Sunlight and Warm Air

Wyoming Science

Objectives:

- Students will understand the difference between radiation and conduction.
- Students will demonstrate the poor conducting value of air molecules.
- Students will discover the conductive value of land and water.
- Students will explore the transfer of heat through convection.

Background:

As the earth rotates in the light of the sun, its atmosphere is warmed by radiation from the sun. Close your eyes and, turn toward the sun, and you can feel the warmth of its radiant energy as it touches your face. It is this same radiant energy that strikes the molecules in the atmosphere, causing them to move, heat up, and strike each other. The number and frequency of molecular hits sustained by the mercury in a thermometer is what causes the mercury to expand and rise or contract and fall. This transfer of heat through the impact of molecules is called conduction.

Some may wonder why the troposphere, which is constantly bathed in radiant heat from the sun, is not hotter than it is. In general, the atmosphere is a poor conductor of heat. Unlike metal, which conducts heat through a tightly packed formation of molecules, air molecules occur randomly and have space between them, making it difficult to transfer heat. Hence the reason for a drop in temperature as the sun begins to set. In the mesosphere, where air molecules are far apart and closer to the sun, they generate lots of heat. However, if you were to measure the temperature of this air with a thermometer, it would appear to be very cold – about –184°F. This is because the thermometer would sustain only a few hits from the molecules on an infrequent basis, not enough to transfer any significant heat from the air molecules to the mercury. Take away the air entirely, as in the sealed walls of a vacuum bottle (thermos), and you have an inexpensive insulation from heat.

A second reason for the range of temperature in the troposphere has to do with the angle of the sun to the surface of the planet. The more direct the angle of the sun is to a particular section of the atmosphere, the greater the likelihood that the air molecules will heat up. As the earth orbits the sun, different parts are tilted toward the sun, so varying

Wyoming Agriculture In The Classroom

Standards

Science

Earth, Space,
& Physical Systems:
1.4, 1.8, 1.9

Science As Inquiry:
2.1, 2.2A, 2.2B, 2.2C,
2.2D, 2.2E

Materials

- Desk lamp or strong flashlight
- Sunglasses
- 3 thermometers
- 2 cups of potting soil
- White paper
- String
- 2 round balloons
- String
- Stick
- Tape
- Desk lamp
- 2 cups liquid dish washing detergent
- Water
- 3 tbsp. Glycerin
- Bubble wands
- 9-oz. Clear plastic cups

Estimated Time

(4) - 40 Minute Activities

Grades 3-4

vocabulary:

- *radiation*
- *conduction*
- *mercury*
- *molecules*
- *conductor*
- *insulation*
- *troposphere*
- *hemisphere*
- *equinox*
- *atmosphere*

amounts of radiant energy enter the atmosphere at different times of the year.

In the Northern Hemisphere, the North Pole is tilted away from the sun in December. Less of the sun's radiant energy reaches the hemisphere directly, resulting in winter. As the earth continues in its orbit, the North Pole begins to tilt toward the sun. The sun rises higher in the sky and daylight increases. In March, at the vernal or spring equinox, the day and night are equal. The amount of sunlight increased until the summer solstice on June 21, when the sun reaches its maximum height in the sky.

As the earth continues its orbit around the sun, the North Pole begins to tilt away again. The autumn equinox occurs in September and daylight continues to decrease until the winter solstice. Of course, as the North Pole tilts away from the sun, giving way to winter, the South Pole is tilting toward the sun, giving way to summer.

A final consideration has to do with the amount of light reaching the planet and what happens once it reaches the surface. About one-third of the solar energy reaching the earth is reflected away from the planet. Another 20 percent is absorbed at various heights in the atmosphere. The remaining 50 percent of the sun's radiant energy passes through the atmosphere and is absorbed by the ground and oceans. As the water and land heat up, they both radiate and conduct heat back into the atmosphere. As the air molecules close to the surface heat up, they spread out, becoming less dense, and begin to rise, distributing heat in a process known as convection. As they rise above the surface, they begin to cool, becoming less dense, and return to the surface.

Talk About the Topic

Begin this lesson by helping the group understand the warming influence of the sun on the earth's atmosphere. Help them think about a time when they closed their eyes and turned their faces toward the sun to feel its radiation. Sometimes, the radiation gets so intense; we put on sunglasses or turn our faces from the sun.

Explain this is the same radiant energy that strikes the molecules in the atmosphere, causing them to move, heat up, and strike each other. The number and frequency of molecular hits sustained by the mercury in a thermometer is what causes the mercury to expand and rise or contract and fall. This transfer of heat through the impact of molecules is called conduction.

Activity Procedures:

Activity 1—Heat on the Move

1. Help the group understand that the sun not only gives off light energy but also gives off invisible energy in the form of radiation. It is this radiant energy that is responsible for the sensation of warmth on our faces as we turn toward the sun. Actually, this radiation excites the molecules in our skin causing them to move rapidly, generating the heat that we feel. Use the following steps to demonstrate this concept.
2. Select someone from the group and give that person a pair of sunglasses.
3. Have the person put on the sunglasses. Use a desk lamp or a strong flashlight to shine the light close to the person's face. Have the person report when the radiant energy from the lamp can be felt.
4. Explain how the same thing happens when the molecules of air get hit by the sun's radiation. They begin to move rapidly, heating up, and transferring the heat to other air molecules or to the surface of our skin. This transfer of heat from molecule to molecule is called conduction and can be experienced as a warm breeze on a summer day.
5. Have the entire group form a circle standing shoulder to shoulder. Explain that each person in the circle represents a molecule of air. Explain that as the sun, you are going to inject some of your radiant energy into the group. Their goal is to see if they can conduct the energy throughout the circle.
6. Position yourself between two of the group members. Tell them that to pass on the energy, they have to give their neighbor a "high-five" as it comes around, meaning once they receive it from the person on their right, they pass it along to the person on their left.
7. Have the group start out slow and complete one circuit around the circle. After two successful tries, tell them you are going to apply more radiant energy, and they have to respond by going faster thereby generating more heat.
8. Conclude remarks with the following question and assignment. What instrument records the amount of heat generated by moving molecules? (Thermometer) Explain that heat generated by moving air molecules is conducted to the mercury in the thermometer, causing it to rise.
9. Assignment: Distribute the copies of Worksheet 1, Temperature Fun. Make an overhead of Transparency B, Reading a Thermometer, and show it to the group. Explain how thermometers measure temperature in Celsius and Fahrenheit. After completing Worksheet 1, have them use Worksheet 2, Fahrenheit and Celsius, to convert Fahrenheit to Celsius.

materials:

Activity 1

Heat on the Move

- Desk lamp or strong flashlight
- Sunglasses
- Worksheet 1, Temperature Fun
- Transparency B, Reading a Thermometer
- Worksheet 2, Fahrenheit and Celsius

materials:

Activity 2

Does Air Hold Heat?

- Transparency A, Layers of Atmosphere

Activity 2—Does Air Hold Heat?

1. Help the group understand that air density contributes to air temperature. Begin by asking if the group can guess where the air temperature is higher, in the troposphere or the stratosphere? Use your Layers of Atmosphere, Transparency A, to remind them where these layers are located. Help them understand that because the molecules are closer together (denser) in the troposphere, air temperatures are higher. Because there are more of them, they have a greater chance of hitting the thermometer and transferring their heat to the mercury.
2. Arrange the group into two equal circles, standing shoulder to shoulder. Pick one group and have them take three steps backwards so that there is a large gap between members. Tell them that this time they are representing the molecules in the stratosphere.
3. Have the other group stand as before and tell them that they represent the molecules in the troposphere.
4. Explain, as before, that you will distribute your radiant energy into the circle. They in turn will need to pass it along as a high five to the person next to them.
5. Have the students guess which group will take longer to pass the energy, the stratospheres or the troposphere's?
6. Help them see that the closer, denser molecules in the troposphere group were quicker at passing along the energy. The same can be said of the molecules in the troposphere. Even with the closeness of molecules in the troposphere, it is a fairy poor conductor of heat. This is evidenced by the dropping of temperature as the sun sets or is obscured by clouds. It is even experienced as the angle of the earth's surface changes with the passing of seasons.
7. Distribute a pair of sunglasses to five of the group members. Have them sit on chairs in a semicircle facing out. Be sure their chairs are touching.
8. Stand facing the middle of the circle and shine the lamp or flashlight toward their faces. Move in close enough so that at least the ones in the middle can feel the heat from the lamp.
   - Explain that like the earth, the temperature of its atmosphere drops when the sun sets. Turn off the light and have them report when they feel cooler.
   - Explain, next, that when clouds obscure the sun, the temperature decreases. Obscure the light by putting your open hand in front of the light and have them report when they feel cooler.
   - Explain, finally, that as the earth travels around the sun, its North Pole points towards it in the summer and away

from it in the winter. Demonstrate this by angling your light away from one side of the circle and toward the other. Those in the direct rays of the light will report higher temperatures.

Ask the questions:

- What happens when I move the lamp away from the group? (They feel the heat.)
- Why would this occur? (More molecules, but more spaces between the molecules to lose heat.)
- Would the absence of air molecules, as in the case of a vacuum, be a good insulator? (Yes, because the vacuum bottle used in a thermos does just this.)

Activity 3—How Land Warms the Air

1. Based on the previous activity, they learned that air is a poor conductor of heat. However, see if they can guess why the planet doesn't freeze up when the sun sets. Knowing that molecules with lots of space between them make poor keepers of heat, have them think about closely packed molecules of stuff that get lots of exposure to the sun. With a little bit of prodding they should begin thinking about the role of soil and water. Explain that since the molecules in the land and the water are much closer together, they play a key role in absorbing the sun's radiant energy and conducting it into the atmosphere. Secondly, because of the insulating nature of soil and the residual heat from inside the earth, the soil tends to conduct heat from below. For example, below six feet, where the soil is insulated from the air above, the ground temperature maintains a constant 55°F. Lastly, although water is less dense than land, it takes longer to heat and cool because of the nature of water molecules. This can be noted during the winter months when the land is frozen but the water below an ice-covered lake is still 45°F.
2. Place a thermometer on a layer of potting soil, another thermometer on a sheet of white paper (to simulate snow), another in a cup of room temperature water, and another suspended from a string. Place all four in close proximity.
3. Take a temperature reading of all four.
4. Shine a desk lamp on all four thermometers for five minutes then take a temperature reading.
5. Remove the light and wait five minutes before taking a temperature reading.
6. The thermometer suspended from the string and on the white paper will show the greatest variability in temperature.

materials:

Activity 3

How Land Warms the Air

- 3 thermometers
- 2 cups of potting soil
- White paper
- String
- Desk lamp

Cricket Fact:

Did you know that a cricket is a great thermometer? Count the number of chirps a cricket makes in 14 seconds then add 40. That will be the local temperature in degrees Fahrenheit.

materials:

Activity 4

How Heat Gets Around

- 2 Round balloons
- String
- Stick
- Tape
- Desk lamp
- 2 cups Liquid dish washing detergent
- 11 cups ofWater
- 3 tbsp. Glycerin
- Bubble wands (or make from 22-gauge insulate wire)
- 9-oz.Clear plastic cups

Soap Bubble Recipe

Mix 11 cups of lukewarm water and three tablespoons of glycerin in a plastic milk jug.

Carefully pour in 2 cups of liquid dish washing detergent.
Swirl the ingredients carefully so as not to create too much foam.

The solution must be thoroughly mixed for the best results.

Ask the following questions:

- What holds its temperature longer, a dark surface or a white surface? (White surface reflects heat dark absorbs heat)
- What happens to the air that comes in close contact with warm water and soil? (Heat conducts from the soil and the water into the air.)

Activity 4—How Heat Gets Around

1. Explain to the group that as air close to the ground is heated, its molecules spread out, making it less dense and allowing it to rise. Remind them that density is a factor of mass (stuff) and volume. A cup of hot air weights less than a cup of cold air. That's because there are fewer molecules in a cup of hot air than in a cup of cold air.
2. You can demonstrate this by setting up the following example using two balloons, a stick, and a string. Make sure the apparatus is balanced before using. Explain that by shining a desk lamp on one of the balloons; you cause it to expand, becoming less dense and rising. Eventually, as the balloon cools, it becomes denser and falls. This rising and falling of air is called convection heating and contributes to local air movement.
3. Distribute a supply of soap bubble solution and bubble wands to the group as described in the Teacher Notes.
4. Explain that the heat of their breath will warm the air in their bubble, causing it to expand, become less dense, and rise. As air (like the bubble) travels away from the heat source, it begins to cool, becoming dense and falling to the ground. Remind them how this rising and falling of air is called convection heating and contributes to local air movement.
5. Ask the following questions:
6. Have they ever noticed a shimmering look above the surface of a road or building in the summer time? (If yes, explain how this shimmering is making of convection currents.)
7. Can they think of a gas that is blamed for keeping in heat? (Carbon dioxide)

Assignments:

- Complete Worksheet 3, Air Temperature
- Complete Temperature Review Test

Lesson Adapted from the "Weather Together"
Ohio State University Extension

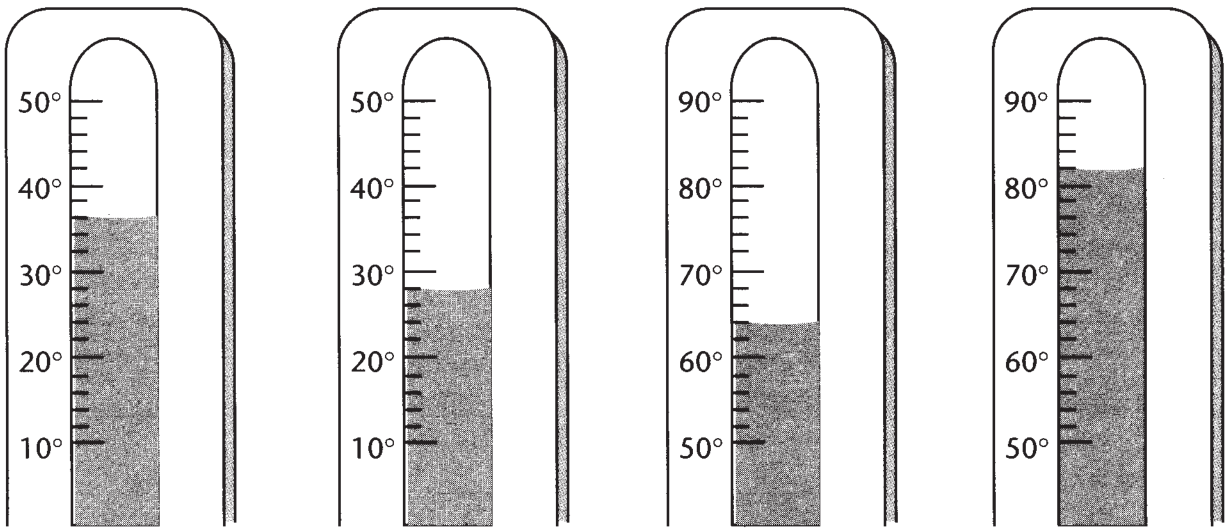
Worksheet #1

Name___________________

Temperature Fun

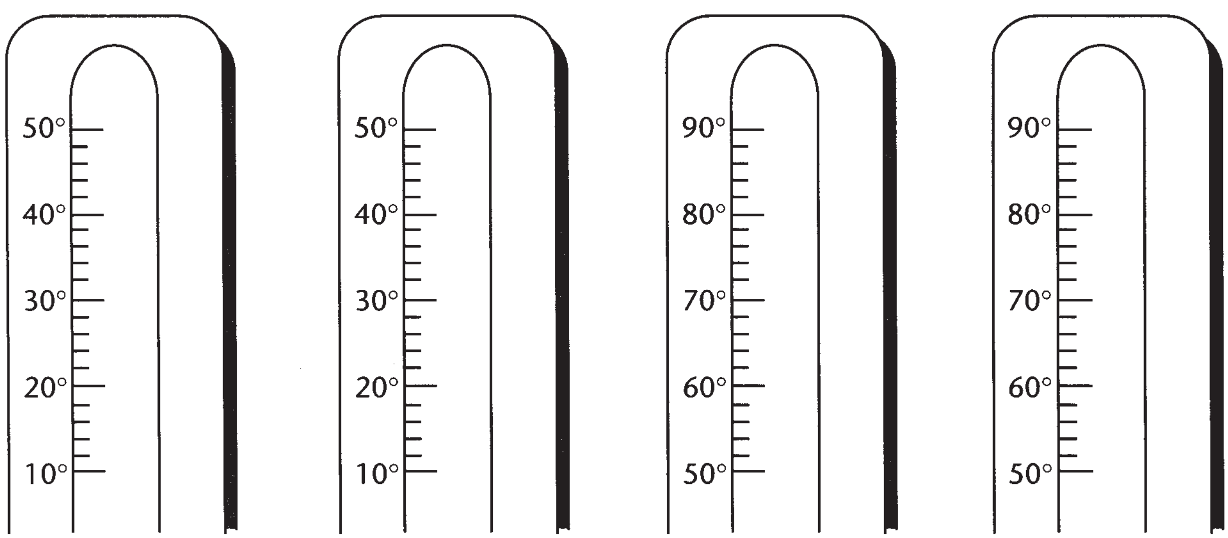
Reading a Thermometer

Look at each thermometer. Write the temperature.



A. __________ B. __________ C. __________ D. __________

Color the thermometer to show the temperature.

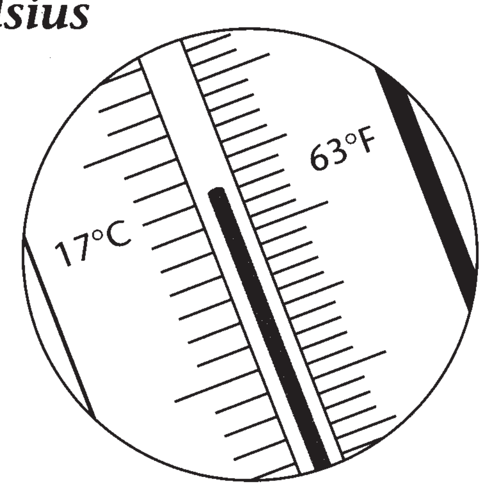


E. 42°C F. 28°C G. 86°F H. 70°F

Worksheet #2

Name___________________

Fahrenheit and Celsius



To change from Fahrenheit degrees to Celsius degrees:

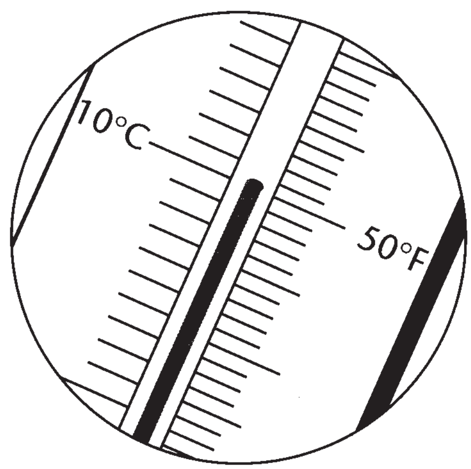
1. Subtract 32 2. Multiply by 5 3. Divide by 9

Follow the steps given earlier to change from Fahrenheit degrees to Celsius degrees.
Write the Celsius degrees.

A. 32°F = ________ °C B. -13°F = ________ °C C. 86°F = ________ °C

D. 77°F = ________ °C E. 50°F = ________ °C F. -5°F = ________ °C

G. 104°F = ________ °C H. 44°F = ________ °C I. 23°F = ________ °C



To change from Celsius degrees to Fahrenheit degrees:

1. Multiply by 9 2. Divide by 5 3. Add 32

Follow the steps shown to change from Celsius degrees to Fahrenheit degrees.
Write the Fahrenheit degree.

J. 35°C = _________ °F K. -10°C = _________ °F L. 12°C = _________ °F

M. 30°C = _________ °F N. 20°C = _________ °F O. 2°C = _________ °F

P. 5°C = _________ °F Q. 45°C = _________ °F R. -15°C = _________ °F

Worksheet #3

Name_________________

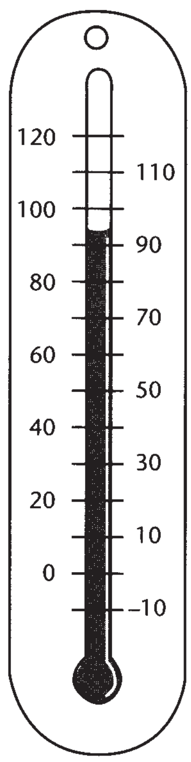
Air Temperature

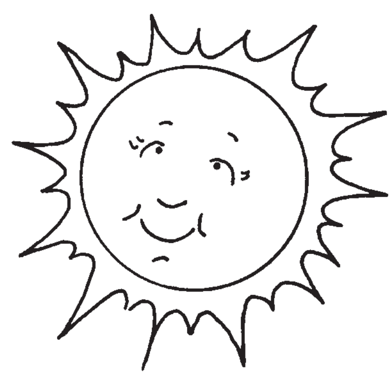
The temperature means how hot or cold something is. The earth gets heat from the sun. But the sun does not heat everything evenly. Some of the heat is soaked up by the atmosphere. Some of it goes into the earth. When the earth is warmed, it heats the air near it. Warm air rises. When this air goes up, cold air above comes down to fill up the gap the warm air left. This makes wind. This also changes the temperature.

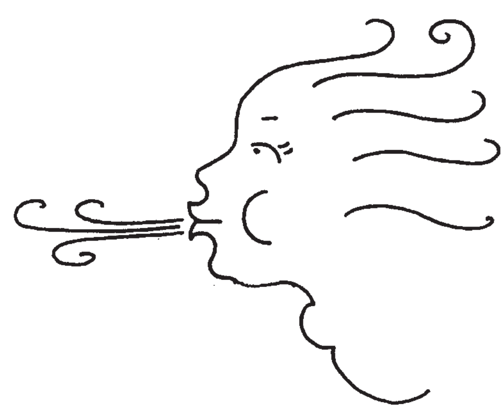
Land soaks up and gives off heat quickly. But the oceans warm and give off heat slowly. All these things make temperatures change. We measure these temperature changes using a thermometer.

Write the answers to the questions.

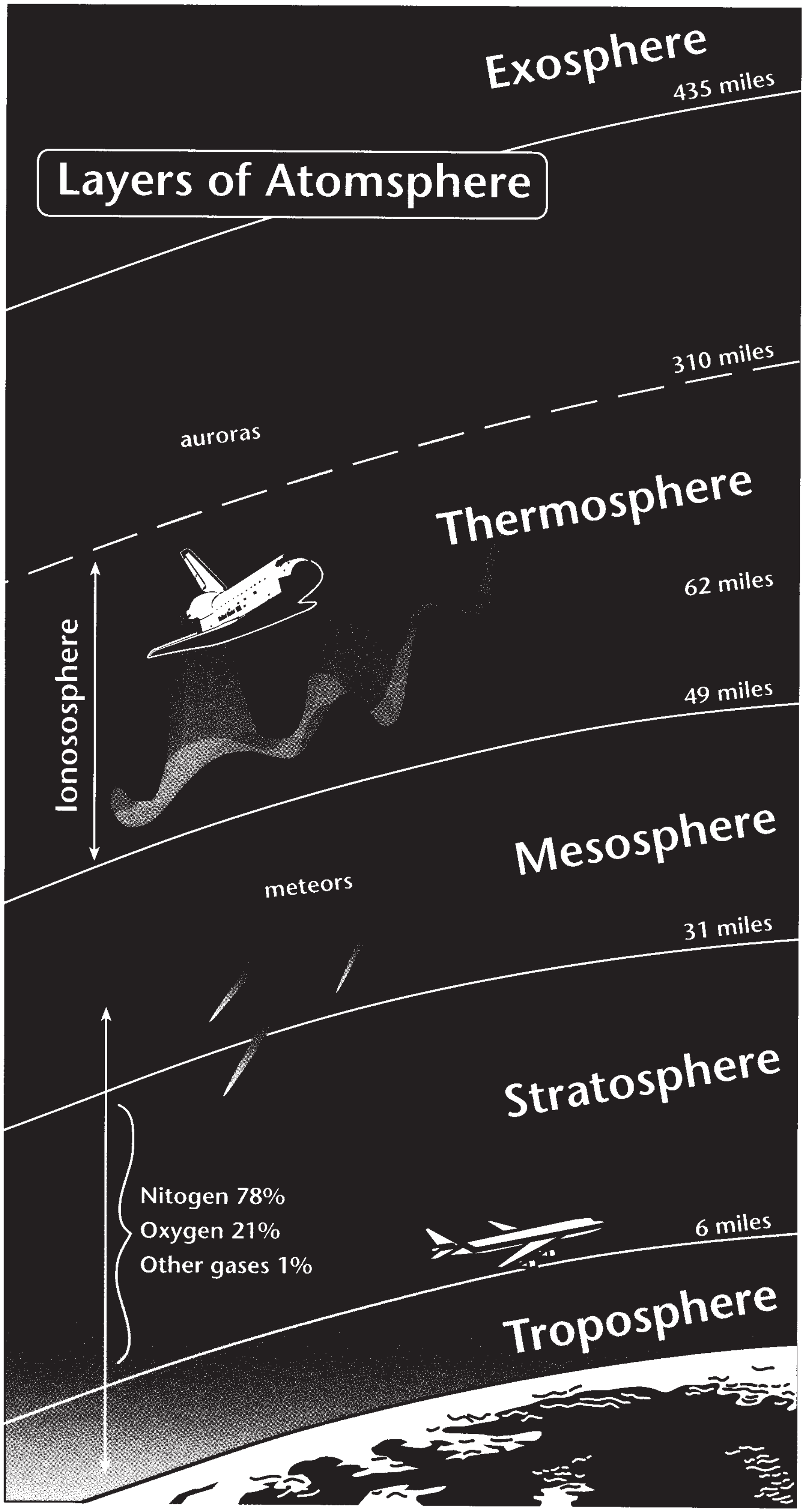
1. Means how hot or cold something is. ______________________________
2. From what do we get our heat? ______________________________
3. Name two things that soak up the heat. ______________________________
4. What soaks up the heat quickly? ______________________________
5. From what do we measure temperatures? ______________________________





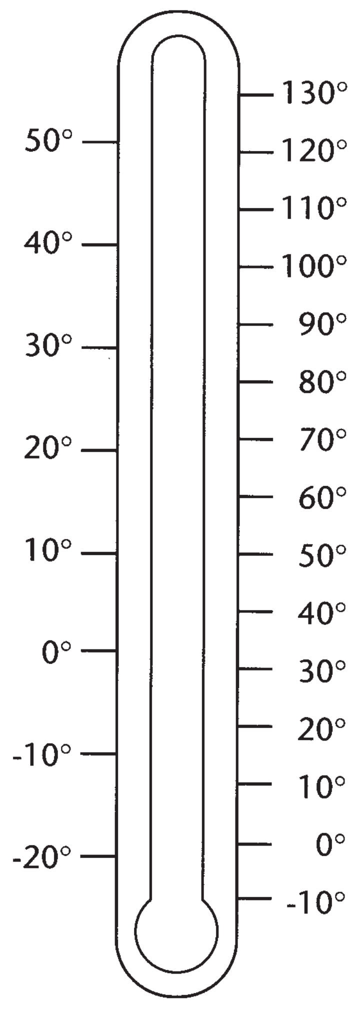


Transparency A *Layers of Atmosphere*



Transparency B

Reading a Thermometer



Cut out this strip and use it as "mercury" to demonstrate various temperatures.

Name___________________

Temperature Review Test

1. True ________ or False ________ Animals may react unusually if a storm is coming.

2. True ________ or False ________ When the temperature increases, the air molecules speed up.

3. True ________ or False ________ The basketball courts are probably the coolest area around a school.

4. Check those items that cause temperature variations.

_______ A. Wind

_______ B. Sun

_______ C. Reflections

_______ D. All of the above

5. What are the temperatures shown on this thermometer?

A. ____________________

B. ____________________

C. ____________________