

CCDP 2100 X Team 8

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Green Roofs

Project Outline

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Section 1

A project outline table describing our project has been added for clarification [See Table 1]

Table 1 : Project Outline

Project topic: Green Roof		Peer mentor: Roya Missaghian	
Project Background: Problem or challenge: There is a lot of carbon dioxide in the air, and not much space to plant trees or have green spaces in cities with lots of buildings Proposed solution: Green roof that houses plants which take carbon dioxide out of the air and create a green space for people to enjoy Benefit of proposed solution to the environment: Green roofs provide many benefits to the environment. They can be used to extend the life expectancy of buildings, therefore reducing materials used. These roofs perform photosynthesis to reduce carbon dioxide in the air and limit greenhouse gases. Plants also have a natural cooling ability which would help lower the heat in urban areas. Client (Report of findings recipient): Melanie Abdelnour (Deep Blue Cleanup) Benefit of solution / research findings to client: Educate high school students on the benefits of green roofs			
Reference: https://www.nps.gov/tps/sustainability/new-technology/green-roofs/benefits.htm			
Team member	Sub-topic	Research question(s)	Engineering theory
Andrew Baker	Removal of Carbon Dioxide from air	How do the plants help reduce greenhouse gasses?	Photosynthesis
Joey Murphy	Waterproofing layer	How does the waterproofing layer work to ensure no water leaks through the roof?	Hydrophobia
Connor Kennedy	Roof life expectancy	How does having a green roof on a building extend the life expectancy of the roof?	Photooxidative degradation
Joshua Gatto	Reduction of Heat Island Effect	How does the green roof reduce the urban heat island effect?	Evapotranspiration

Section 2

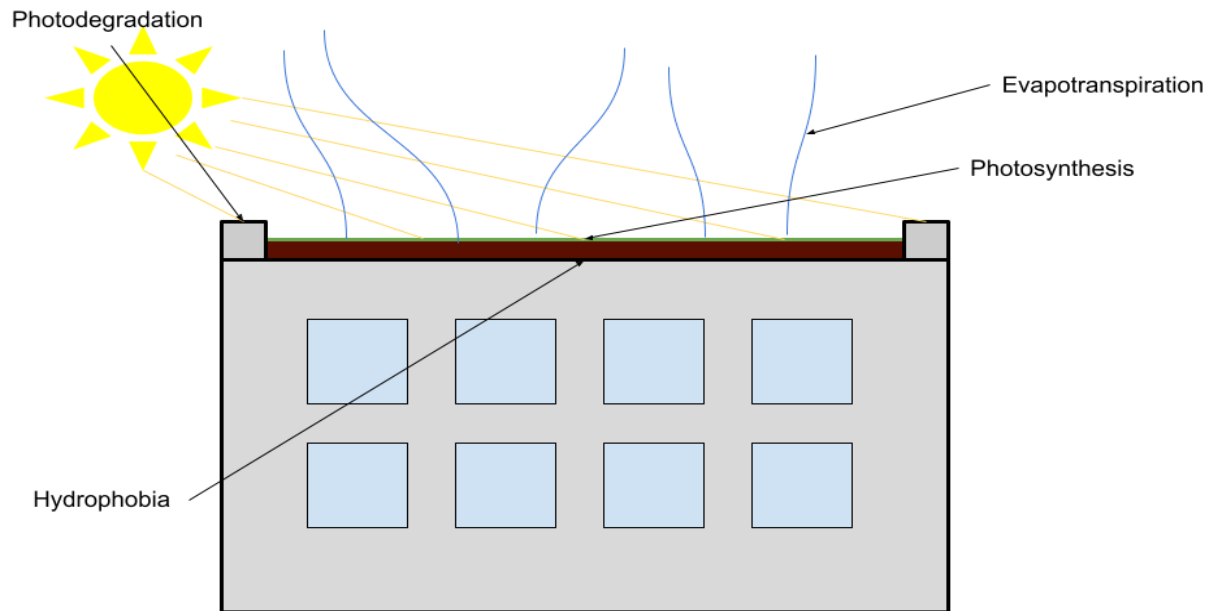


Figure 1: Green Roof System [Joshua Gatto]

Some of the processes that are covered in this outline are not visible to the naked eye. For that reason, certain processes have been drawn to be visible on the diagrams but do not reflect what a person would see in real life. In figure 1, the sun is shining down on the building. This is the cause for some aspects but a solution for others. For example, photodegradation is caused by the sun but is what allows for evapotranspiration and photosynthesis to occur. Finally, the hydrophobic layer on the bottom is a static process that is difficult to portray in a diagram.

Section 3

Photosynthesis - Andrew Baker

Engineering Theory

As time goes on the threat of greenhouse gases resulting in global warming gets more and more prominent. Carbon Dioxide (CO₂) makes up 81% of all greenhouse gas emissions [1]. The plant life on a green roof, within a city can be used as a system to help reduce greenhouse gases and fight against global warming by undergoing the process of photosynthesis, seen below in Figure 2. Photosynthesis is the process every plant undergoes to create their own food source to survive. In order for any plant to survive it has to take in CO₂ [2]. CO₂ being one of the most prominent greenhouse gases causes harm on earth's atmosphere, resulting in global warming [1]. With the consumption of CO₂, it has an indirect cooling effect on earth [3]. When in densely populated areas with little green spaces within, the CO₂ level has to be greater than in the country. Green roofs will help the natural ability of reducing CO₂ within a city.

Photosynthesis is shown below in Figure 2.

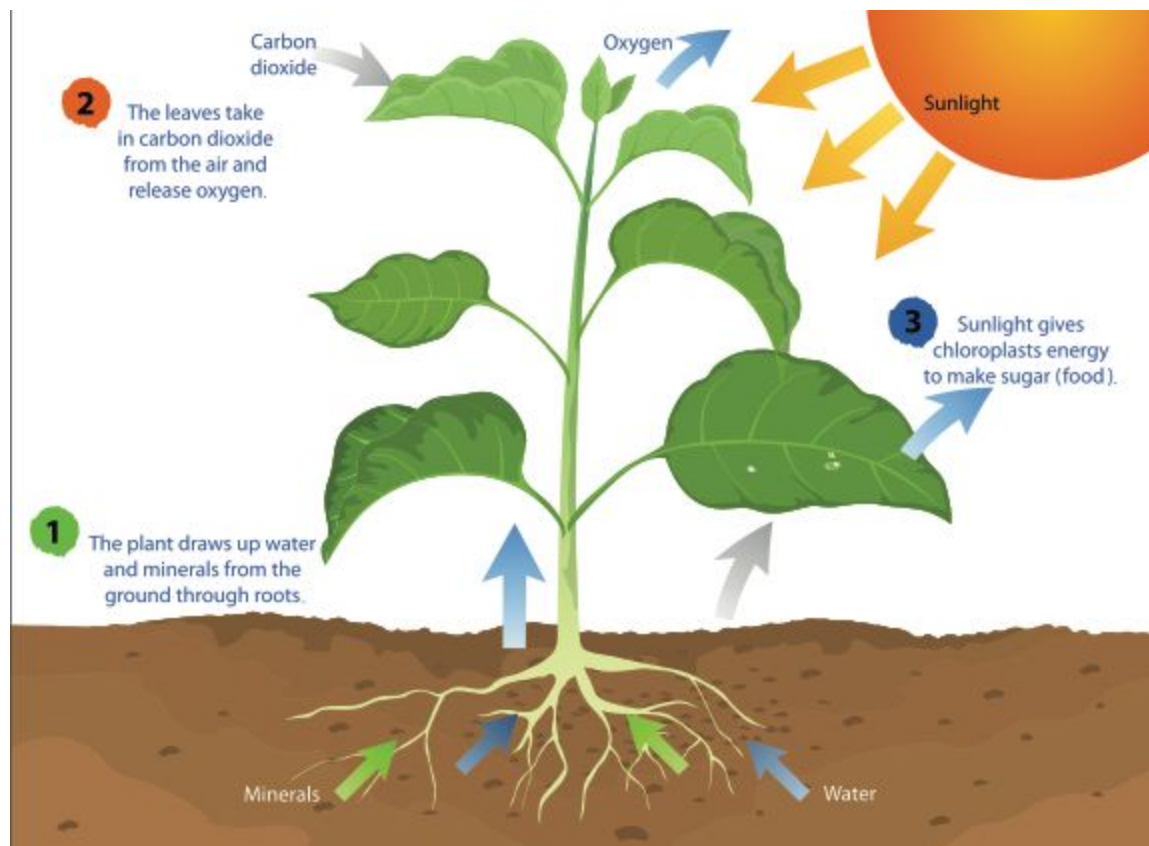


Figure 2: Process of photosynthesis [2]

The process of photosynthesis starts with the plant taking in water and minerals through the roots and absorbing carbon dioxide through its visible parts. The plant absorbs sunlight and releases oxygen into the air all while making food for itself [2]. When the plants take in carbon dioxide, they are helping combat global warming and the threat of greenhouse gases [1].

References

- [1] United States Environmental Protection Agency, “Overview of Greenhouse Gases” epa.gov [Online]. Available: <https://www.epa.gov/ghgemissions/overview-greenhouse-gases> [Accessed Jan. 27, 2021]
- [2] Smithsonian Science Education Center, “What is Photosynthesis” ssec.si.edu. [Online]. Available: <https://ssec.si.edu/stemvisions-blog/what-photosynthesis> [Accessed Jan. 25, 2021]
- [3] NASA Earth Observatory, ‘How Plants Can Change Our Climate’ earthobservatory.nasa.gov, may 6, 2002. [Online]. Available: <https://earthobservatory.nasa.gov/features/LAI/LAI2.php#:~:text=Plants%20consume%20carbon%20dioxide%E2%80%94a%20process%20similar%20to%20sweating>. [Accessed Jan. 25, 2021]

Potential Resources

technical Preservation Services, “Green roofs” nps.gov [Online] Available: <https://www.nps.gov/tps/sustainability/new-technology/green-roofs/benefits.htm> [Accessed Jan. 25, 2021]

- Plants for Green Roofs
- Green Roof Benefits

Annals of Agrarian Science, “Climate Changes and Photosynthesis” sciencedirect.com [Online] Available: <https://www.sciencedirect.com/science/article/pii/S1512188716300215> [Accessed Jan. 25, 2021]

Hydrophobia - Joey Murphy

Engineering theory

While green roofs provide environmental benefits, they can cause some issues to the structure of a building if not dealt with[6]. With the presence of the plants and soil materials, a buildup of water compared to a regular roof is more likely. A waterproofing layer is designed to incorporate these large amounts of water that build up in the soil of the green roof to prevent leaking[7].

When water leaks into the building structure, it can cause substantial damage to multiple elements[6]. Due to the possibility of leaking, this waterproofing design is based around the theory of hydrophobia. The properties of specific materials and how they react when in contact with water is due to the theory of hydrophobicity and hydrophilicity [See Figure 3 below]. This provides an explanation of how the waterproofing layer will protect the building by keeping water out, and the theory behind the use of a waterproofing layer to prevent leaking.

The leaf below is demonstrating hydrophobic properties similar to that of a layer of material used to create a waterproof seal on a green roof. The water forms droplets on top of the surface and is not absorbed by the leaf.



Figure 3 : Hydrophobic Properties [4]

References

- [4] H.Knight, “Superhydrophobic coating is non-toxic and economical to produce”, *theengineer.co.uk*, Dec. 16, 2015. [Online]. Available: <https://www.theengineer.co.uk/superhydrophobic-coating-is-non-toxic-and-economical-to-produce/> [Accessed Jan 24,2021]
- [5] D. Chandler, “Explained: Hydrophobic and Hydrophilic”, *news.mit.edu*, July 16, 2013 [Online]. Available: <https://news.mit.edu/2013/hydrophobic-and-hydrophilic-explained-0716> [Accessed Jan. 24, 2021]
- [6] C. Deziel, “What are the dangers of a leaky roof?”, *homeguides.sfgate.com*, [Online]. Available: <https://homeguides.sfgate.com/dangers-leaky-roof-89489.htm> [Accessed Jan 27, 2021]
- [7] National Park Service, “Physical Impacts:Green Roofs” *National Park Service*. [Online]. Available: <https://www.nps.gov/tps/sustainability/new-technology/green-roofs/physical-impacts.htm> [Accessed Jan 26, 2021]

Potential Resources

D. Chandler, “Explained: Hydrophobic and Hydrophilic”, *news.mit.edu*, July 16, 2013 [Online]. Available: <https://news.mit.edu/2013/hydrophobic-and-hydrophilic-explained-0716> [Accessed Jan. 24, 2021]

- Detailed explanation of Hydrophobic properties
- How surfaces absorb or push away water molecules

ResinLibrary, “What makes a surface waterproof?”, *resinlibrary.com*, Mar. 23, 2020 [Online].

Available: <https://www.resinlibrary.com/articles/what-makes-a-surface-waterproof/> [Accessed Jan 24,2021]

- Hydrophobicity
- Surface texture
- Man made surfaces

Photooxidative Degradation - Connor Kennedy

Engineering theory

The UV rays that the sun emits can have negative effects on roofs by drying and breaking down the polymers in the roof [See Figure 4 below]. This process of UV light breaking down polymers is called photo-oxidative degradation [8]. It occurs when a polymer is exposed to oxygen and UV rays. The UV rays attack the polymers by evaporating the oils from inside causing them to become brittle and more susceptible to cracking. Since many commercial roofs are made from polymers, this can have devastating effects on them. Unlike regular polymers, plants utilize the UV rays to create energy/food through the process of photosynthesis. Plants are made of cellulose which is a polymer, but plants have developed chemical compounds that provide natural protection from photo-oxidative degradation [9]. With these natural defences, plants are certainly more resilient to photo-oxidative degradation than regular polymers.

The negative effects sunlight has on shingles is shown below in Figure 4.



Figure 4: Damage to shingles from Sun's rays [10]

References

- [8] Polymer Properties Database, “Photodegradation of Polymers” *polymerdatabase.com*. [Online]. Available: <http://polymerdatabase.com/polymer%20chemistry/Photo%20Oxidation.html>. [Accessed Jan. 21, 2021]
- [9] A, Coghlan., “Plants make their own sunscreen to block damaging rays” *NewScientist*, October 31, 2014. [Online]. Available: <https://www.newscientist.com/article/dn26485-plants-make-their-own-sunscreen-to-block-damaging-rays/#:~:text=Now%20we%20know%20how%20they,bulk%20of%20this%20UV%20protection>. [Accessed Jan. 21, 2021]
- [10] “Beat Your Roof’s Worst Three Enemies,” *bestlife52.com*, August 11, 2020. [Online]. Available: <https://bestlife52.com/home/shingles-flashing-ventilation/>. [Accessed Jan 24, 2021]

Potential Resources

Polymer Properties Database, “Photodegradation of Polymers” *polymerdatabase.com*. [Online]. Available: <http://polymerdatabase.com/polymer%20chemistry/Photo%20Oxidation.html>. [Accessed Jan. 21, 2021]

- General information about photodegradation and polymers
- Strong chemical explanation of polymers

R&H Roofing, “The Effects of UV Light On Commercial Roofs” *rhroofing.org*, January 17, 2020. [Online]. Available: <https://rhroofing.org/2020/01/the-effects-of-uv-light-on-commercial-roofs/#:~:text=Be%20it%20a%20cloudy%20day,back%20to%20its%20original%20state>. [Accessed Jan. 21, 2021]

- Risks UV light has on roofs

Evapotranspiration - Joshua Gatto

The urban heat island effect is the reason why it is considerably hotter in the city than rural areas.

Its causes range from pollution to the materials we choose to make things out of however, the solution is simple: Green roofs. So then, how do green roofs reduce the urban heat island effect?

Engineering Theory:

Figure 4 is a very simplified diagram of evapotranspiration. Evapotranspiration consists of 2 processes: evaporation and transpiration. Both parts are equally important as nearly half of all water in the atmosphere is transpired from plants. Almost everyone is familiar with evaporation, but transpiration is a new term to most. The cycle begins with rainfall and the plant absorbing the water. When the plant absorbs water, most of it is converted into 'sweat' through the process of transpiration. This releases moisture from the plant via the stoma, into the atmosphere where it will return to the water cycle. The implementation of green roofs could reduce temperatures in cities by as much as 5°F[11]. This factor alone could help reduce the heat island effect to a reasonable level as plants will transpire many times their weight in water[12]. While plants do make up a large portion of this cooling, regular evaporation helps keep temperatures down too. Any water not absorbed by the plants is evaporated into the atmosphere when the temperature permits. With both these factors in mind, green roofs could be a turning point of climate change in the future.

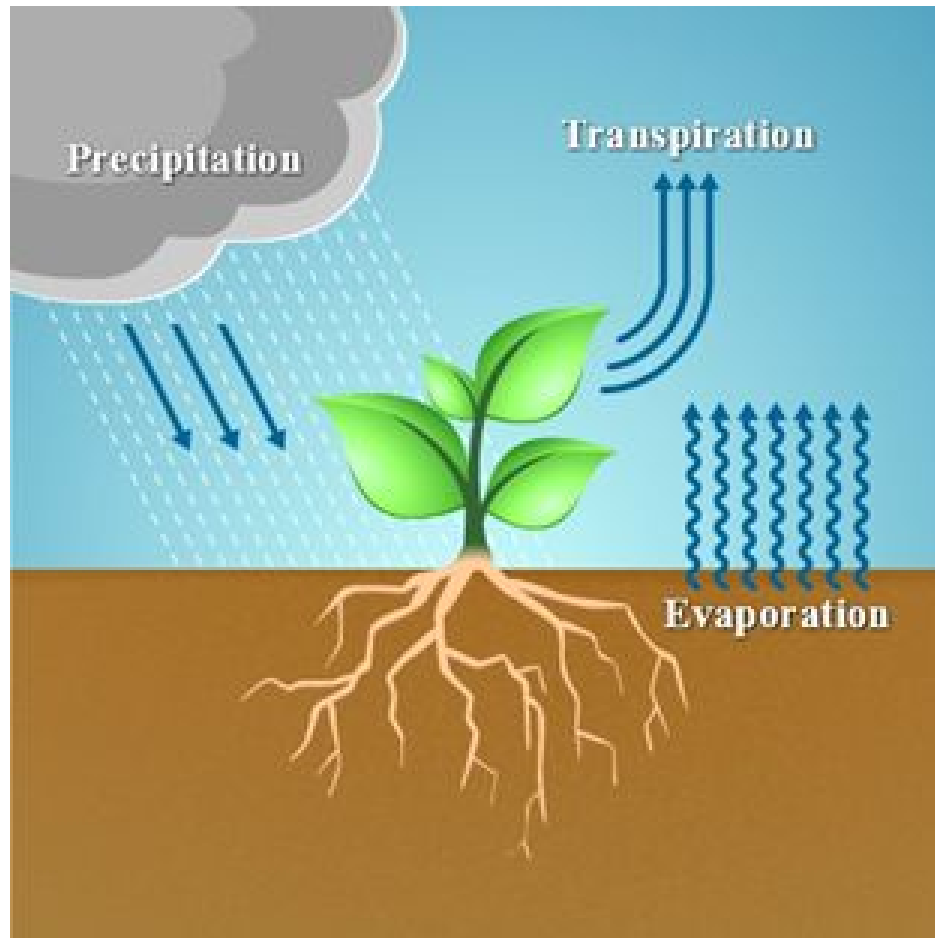


Figure 4: Evapotranspiration Cycle [12]

References:

- [11] “Using Green Roofs to Reduce Heat Islands,” *EPA*, 11-Jun-2019. [Online]. Available: <https://www.epa.gov/heatislands/using-green-roofs-reduce-heat-islands#:~:text=Gree n%20roof%20temperatures%20can%20be,up%20to%205%C2%B0F>. [Accessed: 26-Jan-2021].

Statistics about reduced temperature effect

- [12] M. E. Jensen and R. G. Allen, *Evaporation, evapotranspiration, and irrigation water requirements*. Reston, Virginia: American Society of Civil Engineers, 2016.

Fun, fast facts to get ideas

<https://support.spruceirrigation.com/wp-content/uploads/2019/04/evapotranspiration.jpg>

Potential References:

Evapotranspiration and the Water Cycle. [Online]. Available:

https://www.usgs.gov/special-topic/water-science-school/science/evapotranspiration-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects. [Accessed: 26-Jan-2021].

In depth analysis on the science behind the theory

Z. Samani, “Evaporation, Evapotranspiration, and Irrigation Water Requirement. Manual 70. 2nd edition,” Oct. 27 2016

Regarded as one of the better sources to learn about evapotranspiration.