LIGHT SLEEP

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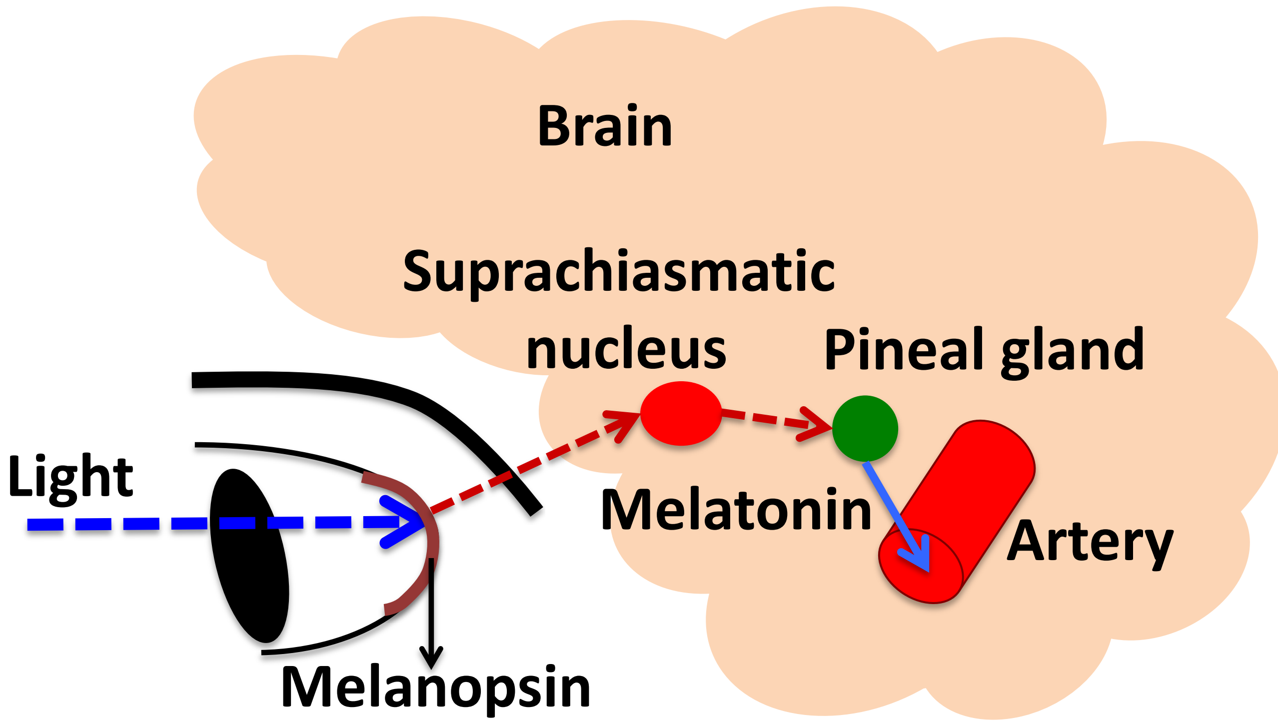
INTRODUCTION



- Photoreceptor melanopsin most sensitive to low wavelength light
- Melanopsin senses light ➔ sends electrical impulses to suprachiasmatic nucleus ➔ sends messages to pineal gland ➔ reduces hormone melatonin production
- Melatonin in blood ↓ ⇒ Wakefulness ↑
- Wavelength ↓ ⇒ Melatonin ↓ ⇒ Wakefulness ↑

⇒ **Low wavelength light not good close to bedtime**

QUESTION

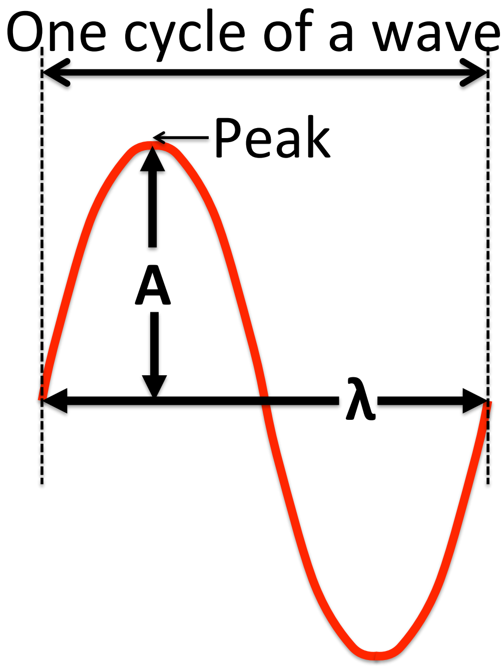
What is the effect of different type of light sources used at home on the intensity (measured in lux) of low wavelength (400-500nm) light produced?

HYPOTHESIS

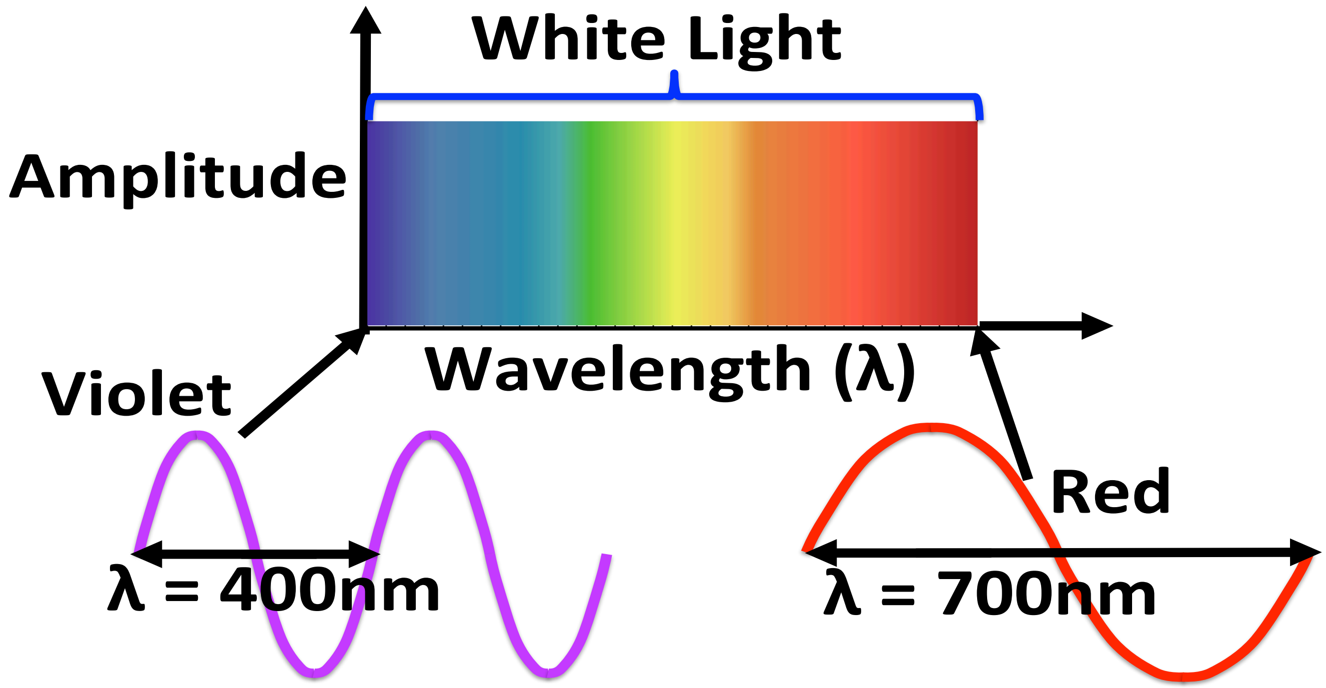
If high color temperature (termed "daylight" type) LED light bulbs are used, they will emit the most amount of light intensity at lower visible wavelengths (400-500nm)

RESEARCH

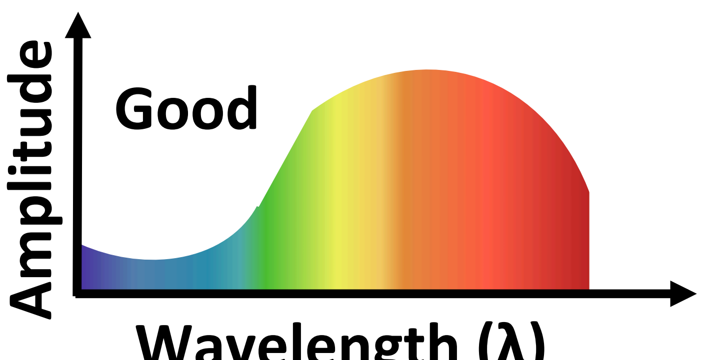
Light travels in waves

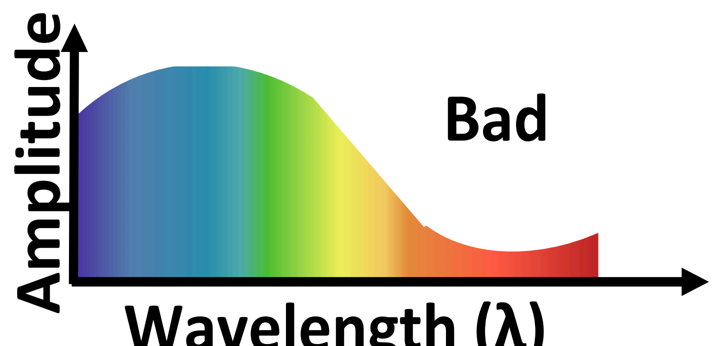


Visible spectrum



Most light sources don’t have equal intensities at different wavelengths

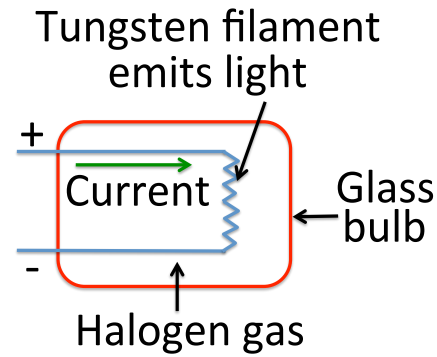




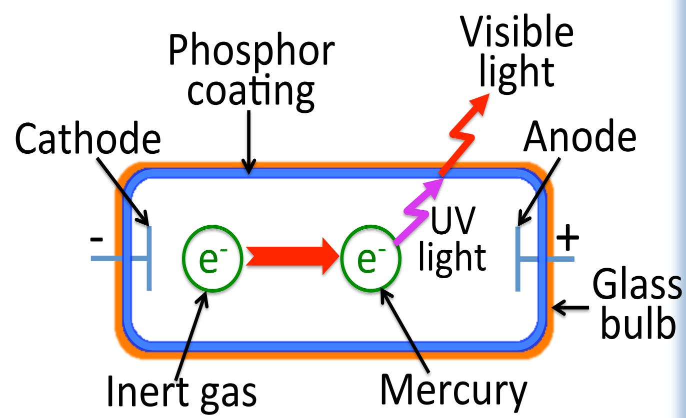
RESEARCH

- Color temperature of light source
  - Surface temperature (Kelvin) of a black body (sun) when it emits similar light spectrum as the source
  - Light sources classified as
    - soft white – 2700-3000K
    - bright white – 3500-4100K
    - daylight – 5000-6500K
- Intensity of light source
  - Intensity of all wavelengths in the source
  - Measured in Lux
    - 1 Lux = 8% of light emitted per square meter by a wax candle
  - Measured in Analog-to-Digital Unit (ADU)
    - Intensity computed by a spectrophotometer by adding pixel intensities at each wavelength on screen

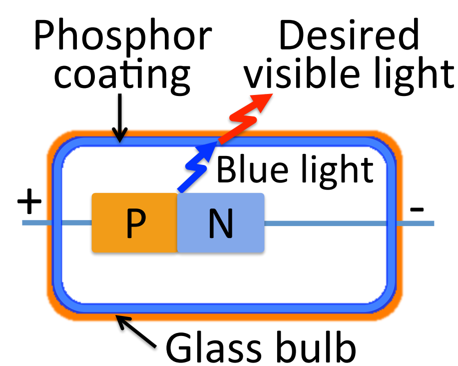
Halogen bulb



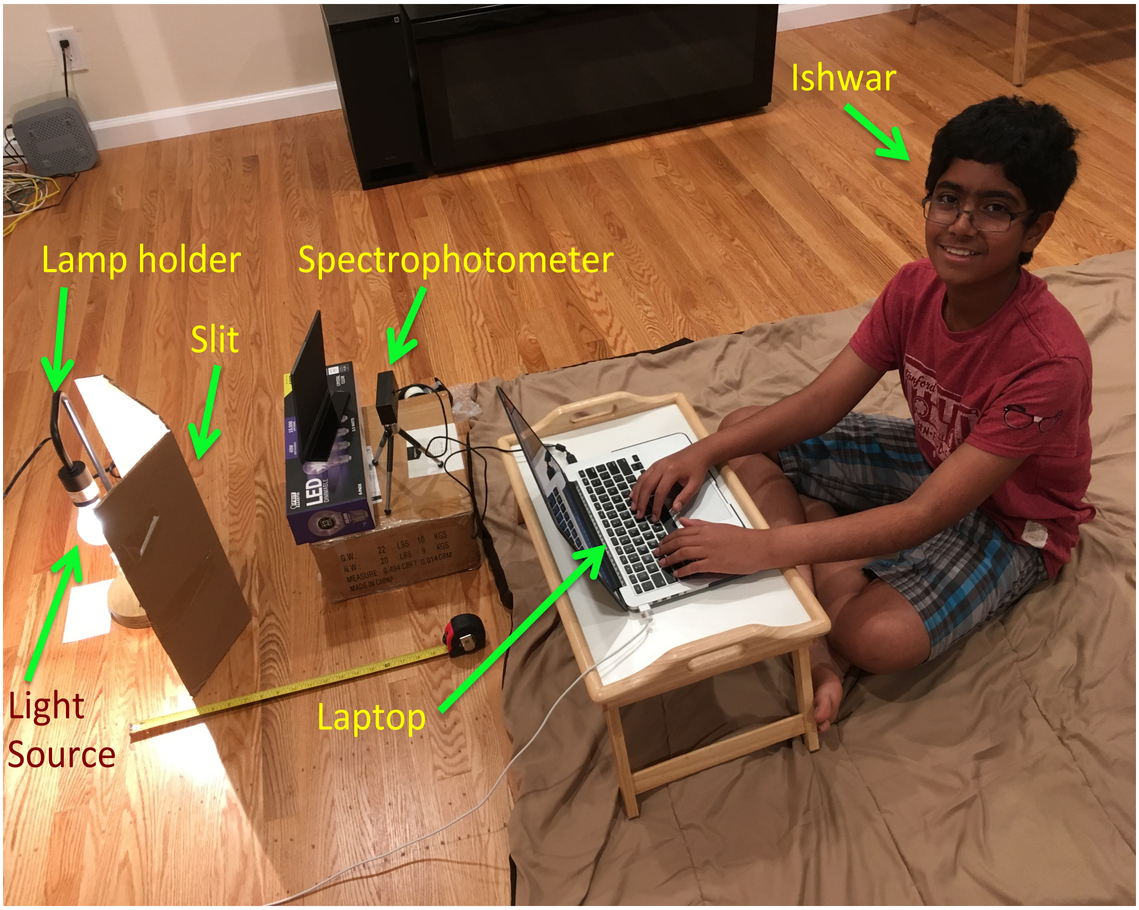
Compact Flourescent bulb

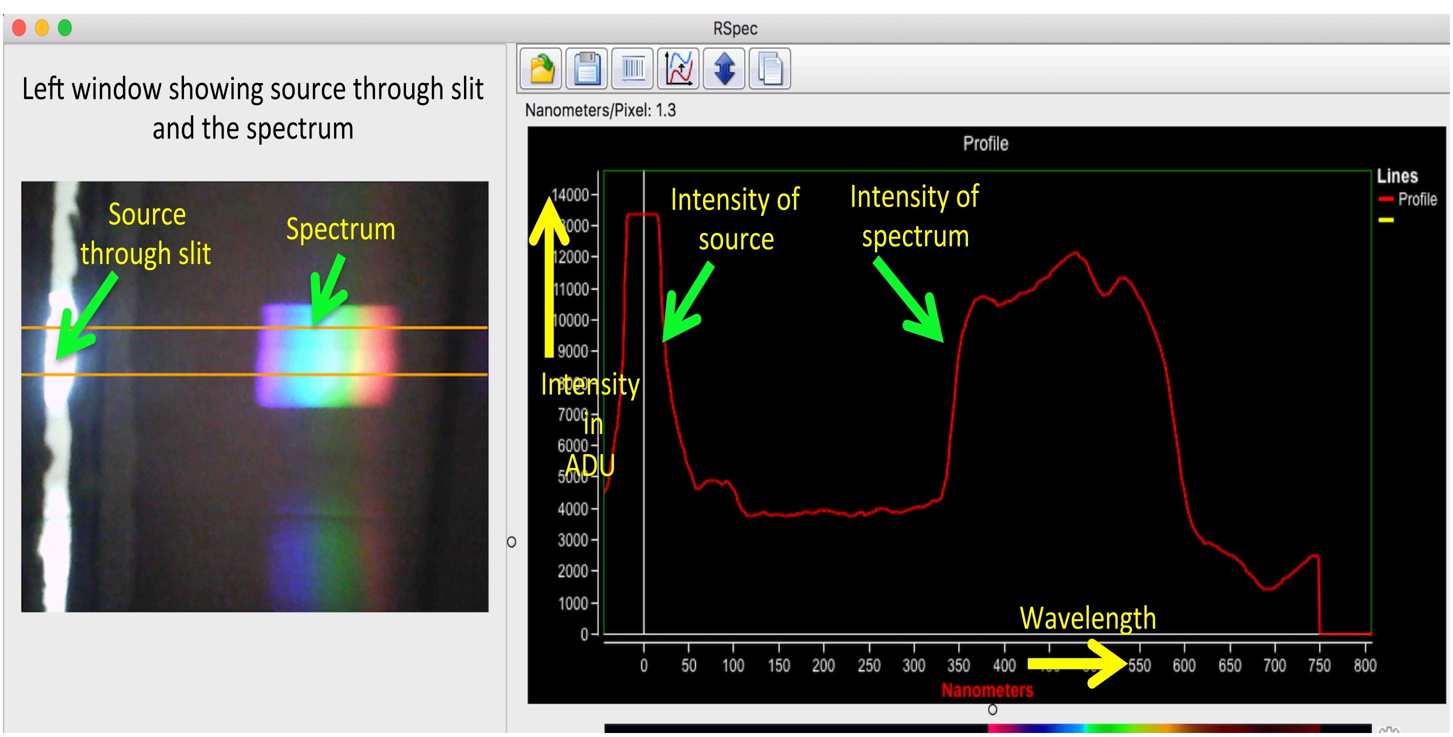


Light Emitting Diode (LED) bulb



SETUP





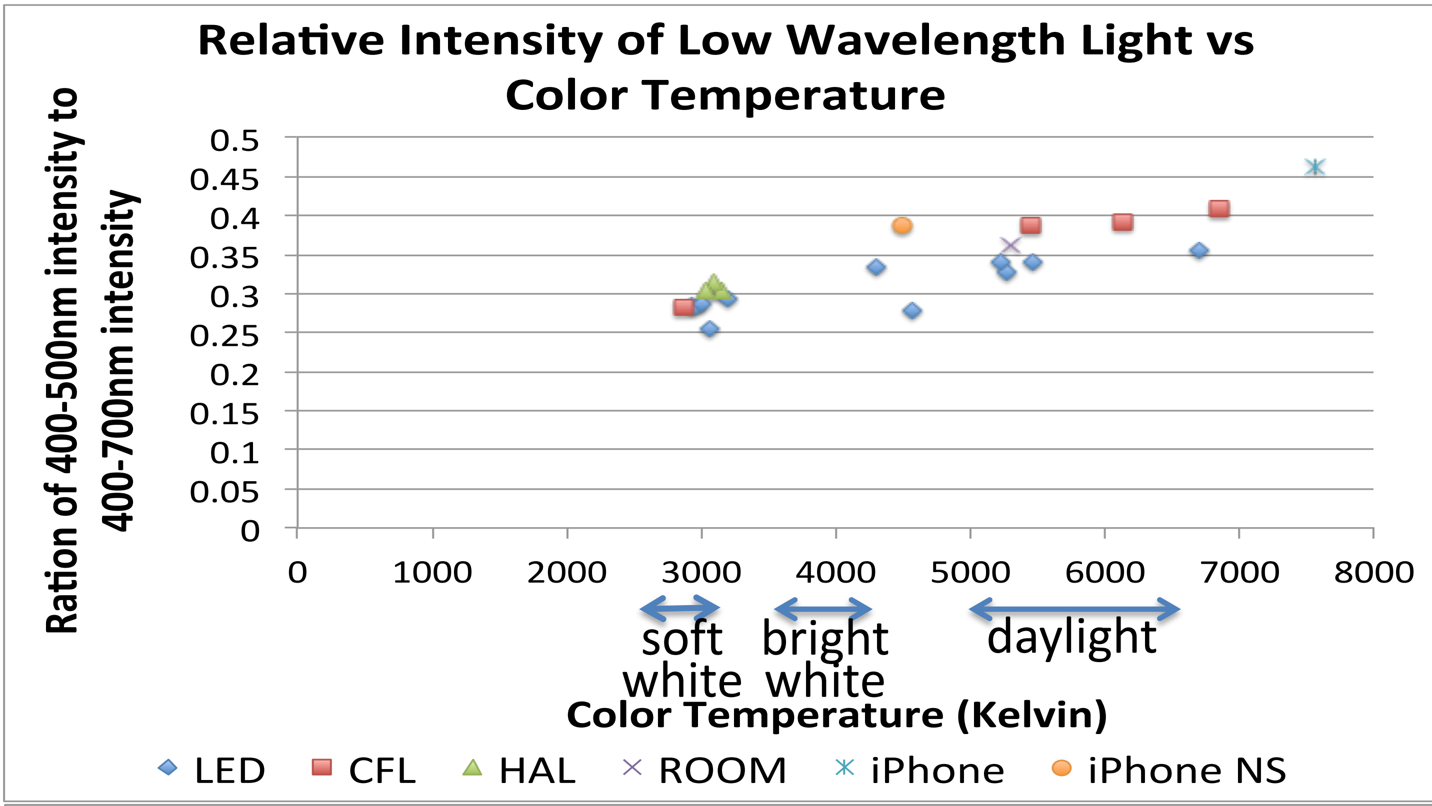
Left window

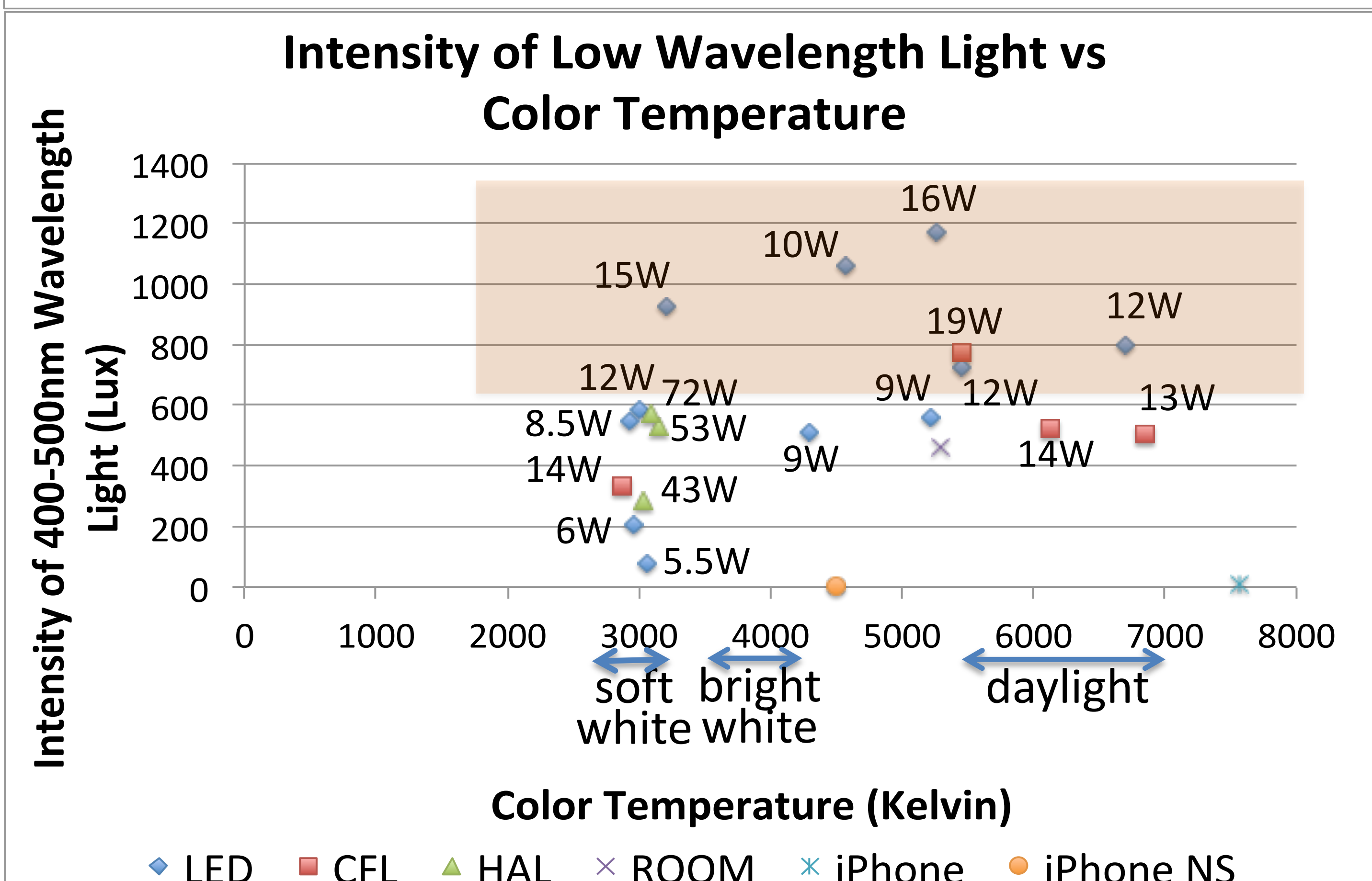
Right window

PROCEDURE

1. Prepare setup as shown in Figure and turn on light source
2. Measure color temperature using iPhone app
3. Align capture gridlines in RSpec software
4. Save visible spectrum intensity distribution as a file with a sequence of (wavelength, intensity in ADU) pairs
5. Measure overall light intensity with lux meter.
6. Repeat steps 3-5 for 3 trials
7. Repeat step 1-6 for each source and for the control, with light in a naturally well-lit room during daytime.
8. Calculate cumulative intensity in the low wavelength (400-500nm) range and that in the full spectrum (400-700nm) range using Python program
9. Calculate ratio of intensity of low wavelength light to that of the full spectrum, total amount of low wavelength light in lux, and total amount of low wavelength light per unit power in lux per watt using Excel

RESULTS





The daylight LED bulb at 16W, 5262K produces the highest intensity of low wavelength light

CONCLUSION

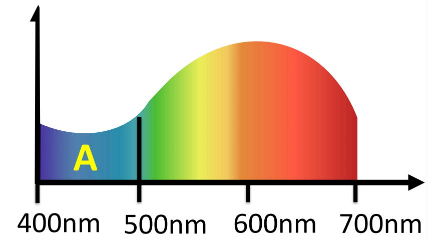
- Results show that hypothesis is correct

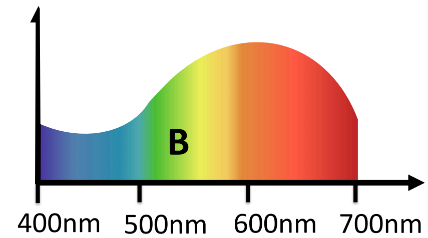
- Highest intensity low wavelength light produced by daylight (5262K) 16W LED bulb
    - LED bulbs > 8.5W produce more low wavelength light than natural light
- High power (> 14W) daylight (> 5000K) CFL bulbs produce more low wavelength light than natural light
- High efficiency LED bulbs produce higher low wavelength light per watt than CFL or halogen bulbs

- 9W LED @ 5225K close to natural light → Good for reading and indoor activities

DATA

- Total light intensity measured is TL
- Low λ ratio RL = A/B
- Low λ intensity LL = RL * TL
- Low λ per unit power, LLPW = LL/P





Light source type	Power P (Watts)	Color Temp (Kelvin)	Mean Ratio RL	Mean Intensity LL (Lux)	Mean per-watt Intensity LLPW (Lux per Watt)
CFL	13	6850	0.409	506.155	38.935
CFL	19	5450	0.388	773.546	40.713
CFL	14	2871	0.282	333.28	23.806
CFL	14	6128	0.391	522.59	37.328
Halogen	53	3155	0.304	527.465	9.952
Halogen	72	3090	0.316	575.371	7.991
Halogen	43	3032	0.304	287.598	6.688
LED	5.5	3065	0.256	74.658	13.574
LED	8.5	2934	0.284	546.685	64.316
LED	6	2954	0.282	203.621	33.937
LED	15	3202	0.293	925.356	61.69
LED	10	4572	0.279	1064.012	106.401
LED	9	4299	0.333	513.605	57.067
LED	12	5456	0.341	727.921	60.66
LED	12	6700	0.355	799.984	66.665
LED	16	5262	0.327	1172.285	73.268
LED	12	3001	0.288	586.11	48.843
LED	9	5225	0.341	560.737	62.304
Room	-	5292	0.36	459.902	-
iPhone	-	7559	0.462	9.184	-
iPhone NS	-	4497	0.388	6.703	-

MATERIALS

- Light sources
  - 3 halogen soft white bulbs
  - 4 spiral CFL soft white, bright white, or daylight type bulbs
  - 11 LED soft white, bright white, or daylight type bulbs
  - iPhone SE
- Bulb holder, and 110V electrical outlet
- RSpec Explorer spectrophotometer (used to split light to its spectrum) and software
- Leaton L830 lux meter to measure light intensity
- Lightspectrum Pro Iphone App to measure color temperature of light source
- Computer and Python program to calculate the cumulative intensity in the 400-500nm range (for low wavelength) and that in the 400-700nm range (for full visible spectrum) for each light source from the file saved from the RSpec spectrophotometer.

FUTURE RESEARCH

- Can be used to evaluate more light sources such as laptop screen and TV
- Can be extended to identify light sources good for growing certain plants

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