URBAN HEAT ISLAND MODULE

LESSON 1:

THERMAL EXPLORATION OF THE SCHOOLYARD

THE GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC
BALTIMORE CITY PUBLIC SCHOOLS
NSF
Cary Institute of Ecosystem Studies

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The following lesson and associated materials are part of the Integrating Chemistry and Earth science (ICE) Urban Heat Island Module. The Module brings together important concepts from Earth science and chemistry to help students build an understanding of why urban areas have higher temperatures both during the day and at night, than their rural counterparts.

ICE Partners

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ICE Integrating Chemistry & Earth Science

Lesson 1: Thermal Exploration of the Schoolyard

Driving Question: *What determines the temperature of objects around the school?*

Summary: The key idea students will be asked to consider/master is "Why is the temperature outside what it is today?" Initially, students will look at global influences—such as the planet's internal heat, and the cold of space. Through exploration using IR thermometers, students will then develop a basic heat model showing heat in terms of the globe and in terms of the local materials they measured with the IR thermometers.

Activity Description:

- **Opening Activity - Thermal Exploration:** Students will explore the local landscape to determine what types of items are warmer or colder.
  - Ask students "What could make objects outside be different temperatures?"
    - Focus on what possible mechanism(s) could explain them being different temperatures.
  - Take students outside to record temperatures of various objects in their schoolyard using the IR thermometers.
    - Students are collecting data to inform them regarding the question "What affects the temperature of Earth's surface?"
    - Challenge students to find the highest and lowest temperatures in the schoolyard.
    - Ask students to record their data and save their data sheets for later in the unit.
    - Possible locations students could check:
      - under a car,
      - asphalt in the sun,
      - asphalt in the shade,
      - leaves,
      - grass in the middle of a field,
      - grass surrounded by bushes,
    - Have students design their data table for recording their data.
      - The table should include:
        - Material
        - Location
        - Temperature
    - *Sample data table:*

Object/Material	**Location**	**Temperature (^{o}C)**
Grass	Front lawn	
Concrete	Sidewalk	
Etc.		

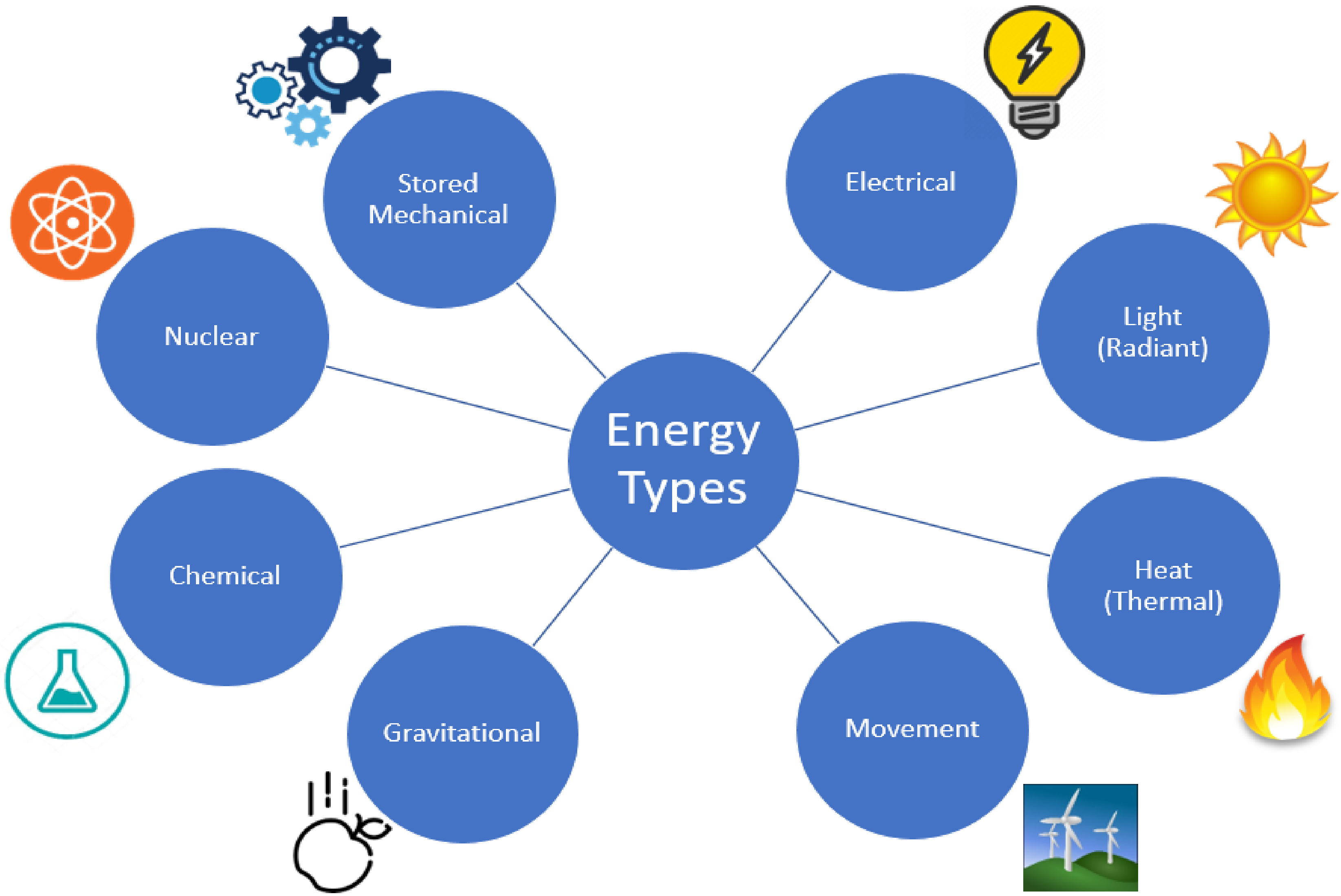
            - Resource for students who need help designing their data table: *Thermal Exploration Data Table*
    - Share data and discuss patterns students observe once you return to the classroom.
- **Why are objects, in Baltimore, the temperature they are?** Teacher or student led discussion of the collected data with focus on what might be causing differences in the data.
    - Ask students:
        - What may be causing the differences in our data?
        - Where might the heat in the objects we observed come from?
    - Survey the students for responses. Possible survey methods include using Poll Everywhere, Goggle forms, or white-boards.
        - Allow all possible answers that address the question.
- **Optional Review:** Students have a chance to review the concepts of heat and temperature if needed.
    - Students use their own words to write definitions of temperature and heat.
        - **Teacher Notes:**
            - Students should have learned about temperature in middle school (MS-PS3-4).
            - This activity is intended as a brief pre-assessment so the teacher can remind/re-teach as necessary.
            - Temperature: How hot or cold a substance is based on the average kinetic energy of the molecules in a substance. (how fast the molecules in a substance are moving on average)
            - Heat: The transfer of thermal energy from a warmer substance to a cooler substance. (the transfer of energy from faster moving molecules to slower moving molecules)
    - Refer students to the different types of energy (see *Types of Energy Graphic*) and ask which of these could be involved in determining the temperature of the objects they observed in the schoolyard.
- **Initial Thermal Models:** Throughout the module, students will be modeling the flow of thermal energy within objects and systems. This is their first attempt and will be used as a base for further modifications.
    - Students use the UHI Modeling Template to draw a model of an object from their field study (e.g., a rock, plant, section of sidewalk, car) using arrows to show inputs and outputs of energy. They should label where energy is stored and write an explanation of their diagram.
        - Students will draw and label arrows to show the energy inputs and outputs they think affect the temperature of their object. Each student model should be different.
        - **Teacher Note:** See the Modeling Template – Teacher Instructions for additional information.

- Have students examine at least three other students' models and give feedback.
- The instructor will generate a generic model, on chart paper, and ask for student input on what should be diagramed based on common ideas from their observed models. Keep this generic model in the room for later additions and edits as students develop their understanding of thermal models.
  - **Teacher Notes:** The file *Sample Heat Model Anchor Chart* shows a fully completed anchor chart. It is expected that the initial form of this chart, as you and your students would create at this point in the lesson sequence, might only have one or two arrows on it. As you continue throughout the unit you will add to the chart, building the complexity of the model.
- Collect and save student models for future use.

- **Discussion Question**
  - Why isn't the Inner Harbor Boiling?/Why aren't we frozen?
    - **Discussion Prompt**: How does energy flow determine the temperature of objects?
  - Students can write or diagram/model their proposed explanation or have a class discussion that pulls in information from class activities.

Thermal Exploration Data Table

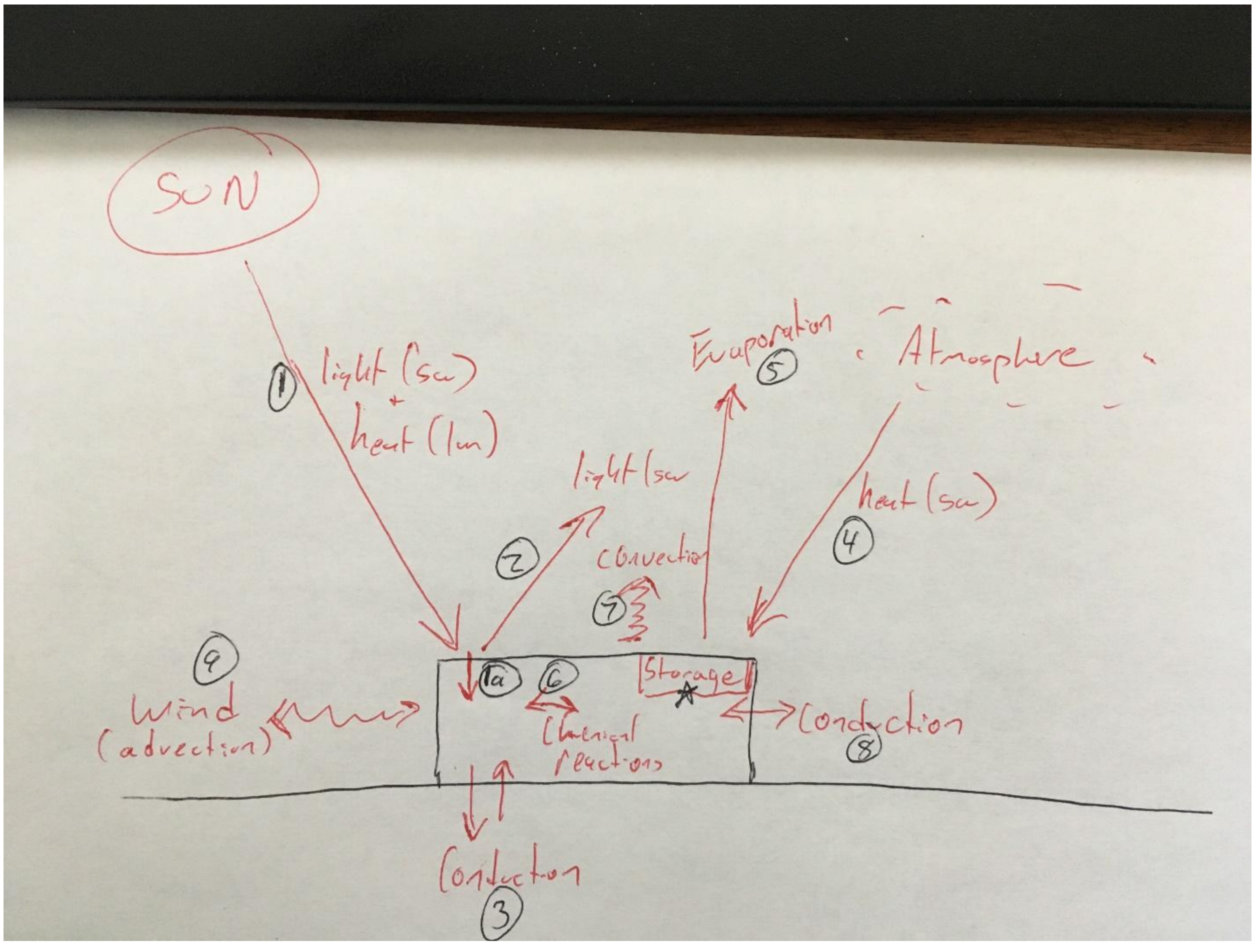
Object/material	Location	Temperature (°C)



Energy Types
Stored Mechanical
Electrical
Nuclear
Light (Radiant)
Chemical
Heat (Thermal)
Gravitational
Movement

Sample Heat Model Anchor Chart

Here is a sample classroom heat model anchor chart. An initial model is unlikely to include all of these components. The complexity of the model should build as students learn about the different pathways and processes by which heat moves between objects.



The object is shown as a rectangle on a surface. It could be 'in' the surface instead (e.g., a slab of concrete, a patch of asphalt, etc.) but there would still be one surface exposed to the air and sun. The object could be a plant, a telephone pole, a person. It also could be air, i.e., the boundaries could be conceptual rather than an actual physical interface between a discrete object and its surroundings.

"Storage" is starred because this is the focal parameter of interest if we're asking about the temperature of the object … the amount of thermal energy it contains.

The fluxes (arrows, processes, etc.) are numbered based on a guess about the order that students might include … from most likely to least likely.

Here is an explanation of each:

1. Radiant energy from the sun as both light (short wave) and heat (long wave, not much)

    1a. Absorbed radiation, increases storage unless fluxes (amount of heat leaving the object) out balance amount absorbed.

2. Radiant energy (light) reflected by the object's surface (function of chemistry/properties of material = albedo)

3. Conduction to or from underlying material. Depends on temperature difference (magnitude, direction) and chemistry/properties of materials.

4. Heat (long wave radiation) received from the atmosphere. The absorption of sunlight by the atmosphere is not pictured but should be considered as one of the two sources of heat in the atmosphere (the other being pathway 2). Heat absorbed by the atmosphere is not directly related to this object's balance.

5. Evaporation (latent heat loss)

6. Chemical reactions internal to the object.

7. Convective heat loss due to thermals.

8. Conduction to/from the air – this is the direct exchange from air touching the object.

9. Wind or advection. This is warm air blowing in and adding heat, or cool air removing heat.