



Title:	<b>Feeling the Heat</b>
Summary:	Students learn about the urban heat island effect by investigating which areas of their schoolyard have higher temperatures. Then they analyze data about how the number of heat waves in an urban area has increased over time with population.
Source:	A Windows to the Universe activity by <a href="#">Lisa Gardiner</a>
Grade level:	6 - 10
Time:	2 class periods
Student Learning Outcomes:	<ul style="list-style-type: none"><li>• Students investigate how trees, grass, asphalt, and other materials affect temperature.</li><li>• Based on their results, students hypothesize how concentrations of surfaces that absorb heat might affect the temperature in cities - the urban heat island effect.</li><li>• Students analyze data about the history of Los Angeles heat waves in a kinesthetic way, learning that the increase in the number of heat waves is due to urban growth and global warming.</li><li>• Students look for patterns in the Los Angeles climate data and explore reasons for the patterns.</li></ul>
Lesson format:	Experiment, data analysis, presentation
National Standards Addressed:	<ul style="list-style-type: none"><li>• <a href="#">5-8: Content Standard A: Science as Inquiry</a></li><li>• <a href="#">5-8: Content Standard B: Properties and Changes of Properties in Matter</a></li><li>• <a href="#">5-8 Content Standard B: Transfer of Energy</a></li><li>• <a href="#">5-8: Content Standard D: Properties of Earth materials</a></li><li>• <a href="#">5-8: Content Standard D: Structure of the Earth System</a></li></ul>

## MATERIALS AND WORKSHEETS:

### Part 1

- A sunny, warm day
- IR thermometers - one for each group of 3-4 students (recommended)
- (Alternative: digital pocket thermometers and 1 m. pieces of string)
- [Data collection worksheet](#) for each student
- Clipboards
- Pencils

### Part 2

- [Los Angeles Data Cards](#) (one set for every 10 students)

- Ropes or logs
- Camera (optional)
- [Feeling the Heat Powerpoint presentation](#) and projector

**DIRECTIONS:**

**Part 1: Understanding Urban Heat Islands**

1. Head outside into your schoolyard on a sunny, warm day. If you are in an area with deciduous trees, you may wish to do this activity at a time when the trees have leaves because of the shade they provide.
2. Ask students to look around and make predictions about which areas of the schoolyard are the warmest and which are the coolest.
3. Choose 6-8 areas of the schoolyard that students have identified. Students will collect temperature data in these areas. Make sure that there is a mix of sunny and shaded areas as well as a mix of paved and grass/natural areas.
4. Provide each student group with data collection pages, clipboards, and an IR thermometer (recommended) or a digital thermometer and a piece of string or ribbon. Instruct students on how to use the thermometers.
  - a. If using IR thermometers, remind students to point the thermometer directly at the ground surface they wish to measure (i.e., concrete, asphalt, grass, dirt, etc.) See the Background Section (below) for more information about IR thermometers.
  - b. If using digital thermometers, remind students to keep it in place for at least two minutes and to shade the thermometer from direct sunlight while taking a measurement. To ensure each measurement is taken the same distance from the ground students should measure from the ground to the top of the string/ribbon and then make their measurement there. (It's important that all groups collect data from the same height above the ground so that data can be compared.) Using this method on a windy day is not recommended.
5. Have student groups head to their locations, take 5 temperature measurements, and record descriptive information about their location on their [data collection worksheet](#). Students should then calculate the average of the temperature measurements.

6. In the classroom, create a chart of the locations. Have student groups fill in the data about their location including average temperature, sun/shade, and ground cover.

7. Discuss the results. Are the results what students predicted? Introduce the concept of microclimates (see Background Section below). Microclimates allow different locations to have different temperatures. Ask students what aspects of the environment affect temperature in these areas. (The

Locations in the Schoolyard					
	1	2	3	4	5
Ground cover	Grass and other plants	Asphalt	Gravel	Trees and grass	Asphalt
Sun/shade	Sun	Shade	Sun	Shade	Sun
Average temperature	25.5 C	28.9 C	38.6 C	22.4 C	39.2 C

Figure 1. Sample data table used to summarize data collected during Part 1 of this activity.

most likely result is that areas in the sunshine were warmer than those in the shade, and areas that had a paved surface were warmer than grass or natural areas.)

8. Ask students, based on these results, which they think would be warmer: urban areas or rural areas. (In urban areas where surfaces like asphalt and concrete are abundant, temperature will be higher.) Introduce the concept of urban heat islands (see Background Section below).

## Part 2: Los Angeles Heat through Time

1. Introduction: Introduce students to heat waves. Discuss what might cause the number of heat waves to change over time. (Global climate change and an increase in the urban heat island effect are the two main ways.) Tell students that in this part of the activity they will investigate heat waves and temperature in Los Angeles, California over 100 years.
2. Lay ropes out along the floor. Ask students to stand in groups of 10 along each rope. (You will probably have 2-3 student groups doing this activity depending on your class size. Have extra students serve as helpers and photographers for each group of 10.)
3. Distribute an LA Data Card to each student. Make sure you have shuffled the cards in each group so that they are not in order. (Ensure that groups do not mix with each other. This will mix up the data.)
4. Explain that each student along the rope has a piece of data about changes in Los Angeles over time. Each card has a range of dates, the population of Los Angeles during that time, the number of heat waves over that time, and the 10-year average temperature. Together, students in each group have 100 years of data.
5. Challenge students to order themselves along the rope by the average temperature. The trick is that they must keep at least one foot on the rope at all times as they move past each other to get in order. Have extra students lead students on the rope about which direction they need to go and how to pass without falling off the rope. Note that students will need to have an understanding of reading numbers to two decimal places to do this part of the activity. You may wish to skip ahead to step 7 if this is too advanced for your students. (*Optional: Have one of the students without a card take pictures of the 10 students on the rope holding their cards so that the data is visible.*)
6. Discuss – Do you see a pattern in the temperature through time? (Encourage students to look to their left and right to see what the neighboring students have.) There is some variation in the data that might make the pattern difficult for students to see. If so, try the following exercise: Ask students to raise their hands if they have a data card that includes years before 1950. (Five students on the end of each rope should raise their hands.) Ask students to raise their hand if they have a card with years after 1950. (The five students on the other end of the rope should raise their hands.)
7. Next, challenge students to arrange themselves by the number of heat waves on their card. There are two decades that have the same number of heat waves. The students with those cards can stand next to each other in any order. (*Optional: Have one of the students without a card take another picture.*)
8. Discuss – When did the most heat waves happen? When did the least? Do you see a pattern through time?
9. Next, challenge students to arrange themselves by population following the same rule. (*Optional: Have one of the students without a card take another picture.*)
10. If you have been documenting the student groups with photographs, show these to the class with a projector. It may be easier for students to recognize the patterns of increasing average temperature, increasing heat waves, and increasing population through time from the photographs than it was when they were standing on the rope.
11. Discuss the data using the powerpoint presentation. The first several slides

are designed to help students look for patterns in the data from the LA Data Cards that they were organizing. This allows students to look at the data in a different way. The latter slides are intended help explain the reason for the warming and increases in heat waves. The following questions might be helpful as you guide the discussion:

- How has the number of heat waves changed over time in Los Angeles? *(Generally, there has been an increase in the number of heat waves over the past 100 or so years. Longer heat waves are also more common today.)*
- How has temperature changed over time in Los Angeles? *(Generally, the average temperature has increased. But notice in the graph that there is a lot of variability from year to year.)*
- Earth's average temperature has increased. Could that affect the temperature of Los Angeles? *(Scientists predict that there will be more heat waves in the future because of global warming.)*
- How population changed over time in Los Angeles? Based on what you explored in Part 1, how could a growing city affect the number of heat waves? *(A growing city can lead to a growing urban heat island effect.)*

## **BACKGROUND INFORMATION:**

### **The Urban Heat Island Effect**

The air in urban areas can be 2 - 5°C (3.6 - 9°F) warmer than nearby rural areas. This is known as the heat island effect. It's most noticeable when there is little wind. An urban heat island can increase the magnitude and duration of a heat wave. It can also influence the weather, changing wind patterns, clouds, and precipitation.

What makes cities warmer? There are many factors that can influence the urban heat island effect. The modifications to the land surface that are made in urban areas have a large impact on whether a heat island forms. For example, many cities have fewer trees than surrounding rural areas. Trees shade the ground, preventing radiation from the Sun from being absorbed. Without them, the ground surface heats up. Dark rooftops and dark pavement absorb more radiation too. Tall buildings reflect and absorb sunlight. Automobiles, which make heat from their engines and exhaust, also contribute to the heat island effect. Fewer plants in urban settings mean that less evapotranspiration occurs, a process that cools the air.

Today, many cities are making an effort to combat the heat island effect. White or reflective materials are being used for roofing and roads. Trees are being planted along city streets. And, in many areas, green roofs - living plants on rooftops - are being installed.

### **Microclimates**

In Part 1 of this activity, students investigate relatively small differences in temperature in their schoolyard. These differences reflect different microclimates. The term microclimate can be used to describe differences in small areas of just a few square meters or much larger areas a few kilometers apart.

Factors that contribute to microclimates in a small area like a school yard include the presence or absence of shade (from trees, buildings) and the type of material at the ground surface (dirt, grass, asphalt, concrete). Shaded areas are generally cooler since much solar radiation is unable to be absorbed by the Earth surface. Ground materials like asphalt and concrete absorb solar energy readily and dark paving will typically be warmer than light color paving because dark colors absorb more heat.

### **IR Thermometers**

Infrared thermometers (IR thermometers) are recommended for Part 1 of this

activity. IR thermometers measure temperature by assessing the amount of energy emitted from an object. When sunlight hits the Earth surface, some of that energy is absorbed and some is reflected. The energy that is absorbed heats and is radiated from the surface. Students can alternatively use digital thermometers as long as they measure to tenths of degrees, but it might be more difficult for them to see the patterns emerge, especially if there is any wind.

### **Heat Waves**

When unusually hot summer weather lasts for several days, it's known as a heat wave. Heat waves are a danger to human health – causing heat stroke, heat exhaustion, cramps, and other ailments.

Recently, a group of scientists analyzed data about heat waves in Los Angeles, California over the past century (Tamrazian et al., 2008). The data came from records of the Department of Water and Power in downtown Los Angeles and Pierce College, a suburban school. Some of that data forms the basis for Part 2 of this activity. The researchers found that Los Angeles is now experiencing more heat waves and more extreme heat days than it was in the past. The average annual maximum temperature has warmed by 2.8°C (5.0°F). The scientists attributed the rise in heat waves to a combination of increase in the heat island effect and global warming.

While Los Angeles is used as the example in this activity, it is not the only location where heat waves have increased. According to the [Intergovernmental Panel on Climate Change](#) 4th Assessment Report (2007), the number of heat waves has risen, especially in Europe and Asia, and heat waves are expected to become more common during the 21st Century. The increase in the number and duration of heat waves in urban areas is due to a combination of global warming and the urban heat island effect.

### **Data Sources**

- Heat wave data from: Tamrazian, A., S. LaDouchy, J. Willis, and W.C. Patzert (2008) Heat Waves in Southern California: Are They Becoming More Frequent and Longer Lasting? APCG Yearbook, Vol. 70, pp. 59-69.
- 10-year average temperatures are from Climate of Los Angeles data archived by NOAA National Weather Service - Los Angeles/Oxnard ([http://www.wrh.noaa.gov/lox/climate/climate\\_intro.php](http://www.wrh.noaa.gov/lox/climate/climate_intro.php))
- Population estimates are from the US Census Bureau. (<http://www.census.gov/popest/estimates.php>)

### **RELATED SECTIONS OF THE WINDOWS TO THE UNIVERSE WEBSITE:**

- [Climate and Global Change](#)
- [Effects of Climate Change Today](#)
- [About the Intergovernmental Panel on Climate Change](#)
- [Urban Heat Islands](#) (from Climate Discovery online course)
- [Growing Green Rooftops in Urban Areas](#)

### **OTHER RESOURCES:**

- [USGS Earthshots: Satellite Images of Environmental Change](#)
- [UNEP Atlas of Our Changing Environment](#) (also available in Google Earth)
- [Los Angeles Mapped, a Library of Congress exhibit online](#)

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