**5E LESSON PLAN**



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| **Heat Island Experiment: Surface and Air Temperature** |
| **Grade/ Grade Band**: 11-12 | **Topic:** Weather and Climate Earth and Human Activity  | **Lesson #** 3  **in a series of** 5  **lessons** | **Teacher Notes**  |
| **Brief Lesson Description**: In this lesson, SWBAT measure air and surface temperatures to determine whether or not communities in the South Bronx are experiencing a “heat island” effect. The term "[heat island](https://www.epa.gov/heat-islands/learn-about-heat-islands)" describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings.  |  |
| **Performance Expectation(s):** Human commercial and industrial activity - notably, vehicle combustion, electrical substations, waste transfer facilities, commercial businesses - coupled with rapid urbanization - removal of trees and soil in favor of pavement and structures has led to heat islands. These islands present a [significant public health risk](https://www.epa.gov/heat-islands/heat-island-impacts) to members of the Bronx community, especially its most vulnerable (the very young and the elderly). Thus, if these heat island exist near schools or senior citizen housing they pose an even more dangerous respiratory health risk. I CAN … design, conduct an [experiment](https://www.epa.gov/heat-islands/measuring-heat-islands), and analyze surface/air temperature data to determine whether or not heat islands exist in the Morrisania section of the South Bronx. In addition, I CAN devise a heat island mitigation strategy or reduction technique to improve the quality of life in my Bronx community.  |  |
| **Specific Learning Outcomes:** SWBAT determine if heat islands are forming in their Bronx community by conducting an experiment that takes place during the summer, fall, winter, and spring; additionally, students will analyze the impact of increased air and surface temperatures (heat islands) on public health. * Students will design a lab that measures and monitors air and surface temperatures (students may elect, via a learning extension, to measure more variables such as air pressure, humidity, dew point, etc. that influence local climate)
* Students will select an area within a mile radius of our school building to take their readings (students may elect, via a learning extension, to take measurements near their home or other locations inside, or outside, of the city); students will use the [National Weather Service](https://www.weather.gov/) weather station located at Laguardia airport as a control
* Students will conduct their experiment, beginning in September, and run it through the spring (May) to measure seasonal variation
* Students will analyze their data to establish (or not) whether or not there are heat islands in the area near our school; and, if there are heat islands, students will evaluate the data to determine what could be contributing to the heat island (e.g. idling vehicles, a major roadway, low plant and tree density, major construction or industry)
* Students will put together a presentation to present to Community Board 3 in our district

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| **Narrative / Background Information**  |  |
| **Background for teachers:*** Review [heat island phenomena](https://www.epa.gov/heat-islands) and impact
* Will need to familiarize themselves with one or both Arduino air and surface temperature sensors running on a Rasberry Pi platform
* Examine existing data to determine whether there are documented heat islands in the area around or near our school; or, whether conditions exist for heat islands to form

**Teacher preparation**: * Test Arduino and/or Vernier sensors - in particular, the sensors ability to collect data wirelessly and organize into an Excel or CSV table that can be analyzed statistically and graphed
* Set-up experimental kits for student groups
* Review content to teach students in advance of lab

**Prior Student Knowledge:** * Understanding of applying the scientific method and all of its steps (emphasis on making a scientifically-sound hypothesis, identifying constants and variables in the first part; making conclusions and analyzing data after the experiment)
* Understand [historical and current temperature data](https://w2.weather.gov/climate/index.php?wfo=okx)
* Understanding the heat island phenomena in terms of its environmental, public health, and justice impact
* Understanding communities that are vulnerable to heat islands such as young people (schools) and senior citizens (convalescent homes)
* Understanding the causes of elevated temperatures in urban environments
* Students should review the [EPA’s recommendations for measuring temperature](https://www.epa.gov/heat-islands/measuring-heat-islands):
* Assess and map the locations of existing data monitors (such as standard weather stations and other monitoring networks) to identify areas of the city with information gaps relevant to your specific analysis.
* Choose data collection sites that are representative of their surroundings in terms of surface materials, geometry, and human activity.
* Establish a reasonable number of monitoring sites in order to avoid bias (e.g., comparing data from just one urban site with data from one rural site may not accurately characterize a city’s heat island).
* Follow a consistent protocol for the location of monitors, the height and direction of sensors, shielding from sunlight, and other key factors that may influence recorded temperatures. For example, rooftops are a popular location for air temperature monitors, but recorded temperatures could be inaccurate if the monitors are too close to heating, ventilation, and air conditioning equipment on the roof.
* Clearly document the study’s methodology and metadata (e.g., time period, spatial area).
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| **Science & Engineering Practices:** [Analyzing and Interpreting Data](http://www.nap.edu/openbook.php?record_id=13165&page=61)Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.* Analyze data using computational models in order to make valid and reliable scientific claims.
 | **Disciplinary Core Ideas:** ESS3.D: Global Climate Change* Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
 | **Crosscutting Concepts:** Stability and Change* Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
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| **Possible Preconceptions/Misconceptions:** * Conflate air and surface temperature
* Not understand the role of specific heat
* The boundaries of the heat island
* Students perception of air quality versus the scientific parameters
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| **LESSON PLAN – 5-E Model**  |  |
| **ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:** 1. Ask students to generate questions related to heat islands - what questions do they have when they hear the phrase.
2. Discuss and review the role of the different variables that influence the formation of heat islands - see [EPA heat island](https://www.epa.gov/heat-islands) info.
3. Research [historical temperature trends](https://w2.weather.gov/climate/index.php?wfo=okx) in NYC.
4. Review the experiment protocols and purpose
5. Examine how to set-up the Arduino (or Vernier) sensors to collect data over the course of the academic year
	1. Some teams may elect to vary the intervals of data collection
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| **EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:** Materials needed for each group: * Rasberry Pi and Arduino sensor kit (air and surface temperature)
* \*Vernier surface temperature sensor and air temperature probe (possibly)
* Laptop to review National Weather Service data
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| **EXPLAIN: Concepts Explained and Vocabulary Defined:** Teacher: * Asks students to conceptualize what a heat island is
* Formally defines heat island and related terms such as thermal inversion
* Addresses the possible causes of heat islands

Students: * Explain research and experimental findings using evidence from text or experiments
* Listen critically to teacher and student explanations
* Pose questions if they do not understand important concepts
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| **ELABORATE: Applications and Extensions:** **Teacher** * Ask students to evaluate data collected during the experiment for the following:
	+ Surface versus air temps
	+ Seasonal variation (compare the summer mean to fall mean to winter to spring)
	+ Other factors influencing temperature
* Based on an evaluation of data reviewed during research and experimentation, ask students what they know about the proof of heat islands and what they don’t know, and why

**Student** * Students investigate local factors that could have influenced the existence of a heat island -- such as ground cover and trees; students study the density of trees/plants as well as the percent cover of dark, heat absorbing media such as asphalt)
* If students find that a heat island in their area of study does not exist, students examine the impact of heat island mitigation or reduction structures (such as a community garden, roofs painted white) or techniques (such as the enforcement of vehicle idling laws) to either intentionally or unintentionally reduce the formation of a heat island
* Student group jigsaw - students from each group send representatives to other groups to gather their data and gather ideas for altering future experiments
* Students seek a class consensus - did we find heat islands or not?
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| **EVALUATE:** **Formative Monitoring (Questioning / Discussion):** * Asks open ended questions such as:
	+ What evidence do you have that best supports or refutes your hypothesis?
	+ Why do you think a heat island does or does not exist in your experimental area?
	+ How does your data compare to the control data (NWS daily temps/Crotona Park)?
	+ How would you explain your results to a friend, a parent, politician?

**Summative Assessment (Quiz / Project / Report):** * Formal lab report
* Powerpoint presentation of findings
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| **Elaborate Further / Reflect: Enrichment:** * Students can examine the relationship between elevated surface runoff and water quality
* Students consider ways of sharing their data with the school and local community -
	+ Presentation to school parent association
	+ Presentation to Bronx Community Board 3, which focuses on parks, to make a case for more green space
* Students develop heat island reduction strategies for the Bronx
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| **Materials Required for This Lesson/Activity** |
| **Quantity** | **Description** | **Potential Supplier (item #)** | **Estimated Price** |
| 6 | Raspberry Pi computers  | COSMOS RET or grant request | $210 (35 each from [Adafruit](https://www.adafruit.com/product/3775?src=raspberrypi))  |
| 6 | Gravity surface temperature sensor  | COSMOS RET or grant request | [$96](https://www.dfrobot.com/product-1495.html) |
| 6 | Gravity air temperature sensor | COSMOS RET or grant request | [$27](https://www.dfrobot.com/product-76.html) |
| 6 | Gravity air quality sensor for Arduino | COSMOS RET or grant request | [$281.40](https://www.dfrobot.com/product-1272.html) |