

SCIENCE FAIR CENTRAL

Maker Corner Activity



BUILDING A GREEN ROOF

Grade Level: High School

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Is there a natural solution to help keep our cities cool?

Overview

Students will learn about urban heat islands and how heat islands can be mitigated through the creation of green spaces on the rooftop of buildings in a city. Student groups will each construct a simple model building out of foam board or cardboard. They will then conduct research to discover what aspects they should add to their roof to decrease the ambient and inside temperature when their building is placed under a heat lamp. They will be able to add colored paint, gravel, various types of plants, grasses, mosses, or materials that can act as insulation. Student groups will compare their designs and the change in temperature when all groups have finished their designs.

Have you ever wondered...

As we continue to face rising temperatures across the globe, how are urban areas that are filled with buildings, asphalt, concrete, and other heat-absorbing substances affected? Is there a natural solution to help keep our cities cool? In this activity you will learn how a little bit of nature goes a long way when the boring roofs of buildings in large cities are transformed into vibrant green spaces that help to lower the air temperature, provide food and habitat for living things, and give people something much better to look at than a concrete jungle.

This activity focuses on the “**Designing Solutions**” and “**Creating or Prototyping**” stages of the Engineering Design Cycle.

Engineering Design Cycle

- Defining the Problem
- **Designing Solutions**
- **Creating or Prototyping**
- Refine or Improve
- Communicating Results

Objectives

Students will be able to:

Discover what heat islands are and how climbing urban temperatures can be mitigated naturally by plants through the creation of green roofs on homes and buildings in cities.

Design a green roof that will use natural materials to mitigate the effects of urban heat islands.

Measure how well their green roof reduces temperatures in a model building and compare the design with others.



Materials

- green roof design plan sheet—1 per small student group
- small or medium sized [cardboard moving box](#)—1 per small student group
- [packing tape](#)
- [duct tape](#)
- [box cutter or utility knife](#)
- [egg crate foam](#)
- [gravel](#)
- [hot glue sticks](#)
- [hot glue guns](#)
- [spray paint](#)
- [potting soil](#)
- [moss](#)
- various small types of [plants and succulents](#)
- [grill thermometer](#)
- [heat lamp](#)
- [heat bulb](#)



Make connections!

How does this connect to students?

While many young people dream of entering the field of architecture or engineering someday, they may not know that these jobs can be done with conservation and sustainability in mind! Green roofs can provide not only aesthetic benefits and green spaces for people in crowded, urban areas, but can also help to combat environmental problems we face such as climate change.

How does this connect to careers?

Landscape Architects work with the human-made and natural environment to create wildlife habitats, innovative spaces, and install sustainable infrastructure in communities. They plan, design and project manage for public and private spaces.

Urban planners create land use plans for cities, and are increasingly involved in the implementation of sustainable infrastructure projects. These projects may include designing parks, greenways, and rain gardens in urban areas.

Horticulturist work with plants, applying their knowledge to fruits, vegetables, ornamentals, and non-food crops to maximize their health or growth.

How does this connect to our world?

As our world faces a changing climate, it is important that we look for innovative solutions as we design and build the buildings, transportation, and products that we depend on and use every day. Sometimes the best solutions to our problems already exist, as we see in the implementation of green roofs in major cities. Bringing plants and green spaces to the rooftops in urban areas has helped to cool the air and keep temperatures down inside buildings by providing insulation.



Blueprint for Discovery

Prior to the Activity:

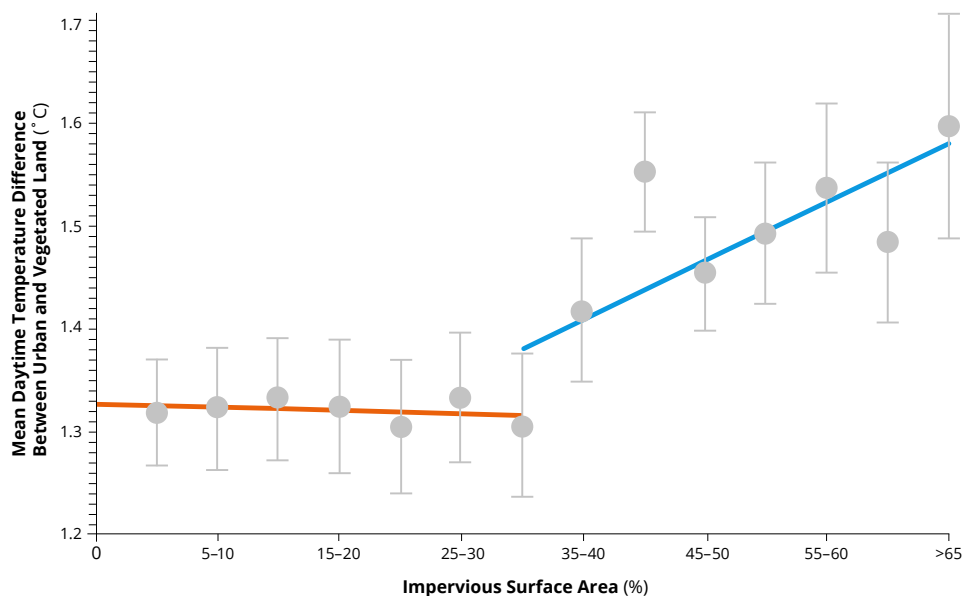
- Before the activity, the instructor should assemble and tape the model buildings (1 per group of students) using cardboard packing boxes and packing tape or duct tape to hold the top, bottom, and sides of the building together. A small hole should be made in the middle of one side of the box that will allow a grill thermometer probe to be inserted inside to measure temperature.

Whole Group Activity

1. Open the lesson by displaying the map of the United States linked below to the class and explain that the red areas of the map show higher temperatures than the surrounding area. Ask students to share any observations they have made from this data (they should realize that the areas that are darker on the map are major cities or large areas of urban development).

Link to map: https://eoimages.gsfc.nasa.gov/images/imagerecords/86000/86440/isatemps_gis_2001_lrg.png

2. Next, ask students to brainstorm with the person beside them why they think urban areas are typically warmer than areas with land that is less developed. Give students the chance to share their ideas with the class.
3. Explain to students that the increase in temperatures is caused by something called the **urban heat island effect**. This means that the asphalt, concrete, stone, and steel that are found in cities absorb heat more readily than vegetation, as well as disrupting natural cooling that plants provide to an area. Display the graph below from NASA that shows how the temperature increases as the amount of impervious surface area (i.e. concrete, asphalt) increases.



4. Ask students if they have ever heard of a **green roof** and if so, what they think the benefits of a green roof might be.
5. Show students the following video that introduces them to one of the largest green roofs in New York City and all the benefits that have come from it: <https://www.youtube.com/watch?v=FlJoBhLnqko>
6. After watching the video, ask students to share some of the benefits and design of green roofs that they noticed in the video. Which of these benefits are related to urban heat island mitigation?

Small Group Activity

7. Explain to students that in this small group activity, they will be designing and building a model green roof with the primary goal of lowering the temperature inside a model cardboard building, as well as in the surrounding air by making smart design choices.
8. In their **Green Roof Design Plan** sheet, ask students to list factors that a green roof should or might have to help lower the air temperature by absorbing less heat.

Questions to think about may include: what building materials are good insulators? does color matter? what types of plants should be used? how will you ensure that rainwater can drain off of a roof?

*They should also add any additional benefits of their green roof design, such as habitat for wildlife or aesthetic benefits to their **Green Roof Design Plan**.

9. Give each student group their model building, a heat lamp, and a thermometer, and give them access to the materials that are available for them to use in the build of their model green roof. They may take some time to test how materials absorb heat from the heat lamp as they continue in their design. Finally, a simple sketch of their green roof design should be created before they can build their model green roof.
10. Once all groups are done with their design, they will each take an initial temperature of their model house without the green roof. This should be done in a way that can be repeated once the green roof is added to the model house, this way the students can compare their data. (To take the temperature inside the model building, students should heat the house from above for a designated amount of time, and then insert the thermometer into the thermometer hole in the side of the box. They should also use a temperature gun to collect the outside air temperature close to the roof.)
11. After they have their initial data, each group should use the provided materials to create their green roof on their model house following the design in their **Green Roof Design Plan**.



12. Once their green roof is constructed, groups will repeat the temperature data collection by following the same procedure as they did for their initial temperature data. The group should analyze the data to determine if their green roof helped to lower the temperature in and around the building.
 13. Student groups can share their designs with each other or the whole class and discuss which elements of their design were more successful and how they might revise their design if they were to alter their green roof.
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Take action!

Now that students have learned about green roofs and their many benefits, they may want to explore how urban heat islands are related to the larger problem of climate change. Students can watch the following videos and read the following articles to learn more about the greater effects of climate change and what they can do to help slow this change down.

- How Will Climate Change Affect US Cities?
<https://www.youtube.com/watch?v=sWye0veuCtY>
- Climate Change Resilience: Cooling an Urban Heat Island
<https://www.youtube.com/watch?v=xri0kqT-HUM>
- What can we do to help? NASA Climate Kids
<https://climatekids.nasa.gov/how-to-help/>

Now that you've built a model green roof, maybe you can actually build one on your school or a building in the community? Want to build a green roof on a building near you? Check out these guidelines when planning a green roof!

http://www.greenroofguide.co.uk/media/en/applications/GRC_DIY_Guide_small.pdf



National Standards

Science

[Next Generation Science Standards](#)

HS-ESS3-1 Earth and Human Activity

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

Technology Education

[Next Generation Science Standards](#) and [International Technology and Engineering Educators Association](#)

Students will develop an understanding of Technology and Society. This includes learning about:

- The cultural, social, economic, and political effects of technology.
- The effects of technology on the environment.
- The role of society in the development and use of technology.
- The influence of technology on history.

Students will develop an understanding of the Designed World. This includes selecting and using:

- Agricultural and related biotechnologies.
- Energy and power technologies.
- Manufacturing technologies.

Mathematical Practice

[Common Core](#)

English Language Arts

[Common Core](#)



Links

- <https://climatekids.nasa.gov/heat-islands/>
- <https://www.epa.gov/heat-islands>
- <https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands>
- <https://www.go-gba.org/resources/green-building-methods/green-roofs/>
- <https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects>
- <https://www.environmentalscience.org/career/horticulturalist>
- <https://www.environmentalscience.org/career/landscape-architect>
- <https://www.environmentalscience.org/career/urban-planner>
- <http://www.greenroof.hrt.msu.edu/benefits/index.html>
- <http://www.greenroof.hrt.msu.edu/benefits/index.html>



Green Roof Design Plan Sheet

Part 1: Why a green roof?

Brainstorm: What are some of the benefits for a city that come with the installation of a green roof?

Write down your initial ideas here.

Now place your group's ideas about the benefits of a green roof into the following categories:

Ways They Reduce Heat Islands	Benefits For Wildlife	Benefits for Humans	Other Benefits

Part II: Background Information/Research

Research: What is important to know in the design of a green roof?

Conduct research to determine the things that are important to know when building a green roof. List them here:

Now, take a look at the materials that your group has been provided with to create your green roof.



Green Roof Design Plan Sheet

In the chart below, list what each of these materials you may want to use and why:

Material	Reason For Using This Material

Part III: Design Sketch

In the space below, create a simple sketch of how you will build your green roof using the materials provided. Make sure to label each part of your green roof!

