How Can We Fix Light Pollution?

How does light pollution affect the lives of Humans and Animals? How do our eyes

✰ *work?* ★

Hewanna Petros
Annie Gale Junior High School

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1.1 Abstract:

This topic is about how light pollution is spreading more and more each day and is affecting the lives of animals, plants, insects and people like their circadian rhythms. (Sleep is a very important thing for us to survive.) Light Pollution is the excess use of unnecessary man-made light sources especially at night hours. Since there is too much excess artificial light at night, dust, air molecules and water droplets reflect the light across the atmosphere causing a chain reaction and the sky to glow when it's supposed to be dark out also known as skyglow. I'm passionate about this project because I think it is important to know about what is happening around the world that's affecting many living creatures including ourselves. In conclusion, I chose this topic because this is happening right in front of my eyes and I'm finally finding out about it now which makes me proud to reveal the truth.

1.2. Why Does It *Matter*?

My project matters because I believe it's important to know how much light pollution actually has an effect on us and other creatures as well. This project also matters because if light pollution keeps increasing at this rate it eventually might not be redo-able. Imagine you ask your friend, “Let’s go stargazing,” but they reply, “What's a ***star?*** I’ve never seen one of them before.” In the future people might not even know what a star **is** or have ever seen one which is very upsetting to think about. In conclusion, at school we should educate children about how much waste they may actually be producing which includes using too much unnecessary light sources which this project mostly focuses on.

1.3 Aims & Objectives

This project aims to spread awareness about light pollution which is affecting everyone, even ourselves and we don’t realize it nor take it seriously. This project also aims to teach more people about the human eye and how that is also tied to light pollution as well. (the human eye is an important factor of your body) Since light pollution is undo-able that means we can fix it before it becomes an even bigger problem. We need to aim to do what we can to stop light pollution all together before it escalates even more. In conclusion, the aim and objective of this project is to reduce light pollution and educate others how we can reduce light pollution and one day stop it.

2.1 Method:

2.2 10 Guiding Questions:

1. Why Can’t We See The Stars Anymore?
2. What is Light Pollution?

~Why is Light Pollution A Problem?~ (Questions Below Answer)

3. How Does Light Pollution Affect Animals, Plants or Insects?

4. How Does Light Pollution Affect Humans? How Do Different Colors Affect Our sleep?

5. How Do We Distinguish Between Colors And Brightness?

6. How Can We See The Stars If They Are So Far Away? What Is A Light Year?

7. How Do We Know The Distance Between The Stars And The Earth?

8. How Does Temperature and Colors of Light Affect Light Pollution?

9. How Can Solar Power Help Fix Light Pollution?

10. How Can We Help Stop Light Pollution?

I separated my guiding questions into 3 parts, "What is Light Pollution? Why is Light Pollution a Problem? & How Can We Fix Light Pollution?" and from those 3 questions more questions sprung from the main 3. My first observation was, "There aren't a lot of stars in the sky like there used to." Which then went to a question, "Why aren't there a lot of stars in the sky anymore?"

2.3. Hypothesis:

Using more artificial light then we need will cause us to see less stars in the sky.

2.4. Sources:

I made sure to avoid unreliable websites like Wikipedia for sources because not all the information has been fact checked which will cause errors in my project.

3.1 Research:

3.2. Why Can't We See The Stars Like We Used To?

We aren't able to see the **stars** like we used to anymore. Over the past hundreds of years we haven't been able to see the stars like we used to because of artificial lights. Artificial lights are light that doesn't come from the Sun which are man-made, things like street lights/lamps, light bulbs, candles, oil lamps, etc. are all artificial light! The sky brightness is increasing from 7-10 percent more light every year and the stars are starting to disappear from our vision due to ***light pollution.***

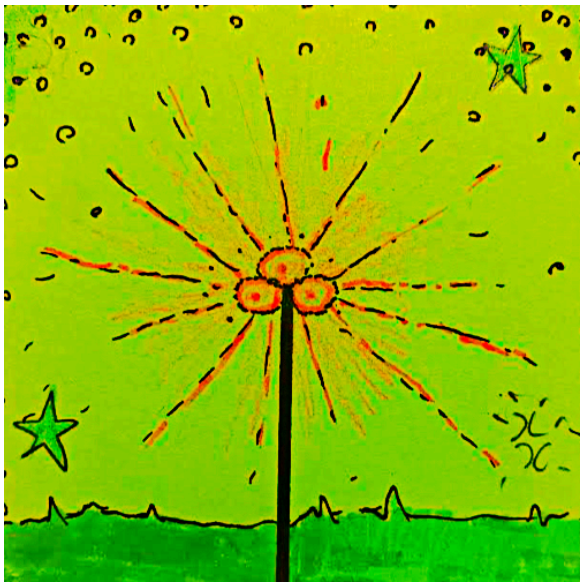


Image by Hewanna

The reason people do this is so we can see at night or they think that the brighter the area is the safer it is which isn't true. They like to light up their yard with lights so there is less criminal activity but when they leave the artificial light outside all night isn't a good thing. Imagine if lots of people do this, that will pollute the sky and there won't be any stars visible. This can also mess with the animals like their sleep cycle or moths who follow the moon light not being able to detect it and crash into the artificial light instead. It is also proven that more crime happens during the day hours/daytime than night.

3.3. What is *Light Pollution?*

First of all, what is light pollution? People mostly know about land pollution, water pollution and air pollution. We have to know that there's light pollution too! Light Pollution is the artificial light we use outside or inside, it affects animals, insects and humans. There are also four different types of Light Pollution:

Image by Hewanna

3.3.2. Skyglow:

is the combination of artificial light sources outside. When it is reflected into the sky it “glows.” That's a reason why we can’t see the stars like we could before anymore. A lot of things in the atmosphere like water and dust reflect the light all across the sky which causes a chain reaction of light making the sky glow brighter which isn’t a good thing.

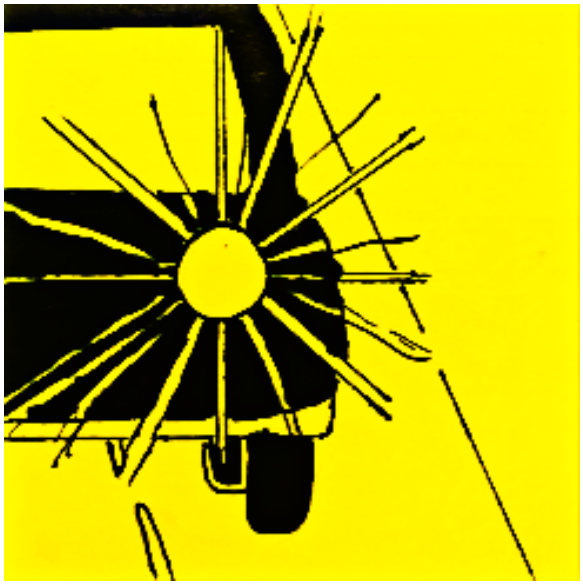


Image by Hewanna

3.3.3. Glare:

is very bright because it’s shining right in your eyes. It can bring discomfort or pain in your eyes too. This happens from reflections from the sun during day time like wet pavement, snow, ice or things that emit light at night time like headlights of cars at night.

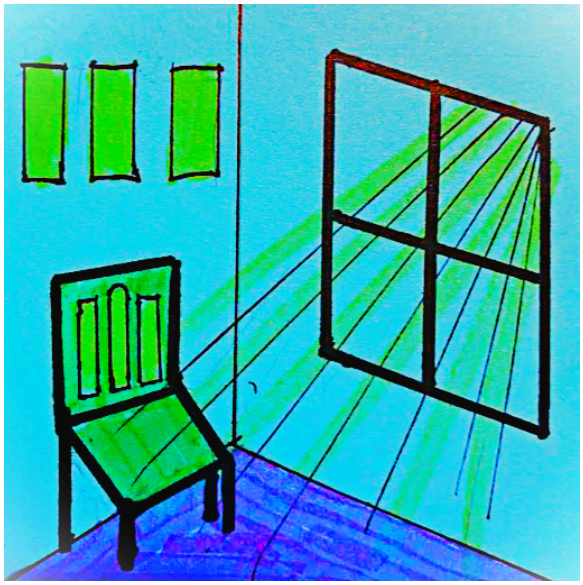


Image by Hewanna

3.3.4. Light trespass:

1. is when light is falling in a place it shouldn't be. For example if you are trying to sleep and a car's headlights peak inside your room or a street light doing the same thing.

Image by Hewanna

3.3.5. Light Clutter:

is when there are multiple bright light sources in different directions which can make you feel dizzy or confused. If there are some Street lights on the road without having any shields to make the light go downwards is an example of Light Clutter.

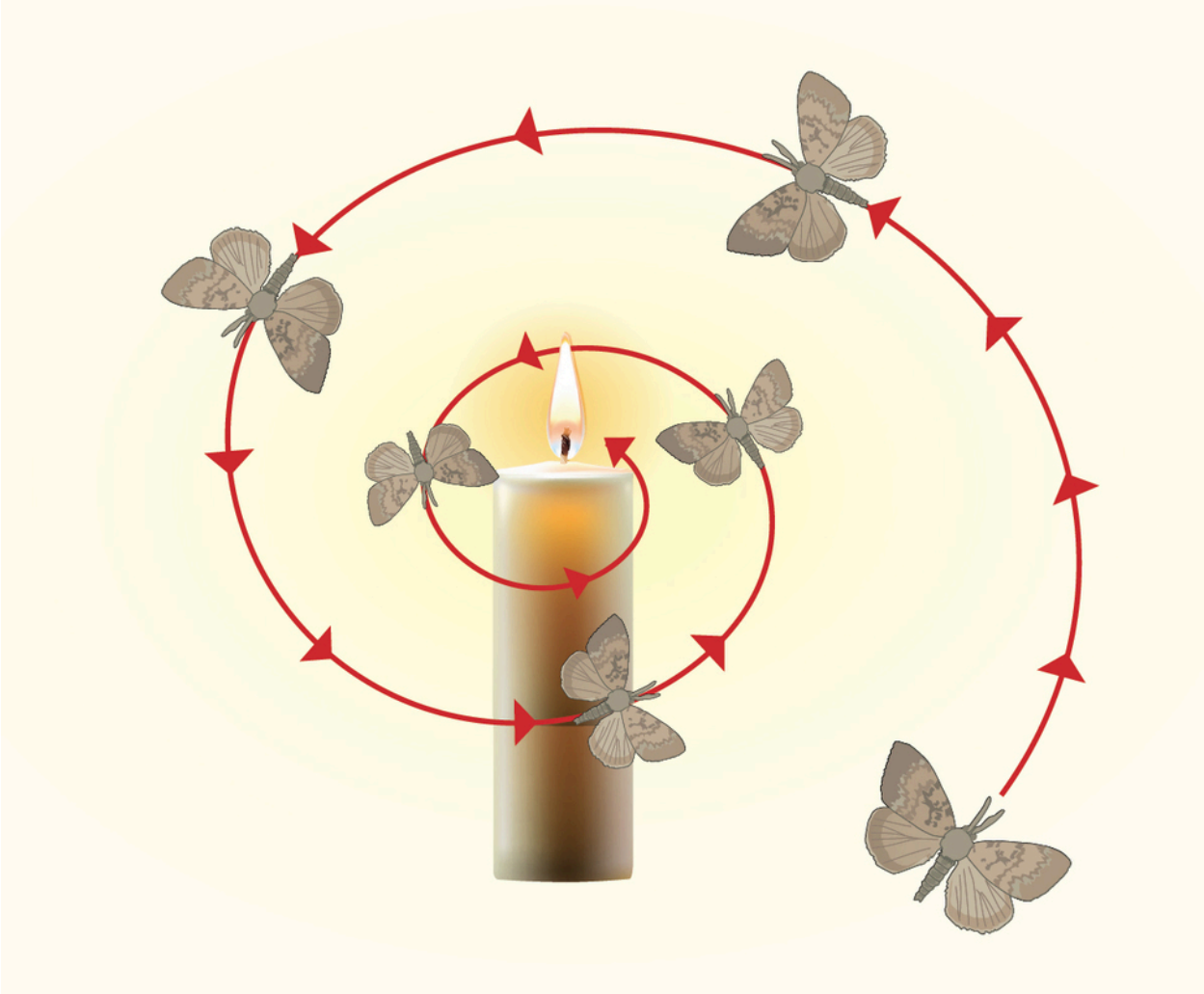
*Why is Light Pollution A **Problem?***

3.4. How Does Light Pollution Affect Animals, Plants and Insects?

Us Humans need to understand that we share this world with animals too and it's not just easy to close your blinds and turn off the light so it's dark so you can sleep. Animals rely on nature and if we are adding pollution that's interrupting these cycles then it is our own fault these things are happening to them. Light Pollution affects animals in many ways like attracting animals into the area in the first place. This can affect animals' sleep cycles, migration, hiding from predators, or when to hunt for food. Many birds that were migrating for the winter were heading south and since the sun is south the birds thought it was daytime and the Calgary tower is very bright and then several birds hit the Calgary tower window. Volunteers helped pick the birds from the ground. 107 animals in total hit the Calgary tower. 72 birds, 5 bats, and 35 feathers of other deceased birds. Only 19 out of 107 birds were alive but the other 88 birds passed away, 88 birds! All because of ***light pollution***.

Light Pollution also affects plants as well because plants need to prepare for winter. In the summer, the days are longer while the days in winter are shorter so when there is light pollution it tricks the plants into thinking the days are longer which is the same as summer so they keep their leaves and then they don't fall off when they are supposed to. This is a bad thing because if the leaves don't fall off during winter in time then the plant will be weaker and could die because of frost and the weather. It's like if a human were to go outside with summer clothing in winter. Same thing applies to plants except they don't have shelter like we do so they have to stay outside all the time. We share this world with many other creatures and we must acknowledge that.

Last, light pollution has an effect on insects like moths because the moon guides their way around at night but when they detect ultraviolet light they go straight towards it because how they find pollen on flowers is by detecting the ultraviolet rays from the pollen. Artificial light has UV rays (ultraviolet light) so it attracts the moth to go straight towards it. I observed moths go into my classroom and one of them tried to go into my room then hit the window but survived. That's why you should always close your curtains at night. The moth usually circles the light source over and over again but if it fails to go to the light source it will hit the window and fall or fly away if it doesn't take a hard hit. If there is a flame like a candle the moth will just circle the candle getting closer and closer instead of flying into the candle at an instant. Light is like a compass for the moth so light clutter can throw them off. So we should be more careful and aware about other species.

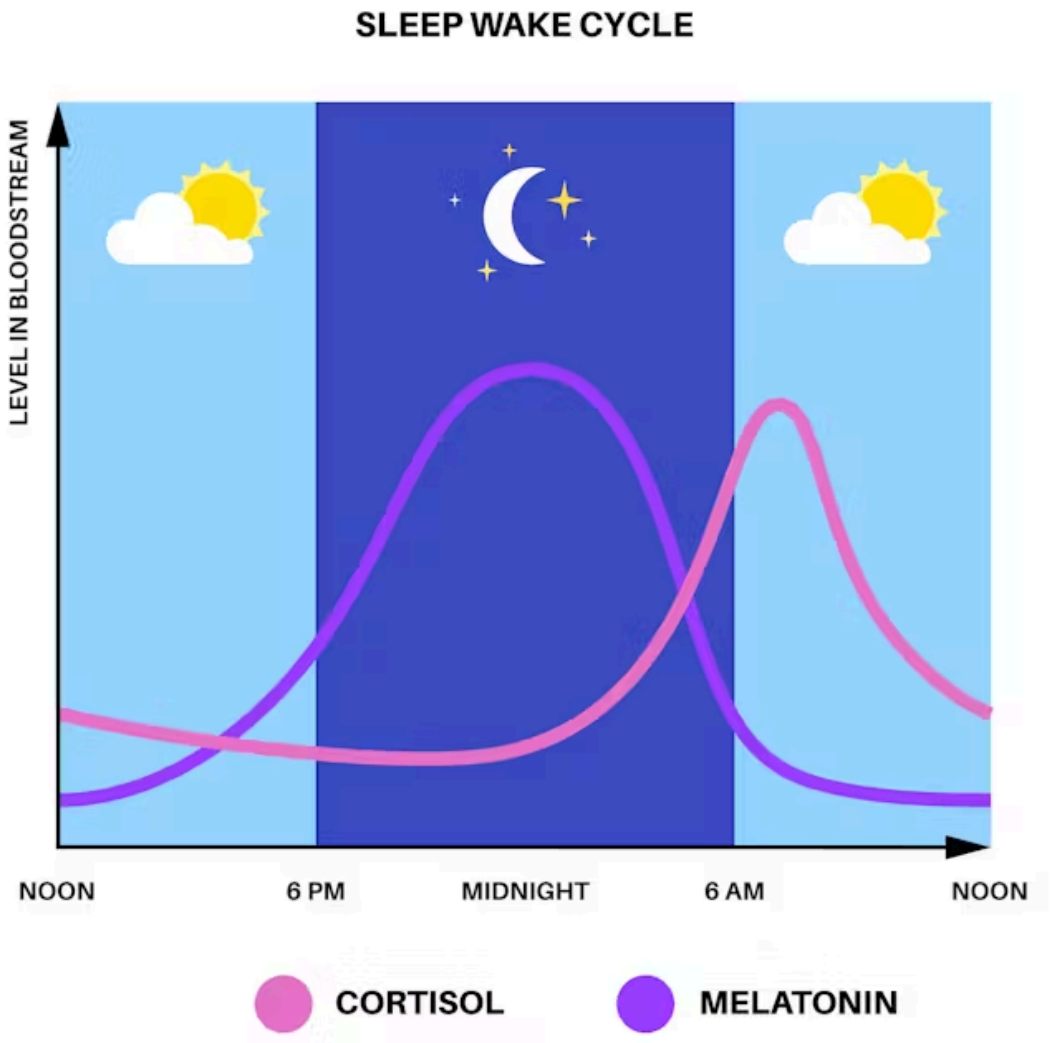


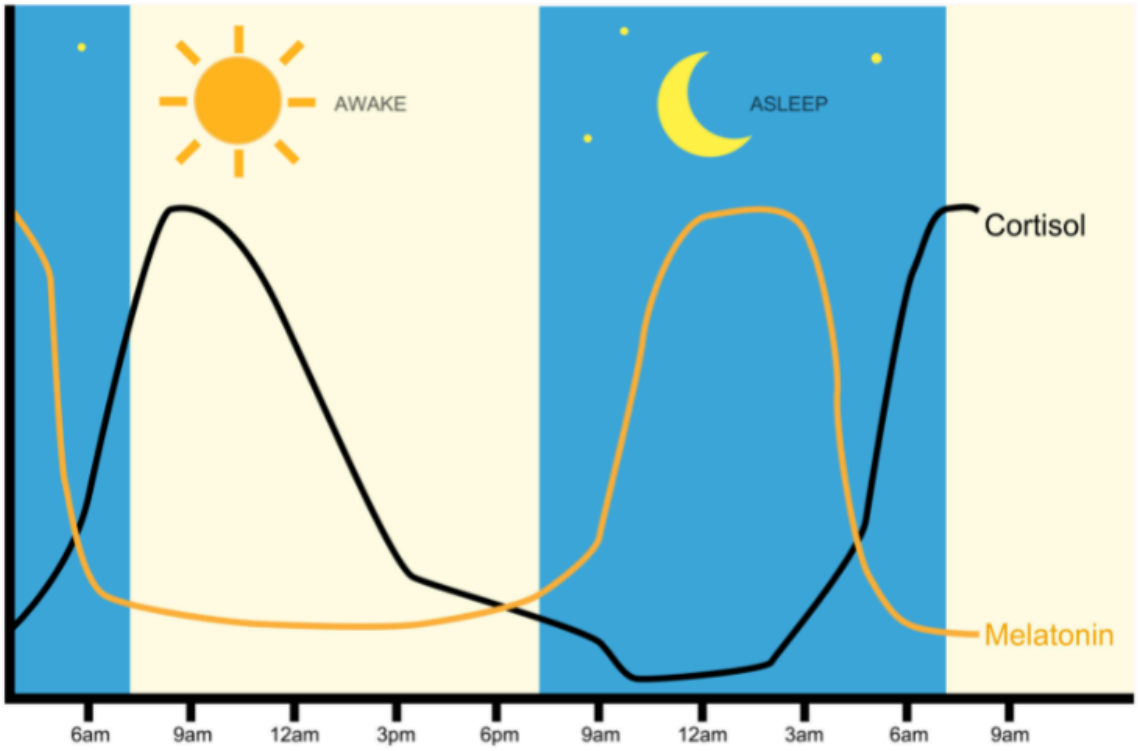
3.5. How Does Light Pollution Affect Humans? How Does Light Pollution Affect Your Sleep?

Now that we know how Light Pollution affects animals, plants and insects it also affects humans too. Sleep is one of the things that light Pollution affects the most because of how our body reacts to light when it’s time to sleep.

Light Pollution affects humans' sleep cycles as well because our bodies also have their own cycle so when the sun sets our bodies start to feel tired and need to go to sleep. The feeling of tiredness is from melatonin. Melatonin is a hormone that your brain creates to respond to darkness. Imagine your body is a 24 hour clock ticking and then when it

starts to get late your brain starts your sleep cycle.





Cortisol is a hormone also known as the “stress hormone” because it gives our body energy to fight different kinds of stresses such as high fevers/illness, injuries (depending on how bad the injury is) or if you are in a dangerous situation your body gives a “fight-or-flight” response also called **adrenaline.** In this situation this will signal your body to turn stored fat, protein, glaucous (sugar), and oxygen into energy. This process is called metabolism. Your brain signals your body to this to save you from a fatal situation.

Melatonin and cortisol have an opposite relationship so when melatonin is high, cortisol should be low and when melatonin is low cortisol should be high. When they are unbalanced, that's when your sleep is affected negatively and a reason why they can come unbalanced is because of light pollution. When you are exposed to light at night, your melatonin is supposed to be up but because of being exposed to light your melatonin will decrease instead along with the cortisol. This explains why light pollution is affecting our sleep negatively.

When we sleep we should sleep in a dark room but if there’s light then there should be warmer hues like red, orange, and yellow because when the sun sets those are the colors

of the sky. If you also think about wavelengths, red is the shortest wavelength which means it has the lowest frequency and it has the lowest energy. When you sleep it's good to use red light because it isn't very bright and it will increase melatonin levels. On the other hand there are many colors that can help or disrupt your sleep:

~Best Colors For Sleep~

Red Light:

Red light can actually improve your sleep because it doesn't affect your circadian rhythms. Circadian rhythms are your 24 hour internal clock and is when your brain responds to light changes around you. This affects your alertness and sleepiness. On the other hand, lighter red light isn't good for melatonin production.

Orange/Yellow Light:

Bright Orange and Yellow light are not the best for sleep but dim Orange and Yellow light may be able to increase melatonin production which is better the cooler colors of light.

~Worst Colors For Sleep~

Blue Light:

Cooler tones of light can reduce melatonin which will keep you awake for longer even before sleep. When our eyes respond to changes in light (circadian rhythms) that's usually when the sunsets at night. Sunsets are red, orange and yellow hues while in the day time the sky is cooler hues like blue which signals your body to wake up. So if you think about it, it's not a good idea to use blue light before or during sleep. Electronics emit blue light and as we know blue light is not good for your circadian rhythms.

Green Light:

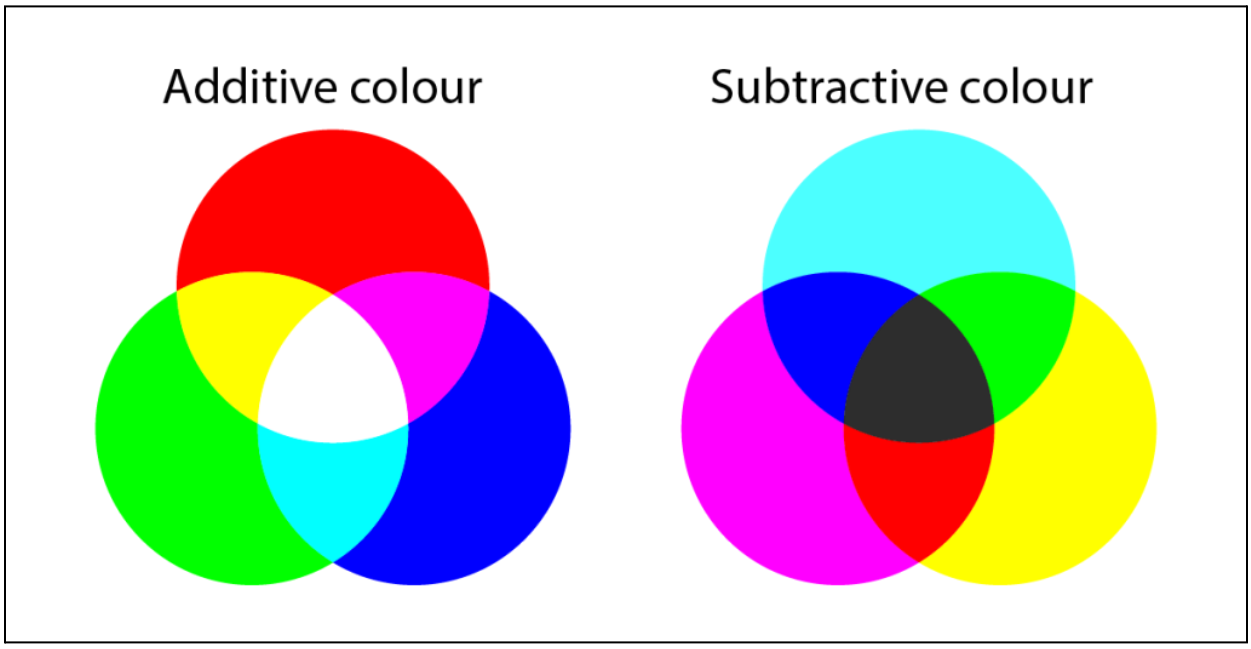
Green light is the brightest colored light and reduces melatonin so it will be harder to sleep with this light. Violet light has the highest frequency and is brighter than red light so others may think it's one of the brightest colors of light since red is one of the dimmer colors but that's not the case. Green light is actually brighter than Violet light because our eyes view the middle of the spectrum brighter than the outside colors like red and violet.

Connection:

A star at the beginning of it's life is white or blue with the most energy while when the star becomes red it's near the end of it's life with the least amount of energy. This can also show how we see light on the spectrum. (colors like red have the highest frequency and the least amount of energy while blue has the highest frequency and the most energy.)

3.6. How Do We Distinguish Between Colors And Brightness?

First of fall, different colors are part of two different color theories, additive and subtractive systems. Colors of light are part of the **additive color theory**. The additive color theory is when everytime you add color the hues end up becoming brighter, this is used for light. On the other hand, the subtractive color theory is when you add color but the hues become darker, this is used for inks and paints. CYMK (cyan, yellow, magenta & black) Is part of the subtractive color theory and printers use these colors.



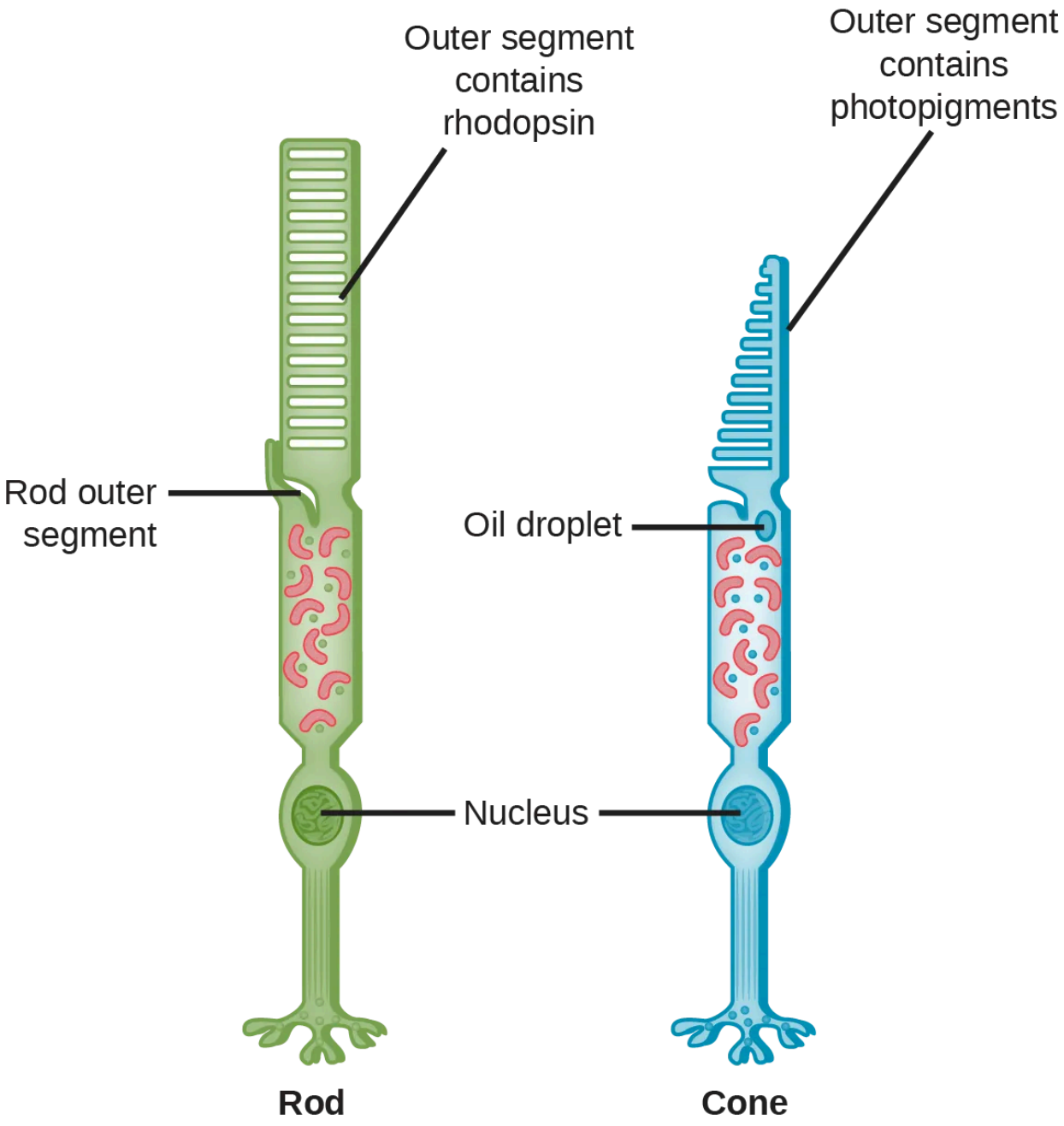
★ To determine whether a color is brighter or darker is through ***saturation***

★ To determine whether a shade is lighter or darker is through ***value***

★ To determine whether a color is maybe green, blue or in between is through **hue**

For example; let's say there are 3 colors. Light red, dark red, and pure red. Light red and dark red will never be as bright as pure red no matter what. Even though light red is lighter doesn't mean it's brighter.

How our eyes distinguish between colors is through our **cone** photoreceptors and how we distinguish between shades is through our **rods** both located in our **retina.** Our rods help us see in low light conditions because the reason we can see color is because different objects either absorb or reflect light into our retina in the back of our eye. So in the dark there isn't a lot of light so it's hard to see with our cones so we have rods to take over. Even so in the human eye our rods are still hard to see through so we created night vision goggles which makes us see green light. They chose to design the goggles this way because green is one of the brightest colors also making it the easiest to see.


Outer segment contains rhodopsin
Outer segment contains photopigments
Rod outer segment
Oil droplet
Nucleus
Rod
Cone

3.7. How Can We See The Stars If They Are So Far Away?

We are not seeing the star itself in the sky but the light of the star from ten thousands or hundred thousands of **light years ago.**

A ***light year*** is a unit of time of how far light travels in one Earth year.

Light is the fastest speed in the universe so it is a good unit of measurement. Since light travels very fast, when we see the light of the star from years ago we don't know what could have happened to it. For example; If I see a star tonight and see it again the next night we have no way of knowing if that was the same star from the night before which is truly **astonishing.** This means everytime we look at a star in the sky we are looking into the past because that light that enters our eyes is from centuries ago. This is the closest thing we'll ever have to time traveling because we are seeing that light from the past and will never know what happened to the star or if it stayed the same in the present.

3.8. How Do We Know The Distance Between The Stars And The Earth?

How astronomers figure out the distance between the Earth and the stars is using a thing called the ***parallax.*** Since they're measuring the distance between our Earth and stars we call it a ***stellar parallax.*** A parallax is viewing the same object or thing from different angles. For example; when you are in a car, things that are closer like trees or traffic signs move really fast but the things that are far away like the mountains or hills move much slower. Things that are in the sky like stars or the Moon don't really move as much. That's called the parallax. Astronomers also use the stellar parallax to measure the distance between the Earth and stars. A star that moves faster means that the star is closer to us while other stars that don't look like they are moving at all. All stars in space are always moving but for us it looks like they're not moving at all. That's called apparent motion when an object looks like it's moving but in reality it's an illusion.

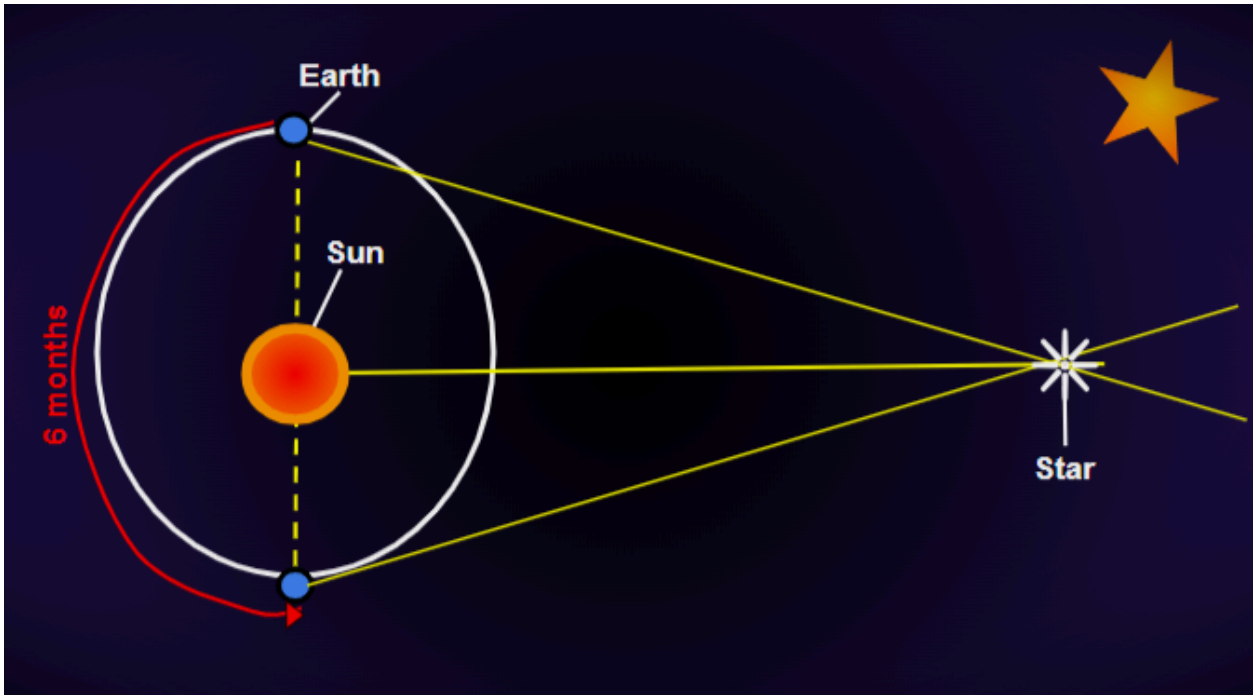


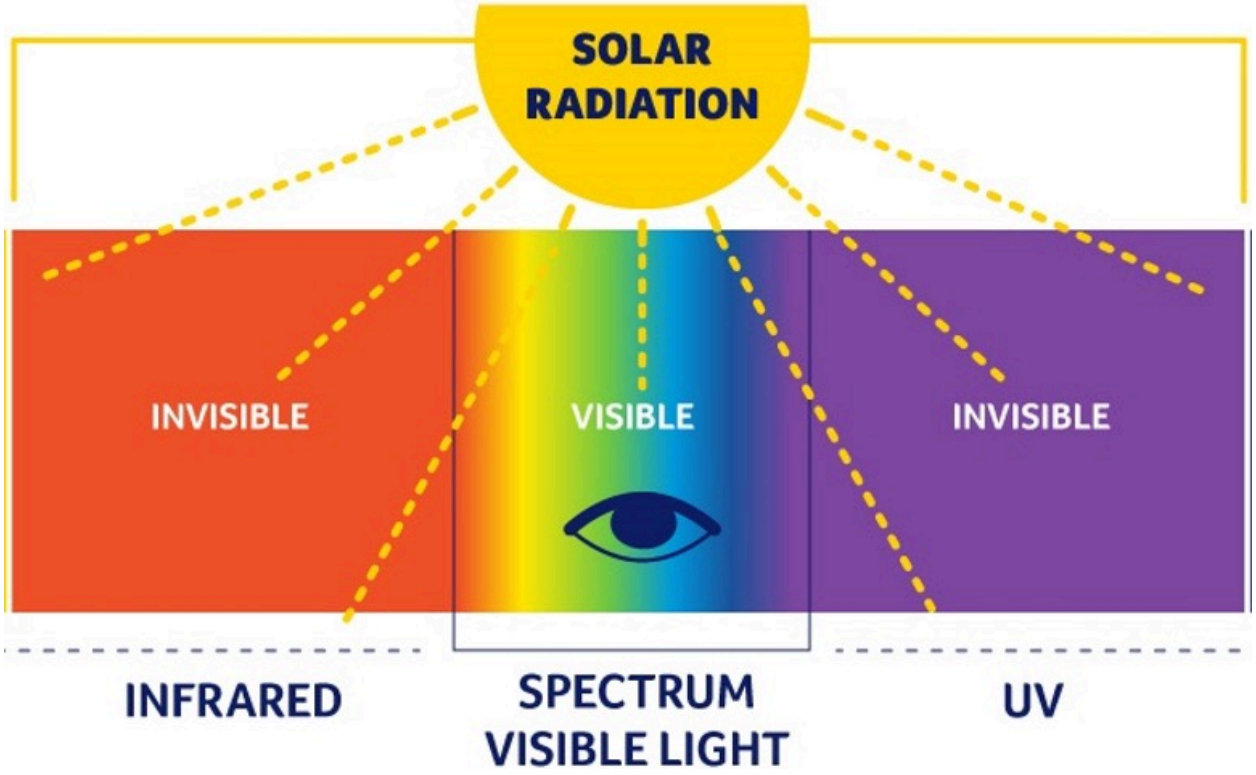
Image by Hewanna

3.9. How Does Temperature And Colors of Light Affect Light Pollution?

First, temperature affects wavelengths of light because the higher the temperature the faster the frequency of the wavelength which means hotter things have a shorter wavelength like Blue, warm objects have a medium wavelength like green, while colder things have a longer wavelength like red. After I researched this information I realized that isn't red suppose to be a hotter color and isn't blue is supposed to be a cooler color? Not in the case of light. We can use our sun as an example. The sun is our main light source and it has yellow hues because it is in the middle of its life span. On the other hand, newborn stars are blue then move on to blue-white and they are the hottest stars. When the stars are red they are at the end of their life span and emit the least amount of heat so they are the coldest stars. It also applies to flames of course. This shows that even though the red might look hotter than blue that is not the case for light. We grow up seeing things that are hot represented by warmer colors and things that are cold represented by cooler colors but now we know the truth. Overall, cooler temperatures of light and warmer hues of light like red will help to reduce light pollution.

3.10. How Can Solar Power Help Fix Light Pollution?

We have been producing light pollution for over dozens of years and it has become so much that we can now see the light from space too. Solar power was made to absorb light from the sun and turn that sunlight into electricity and energy. Now that there is light pollution it's enough for the solar power to absorb it but solar panels will not produce enough energy from artificial light as it would from sunlight. Sunlight has more energy than artificial light because artificial light only produces light from the spectrum of visible light which is the light we can see but sunlight produces two more different kinds of light called **infrared** light and **UV rays** (ultraviolet light).



Infrared light is energy we feel as heat. The human eye can only see between 380 and 700 nanometers which is the visual spectrum but anything below or above that is invisible to our eyes. Infrared light is over 700 nanometers so it isn't visible to the naked eye but we can feel the radiation (heat). Infrared is a longer wavelength with a low frequency and has red in its name giving a hint it's just above the red wavelength. On the

other hand, ultraviolet light is electromagnetic radiation that is invisible to the human eye and we can't feel it when it's present. UV rays are under 380 nanometers, having the highest frequency. That is also why it's called "Ultra-violet." We may not be able to see or feel ultraviolet light but we can see its effects. For example; you get a sunburn from UV rays which means you can feel it which isn't true. The truth is that you're already sunburned and you start to feel the effects. This means you couldn't feel the ultraviolet rays while it was taking effect on you until after.

Animals like snakes are able to see infrared light which helps them to find prey because of their body heat. The warmer the hues the warmer the temperature.

Many animals like birds or butterflies can detect UV rays. This can help birds find prey easier and find fruits because ultraviolet rays make things look brighter and more neon. This helps butterflies too because they use UV rays to detect nectar so this can help them know what flowers do and don't have nectar. The Uv spectrum of light is below our visible light spectrum so we will not know exactly how insects that pollinate see flowers because we can't see Ultraviolet light. Not everyone sees colors exactly the same which makes it hard to even know what another human is seeing.

Now that we know the difference between sunlight and artificial light, solar panels will not be charged up to its fullest with artificial light. It can work but it won't be enough. The people who designed these solar panels came up with a solution to use solar batteries that can one, save electricity from the day, and two use that extra energy at night, which solar power will only use when it’s necessary. This will help reduce the amount of light pollution significantly because this will stop the excess artificial light.

4.1 Application:

4.2. How Can We Help Fix Light Pollution?

You may think light pollution is undoable and we can't do anything to stop it, which isn't true. We are the reason there is light pollution in the first place is because we are using excess light we don't need. Things we can do to reduce light pollution are:

4.2.2. Using Less Electricity:

We can use less electricity by turning off light we aren't using in a different room for example and not leaving the Television on when no one is watching. Speaking of devices, blue light from your screens has more of an impact than a room light. What we can do to reduce that is when it's evening, switch your devices to night shift mode. Another way to use less electricity is if you have to leave a light on. You can use dimmer light bulbs in every room so it doesn't show a lot of light outdoors. Especially at night we should turn off all the lights because you don't need light when you're sleeping but if you want to have a night light make sure it's dim with a warmer hue. Not only does this reduce light pollution, it also reduces electricity bills.

4.2.3 Close Your Blinds!

At night to prevent even more light from leaking outside we should close out blinds or drapes. Curtains aren't very good at preventing light from going outside so we should only use curtains in the summertime where the days are longer and more sunlight can come inside instead of outside. This will help us to save more electricity at night when it's summer because it is already bright outside. When the sun is out you can also use more solar power as well which will help reduce light pollution as well.

4.2.4. Avoid Driving At Night

A car's headlights are very bright and will definitely increase light pollution so try your best to avoid driving at night unless it's completely necessary. Try to avoid night shifts and do more of your work during the day. Not only is not driving at night safer, it can also reduce more car accidents as well!

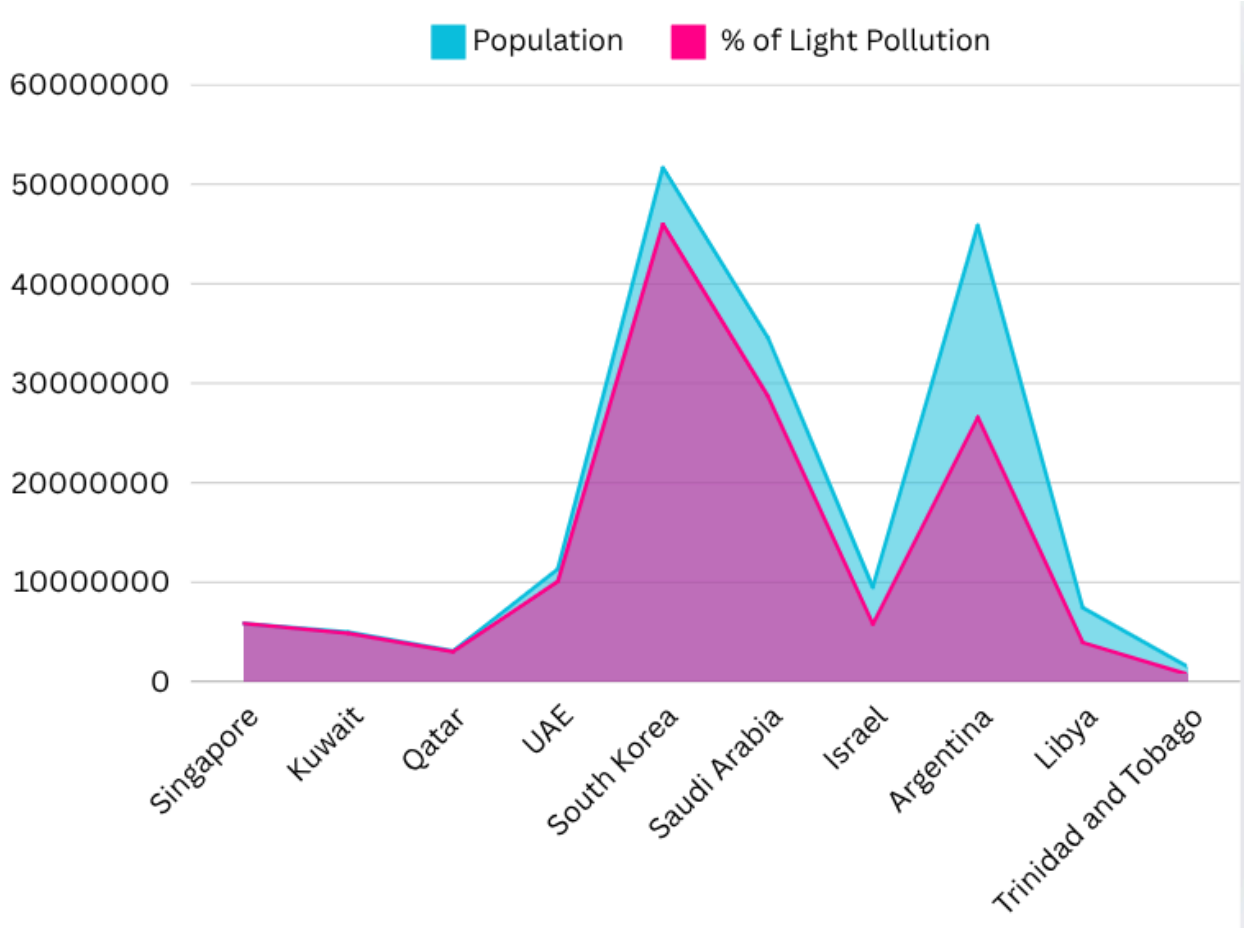
4.2.5. Point Your Lights Towards the Ground When Going Outside At Night

When you go outside using a flashlight or headlights to guide the way, try to direct the light towards the ground because you may think pointing a tiny ray of light upwards won't affect anything but many other people all around the world do it as well which will affect light pollution whether you like it or not.

4.2.6. Let Your Eyes Adjust to Less Light Instead of Turning on Lights:

After some research, your eyes are capable of adjusting to low-light or even no light conditions if you just give it a few minutes to adjust. This happens because the muscles in your iris called the *iris sphincter* are circular muscles that increase the size of the pupil in low-light conditions or decrease the size in light conditions.

5.1 Data/Analysis: (Left-Right Highest to Lowest)



Data/Analysis- How Much Light Pollution Do DIfferent Countries Have?

Country	Population	Amount Of Light Pollution
Singapore	5,870,750	100%
Kuwait	4,983,479	98%
Qatar	3,115,889	97%
United Arab Emirates	11,346,000	93%
South Korea	51,667,029	89%
Saudi Arabia	34,566,328	83%
Israel	9,517,181	61%
Argentina	45,851,378	58%
Libya	7,458,555	53%
Trinidad and Tobago	1,511,155	50%

5.2 Mathematical Explanation:

Step 1: Divide the numerator by the denominator x/y (Kuwait e.g. 4883809/4983479= 0.98) Make sure to round to the nearest whole if it is a long decimal. Then, multiply the answer by 100 to get the percentage (0.98 x 100= 98%)

6.1 Conclusion:

In conclusion my hypothesis was correct because even though we may need artificial light to illuminate dark places to help us see, work, etc. we use an excessive amount of it. This negatively affects the animals, plants, insects, environment around us, and ourselves too.

6.2. Affects animals because they rely on light patterns to migrate, sleep cycles, hiding from predators, or when to hunt for food.

6.3. Causes plants to bloom too early and can die from frost. Many insects rely on plants which affect them too.

6.4. Affects humans sleep cycles and causes them to have low amounts of melatonin at night.

Plants are the producers of the food chain and as the food chain goes up more and more animals and insects are affected. Without plants there would be no food. As the population increases, light pollution increases even more. Studies have shown that light pollution increases 7-10% per year. As the population increases the percentages will rise up more and more. Working together, we can reduce light pollution but only if everyone tries their hardest. There are many companies out there working to stop light pollution but they can't do it alone without *your* help.

To the world to know…

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