Chapter 15 – The Atmosphere and Weather

Day	Activity	Homework
1	Notes I- II	
	Layers of the atmosphere*	
2	Notes III	
	Air Pressure Labs*	
3	Notes IV	
	Global Winds Activity*	
4	Complete Notes	Concept Map
	Relative Humidity and Heat Index	
	Making Hail*	
	"Weather Wars" *	

Alternate Activities

1. This website contains instructions for building a weather station.

http://school.discovery.com/lessonplans/activities/weatherstation/

2. "Weather Wars"- The website below contains an article about possibly using weather modifications as war strategies in the future. Students may also need some background information about cloud seeding before reading the article.

http://www.popularmechanics.com/science/military/1997/2/weather_wars/

NC Goals:

5.01 Analyze air masses and the life cycle of weather systems:

- Planetary wind belts
- Air masses
- Frontal systems
- Cyclonic systems

Chapter 15 – The Atmosphere and Weather

Why can't we control the weather?

I. The Past Atmosphere

A. Scientists theorize that 4 billion years ago the Earth's atmosphere was quite different than it is today. It was a volatile atmosphere containing a small amount of water and two deadly gasses: methane and ammonia.

1. Methane is a poisonous compound made of carbon and hydrogen.
2. Ammonia is also a poisonous compound made of nitrogen and hydrogen.

B. This deadly atmosphere began to change around 3.8 billion years ago when sunlight triggered chemical reactions among the methane, ammonia and water vapor.

1. Hydrogen, a lightweight gas, escaped into space.
2. Nitrogen was left in great abundance, as well as carbon dioxide and water vapor.
3. Volcanic activity also released carbon dioxide, water vapor, nitrogen and sulfur compounds into the atmosphere.
4. The water vapor from volcanic activity formed clouds that continually rained on the early Earth to form the oceans.

C. As organisms evolved, blue-green bacteria used the energy from the sun, carbon dioxide, and water to produce its own food through photosynthesis. As a byproduct of this process, oxygen was released into the atmosphere.

D. As oxygen began to accumulate the atoms combined to form the ozone layer.

E. With protection from ultraviolet radiation provided by the ozone layer, many new organisms evolved and the amounts of carbon dioxide and oxygen began to level off.

II. The Present Atmosphere

A. Our present atmosphere contains gases including nitrogen, oxygen, carbon dioxide, water vapor, argon, and trace gases.

1. Nitrogen gas makes up 78%
   a. All living things need nitrogen to make proteins for growth and repair.
   b. Bacteria play an important role in converting the nitrogen gas into a usable form for plants and animals.
   c. Nitrogen is recycled back into the atmosphere when plants and animals decay.
2. Oxygen makes up 21%
   a. Used directly by most living things for respiration (breaking down food to release needed energy)
   b. Necessary for combustion (burning) of fuels
3. The remaining 1% is a combination of carbon dioxide, water vapor, argon and trace gases.
   a. Carbon dioxide is important for plants to make their own food (photosynthesis)
   b. Carbon dioxide is returned to the atmosphere through decay and respiration (we exhale carbon dioxide)
   c. Water vapor plays an important role in our weather, and absorbing heat in our atmosphere.

B. Without our gaseous atmosphere Earth would be a cold ball of ice with a temperature of -60 degrees Fahrenheit.

C. The present atmosphere is also needed to absorb, or deflect, cosmic rays, charged particles, and UV radiation.

Review Questions

1. Explain how our present atmosphere differs from the past atmosphere.

2. Explain how the three main gases that make up our atmosphere are important to living things.

III. Layers of the Atmosphere

A. Our atmosphere extends upward for about 120 miles and is divided into four unequal layers. These layers are divided according to major temperature changes.

1. As you travel up into the atmosphere temperatures change and air pressure decreases.
2. Because air pressure decreases with increasing altitude, there is less available oxygen as you go up into the atmosphere.
3. The tolerable limit for humans is between 5,000 and 18,000 feet. Above 25,000 feet- known to climbers as the Death Zone- tremendous stress is placed on the body.

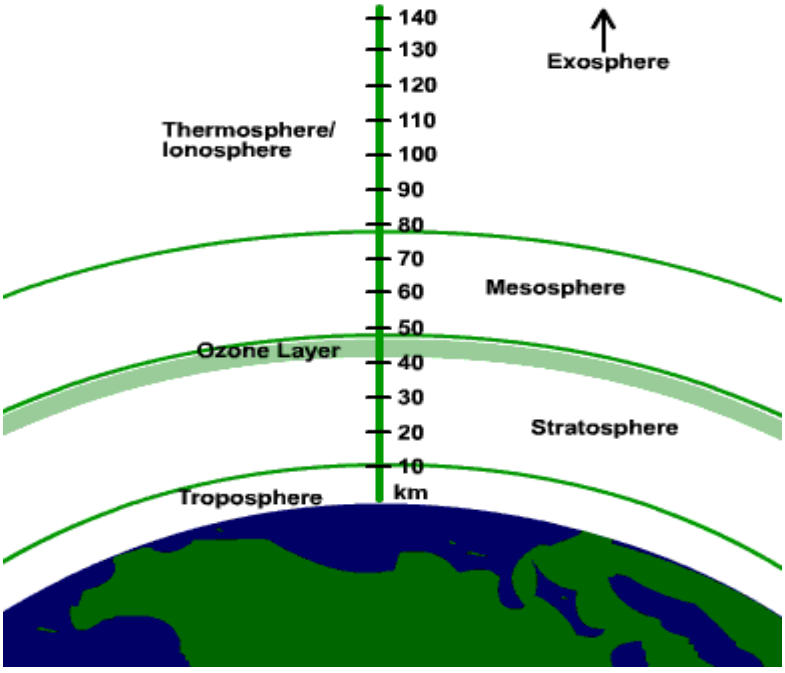
B. The four layers of the atmosphere, beginning with the layer closest to Earth's surface are the troposphere, stratosphere, mesosphere, and thermosphere.

1. Troposphere (or "turning" sphere)- the layer that we are able to live in because of the warmth and oxygen it provides
   a. Ten miles thick at the equator and six or seven miles in temperate latitudes (such as North Carolina)
   b. Makes up 80% of the atmosphere's mass, virtually all water, and all weather are contained in this layer
   c. Temperatures at the edge of the troposphere are about -55 degrees Celsius
2. Stratosphere- extends up to 50 kilometers above Earth's surface
   a. The air in the lower stratosphere consists of strong eastward winds called the jet stream.
   b. Also contains the ozone layer which absorbs ultraviolet radiation from the sun.
   c. The ozone layer is also responsible for the increase in temperature to 18 degrees Celsius in the upper stratosphere.
3. Mesosphere- extends up to 80 kilometers above Earth's surface
   a. Temperatures drop to -100 degrees Celsius at the upper regions (the coldest region of the atmosphere)
   b. Protects the Earth from meteoroids entering the atmosphere- the heat produced by friction and rubbing between the meteoroid and atmosphere cause them to burn. Some are large enough to pass through the atmosphere and are called meteorites.
4. Thermosphere ("warm-layer") - no well-defined upper limits
   a. Temperatures in this layer may reach as high as 2000 degrees Celsius! A great deal of nitrogen and oxygen in this layer absorb ultraviolet radiation from space and convert it into heat.

b. The air in the thermosphere is very thin, meaning that there are very few air molecules. So, even though each molecule is very warm (moving fast), they are far apart and rarely come in contact with one another. This means that space shuttles must enter the thermosphere at angles no greater than 6 degrees. If they were to enter the atmosphere too quickly and at the wrong angle there would be enough molecules to create drag and become combustible.

c. The lower part of the thermosphere is the ionosphere. Here, gas particles become electrically charged by absorbing UV radiation and X-rays given off by the sun. These ions (charged particles) become important for radio communication.

d. The upper thermosphere is called the exosphere. This is where artificial satellites orbit the Earth.



Review Questions

1. List the layers of the atmosphere beginning with the layer closest Earth's surface.

2. What component of the stratosphere is important to life on Earth?

3. What characteristics make the thermosphere useful to humans?

IV. Weather

A. Defined as the daily condition of Earth's atmosphere

B. Four factors interact to cause our weather:

1. Heat Energy- the sun's radiant energy warms the Earth

a. This energy warms the Earth by absorbing, storing, and recycling radiant energy.

b. The energy absorbed is spread throughout the atmosphere in three ways:

i. Conduction- direct transfer of heat from one substance to another (the ground is warmed and the air in contact is also warmed)

ii. Convection- unequal heating of the atmosphere causes warm air to rise, and cool air to sink creating convection currents (up and down motions of air)

iii. Radiation- transfer of heat by wave motion (Ex. you can feel the heat coming from a hot stove)

2. Air pressure or atmospheric pressure- is a measure of the force of the air pressing down on Earth's surface (air does have weight!)

a. Depends on the density of air (cold air is more dense and therefore creates a higher air pressure, whereas warm air is less dense and creates lower air pressure)

b. Affected by three factors:

i. Temperature- cold temperatures = high pressure

high temperatures = low pressure

ii. Water vapor- moist air is less dense than dry air (water molecules have less mass than nitrogen or oxygen molecules)

iii. Elevation or altitude- as you go up in altitude air pressure decreases

c. Air pressure is measured with an instrument called a barometer.

d. Air pressure differences create wind

e. Pressure is greater at lower altitudes because the air's molecules (being pulled down by gravity) are squeezed under the weight of the air above. This change in pressure is evident when your ears "pop" as you go up in altitude.

f. Air pressure can help predict the weather. For example, high pressure usually indicates fair weather while low pressure can lead to cloudy, rainy weather.

3. Wind- created by differences in air pressure (winds blow from high pressure to low pressure areas) due to unequal heating of the atmosphere. There are two types of winds: local and global

a. Local winds are created due to land heating up faster than water.

i. Land breeze- a flow of cooler air moving from land to sea, usually occurring at night

ii. Sea Breeze- the flow of cooler air moving from sea to land, usually occurring during the day

iii. Monsoon- a major land and sea breeze bringing a rainy season and warm temperatures (common in Asia)

b. Global Winds- large systems of wind that are influenced by the unequal heating of Earth's surface. (Ex. at the equator warm air rises and moves towards the poles, and cooler air at the poles sinks and moves toward the equator)

i. Coriolis effect- the apparent shift in the path of any fluid or object moving above Earth's surface due to the rotation of the Earth. It explains why winds in the Northern hemisphere curve to the right, and winds in the Southern hemisphere curve to the left.

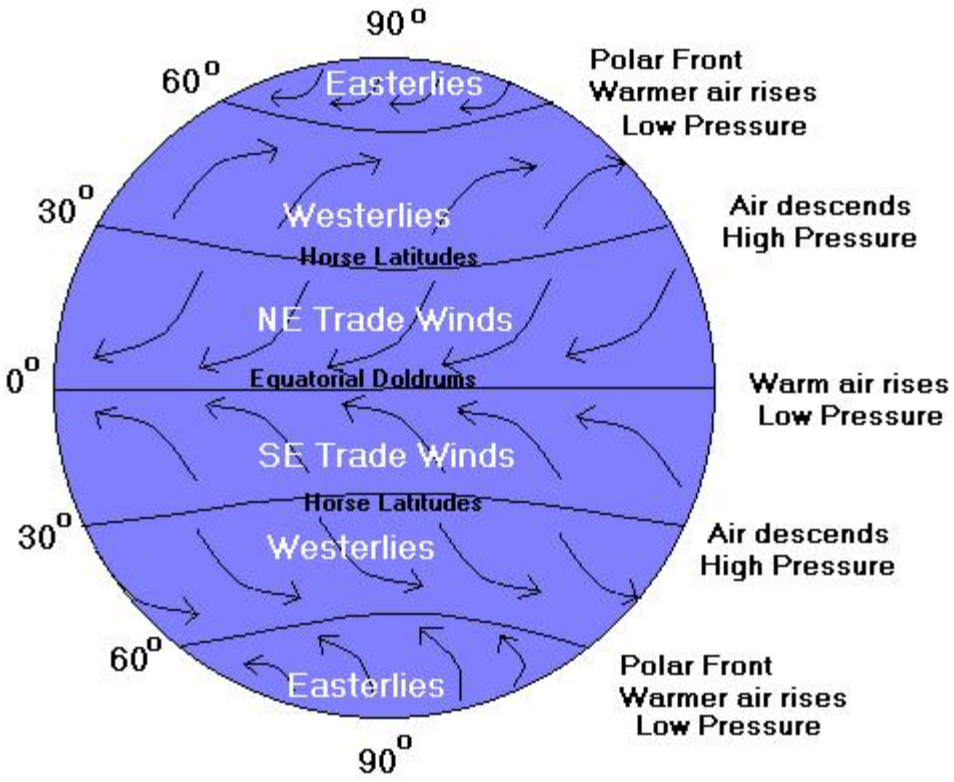
ii. Doldrums- areas at the equator (0 degrees latitude) where winds are quite calm, this area can cause problems for sailing ships

iii. Trade Winds-(the winds that carried Columbus) located 30 degrees north and south of the equator where warm air rising from the equator begins to sink. In the northern hemisphere these winds are called northeast trades, in the southern hemisphere they are called southeast trades.

iv. Prevailing Westerlies- winds blowing from west to east located in a belt from 40 to 60 degrees latitude in both hemispheres

v. Polar Easterlies- cold, weak winds around the poles flowing from the east

vi. Jet stream- wandering, narrow bands of high-speed winds in the upper atmosphere that flow from west to east



4. Moisture in the Air

   a. Moisture enters the air through evaporation, a process by which water molecules escape into the air.

   b. Humidity- water vapor, or moisture, in the air

      i. Relative humidity is the amount of moisture in the air relative to the amount that it could hold at a particular temperature (warm air holds more moisture than cold air)

      ii Measured using a psychrometer, an instrument containing two thermometers, a wet-bulb (thermometer covered with a wet cloth) and a dry-bulb. Evaporation of water on the wet-bulb requires heat which cools the temperature of the wet-bulb. The relative humidity can then be measured by finding the difference between the dry-bulb and wet-bulb temperatures. Then, using those

numbers, a chart gives you the relative humidity expressed as a percentage.

c. Clouds- form from rising moisture in the air. Process of cloud formation:

i. Warm air, holding more moisture than cold air, begins to rise in the atmosphere

ii. As the air moves up the temperatures begin to drop and cold air becomes saturated with moisture.

iii. At this temperature, water vapor begins to condense, or change into liquid (dew point)

iv. The moisture begins to collect on small dust particles or other solids in the air and a cloud forms

v. There are three main types of clouds: cumulus (cotton balls in the sky), stratus (smooth and gray), and cirrus (feathery)

d. Precipitation- water that falls from the atmosphere to Earth

i. Cloud droplets begin to increase in size, become too large to remain suspended, and fall to Earth as rain

ii. If the falling drops pass through cold air and freeze they become sleet

iii. Water vapor that changes directly into a solid forms snow

iv. Hail forms in cumulonimbus (thunderstorm) clouds as water droplets hit ice pellets in a cloud and freeze. If the wind is strong enough, it moves the hailstones around in the cloud allowing them to form layers of new ice before falling to the ground.

C. The interactions of heat energy, air pressure, wind and moisture are constantly interacting and changing to cause our weather.

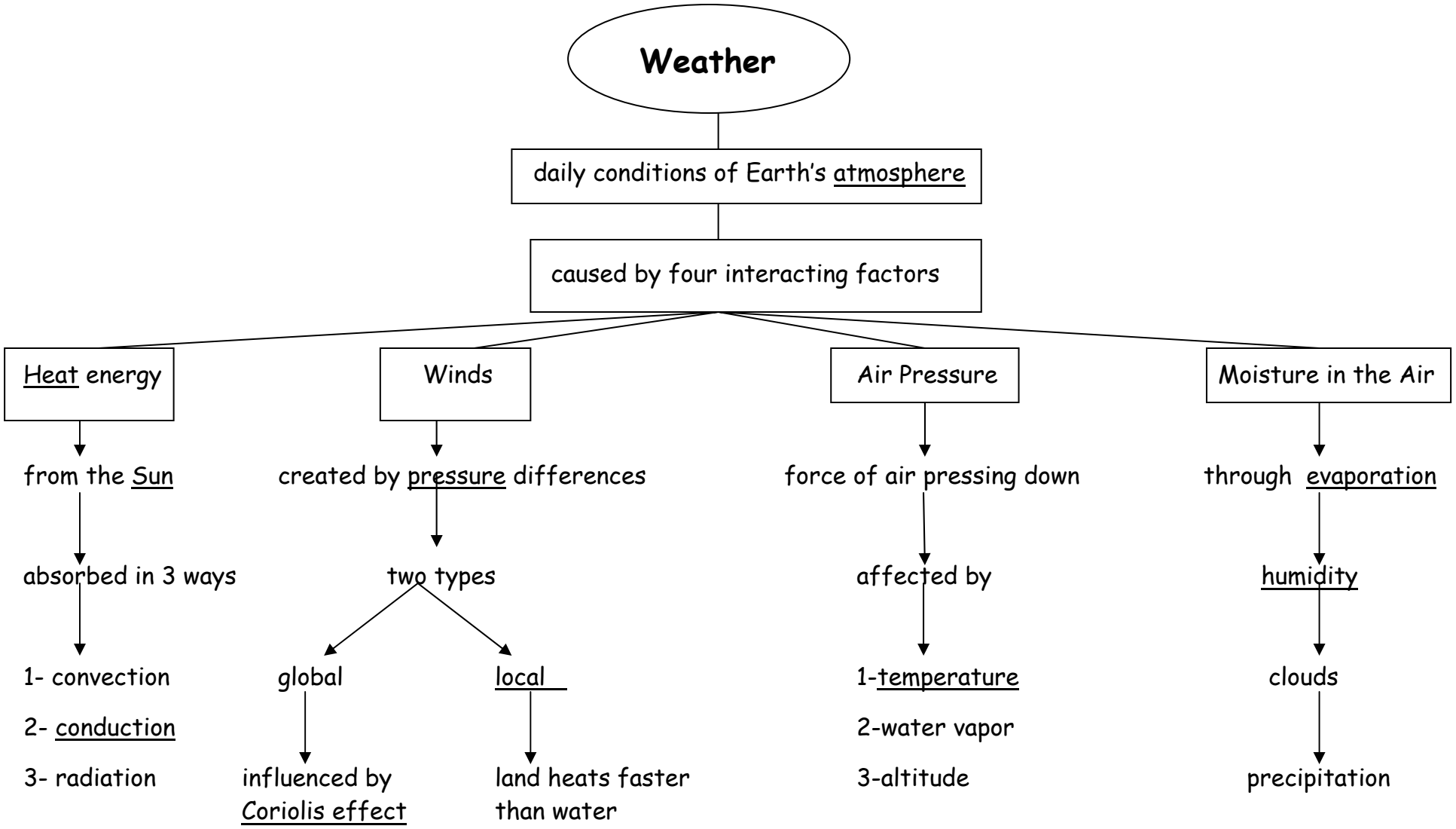
Review Questions

1. What are the four factors that influence our daily weather?

2. Explain why winds in the northern hemisphere curve to the right and winds in the southern hemisphere curve to the left.

3. Explain how air pressure and winds are related.

4. What does 100 % humidity indicate about the air?



Word Bank

humidity	heat	evaporation	Coriolis effect	pressure
sun	temperature	atmosphere	local	conduction

Relative Humidity and Heat Index

(created by Project Earth Science)

Introduction:

If you are outside working and it is really muggy, why does it feel so much hotter than the actual temperature? How does mugginess affect how you hot you feel?

Objective: The amount of moisture in the air affects how much water can evaporate into the air. The more moisture in the air, the less water that will evaporate into it. If this evaporation is from the bulb of a thermometer, then the evaporation can be measured as a temperature change. The greater the evaporation, the greater the temperature change. In this activity, we will measure the **RELATIVE HUMIDITY** and we will use the humidity to estimate the heat index. The **HEAT INDEX** is used to describe how hot it "feels" due to both temperature and humidity effects. The more humid it is the smaller the amount of evaporation from the skin and, therefore, the smaller the amount of cooling felt due to evaporation.

Materials:

2 thermometers	Relative humidity chart (Textbook)
Wet cloth	Heat index chart

Procedure:

1. Take your 2 thermometers outisde and wait about 1 minute to get a starting temperature reading.
2. Record the starting temperature in the chart below.
3. Place the wet cotton cloth over the bulb of each thermometer.
4. Spin the thermometers in the air for 30 seconds.
5. Record the new temperatures in the chart below.
6. For each thermometer, subtract the wet-bulb temperature from the dry-bulb temperature.
7. To find the relative humidity:
    a. Find the dry bulb outside temperature in the left column of the chart.
    b. Find the temperature difference across the top.
    c. God down the chart until the row and column meet. That is the relative humidity.
    d. For each set of temperatures, record the humidity in the chart below.
8. Average the 2 humidity readings by adding the 2 numbers together and dividing by 2.
9. To figure out the heat index, use the second chart and find the humidity down the left column and the current temperature across the top.

10. Where those two numbers intersect represents the heat index.
11. Record the heat index for each humidity and temperature in the chart below.

Thermometer	Start Temp.	- Wet Bulb Temp.	= Temp. Difference	Humidity	Heat Index
1					
2					

Average Humidity = _____

Heat Index Chart

		Temperature							
		70	75	80	85	90	95	100	105
H	0	64	69	73	78	83	87	91	95
u	10	65	70	75	80	85	90	95	100
m	20	66	72	77	82	87	93	99	105
i	30	67	73	78	84	90	96	104	113
d	40	68	74	79	86	93	101	110	123
i	50	69	75	81	88	96	107	120	135
t	60	70	76	82	90	100	114	132	149
y	70	70	77	85	93	106	124	144	
	80	71	78	86	97	113	136		
	90	71	79	88	102	122			
	100	72	80	91	108				

Analysis Questions:

1. What effect does evaporation have on temperature?

2. Why do humans sweat?
3. How does the amount of moisture in the air affect evaporation?

4. What would the humidity be if the temperature were:
    5 degrees warmer than it is today?
    5 degrees cooler than it is today?
5. How does humidity affect the heat index?

6. Using today's humidity reading, what would the heat index be if the temperature were:
    a. 90°?
    b. 95°?
    c. 100°?
7. Based on the relative humidity you found, can the air hold more evaporated water?

8. Suppose you exercise in a room in which the relative humidity is 100%.
    a. Would the moisture from your skin from perspiration evaporate easily?
    b. Would you be able to cool off readily? Explain.

9. Suppose you have just stepped out of a swimming pool. The relative humidity is low, about 30%. How would you feel- warm or cool? Explain