

LAB 16

Lab Handout

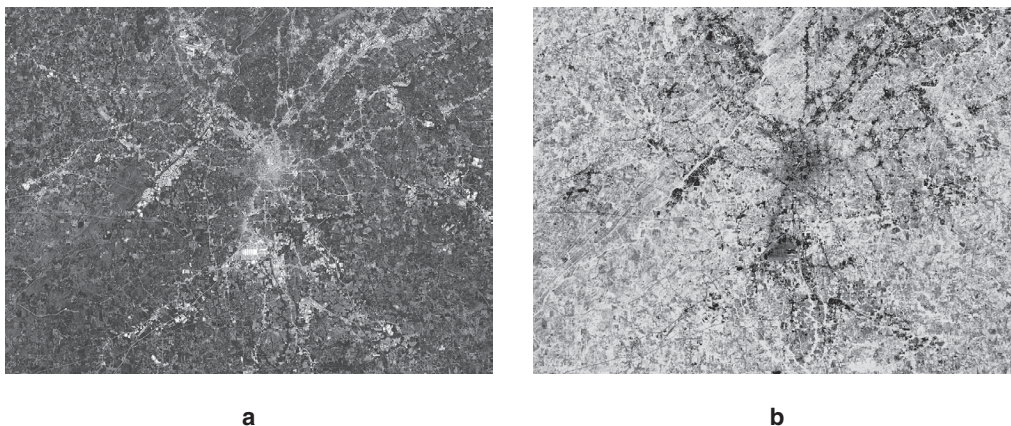
Lab 16. Surface Materials and Temperature Change: How Does the Nature of the Surface Material Covering a Specific Location Affect Heating and Cooling Rates at That Location?

Introduction

Inner cities and suburbs tend to be much warmer than rural areas as a result of land use and human activities. Scientists call this phenomenon the urban heat island effect. Take Atlanta, Georgia, as an example. Figure L16.1 shows two Landsat satellite images of Atlanta taken on September 28, 2000. Image A is a true-color picture of Atlanta, where trees and other vegetation are dark green and roads or buildings are different shades of gray. Image B, in contrast, is a map of land surface temperature. In image B, cooler temperatures are yellow and hotter temperatures are red. Downtown Atlanta is in the center of both images. On this day in 2000, the temperature in the areas in and around downtown Atlanta reached 30°C (86°F), while some of the less densely developed areas outside of the city only reached 20°C (68°F). Las Vegas, Nevada, also experiences a significant urban heat island effect. On hot summer days, it can be 13°C (24°F) warmer in downtown Las Vegas than it is in the surrounding desert. Downtown Las Vegas also has, on average, 22 more days that are above 32°C (90°F) each year when compared with the surrounding rural areas. Most major cities in the United States, including Dallas, Phoenix, New York, Los Angeles, Denver, and Washington, D.C., experience a significant urban heat island effect.

FIGURE L16.1

Two Landsat satellite images of Atlanta: (a) a true-color picture of the city and (b) an image showing the differences in temperature for the city and areas around the city in the afternoon



Note: A full-color version of this figure can be downloaded from the book's Extras page at www.nsta.org/adi-ess.

Surface Materials and Temperature Change

How Does the Nature of the Surface Material Covering a Specific Location Affect Heating and Cooling Rates at That Location?

In our everyday conversations, we often use the terms *temperature* and *heat* interchangeably. In science, however, these two terms have different meanings. *Temperature* is used to describe the average kinetic energy of the atoms or molecules that make up an object. *Heat*, on the other hand, is the transfer of thermal energy into, within, or out of an object. There are three ways thermal energy can transfer into, within, or out of an object: conduction, convection, and radiation.

- *Conduction* is the transfer of thermal energy due to the collision of the atoms or molecules within an object or between two objects in contact. Thermal energy always transfers from an object or area of higher temperature to an object or area of lower temperature.
- *Convection* is the transfer of thermal energy due to the mass movement or circulation of particles within a fluid. Fluids are liquids (like lakes or oceans) and gases (such as air).
- *Radiation* is the transfer of thermal energy through electromagnetic waves. An example of radiation is what happens to a car when it sits in the sunlight on a hot summer day. The car absorbs sunlight, and the temperature of the car increases. As more sunlight is absorbed over time, the temperature of the car increases as well.

When thermal energy transfers into an object, the temperature of the object will increase; when heat transfers out of an object, the temperature will decrease. However, not all objects will undergo the same change in temperature when the same amount of thermal energy is added to them. For example, adding 1 joule (J) of thermal energy to a 1-kilogram (kg) sample of lead will cause the piece of lead to increase in temperature by about 8°C. Adding 1 J of thermal energy to a 1 kg sample of water, however, will only increase the temperature of the water by approximately 0.2°C.

There are many potential explanations for the urban heat island effect. First, cities have more people living in them. Some scientists have therefore speculated that a higher concentration of people using air conditioners may be causing the urban heat island effect because air conditioners remove heat from the air in buildings and transfer it outside. Other scientists have suggested that car exhaust is causing the urban heat island effect because the gases in exhaust can trap thermal energy, and there are many more cars in cities than there are in rural areas. Finally, other scientists suggest that the materials we use to build roads, homes, and other buildings are the source of the urban heat island effect. Scientists studying this possibility note that in cities that experience an urban heat island effect, there tends to be a much higher concentration of concrete inside the city when compared with the area surrounding the city, which tends to be covered by naturally occurring materials such as plants, sand, or water.

LAB 16

Your Task

Use what you know about heat and temperature, cause-and-effect relationships, and stability and change in systems to plan and carry out an investigation that will allow you to determine the relationship between the materials covering an area and the rate at which the temperature of that area changes over time. This investigation will aid you in understanding the underlying cause of urban heat islands.

The guiding question of this investigation is, *How does the nature of the surface material covering a specific location affect heating and cooling rates at that location?*

Materials

You may use any of the following materials during your investigation:

Consumables

- Water
- Soil
- Dark sand
- Light sand
- Concrete
- Sod

Equipment

- Safety glasses or goggles (required)
- Chemical-resistant apron (required)
- Gloves (required)
- Styrofoam cups
- Electronic or triple beam balance
- Infrared lamp and reflector
- Partial immersion (nonmercury) thermometers
- Digital or laser thermometer (optional)
- Graduated cylinder (250 ml)
- Support stand
- Ruler

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

- Wear sanitized indirectly vented chemical-splash goggles and chemical-resistant, nonlatex aprons, and gloves throughout the entire investigation (which includes setup and cleanup).
- Use only a GFCI-protected electrical receptacle for the lamp to prevent or reduce risk of shock.
- Handle the infrared lamp with care; it can get hot enough to burn skin.
- Do not spill or splash water on the hot lamp bulb—this can crack glass and form a projectile.
- Report and clean up spills immediately, and avoid walking in areas where water has been spilled.
- Wash hands with soap and water when done collecting the data and after completing the lab.

Investigation Proposal Required? Yes No

Surface Materials and Temperature Change

How Does the Nature of the Surface Material Covering a Specific Location Affect Heating and Cooling Rates at That Location?

Getting Started

To answer the guiding question, you will need to design and carry out an experiment. Figure L16.2 shows how you can use a heat lamp to warm different types of materials, such as soil, water, sand, concrete, or sod (grass). Before you begin to design your experiment using this equipment, think about what type of data you need to collect, how you will collect the data, and how you will analyze the data.

To determine *what type of data you need to collect*, think about the following questions:

- What are the components of the system you are studying?
- Which factor(s) might control the rate of change in this system?
- How will you measure how quickly the materials heat up (or rate of change)?
- How will you measure how quickly the materials cool down (or rate of change)?

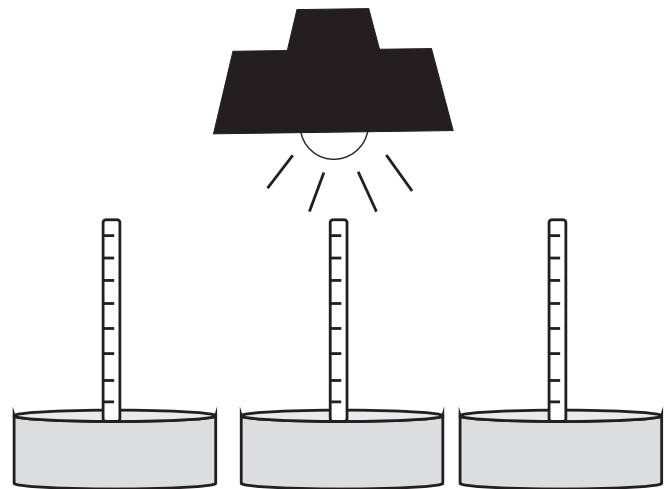
To determine *how you will collect the data*, think about the following questions:

- What conditions need to be satisfied to establish a cause-and-effect relationship?
- What will serve as your independent variable and dependent variables?
- How will you vary the independent variable while holding the other variables constant?
- How will you make sure the amount of each material is the same?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of and organize the data you collect?

To determine *how you will analyze the data*, think about the following questions:

- What type of calculations will you need to make?
- How could you use mathematics to document a difference between conditions?
- What type of table or graph could you create to help make sense of your data?
- How will you determine if rates of change are the same or different?

FIGURE L16.2 _____
How to use a heat lamp to warm different types of materials



LAB 16

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

As you work through your investigation, be sure to think about

- the difference between laws and theories in science, and
- the types of questions that scientists can investigate.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group's answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the

justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L16.3.

FIGURE L16.3

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other

arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Surface Materials and Temperature Change

How Does the Nature of the Surface Material Covering a Specific Location Affect Heating and Cooling Rates at That Location?

Critiques of our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their' arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

LAB 16

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.