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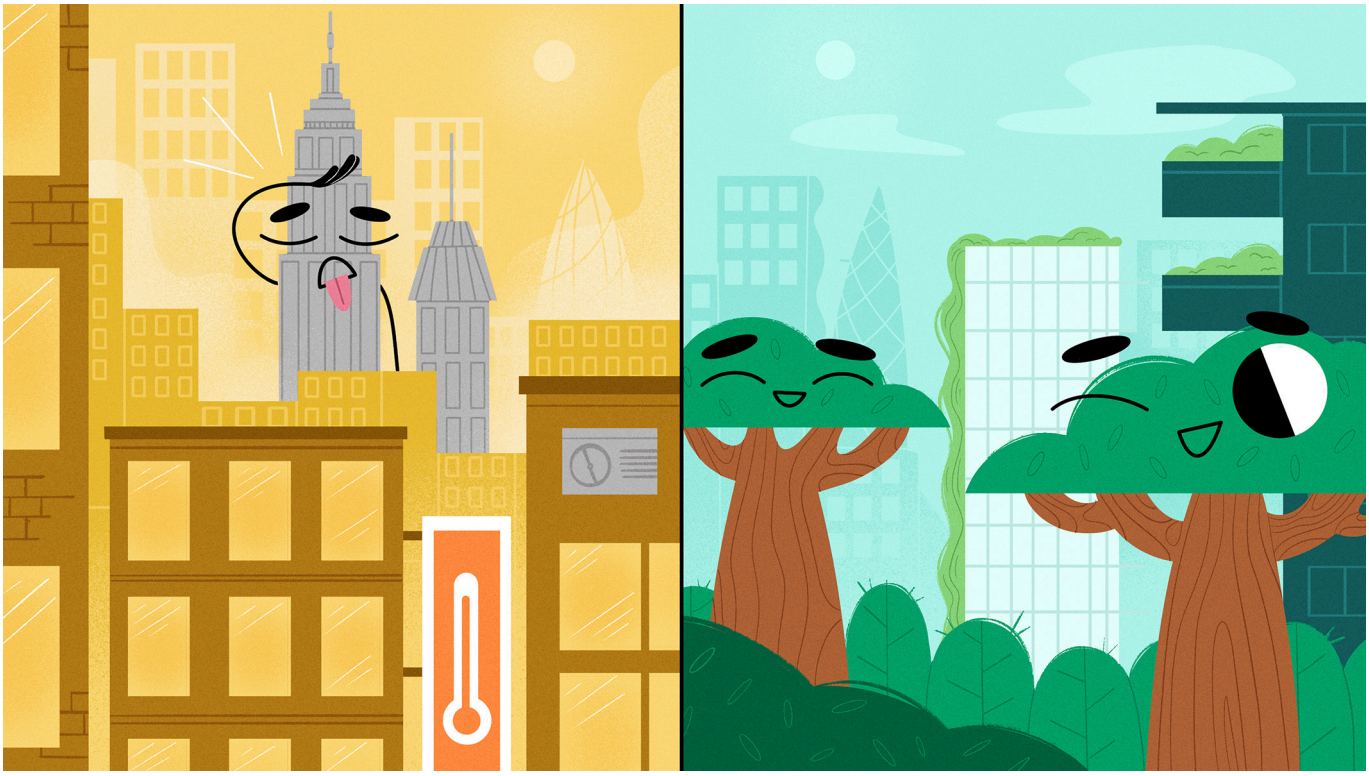

HOW CAN WE COOL WARMING CITIES USING NATURE-BASED SOLUTIONS?

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YOUNG REVIEWERS:

BENJAMIN
AGE: 11

CELINE
AGE: 14

If you live in a rural area and drive into a nearby city or vice versa, you may feel a temperature difference between the city and the countryside. Rural areas are usually cooler, while cities can be much warmer than surrounding areas. This temperature difference is called the urban heat island effect. This effect occurs for several reasons, including the types of materials used to build cities and their lack of vegetation and natural spaces. The urban heat island effect affects human health and a city's economy and can harm Earth's environment. Fortunately, there are many solutions to tackle urban heat islands—and some of those solutions are based on nature.

CAUSES OF URBAN HEAT ISLANDS

What do you picture when you imagine a large city? You might think of skyscrapers built close together, dark brick buildings, asphalt and concrete roads and bridges, and only a few trees (Figure 1A). All these characteristics of a city lead to an **urban heat island**—a phenomenon in which a city has a higher temperature than its nearby rural areas. There are three main causes of urban heat islands, which we will discuss in the next sections.

URBAN HEAT ISLAND

A phenomenon in which a city has a higher temperature than its nearby rural areas.

Figure 1

(A) Differences between a rural area and a city. **(B)** Surfaces like asphalt, brick, light soil, water, and snow reflect different amounts of sunlight. The amount of light a surface reflects is its albedo. **(C)** Evapotranspiration is the process through which water evaporates from plants (transpiration) and soil (evaporation). Cities have less vegetation, so there is less evapotranspiration, which means less cooling. **(D)** The urban canyon effect occurs when tall buildings block wind, reducing ventilation and trapping heat.

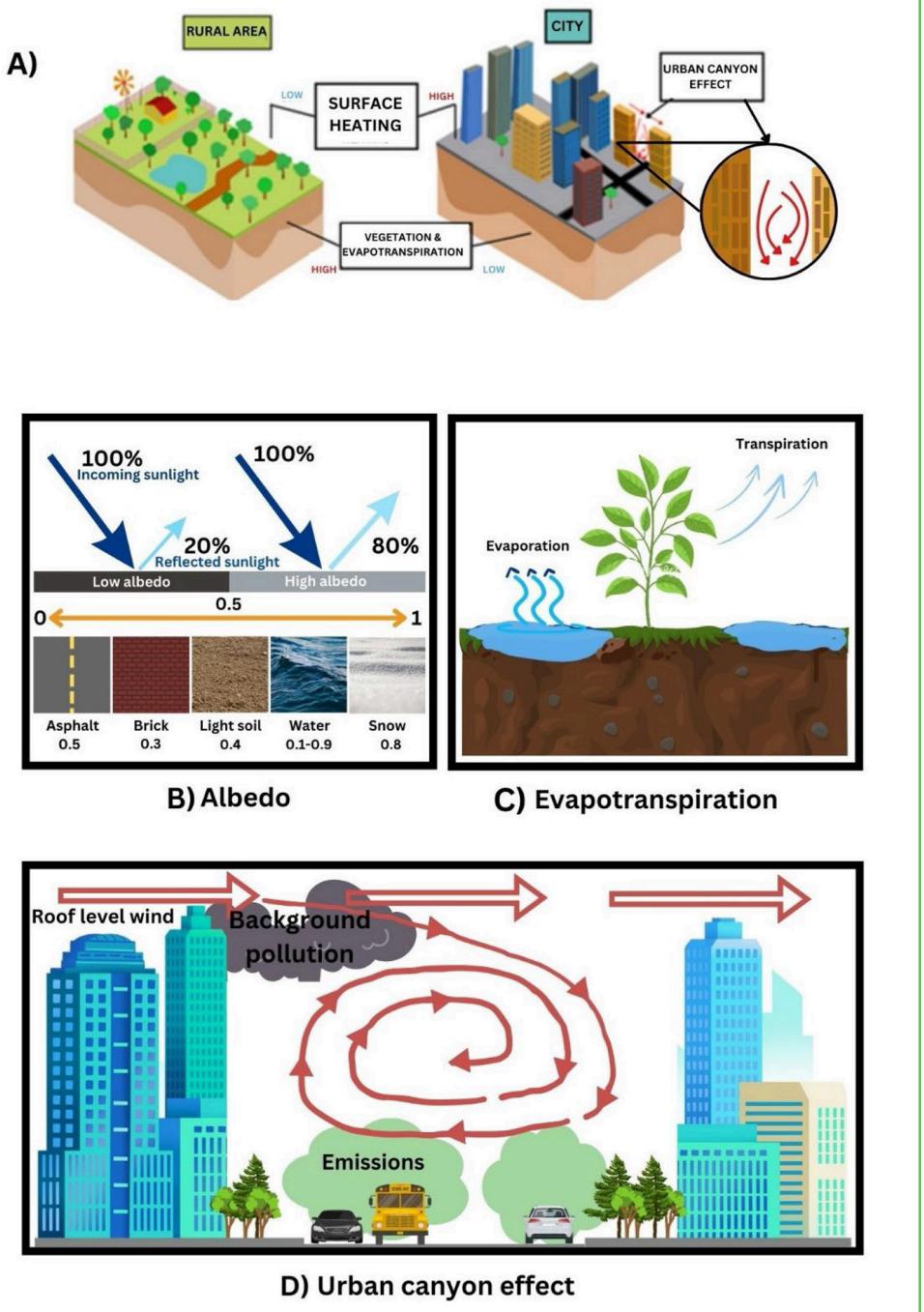

Figure 1

Surface Heating and the Albedo Effect

ALBEDO

A measure of how much sunlight a surface reflects.

SURFACE HEATING

The absorption of sun heat by urban materials.

Albedo describes how well something can reflect sunlight. Different materials reflect sunlight differently, meaning they have different albedos (Figure 1B). Dark-colored surfaces absorb more sunlight than lighter ones, so we say they have a lower albedo because less of the sun's energy is reflected away. This means dark surfaces have more **surface heating**, which refers to how much heat a surface absorbs. In fact, darker surfaces are ~10–25°C warmer than lighter surfaces. In cities, the buildings and roads, which are usually dark in color, have a low albedo and thus absorb and store large amounts of the sun's heat in the daytime. The heat is slowly released at night. This increases the temperature of the city, which leads to urban heat islands [1].

Evapotranspiration

EVAPOTRANSPIRATION

The combined loss of water from plants (transpiration) and soil (evaporation).

Rural areas generally have more trees and plants than cities do. Trees and plants provide shade and help lower local temperatures. Trees and plants also help to cool off the local environment through **evapotranspiration** (Figure 1C). In this process, water evaporates from plants (called transpiration) and soil (called evaporation) [2]. Evapotranspiration cools the air by removing heat from the surrounding air as water changes from a liquid to a gas. Evapotranspiration is an important component of the water cycle, which describes how water moves through Earth's atmosphere, land, and oceans. You can try a small experiment to see the effect of evapotranspiration on cooling. Find a green area, such as your backyard, and water all trees, plants, and soil. After just a few minutes, the air might feel cooler as the temperature drops! However, cities have less vegetation, and thus less shade and less evapotranspiration. This increases the temperature of the city and results in an urban heat island.

Urban Canyon Effect

URBAN CANYON EFFECT

The trapping of heat, reduced airflow, and increased temperatures in narrow city streets surrounded by tall buildings.

Poor city design is another cause of urban heat islands. In cities, buildings are usually built very close to one another. As a result, wind cannot pass between the buildings to ventilate and cool the area, so hot air and pollution get stuck between buildings, the way they would in a deep canyon between mountains. This is called the **urban canyon effect**, and it both raises the overall temperature of the city and lowers air quality (Figure 1D).

EFFECTS OF URBAN HEAT ISLANDS

Urban heat islands can cause a lot of health, environmental, social, and economic problems that can impact the daily lives of people in cities. For example, in Lahore, Pakistan, temperatures often exceed 49°C (120°F), leading to severe health emergencies and affecting residents' ability to work. Similarly, in the Persian Gulf region, cities like Dubai experience high temperatures during summer that can surpass

50°C (122°F). Some of the negative impacts of urban heat islands are discussed in the following sections.

Environmental Impacts

Because of the high temperatures in cities, a lot of electrical energy is required to cool down buildings and homes [3]. This can lead to an increase in the emissions of dangerous pollutants and greenhouse gases as by-products of power plants generating electricity [1]. Urban heat islands are closely connected to global warming, as both involve rising temperatures but on different scales. Global warming increases average temperatures all over the world, which can intensify urban heat island effects by making cities even hotter [4]. Further, urban heat islands worsen the effects of global warming by affecting the water cycle and causing climate hazards. For instance, droughts reduce water levels, limiting the amount of hydroelectric power that can be generated [4].

Health Impacts

Many people who live in cities suffer from respiratory (breathing) problems because the air quality in cities is so bad. Higher temperatures in cities often provide perfect conditions for insects to grow, including those that carry diseases. Insects that spread diseases to other living organisms are called **vectors**. Higher temperatures increase the number of vectors and thus boost the spread of dangerous vector-borne diseases in cities. Higher temperatures in cities may also lead to heat strokes, heart attacks, and other heat-related health problems [3, 4].

VECTORS

Any living organism that carries and spreads disease from one organism to another, e.g., a mosquito.

Economic Impacts

When cities get really hot, fewer people go to work and businesses get interrupted. For example, factories may need to shut down if workers do not report to work, which decreases their production. Sometimes, power plants break down during extreme heat waves due to a sudden increase in the demand for electricity to cool off buildings. In May 2024, there was a power outage in Mexico due to a heatwave. All these factors have a negative impact on the city's economy. When there is less business occurring in a city, many people may choose to move out of the city to nearby rural areas. When fewer people spend time and money in a city, the city's economy is further affected.

NATURE-BASED SOLUTIONS FOR PREVENTING URBAN HEAT ISLANDS

To make cities suitable for living, it is important to find solutions to reduce the negative effects of urban heat islands. There are many solutions to this problem, including cool materials and reflective surfaces, urban design and planning, technological solutions, and behavioral and policy interventions. Some solutions are nature-based,

such as good urban planning, planting urban forests, and creating green spaces in cities—natural solutions can make a big difference [4]. Nowadays, people frequently choose natural solutions because those solutions often cost less and have lower environmental impacts.

Incorporating Waterbodies

During urban planning, incorporating large bodies of water (lakes, ponds, canals, etc.) into cities is one of the nature-based solutions to cool down urban spaces (Figure 2A). Heat evaporates the water, which results in cooling [1]. Although water bodies can only cool the immediate area around them, they also act as a glue for pollutants and help clean the air in cities. However, water availability is a critical concern, especially in dry regions where water resources are scarce [2]. Other options, as described below, might be a better choice in water-limited environments.

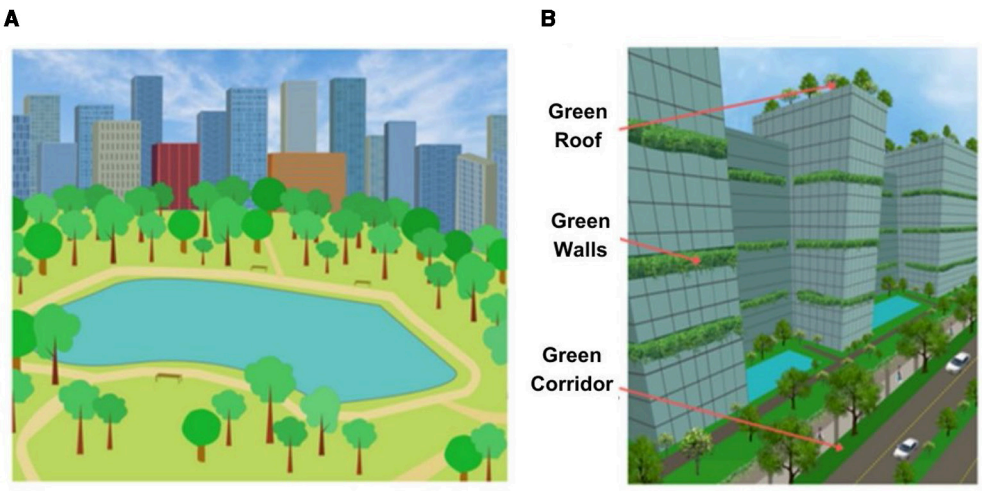

Figure 2

(A) Urban parks and water bodies help to cool down a city. **(B)** Vegetation grown on buildings throughout cities helps to reduce the effect of urban heat islands.

Urban Forests and Green Spaces

Urban forests can be grown in most cities (Figure 2A). Some urban parks, such as Central Park in New York City, contain urban forests. Planting trees in cities can reduce the effects of urban heat islands because trees increase the amount of evapotranspiration, provide more shade, and improve air quality. The amount of green space a city needs depends on the city's size and layout and the type of vegetation. Research suggests that about 20%–40% of urban green cover can significantly reduce urban heat island effects by lowering temperatures through shading and evapotranspiration. Further, urban parks and tree-lined streets can reduce local temperatures by 2–4°C (3.6–7.2°F), on average. Trees can also be planted on sidewalks, green belts, and between road lanes (Figure 2B). No matter where they are planted, planting trees supports **biodiversity**, helping to keep the local environment healthy.

BIODIVERSITY

All the types of living organisms in one area, such as animals, insects, plants, and bacteria.

GREEN ROOFS

Roofs are rooftops covered with greenery or vegetation.

Green Roofs

Sometimes it is difficult to grow urban forests because there is little available land in cities. In these cases, green spaces can be achieved by growing greenery on the roofs and walls of buildings (Figure 2B). Roofs with greenery growing on them are called **green roofs**. There are three main types of green roofs: extensive, intensive, and semi-intensive. Extensive roofs are the cheapest type and are used to grow simple, hardy plants, like Acacia and Neem. Extensive roofs help to increase the albedo of a building and require low maintenance. Intensive roofs are the most expensive type—these grow large plants and require high maintenance. Intensive roofs are like parks on the roofs of buildings. Intensive roofs can also be used for growing fruits and vegetables. Semi-intensive roofs are a mix of both types. Green roofs have been shown to lower building temperatures by up to 5–7°C (9–12.6°F).

KEY TAKEAWAYS

Many cities around the world are affected by urban heat islands. Luckily, there are several natural solutions to decrease city temperatures and urban heat islands, including incorporating large water bodies and planting trees. Adding more greenery, parks, and water bodies in cities helps to both cool urban areas and protect biodiversity. Greenery restores natural habitats in cities—more flowers can mean more animals, birds, and insects, for example. This biodiversity helps cities maintain healthy local ecosystems. Healthy ecosystems, in turn, can make the residents healthier and happier by providing a cleaner, more comfortable environment for people and other living things.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

BENJAMIN, AGE: 11

I am 11 years old, and I am a sixth grader. I like to play electric guitar and soccer with my friends. I go to Pacific Beach Middle School and my favorite subject is math. I really like sharks, and I care for the earth. I enjoy working with my mother on these papers, by being a young reviewer I have learned things that I would have never learned otherwise from these papers.

CELINE, AGE: 14

Hi, my name is Celine and I am a high school student from Vancouver BC. I really enjoy studying chemistry and biology on my own time. Also, I like to play sports outside with my friends for fun. My other hobbies are reading, drawing, and scrolling on the internet.

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