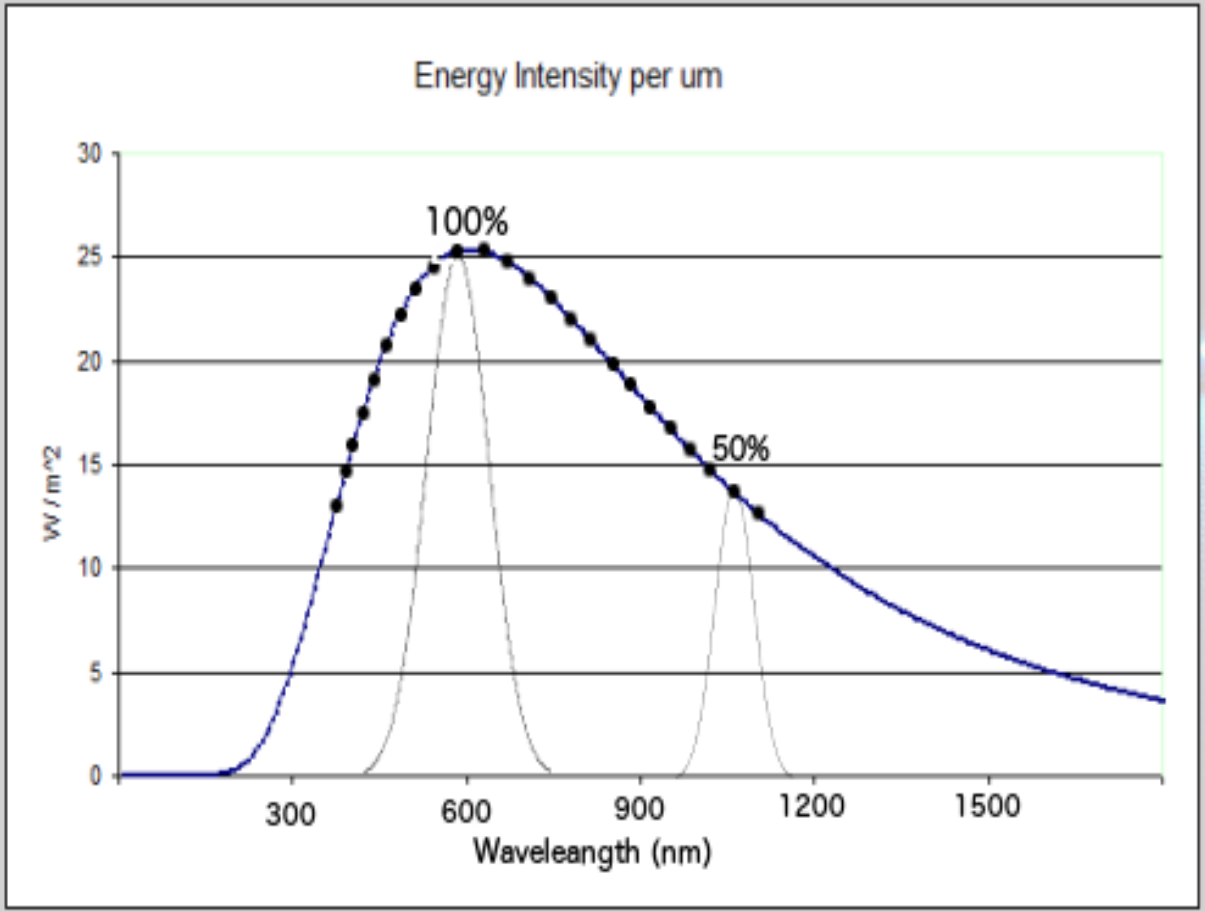

Radiated Power Density
Planck Law
$S(\lambda) = \frac{2\pi c^2 h}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$
Power density (10^{13} watts/m^3)
10
9
8
7
6
5
4
3
2
1
Visible
6000 K
5000 K
4000 K
3000 K
100
500
1000
1500
2000
2500
Wavelength (nm)

Recreating a Spectrum Output



- Only interested in 400nm - 1100nm
- Utilize digital approximations to store graph data
- Export graph data as an array to be interpreted by program

Recreating a Spectrum Output (cont.)



- Each point will represent one LED relative power output
- Power will be adjusted using PWM
- Summation of all data points will give a close approximation

analogWrite(Pin, Value)

- Allows us to assign intensity values to each LED separately
- Given enough data points, can accurately recreate an intensity vs. wavelength graph
- Can be updated within the code in real time.

Coding

```
int i = 1;



// declares an array of integers
int[] value;

// allocates memory for 25 integers
value = new int[25]

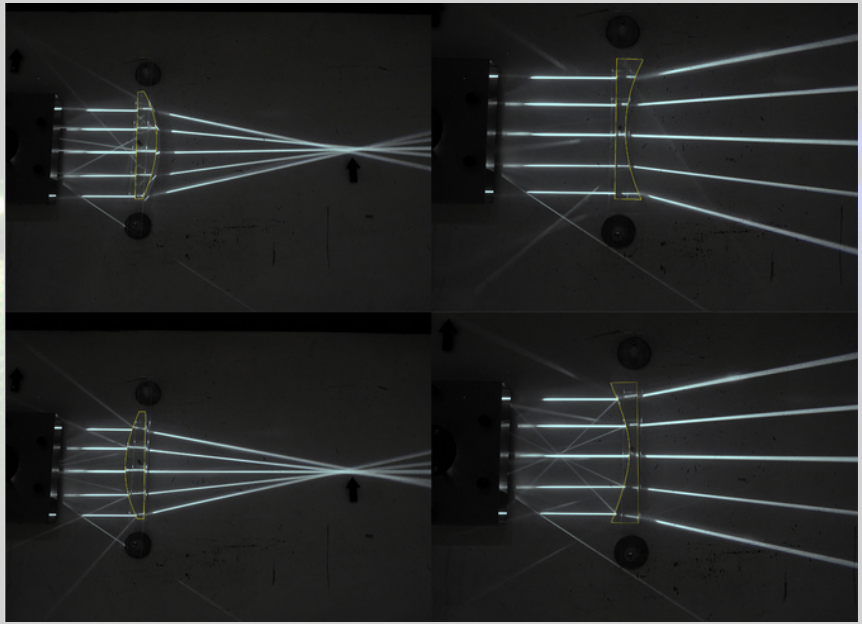


// Continuously updates output
while (i < 26)
{
      analogWrite(i,value[i];
      i++;
}

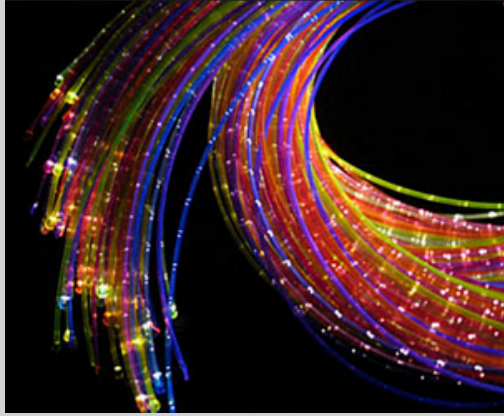
i=1;
```

- Simplicity allows flexibility
- Array can be created from multiple sources.
- Array values can be updated at any time.

Optics



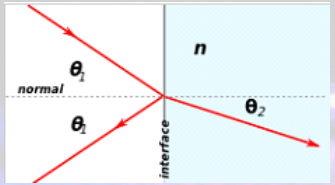
Optics

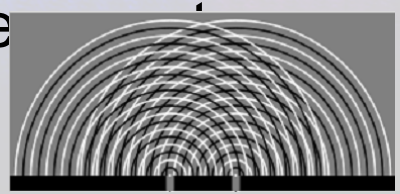


- Optics explains the phenomena of electromagnetic waves.
- Infrared, ultraviolet, and visible light.
- It also studies the construction of the instruments used to detect it

Optics

- Optics is usually studied in two practical modes:
  - Geometric optics
    - treats light as a collection of rays that travel in a straight path and bend as they e surface.

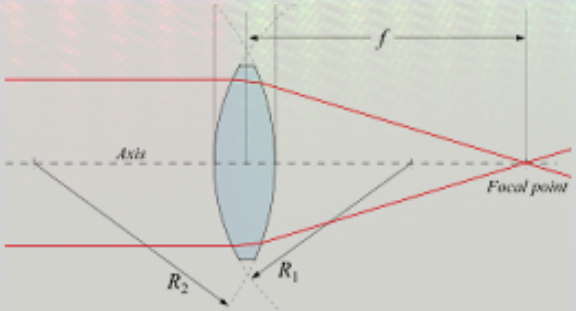


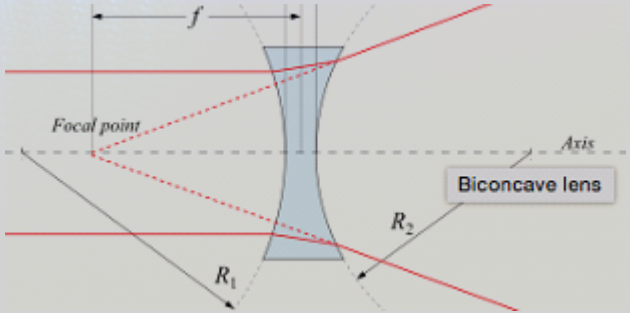


  - Physical optics
    - treats the electromagnetic spectrum as a comprehensive model of light.

Lenses (Optics)

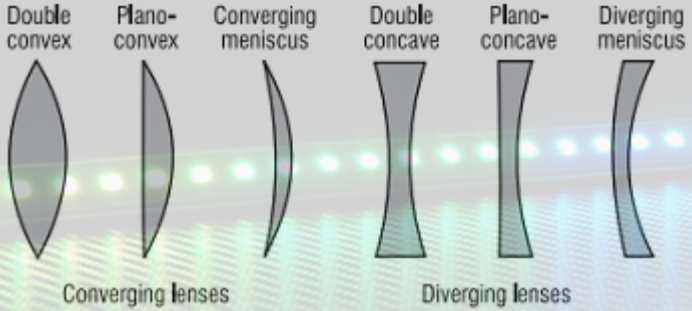
- Lens
  - made out of transparent material
  - optical instrument
    - focusing of light through reflection and refraction
    - can diverge or converge light





Lenses

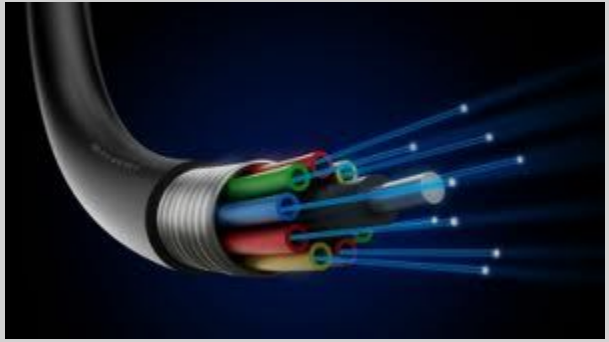
- Different types of Lenses



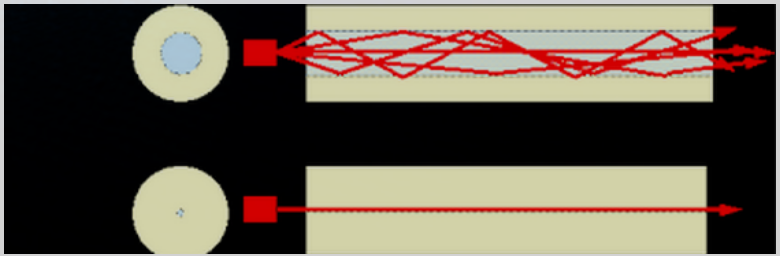
Lenses Applied

- Lenses will be used to focus the light
  - Consider for LED radiation
    - does not operate as a laser beam
      - makes it harder to focus
    - Need an alternative
      - Housing
      - Fiber Optic Cable

Fiber Optic Cable



- Fiber optic cable
  - Is able to bend light
  - is going to output a narrow beam
    - may not be as straight as desired



Housing

- Reflective housing
  - To reflect light
    - Set it to a straight pattern



Jaundice Treatment

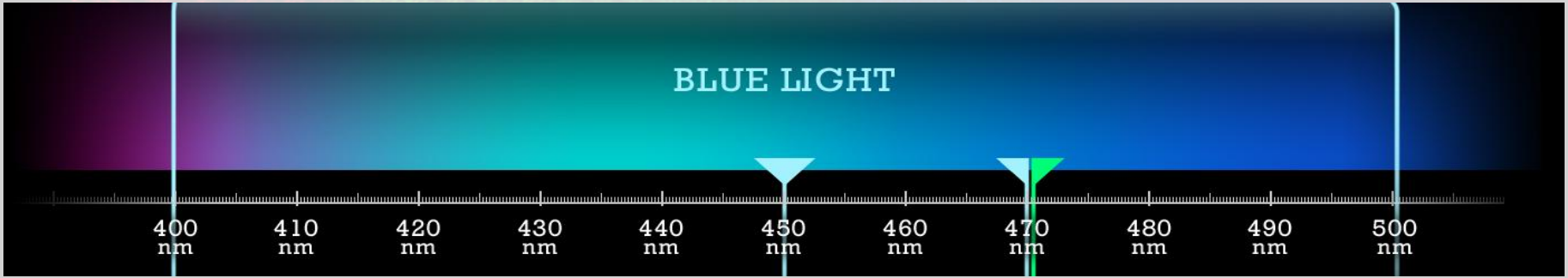
- Developed by 60% of Newborns
- Caused by a buildup of the chemical Bilirubin
- There is an extremely wide variety of causes including:
  - Chemicals in breast milk
  - The liver not yet mature
  - Collection of blood under scalp
  - Incompatible blood type

How it presents itself

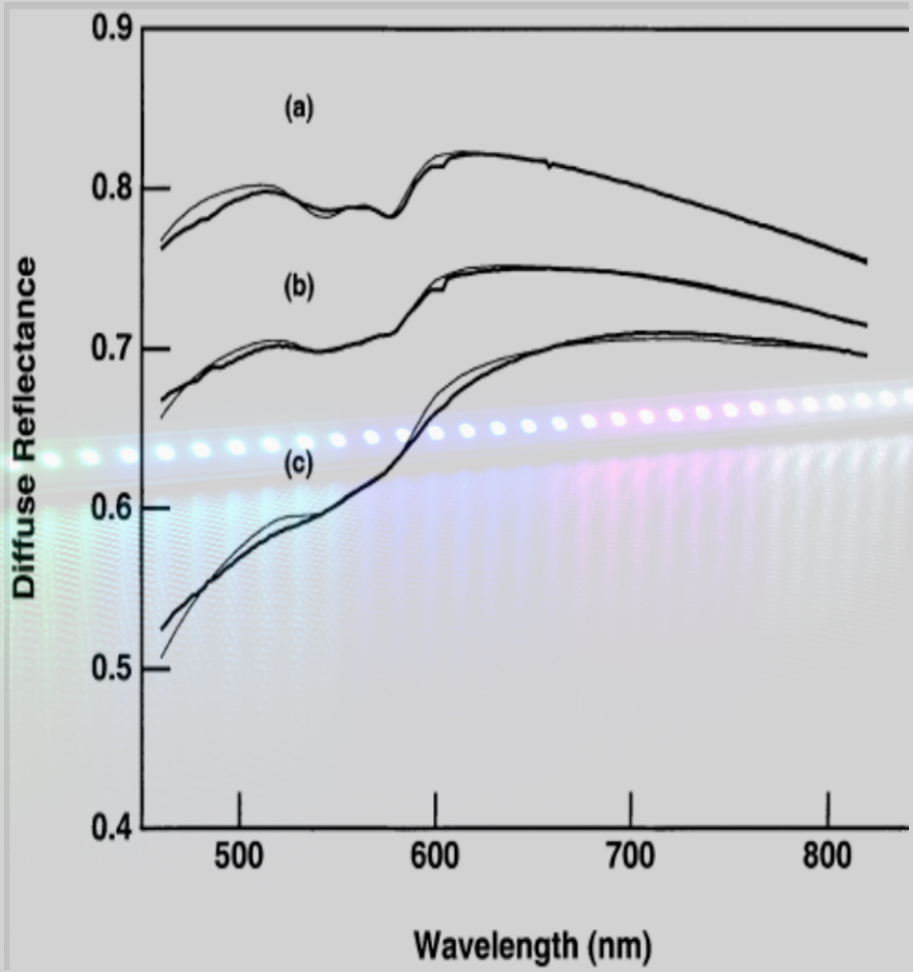
- Yellowing of the skin
- Can cause
  - Brain damage
  - Hearing loss
  - Physical abnormalities
  - Death



- When exposed to blue light Bilirubin breaks down
- Typical severe Jaundice level of Bilirubin is 20 mg/dL
- More critical cases require a higher frequency of blue light than less extreme cases.
- Customization of frequency has led to a decrease in treatment time



- Customization of intensity can also increase effectiveness of treatment
- When less melanin is present more blue light will be reflected away from the skin



- Our design can be applied by:
  - Creating a blue LED array
  - Adjusting our lenses
  - Same programming with different GUI



Plant Growth

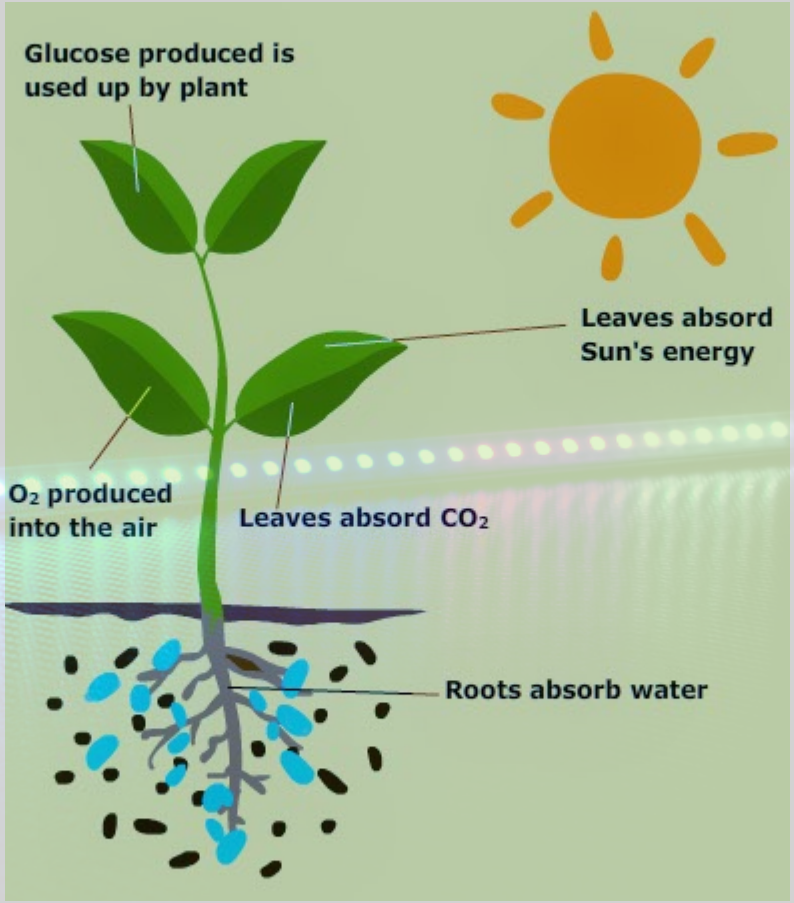


Photosynthesis

How plants produce food

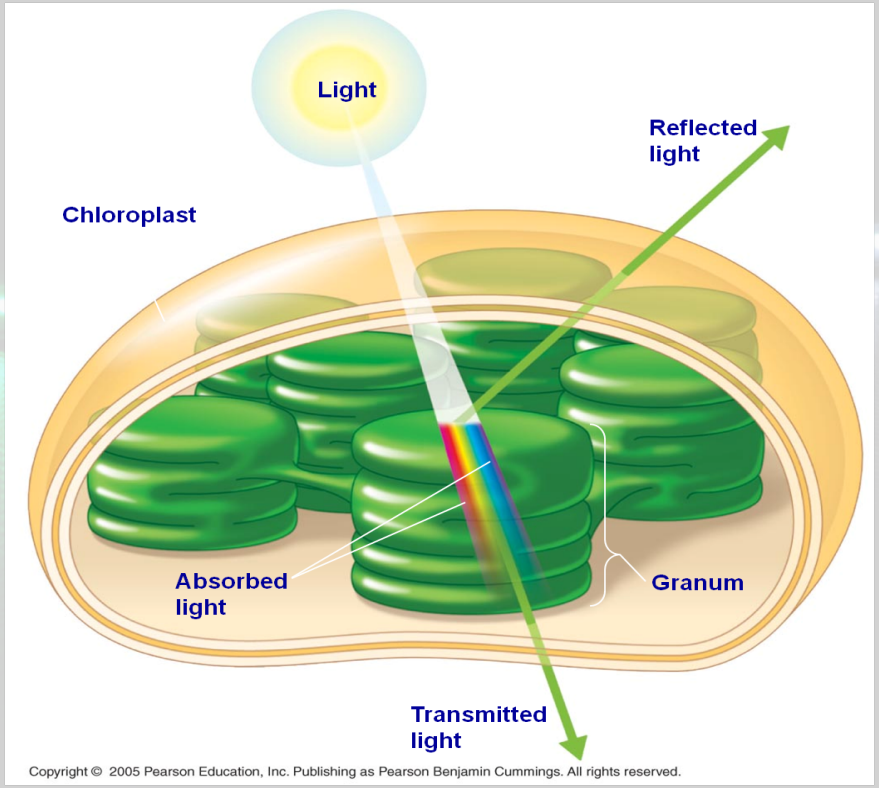
$6CO_2$ Carbon dioxide + $6H_2O$ Water $\xrightarrow{\text{Light}}$

$C_6H_{12}O_6$ Sugar + $6O_2$ Oxygen



Photosynthetic Pigments

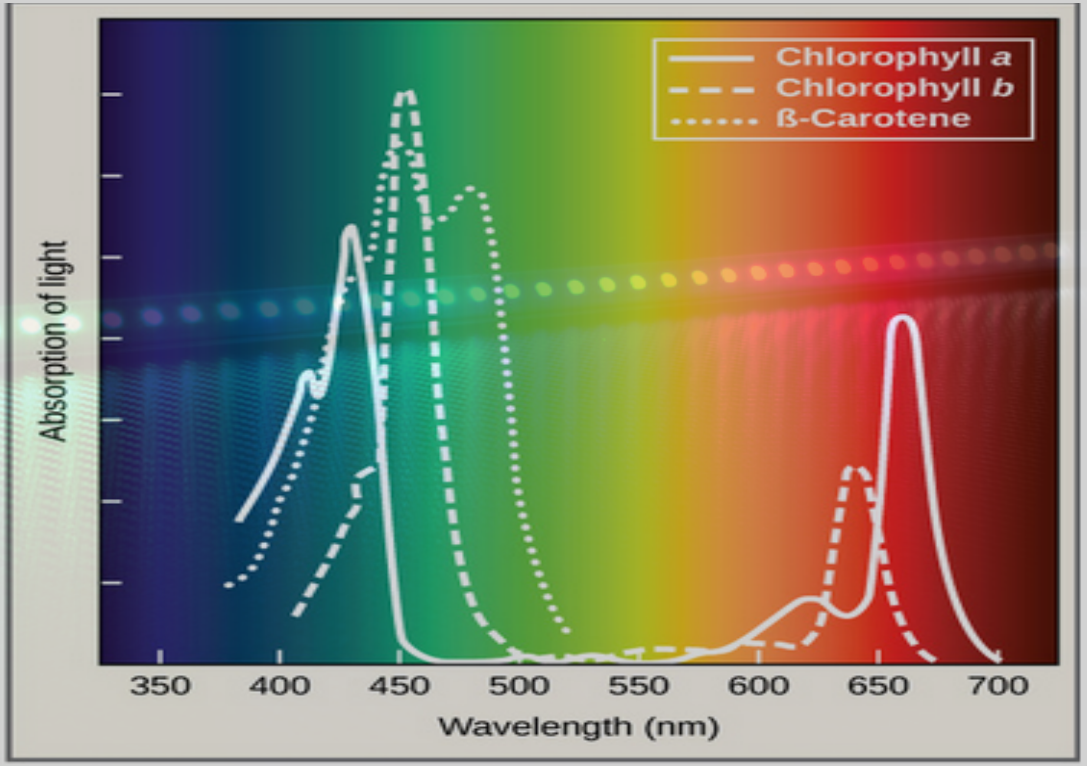
- Absorb and Reflect Light
- Major Pigments
  - chlorophyll (green)
    - Range 400nm to 700nm
  - carotenoids



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Absorption Spectrum

- Pigment's Light Absorption vs Wavelength



Project Relevance

Apply to Greenhouses/ Indoor Growing

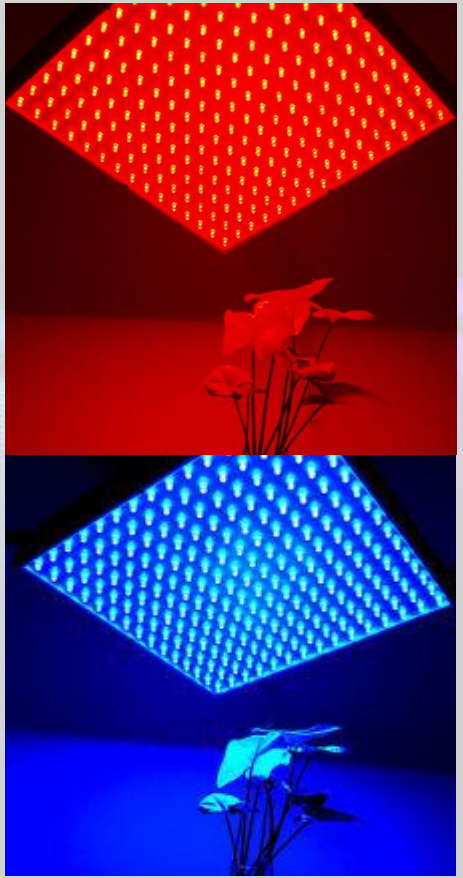
Tweak our Design to output only the wavelengths needed for Photosynthesis (plant growth)



Control over Growth Stages

Red Light(650 nm > λ < 750 nm)
induce Flowering Stage

Blue (λ < 450nm)
induce Vegetative Stage (plant growth)



Conclusion

- Low Cost
- Minimal Power Consumption
- Tunable Design

Questions?