Module 6.3

Weather

Local and regional weather are affected by the amount of solar energy the area receives and proximity to a large body of water.

CT Science Framework Topics

Science Content Standard 6.3 ***CMT Expected Performances***

SCIENCE CONTENT STANDARD 6.3		
CONCEPTUAL THEME: *Energy in the Earth's Systems – How do external and internal sources of energy affect the Earth's systems?* CONTENT STANDARD: **6.3 - Variations in the amount of the sun's energy hitting the Earth's surface affect daily and seasonal weather patterns.**	**GRADE-LEVEL CONCEPT:** ◆ Local and regional weather are affected by the amount of solar energy the area receives and proximity to a large body of water. **GRADE-LEVEL EXPECTATIONS:** 1. Earth is surrounded by layers of gases (atmosphere) that influence the environment and support life. Weather on Earth is caused by the daily changes in the temperature, pressure and amount of moisture in the lower atmosphere. Regions of the earth experience distinct long-term climate conditions caused, in part, by different amounts of solar energy they receive. 2. Heat energy causes molecules to move. The molecules that make up all matter are in constant motion. Solids, liquids and gases differ in the movement and arrangements of their molecules. Molecules in gases move randomly and independently of one another. Molecules in liquids move around each other randomly, but are loosely held together by an attraction force. Molecules in solids are closely locked in a patterned position and can only vibrate back and forth. 3. When heat energy is added to a substance, its molecules move faster (increased temperature) and spread apart from each other (become less densely arranged). When heat energy is removed, molecules move slower (decreased temperature) and come together (become more densely arranged). 4. If enough heat energy is absorbed by a solid or a liquid, the molecules may overcome the forces holding them together and change to a new state of matter. Solids change to liquids (melt) and liquids change to gases (vaporization) when heat energy is absorbed from the surroundings. Conversely, heat energy is given off when gases change to liquids (condensation) or liquids change to	**CMT EXPECTED PERFORMANCES** **C 4.** Describe the effect of heating on the movement of molecules in solids, liquids and gases. **C 5.** Explain how local weather conditions are related to the temperature, pressure and water content of the atmosphere and the proximity to a large body of water. **C 6.** Explain how the uneven heating of the Earth's surface causes winds.

	solid (freezing). 5. Different surfaces on Earth absorb and release solar energy at different rates. Land has a lower heat capacity than water; therefore land temperatures change more rapidly than water temperatures do. The surface temperature of large bodies of water, such as the oceans that cover a great deal of the earth, affects the temperature of the air above them. 6. Earth's atmosphere (air) is a mixture of different amounts of gases (mainly nitrogen, followed by oxygen, carbon dioxide and water vapor). Air molecules constantly press on and around objects on Earth (air pressure). Due to the pulling force of Earth's gravity, air close to Earth is more dense than air higher in the atmosphere; denser air causes greater air pressure. 7. Wind is caused by air moving from areas of high pressure to low pressure. Cool, dense air is high pressure and tends to sink; warm, less dense air is low pressure and tends to rise. Local and global winds move in predictable patterns based on uneven heating of Earth's surface. 8. Local winds can be influenced by atmospheric conditions, terrain (mountain, deserts) and closeness to large bodies of water. Near coastal areas, the day to night temperature and pressure differences between land and water cause local winds to blow from ocean to land ("sea breeze") during day and from land to ocean ("land breeze") at night. **CONTENT STANDARD 6.3 - continued** 9. Global winds are caused by the circulation of cold, dense polar air and warm, less dense equatorial air. The rotation of the earth, combined with the location of the continents, causes bands of wind patterns on the earth. For example, weather tends to move generally from west to east. 10. Oceans are a major source of water in the air as water cycles between Earth's surface and the atmosphere. Large bodies of water absorb heat energy, causing water to evaporate. The amount of water vapor in the	

	atmosphere (humidity) is dependant on the temperature of the air. Warm air holds more water vapor than cool air because it is less dense. As warm, humid air rises and cools, its molecules become more closely spaced and the water vapor condenses into tiny water droplets that are less dense than air (clouds). Tiny droplets may combine and become heavy enough to fall as rain (or other types of precipitation). 11. Weather on Earth is caused by daily variations in the temperature, pressure and humidity of different bodies of air (air masses). Warm, moist, less dense air masses rise, thus decreasing air pressure usually indicates that cloudy, wet, warmer weather is approaching. Cool, dry, denser air masses sink, thus increasing air pressure usually indicates clear, dry, cooler weather is approaching. 12. When masses of warm, moist air interact with masses of cool, dry air, the boundary is called a warm front. The way in which the air masses move past one another influences the type of weather that results. At the front, warm air rises above cold air, causing clouds and precipitation (and sometimes storms). Weather predictions can be made based on the pattern of warm, wet, low pressure air being typically followed by cool, dry, high pressure air. 13. Connecticut, and the northeast in general, often has rapidly changing weather because three patterns of moving air interact here: cold, dry air from the north, warm, moist air from the Atlantic ocean coastline, and air moving across the US from west to east. **SCIENTIFIC LITERACY TERMINOLOGY:** molecule, dense, solid, liquid, gas, melting, freezing, condense, evaporate, air pressure, humidity, air mass, cold/warm front, precipitation, global wind, sea breeze, land breeze.	

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Module 6.3: Weather

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CT Science Framework Topics

Science Content Standard 6.3	*CMT Expected Performances*
14. Earth is surrounded by layers of gases (atmosphere) that influence the environment and support life. Weather on Earth is caused by the daily changes in the temperature, pressure and amount of moisture in the lower atmosphere. Regions of the earth experience distinct and predictable weather conditions (climate) caused, in part, by different amounts of solar energy they receive. 15. Heat energy causes tiny particles (molecules) to move. The molecules that make up all matter are in constant, though invisible, motion. Solids, liquids and gases differ in the movements and arrangements of their molecules. Molecules in gases move randomly and independently of one another. Molecules in liquids move around each other randomly, but are loosely held together by an attraction force. Molecules in solids are closely locked in a patterned position and can only vibrate back and forth. 16. When some heat energy is added to a substance, its molecules move faster (increased temperature) and spread apart from each other (become less densely arranged). When heat energy is removed, molecules move slower (decreased temperature) and come together (become more densely arranged). 17. If enough heat energy is absorbed by a solid or a liquid, the molecules may overcome the forces holding them together and change to a new state of matter. Solids change to liquids (melt) and liquids change to gases (vaporization) when heat energy is absorbed from the surroundings. Conversely, heat energy is given off when gases change to liquids (condensation) or liquids change to solid (freezing). 18. Different surfaces on Earth absorb and release solar energy at different rates. Land absorbs and releases heat faster than water. The surface temperature of large bodies of water, such as the oceans that cover a great deal of the earth, affects the temperature of the air above them. This is one reason that Connecticut's inland areas are warmer in the day (and in summer) and cooler at night (and in winter) than coastal areas. 19. Earth's atmosphere (air) is a mixture of different amounts of gases (mainly nitrogen, followed by oxygen, carbon dioxide and water vapor). Air molecules constantly press on and around objects on Earth (air pressure). Due to the pulling force of Earth's gravity, air close to Earth is more dense than air higher in the atmosphere; denser air causes greater air pressure. 20. Wind is air moving from areas of high pressure to low pressure. Air above cool areas is high pressure (dense) and tends to sink, while air above warm areas is low pressure (less dense) and tends to rise. Local and global winds move in predictable patterns based on uneven heating of Earth's surface. 21. Local winds can be influenced by atmospheric conditions, terrain (mountain, deserts) and closeness to large bodies of water. Near coastal	**C.7 Describe the effect of heating on the movement of molecules in solids, liquids, and gases.** Exercise 6.3.1 Thermal Expansion & Contraction **C.8 Explain how local weather conditions are related to the temperature, pressure and water content of the atmosphere and the proximity to a large body of water.** Exercise 6.3.2 Differential Heat Absorption and Radiation

areas, the day to night temperature and pressure differences between land and water cause local winds to blow from ocean to land ("sea breeze") during day and from land to ocean ("land breeze") at night. 22. Global winds are caused by, among other factors, the circulation of air between polar regions that receive less solar energy (colder, denser air) and equatorial regions that receive more solar energy (warmer, less dense air). The rotation of the earth, combined with the location of the continents, causes bands of wind patterns on the earth. For example, weather tends to move from the southwestern United States toward Connecticut. 23. Oceans are a major source of water in the air as water cycles between Earth's surface and the atmosphere. Large bodies of water absorb heat energy, causing water to evaporate (see GLE 4). The amount of water vapor in the atmosphere (humidity) is constantly changing, depending on the temperature of the air. Warm air holds more water vapor than cool air because it is less dense. As warm, humid air rises and cools, its molecules become more closely spaced and the water vapor condenses into tiny water droplets that are less dense than air (clouds). Tiny droplets may combine and become heavy enough to fall as rain (or other types of precipitation). 24. Weather on Earth is caused by daily variations in the temperature, pressure and humidity of different bodies of air (air masses). Warm, moist, less dense air masses rise, thus decreasing air pressure usually indicates that cloudy, wet, warmer weather is approaching. Cool, dry, denser air masses sink, thus increasing air pressure usually indicates clear, dry, cooler weather is approaching. 25. When masses of warm, wet air interact with masses of cool, dry air, their boundary is called a front. The way in which the air masses move past one another influences the type of weather that results. At the front, warm air rises above cold air, causing clouds and precipitation (and sometimes storms). Weather predictions can be made based on the pattern of warm, wet, low pressure air being typically followed by cool, dry, high pressure air. 26. Connecticut, and the northeast in general, often has rapidly changing weather because three patterns of moving air interact here: cold, dry air from the north, warm, moist air from the Atlantic ocean coastline, and air moving across the US from west to east.	**C9. Explain how the uneven heating of the Earth's surface causes winds and affects the seasons** Exercise 6.3.3 Air Pressure Exercise 6.3.4 Wind Exercise 6.3.5 Humidity Exercise 6.3.6 Air Masses & Weather

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Glossary

solid, liquid, gas, melting, freezing, condense, evaporate, cloud, wind, air pressure, humidity, air mass, cold/warm front, precipitation, storm, global wind, sea breeze, land breeze.

Inquiry Lesson 6.3.1 Thermal Expansion & Contraction

Content Standard	Expected Performance
6.3 Variations in the amount of the Sun's energy hitting the Earth's surface affect daily and seasonal weather patterns ♦ Earth is surrounded by layers of gases (atmosphere) that influence the environment and support life. Weather on Earth is caused by the daily changes in the temperature, pressure and amount of moisture in the lower atmosphere. Regions of the earth experience distinct and predictable weather conditions (climate) caused, in part, by different amounts of solar energy they receive. ♦ Heat energy causes tiny particles (molecules) to move. The molecules that make up all matter are in constant, though invisible, motion. Solids, liquids and gases differ in the movements and arrangements of their molecules. Molecules in gases move randomly and independently of one another. Molecules in liquids move around each other randomly, but are loosely held together by an attraction force. Molecules in solids are closely locked in a patterned position and can only vibrate back and forth. ♦ When some heat energy is added to a substance, its molecules move faster (increased temperature) and spread apart from each other (become less densely arranged). When heat energy is removed, molecules move slower (decreased temperature) and come together (become more densely arranged). ♦ If enough heat energy is absorbed by a solid or a liquid, the molecules may overcome the forces holding them together and change to a new state of matter. Solids change to liquids (melt) and liquids change to gases (vaporization) when heat energy is absorbed from the surroundings. Conversely, heat energy is given off when gases change to liquids (condensation) or liquids change to solid (freezing).	**C 7. Describe the effect of heating on the movement of molecules in solids, liquids, and gases.** Exercise 6.3.1

Science Materials:

Balloons, Small plastic water bottles, 1 L Pyrex^{tm} beakers, hot plates, Tongs, oven mitts, water, ice cubes, plastic bowls, paper, pencils

Student Handout 6.3.1 – Balloon Science classroom exercise

Vocabulary: Changes of State Sublimation Condensation Evaporation Plasma Solid Liquid Gas Molecules Atoms Bonds

Inquiry: In this exercise, students will investigate the effect of heating and cooling on air molecules. Students will work in groups of four and will take turns being the experimenters and the data recorders.

Procedures and Directions: Review the concepts covered in the literacy handouts.

Science Concepts: When a substance undergoes a physical change it means the substance changes its form but does not change its chemical composition.

For example, liquid water placed in a freezer becomes ice. Ice still has the same chemical composition as liquid water – it is made up of 2 atoms of Hydrogen for every atom of Oxygen – it is just in a solid form while water is liquid. If you heat water to boiling, it becomes water vapor (steam). Water vapor is still H_2O – just in gaseous form – you cannot see it or touch it very readily – and it is certainly not liquid. Changes of state (physical changes) occur because energy (in the form of heat) is either added to or taken away from a substance. When you add heat energy to a substance, the molecules that make up the substance absorb the heat and start to vibrate faster and faster. The faster they vibrate, the greater becomes the space between them. The reverse happens if you remove energy from a substance – the molecules vibrate slower and become more tightly crammed together – thus, ice forms from liquid water.

TEACHER GLOSSARY & BACKGROUND

Changes of State Sublimation Condensation Evaporation Plasma Solid Liquid Gas Molecules Atoms Bonds

Student Exercise 6.3.1: Balloon Science

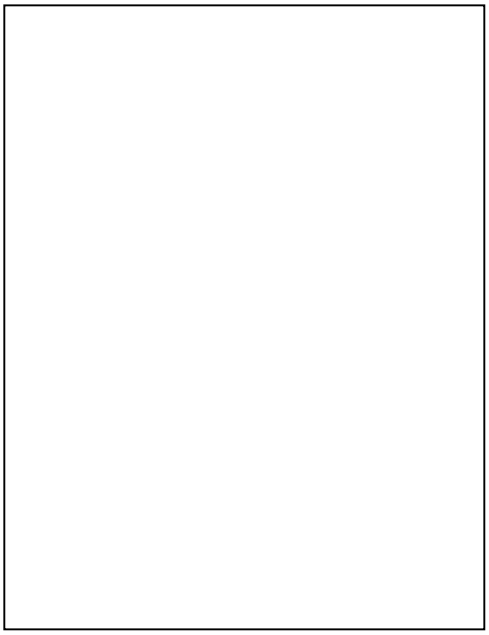
Purpose: This experiment explores the effects of temperature on the movement of air molecules.

Materials: 6" round party balloons – at least 4 for each group
Small plastic water bottles (e.g. Poland Springs^{tm} Aquapod bottle) – 1 for each group
1000 ml Pyrex^{tm} beaker – 1 for each group
Hot plates or other sources of heat – needs to be carefully supervised
Test Tube Tongs or Oven Mitts – one for each group
Water
Ice Cubes in a medium plastic bowl – 1 bowl for every group
Paper
Pencils
Data Sheet

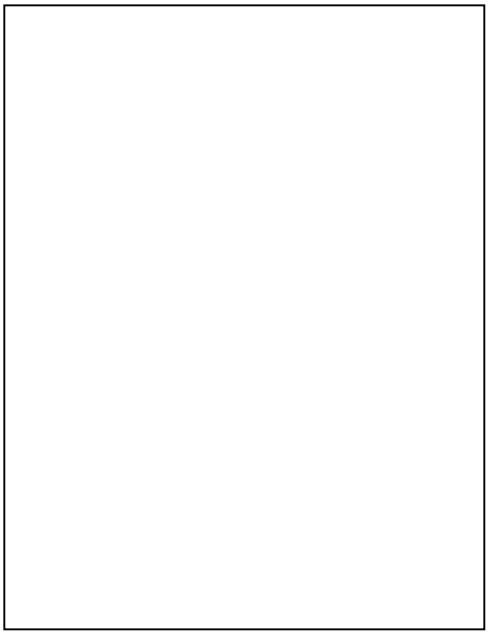
Methods:

1. Carefully pour 100 ml of water in the 1 L beaker.
2. Carefully stretch a balloon onto the opening of the empty water bottle. Observe the position of the balloon – write it down.
3. Place the water bottle - balloon apparatus into the beaker and place the beaker onto the hot plate.
4. Turn on the hot plate.
5. Observe what happens to the water in the beaker as it warms up. Write down your observation.
6. Observe what happens to the balloon. Write down your observations and make a sketch of what you see.
7. Turn off the hot plate.
8. Using the tongs or the oven mitt, carefully remove the test tube-balloon apparatus from the beaker and place it in the ice bowl. Observe what happens to the balloon. Record your observations and sketch what you see.
9. Carefully place the test tube-balloon apparatus back into the still warm water inside the beaker and observe what happens to the balloon. Write down your observations and sketch what you see.

Data Chart:



Heated



Cooled

Discussion:

1. Explain what happened to the balloon when the bottle-balloon apparatus was heated. What caused the change you observed?

2. Explain what happened to the balloon when the bottle-balloon apparatus was cooled in the ice bath. What caused the change you observed?

3. Although you could not directly see the air molecules, what can you infer about their motion when the bottle-balloon apparatus was heated ?

4. Describe the motion of the air molecules when the bottle-balloon apparatus was cooled.

5. Based on your observations in the lab, what do you think happens to air that gets heated at the Earth's surface?

6. Based on your observations, what happens to air at the Earth's surface if it cooled? _____

Conclusion: (Make a statement about the relationship between temperature and the movement of air molecules as demonstrated in this experiment.)

Inquiry Lesson 6.3.2 Differential Heat Absorption & Radiation

Content Standard	Expected Performance
6.3 Variations in the amount of the Sun's energy hitting the Earth's surface affect daily and seasonal weather patterns ♦ Different surfaces on Earth absorb and release solar energy at different rates. Land absorbs and releases heat faster than water. The surface temperature of large bodies of water, such as the oceans that cover a great deal of the earth, affects the temperature of the air above them. This is one reason that Connecticut's inland areas are warmer in the day (and in summer) and cooler at night (and in winter) than coastal areas.	**C.8 Explain how local weather conditions are related to the temperature, pressure and water content of the atmosphere and the proximity to a large body of water.** Exercise 6.3.2 Differential Heat Absorption and Radiation

Science Materials: Plastic Cups, Scissors, Black Gravel, White Gravel, Water, 4 Thermometers for each group, Heat Source (Lamp of some kind) – 1 for each group

Student Handout 6.3.2 – The Race to Heat Up & Cool Down

Vocabulary:

Inquiry: In this exercise, students will investigate the absorption, retention, & release of heat by different materials. Students will work in groups and will take turns being the experimenters and the data recorders.

Procedures and Directions: Review the concepts covered in the literacy handouts.

Science Concepts:

Student Exercise 6.3.2: The Race to Heat Up & Cool Down

Purpose: To explore how the ability to absorb heat and retain heat differs among different materials.

Materials Needed:

For Each Group: 3 Plastic Cups
Scissors
Black Fish Gravel or Sand
White Fish Gravel or Sand
Water
4 Thermometers
Desk Lamps

Methods:

1. Fill each cup with one of the following materials: black gravel, white gravel, & water.
2. Place the cups side by side on the table in front of you.
3. Put a thermometer in each cup and place one thermometer on the desk in front of the cups. Let the thermometers sit for two full minutes.
4. Record the temperature reading on each thermometer in the chart provided.
5. Turn on the lamp above all the cups.
6. After five minutes, record the temperature reading on each thermometer in the chart provided. Do not forget to record the temperature of the thermometer sitting on the desk.
7. After ten minutes has passed from the start of the experiment, record the temperature reading from every thermometer in the chart provided.
8. After fifteen minutes has passes from the start of the experiment, record the temperature reading from every thermometer in the chart provided.
9. Turn off the lamp. Wait five minutes and record the temperature reading from every thermometer in the chart provided.
10. Wait another five minutes, record the temperature reading from every thermometer in the chart provided.

Data Chart:

Time with Light On	White Gravel	Black Gravel	Water	Desk (Air)
0 minutes				
5 minutes				
10 minutes				
15 minutes				

Time with Light Off	White Gravel	Black Gravel	Water	Desk (Air)
5 minutes				
10 minutes				

Results:

1. The material with the highest temperature reading after 15 minutes in the light was _____.

2. The material with the lowest temperature reading after 15 minutes in the light was _____.

3. The material with the highest temperature reading after 10 minutes without the light on was _____.

4. The material with the lowest temperature reading after 10 minutes without the light on was _____.

Discussion:

1. Compare the temperature of each material at the start of the experiment to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Can you explain your answer ? `_____

_____
_____
_____
_____
_____
_____

2. Compare the temperature of each material after five minutes under the light to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Can you explain your answer ? `

3. Compare the temperature of each material after ten minutes under the light to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Can you explain your answer ? `

4. Compare the temperature of each material after fifteen minutes under the light to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Can you explain your answer ? `

5. Compare the temperature of each material after five minutes without the light to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Were they higher, lower, or the same as the temperatures you recorded with the light on ? Can you explain your answer ?

6. Compare the temperature of each material after ten minutes without light to the air temperature (the thermometer sitting on the desk). Were they similar or were they very different? Were they higher, lower, or the same as the temperatures under the light? Can you explain your answer ? `

7. If the water represents the world's oceans and the black and white gravel represents the world's land area, what can you say about how the Sun's energy is absorbed, retained, or returned to the atmosphere by the oceans and the land ?