# MEET METEOROLOGY

**Grade Level or Special Area**: Fourth Grade
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**Length of Unit**: Nine lessons (each lesson approximately 50 minutes in length)

## I. ABSTRACT

This unit is designed to provide fourth graders with an overview of meteorology and to provide teachers with lessons to cover all of the fourth grade meteorology requirements from the *Core Knowledge Sequence*. Through observation and hands-on activities, the students will gain a foundation of understanding about the design and workings of meteorology.

## II. OVERVIEW

A. Concept Objectives
   1. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (Colorado State Science Standard 4)
   2. Students recognize and understand interrelationships among science, technology and human activity and how they can affect the world. (Colorado State Science Standard 5)
   3. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (Colorado State Science Standard 6)

B. Content from the *Core Knowledge Sequence*
   1. Fourth Grade Science: Meteorology (page 106)
      a. The water cycle (review from grade 2): evaporation, condensation, precipitation
      b. Clouds: cirrus, stratus, cumulus (review from grade 2)
      c. The atmosphere:
         i. Troposphere, stratosphere, mesosphere, ionosphere
         ii. How the sun and the earth heat the atmosphere
      d. Air movement: Wind direction and speed, prevailing winds, air pressure, low and high pressure, air masses
      e. Cold and warm fronts: thunderheads, lightning and electric charge, thunder, tornadoes, hurricanes
      f. Forecasting the weather: barometers (relation between changes in atmospheric pressure and weather), weather maps, weather satellites
      g. Weather and climate: "weather" refers to daily changes in temperature, rainfall, sunshine, etc., while "climate" refers to weather trends that are longer that the cycle of the season.

C. Skill Objectives
   1. Students will make predictions based on prior experiences and understandings.
   2. Students will explain scientific principles by writing definitions based the student's own understanding.
   3. Students will describe the general characteristics of the layers of the atmosphere.
   4. Students will summarize how the sun affects atmospheric circulation.
   5. Students will identify how a barometer operates.
   6. Students will describe existing weather conditions by collecting and recording weather data.
   7. Students will illustrate the process of the Earth's water cycle.

8. Students will identify and recognize the three main cloud types; cirrus, stratus, cumulus and the properties of each.
9. Students will investigate the occurrence of storms.
10. Students will recognize and label different fronts and their characteristics.
11. Students will summarize how and why each weather condition is caused.
12. Students will investigate different weather conditions caused by cold and warm fronts.
13. Students will investigate and construct a weather forecast.
14. Students will demonstrate their knowledge of weather through a formal assessment.

## III. BACKGROUND KNOWLEDGE

A. For Teachers
   1. *Spencer Christian's World of Wonders: Can it Really Rain Frogs?,* by S. Christian and A. Felix
   2. *How the Weather Works: 100 Ways Parents and Kids Can Share the Secrets of the Atmosphere,* by M. Allaby
   3. *Eyewitness Books: Weather,* by B. Cosgrove

B. For Students
   1. *Core Knowledge Sequence*: 2nd Grade: Science: Cycles in Nature: Water Cycle
   2. *Core Knowledge Sequence*: 3rd Grade: Science: Astronomy

## IV. RESOURCES

A. Several video taped weather reports from a local TV station (needed for Lesson One)

## V. LESSONS

**Lesson One: Weather vs. Climate an Introduction to Meteorology (approximately 50 minutes)**

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
      b. Students recognize and understand interrelationships among science, technology and human activity and how they can affect the world.
      c. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
   2. Lesson Content
      a. Weather and climate: "weather" refers to daily changes in temperature, rainfall, sunshine, etc., while "climate" refers to weather trends that are longer that the cycle of the season.
   3. Skill Objective(s)
      a. Students will make predictions based on prior experiences and understandings.
      b. Students will describe scientific principles by writing definitions based on the student's own understanding.

B. *Materials*
   1. A video tape of the local weather cast
   2. Classroom globe
   3. Flashlight
   4. One 9" x 11" piece of colored construction paper for each student

5. 10 pieces of blank 8 ½" x 11" white paper for each student – the construction paper and white paper will be used to create a Meteorology Journal, which will be used throughout this unit; these Journals could be assembled ahead of time; look at procedure number 15 for further details
6. Appendix A: Meteorology Journal Rubric one copy for each student

C. *Key Vocabulary*

1. Meteorology – the scientific study of weather
2. Meteorologist – the name given to a scientist who studies weather
3. Weather – the condition of the air around the Earth
4. Climate – pattern of weather that occurs over long periods of time
5. Equator – invisible latitude line around the center of the Earth
6. Polar Climate – very cold almost all the time
7. Mountain Climate – changes with elevation
8. Cold Forest Climate – tundra areas near the polar regions
9. Temperate Climate – not too hot and not too cold with a reasonable amount of rainfall
10. Dry desert – hot scarcely any rain fall, tropical-hot and wet

D. *Procedures/Activities*

1. To introduce this lesson, tape a local news broadcast of the weather segment. Show the clip to the students.
2. Discuss with the students briefly some of the reasons why the news broadcast would take time to show a weather segment. (Weather affects our daily lives.)
3. Ask students how weather affects their daily lives. (Possible answers: Rain could postpone a baseball game. Sunny day could mean a trip to the beach. Snowstorm could cancel school. Daily weather affects the way we dress.)
4. Ask students to describe some of the tools the meteorologist used to share the weather forecast (computers, satellites, Doppler Radar, thermometer, barometer-instrument to measure air pressure, maps, hygrometer-instrument that measures relative humidity, anemometer – instrument that measures wind speed, weather vane or wind sock-instrument to measure wind direction).
5. Allow students to explain why forecasts are not always correct. (Even with all the technology to predict the weather sometimes nature can change its course suddenly)
6. Have students mention briefly some of the specific weather vocabulary that they heard during the broadcast. (Possible answers but not limited to: meteorologist, temperature, cold front, stationary front, warm front, type of cloud cover, humidity, air pressure, wind direction, jet stream, wind chill, forecast.)
7. Solicit responses from students to describe the most exciting weather event they have ever *witnessed* (severe thunderstorm, lightning storm, tornado, blizzard, hurricane, hail storm, raining or snowing while the sun was still shinning).
8. Explain to students that this science unit is the study of all the processes that take place in the atmosphere and their relationship with processes at the surface of the earth-especially the study of weather. The study of these processes is called Meteorology. The scientist who studies Meteorology is identified as a Meteorologist.
9. Mention some of the topics that the students will be studying throughout this unit to give students the big picture idea of the unit. This process is intended to give students a brief idea of what they will be learning in this unit. Ideas to share at this time: inform the students they will be reviewing cloud types and the water cycle from 2nd grade, learning about the layers of the atmosphere, how the sun effects patterns of weather, how to measure different parts of the weather using

special instruments and making some of these instruments, learning how to forecast the weather and the difference between climate and weather.

10. Begin the process of learning about meteorology by explaining the difference between climate and weather:
    a. Climate: the pattern of weather that occurs over long periods of time
    b. Weather: what happens outside our windows every day
11. Explain to students that different parts of the world receive varying amounts of heat from the Sun. The axis of the Earth is tilted at an angle to the direction it is traveling, so the Sun's rays hit different regions of the Earth at different angles, therefore different places on our Earth have different climates. This should be a review from 3rd grade Core Knowledge (for more information, refer to page 324 in *What Your Third Grader Needs to Know Revised Edition*). Using a world map, point out places near the equator and ask students what type of climate would these countries have (the hottest climates). Point out countries near the North or South Pole. Ask students what the climate would be like in these locations (climates gradually get cooler as you move north and south away from the equator).
12. You may want to explain that the world can be divided into regions with similar kinds of climates. There are about six main kinds of climates found throughout the word: Polar-very cold almost all the time, Mountain-climate changes with elevation, Cold forest-tundra areas near the polar regions, temperate-not too hot and not too cold with a reasonable amount of rainfall, dry desert-hot scarcely any rain fall, tropical-hot and wet.
13. Explain to students in most parts of the world, day to day weather changes gradually throughout the year with the seasons. Explain that the seasons occur because of the way the Earth spins on its axis as it rotates around the Sun. This along with other factors (to be discussed later on in the unit-like wind direction, air pressure, and humidity) causes our day-to-day weather. To demonstrate this principle, use a globe and a flashlight. Have a student come up and shine the flashlight on the equator. Have another student come up and hold the globe at both poles. Then have the student tilt the top (north) of the globe a little towards the flashlight. This position demonstrates summer for the continents in the Northern Hemisphere as these areas of the world are receiving more direct light from the sun. Next, have the student tilt the top (north) of the globe slightly away from the flashlight. The continents in the Southern Hemisphere are receiving more direct sunlight, therefore; the people in the Northern Hemisphere are in the season of winter as they are receiving less direct sunlight (for a diagram of this process see *What Your Third Grader Needs to Know Revised Edition* page 325). What about the countries closer to the equator? Do they experience four seasons? Why do you think this is? (No, usually they experience only two seasons and the seasons are often referred to as the wet season and the dry season. They are closer to the equator.)
14. For clarification, ask students the question what is the difference between weather and climate. (Weather is what happens outside the window day to day based on the seasons and other factors. Climate is the pattern of weather that occurs over a long period of time and a strong factor in determining climate is how closely located the land is to the equator.)
15. Have students create a Meteorology Journal – each student needs one sheet of 9" x 12" piece of construction paper. Students place five plain 8 ½" x 11" white pieces of paper on top of the construction paper. Fold the construction paper and the white paper in half horizontally together as to create a book where the

construction paper is the cover. Staple twice in the middle where the fold is once near the top and once near the bottom of the book. (It is recommended that this journal be created ahead of time so the book is ready to hand out to the students.) Have students create a front cover with the title of Meteorology, their first and last name, and a drawing related to Meteorology. This book will be used throughout this unit as the students' science journal.

16. On the first white page of their journal have students write their own definition of meteorology and draw a picture using color to demonstrate their understanding of their definition.
17. On page 2 of their journals have students write the definition of meteorologist in their own words and draw a picture using color to demonstrate their understanding of their definition.
18. Have students use page 3 to write the definition of weather in their own words and draw a picture using color to demonstrate their understanding of their definition.
19. On the next page have students write the definition of climate in their own words and draw a picture using color to demonstrate their understanding of their definition.
20. Closure - review the difference between climate and weather and why the study of meteorology is important to our lives.

E. *Assessment/Evaluation*
   1. Collect students' Meteorology Journals and check for students understanding of the key vocabulary words (see Appendix A for Evaluation Rubric).

**Lesson Two: Layers of the Atmosphere and Heating of the Earth (approximately 50 minutes)**

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
      b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
   2. Lesson Content
      a. The atmosphere
         i. Troposphere, stratosphere, mesosphere, ionosphere
         ii. How the sun and the Earth heat the atmosphere
   3. Skill Objective(s)
      a. Students will describe the general characteristics of the layers of the atmosphere.
      b. Students will summarize how the sun affects atmospheric circulation.

B. *Materials*
   1. Students' Meteorology Journals
   2. Lamp without a shade
   3. Timer
   4. Baby Powder

C. *Key Vocabulary*
   1. Atmosphere – all of the protective layers of gases surrounding the Earth
   2. Troposphere – 0-11 miles above the Earth's surface; weather mostly occurs in this level of the atmosphere; temperatures decrease with height

3. Stratosphere – 12-31 miles above the Earth's surface; has almost no weather activity; temperatures increase with height
4. Mesosphere – 32-50 miles above the Earth's surface; temperatures decreases with height
5. Thermosphere – 51-22,000 miles above the Earth's surface; the final layer of the atmosphere is divided into two sections the ionosphere and the exosphere; this layer is very thin and the temperatures are very hot reaching as high as 1,100 degrees Fahrenheit
6. Ionosphere – 51-125 miles above the Earth's surface; when you see a falling star, a meteor burning up in the atmosphere, you're looking into the ionosphere
7. Exosphere – 126-22,000 miles above the Earth's surface; has almost no air; satellites and other spacecraft travel in this level of the atmosphere.
8. Greenhouse Effect – the filtering system in the atmosphere that prevents the Earth's warmth from escaping into space
9. Global warming – a gradual increase in the temperature of the earth due to the greenhouse effect

D. *Procedures/Activities*

1. Review from yesterday the difference between weather and climate. (Weather is what happens outside the window day to day based on the seasons and other factors. Climate is the pattern of weather that occurs over a long period of time and a strong factor in determining climate is how closely located the land is to the equator.)
2. Introduce today's lesson by explaining that the students will be learning about the layers that surround the Earth, which have an affect on the weather and climate of our planet.
3. A layer of air that we call the atmosphere surrounds the Earth. The atmosphere is made up of protected layers of gases that surround the Earth. To give the students an idea of how thick the atmosphere is, use the globe as the model of the Earth. The atmosphere around the globe would be approximately as thick as a layer of clear coat varnish.
4. Scientists believe that there are four layers of the atmosphere: troposphere, stratosphere, mesosphere, and ionosphere. There are no true dividing lines, each layer blends into the next. However, scientists are sure that the atmosphere becomes thinner and thinner the farther the layer is from Earth.
5. Describe the different layers of the atmosphere and at the same time students can be taking notes in their Meteorology Journal.
    a. Troposphere: It is the layer of the atmosphere that is closest to the Earth's surface 0-11 miles above the Earth's surface. We live and breathe in this atmosphere. This is also the layer in which most weather occurs. As you travel further up in this atmosphere the temperature decreases until you reach about 11 miles above the Earth's surface and then the temperature does not drop any more. This section is called the tropopause.
    b. Stratosphere: Is the second layer of the atmosphere. The layer begins about 12 miles above the Earth's surface and ends about 31 miles away from the Earth. There is not a lot of moisture in this section of the atmosphere, so there are very few clouds in this layer. This is the layer in which airplanes usually fly. Therefore, you are traveling above the weather so your ride should be smoother. The temperature increases with altitude until the top of the stratosphere is reached. Then you have

reached the section known as the stratopause. This upper part of the stratosphere is where many ultraviolet rays from the sun are trapped.

c. Mesosphere: This layer goes 32-50 miles above the Earth's surface. Temperatures drop with increases in altitude. There are very strong winds that blow in this layer of the atmosphere. The top part of the mesosphere is called the mesopause.

d. Thermosphere: The final layer of the atmosphere is broken into two parts the ionosphere and the exosphere. These final layers of the atmosphere are very thin. The temperature of this layer of the atmosphere is very hot with temperatures reaching as high as 1,100 degrees Fahrenheit.

i. The ionosphere 51-125 miles above the Earth's surface, reflects radio waves back to Earth and stops them from traveling all the way into space. This is part of the atmosphere that creates auroral displays also known as the Northern Lights.

ii. The second division of the thermosphere is the exosphere 126-22,000 miles above the Earth, has almost no air. Satellites and other spacecraft can travel in this part of the atmosphere.

6. Have the students draw and label the different levels of the atmosphere in their Science Journal. They need to include one fact with each level. For example: troposphere is 0-11 miles above the Earth's surface. This is the layer in which most weather occurs. Stratosphere is 12-31 miles above the Earth. This is the layer in which airplanes fly. Mesosphere is 32-50 miles above the Earth's surface. Strong winds occur in this layer. The thermosphere is very hot and is divided into two layers. The first division is the ionosphere, which is 51-125 miles above the Earth's surface and radio wave are reflected back to the Earth's surface. The last division of the atmosphere is called the exosphere, which is 126-22,000 miles above the Earth has almost no air and this is the area in which satellites travel.

7. After giving students time to complete their drawing continue explaining how the heat from the Sun affects the atmosphere and weather (while students are still working, prepare for the next demonstration by turning on the lamp).

8. Explain to students that without the Sun there would be no weather - the heat and energy that the sun produces keeps the air in the atmosphere constantly in motion-producing every kind of weather, as the sun moves through the sky from sunrise to sunset.

9. A great deal of the sun's heat is absorbed on its way through the atmosphere, and just about half reaches the ground.

10. Teacher demonstration of how the Sun affects the atmosphere and weather:

a. Turn on the lamp for about five minutes. Caution: Do NOT touch the light bulb; it may get very hot.

b. Before sprinkling a tiny pinch of the baby powder above the light bulb ask students to predict what they believe will occur.

c. Turn off the classroom lights then sprinkle a tiny pinch of the baby powder above the light bulb.

d. Discuss with the students what happened and why they believe this process occurred. (The powder should float upward. When the light bulb heated up, it also heated the air above it. Warm air always rises.)

11. This experiment demonstrates how the Sun heats the Earth then warms the air above it. Cool air moves down to take the place of warm air. This movement of warm and cool air masses is what causes most winds, which we will discuss in more detail later in the unit.

12. Explain to students that only half of the heat from the Sun reaches the Earth, but the Earth is able to stay warm because of the greenhouse gases in the air, which keeps most of the heat in. Greenhouse gases are like the windowpanes in a greenhouse. They trap heat and keep the Earth warm. Just as in a greenhouse the right quantity of heat is good for plants to grow a certain amount of heat trapped in the Earth is also good, but meteorologist believe that the greenhouse gases are keeping the Earth too warm. One of the primary greenhouse gases is carbon dioxide. Carbon dioxide is produced from burning coal, oil and wood as well as car and truck exhaust. Meteorologists are concerned about the greenhouse effect as it is increasing the overall warmth of the Earth. At this point global warming is too slight to be measured, but if the Earth continues to warm in this manner, the polar ice could begin to melt possibly drowning such low-lying cities like New York, Sydney, and London.
13. Discuss with the students possible ways in which to decrease the rising effects of the greenhouse effect (possible answers: carpooling, traveling by bike, reducing the amount of car pollution, factory regulations to reduce air pollution, reduce the cutting down of rain forests, or increasing planting crops of fast growing trees not needed for farms, as the trees use carbon dioxide to make food, this reduces the level of carbon dioxide in the air).

E. *Assessment/Evaluation*
1. Collect students' Meteorology Journal and check the students' notes of the Layers of the Earth's atmosphere (use Appendix A for the Evaluation Rubric).

**Lesson Three: Air Pressure and Barometers (approximately 50 minutes)**

A. *Daily Objectives*
1. Concept Objective(s)
   a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
   b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
2. Lesson Content
   a. Air movement: air pressure, low and high pressure, air masses
3. Skill Objective(s)
   a. Students will make predictions based on prior experiences and understandings.
   b. Students will identify how a barometer operates.

B. *Materials*
1. Students' Meteorology Journals
2. Tape
3. Ruler
4. Thread/string
5. Two balloons of equal size
6. One small/medium sized balloon
7. One safety pin
8. Transparent tape
9. Two rubber bands
10. A large, narrow, plastic bottle
11. A large bowl or tub
12. 1 inch strip of cardboard
13. Appendix B: Pressing On (one copy for each student)

C. *Key Vocabulary*

1. Air pressure – the weight of the atmosphere pressing down on the Earth
2. Barometer – an instrument that measures air pressure
3. Rising pressure – or the presence of a high-pressure system indicates improving weather
4. Falling pressure – or the presence of a low-pressure system indicates stormy weather

D. *Procedures/Activities*

1. Explain that air is all around us: we breathe it, use it to inflate tires, we can't see it or taste it, but sometimes we can feel, hear, or smell air. It is a critical part of our lives.
2. Have students open and close their hands. Did they feel air in their hand?
3. Next have students take a deep breath while watching their lungs. Could they see something substantial filling their lungs?
4. To show that air in the atmosphere has weight and takes up space follow this experiment:
    a. Place a piece of tape onto the middle of the ruler. Tie a piece of thread around the tape.
    b. Lift the ruler and adjust the position of the thread so that the ruler balances.
    c. Blow up one balloon and leave the second one deflated. Tape them to opposite ends of the ruler.
    d. Hold up the ruler with the thread and discuss the results. (The larger balloon makes the ruler dip down. It is heavier than the deflated balloon because the blown up balloon contains more air.) The air in the atmosphere has weight and presses down on the ground with a certain force.
5. Next, using another balloon, demonstrate to the class the idea that air in a container exerts pressure on its surroundings.
    a. Blow up a balloon and tie it.
    b. Discuss how you have just forced air inside, increasing the pressure inside the balloon.
    c. Have a student push on the surface of the balloon.
    d. Ask if the student can feel the high-pressure air inside the balloon pushing back (the student should be able to feel the pressure).
    e. Puncture the balloon with a small safety pin have a student put their hand above the hole. Ask the student is he/she can feel the force of the air rushing out. (The student should be able to feel the air rushing out of the balloon with a force.)
    f. Discuss how more tightly air is packed, the stronger the force. This pressure creates wind and weather, allows airplanes to fly, curve balls to curve, and car tires to inflate. Air pressure is a part of all we do. Have students think about pumping up the tires on a bicycle. When the tires are filled with air the pressure has increased inside the tire. Increased air pressure makes air masses move around the world.
6. Continue the discussion mentioning how meteorologists use the air pressure to describe the current weather conditions or predict the weather. Meteorologists will often inform viewers if the pressure is rising or falling. This is called the barometric pressure.
    a. Rising pressure or the presence of a high pressure system indicates improving weather, usually warm air.

b. Falling pressure or the presence of a low-pressure system indicates stormy weather, usually cool air. For example, when you climb a mountain, the higher the elevation the thinner the air is, which means the pressure is lower and the air is usually cooler.

7. Evangelista Torricelli an Italian mathematician and physicist invented the first barometer in the mid 1600's.
8. Create a classroom barometer:
   a. Cut a 1 inch strip of thin cardboard and draw a scale along one edge. Attach the cardboard to a large narrow plastic bottle using the rubber bands. This cardboard should not be immersed in the water.
   b. Fill the bottle with water so it is three quarters full. Also fill the bowl or tub nearly to the top with water.
   c. Place your hand over the top of the bottle and turn it upside-down. Put your hand into the bowl so that the neck of the bottle is under the water. Remove your hand from under the bottle and stand it in the bowl.
   d. Place the experiment somewhere in the classroom where students can see the level of the water changing, but where the apparatus will not easily get bumped. Also the barometer should be placed away from direct sunlight or other heat sources. Have students observe whether the pressure is rising or falling or remaining the same over the next few days.
   e. The water level in the bottle should rise and fall with the air pressure, as more or less air pushes down on the water in the bowl.
9. Pass out Appendix B: Pressing On. Have students complete this worksheet.
10. In the students' Meteorology Journals have students write down the definition for air pressure and barometer.
11. In conclusion, review with students how the downward push put forth by the weight of the air is called its pressure. Discuss how the difference in the pressure of the air in different places causes the air to move around as wind. When the air molecules are squeezed together by the weight of the air above, making the air denser near the bottom of the atmosphere than at higher altitudes. Therefore, air density and pressure are greatest at sea level. Heat also makes air less dense therefore the warmer the air the lower the air pressure.

E. *Assessment/Evaluation*
   1. Collect the worksheet Pressing On. Answers to worksheet Pressing On:
      a. Air pressure
      b. Water level should move up with an increase in air pressure
      c. Water level should move down with a decrease of air pressure
      d. Since air pressure is affected by temperature, the location of the barometer could be an important factor.
      e. Warm air rises, causing low pressure on the earth. Cold air drops, causing high pressure on the earth.

**Lesson Four: Air Movement (approximately 50 minutes)**

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
      b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.

2. Lesson Content
    a. Air movement: wind direction and speed, prevailing winds
3. Skill Objective(s)
    a. Students will describe existing weather conditions by collecting and recording weather data.

B. *Materials*
1. Students' Meteorology Journals
2. Stapler
3. Ruler
4. Scissors
5. Markers
6. Each student needs the following materials:
    a. Unsharpened pencil with an eraser
    b. Piece of stiff cardboard at least 4 inches by 12 inches
    c. Four small paper cups
    d. Pushpin
    e. Small ball of modeling clay

C. *Key Vocabulary*
1. Coriolis Effect – a force that makes wind change direction, caused by Earth's rotation
2. Prevailing winds – the winds in a large area or region of the world where the air movement almost always travels in the same direction
3. Polar Easterlies – wind patterns beginning at the North Pole and the South Pole and extending to 60 degrees latitude
4. Westerlies – from 60 degrees to 30 degrees these winds flow from the west to the east
5. Trade winds – air that moves steadily toward the equator from an easterly direction
6. Doldrums – the narrow area above the equator with calmer air movement because there is little change of temperature
7. Anemometer – instrument used to measure the speed of wind
8. Jet stream – a high-speed, narrow band of upper level winds that flows from west to east around the globe

D. *Procedures/Activities*
1. Explain to students that not only does air pressure affect weather, but air movement does as well. Students should recall that the air around the equator is warmer and warm air rises and as it rises it leaves an area of low pressure. Also, you may remember from our discussion on air pressure that air moves from areas of higher pressure to areas of lower pressure. So as the warm air from the equator is moving to the poles, the cooler air from the poles moves to the area around the equator. As this cooler air moves to the location around the equator it warms up and becomes warm air and the cycle is repeated again and again. Actually this process is not quite as simple as this because while the air is moving, the Earth is rotating almost at a speed of 160 miles a minute. Therefore, the rotation of the Earth breaks the north-south winds into several large circular wind systems. These wind systems flow at an easterly or westerly direction. The winds curve to the right north of the equator and to the left in the south of the equator. This is known as the Coriolis Effect.
2. At ground level we experience the horizontal forces of the air movement in the form of wind. Winds are named for the direction FROM which they flow.

3. There are four basic types of winds: prevailing winds, seasonal winds, local winds, and storm winds. In this unit we are just going to take a closer look at the prevailing winds.
4. The prevailing winds are rings of wind that blow generally in the same direction all around the Earth. These winds are an important part of the system that moderates the temperatures on our planet and are broken down into four categories.
    a. Polar Easterlies-beginning at the North Pole and the South Pole and extending to a latitude of 60 degrees; remembering that winds are named for the direction FROM which they blow these winds come from the East and flow towards the west
    b. Westerlies-from 60 degrees to 30 degrees these winds flow from the west to the east
    c. Trade winds-are steady northeast winds above the equator; below the equator the trade winds are steady southeast winds
    d. Doldrums-the narrow area above the equator with calmer air movement because of the little change of temperature
5. Wind direction was probably one of the first weather observations made by early humans. Not the complicated system of prevailing winds, but rather just knowing what direction the wind is flowing by picking up some leaves then letting them drop while watching which direction they fall. Ask the students why they think knowing the direction of the wind was important to these early humans. (Possible answer: when hunting they would want to be downwind from the animal so the animal couldn't smell them coming). The ancient Greeks and Romans used weather vanes. They were simple pointers that would rotate as the wind direction changed. Today weather stations still use weather vanes along with windsocks, satellites and helium-filled balloons. An interesting fact to share with your students about why the rooster is portrayed on many weather vanes: A law was passed in the ninth century by a pope to make weather vanes shaped like roosters. The pope took the image of the rooster as a reminder of temptation for everyone from the story of Peter denying he knew Christ three times before the rooster crowed. Although the religious purpose of the rooster weather vane has long been forgotten, it still is a popular symbol today.
6. As wind vanes are used to measure wind direction, scientists created another instrument that would allow them to measure wind speed. This device is known as an anemometer. In 1667 scientists developed the first anemometer. Today most anemometers are designed with three or four small cups attached to a short pole. The wind blows into the cups, making them rotate. The faster the wind blows the faster the cups rotate. The speed of wind is calculated from the number of complete rotations of the cups in a given amount of time.
7. In 1805, a British Admiral, Sir Francis Beaufort created a scale in which to measure air movement. He developed this scale while out at sea, later the scale was modified and used on land as well. The Beaufort scale is still used today by many weather stations to measure the force of air movement.
    a. Wind strengths are divided into 12 forces
        i. Complete calm is Force 0
        ii. Force 1 light air-less than 1 mph- smoke rises
        iii. Force 2 light breeze-1-3 mph- smoke drifts
        iv. Force 3 gentle breeze- 4-7 mph-leaves rustle slightly and flags stir
        v. Force 4 moderate breeze- 8-12 mph-leaves and twigs move

vi. Force 5 fresh breeze-13-18 mph-small branches move and flags flap
vii. Force 6 strong breeze-19-24 mph-small trees sway and flags ripple
viii. Force 7 near gale-25-31 mph-large branches move and flags beat
ix. Force 8 gale-32-38 mph- whole trees move and flags extend
x. Force 9 strong gale-39-46 mph-twigs break and walking is difficult
xi. Force 10 storm-47-54 mph-signs and antennas blow down
xii. Force 11 violent storm 55-73 mph- trees uprooted, damage to buildings
xiii. Force 12 hurricane 74+mp

8. Students make their own simple anemometer.
   a. Draw two rectangles on the cardboard. Each rectangle should measure 2 inches wide and 12 inches long. Cut out both rectangles.
   b. Cross the cardboard strips to make a plus (+) sign and staple them together. (It is recommended that steps *a* and *b* be completed ahead of time, so the teacher can hand the cardboard strips to the students.)
   c. Use a ruler to draw two lines, one each from opposite corners where the two strips cross each other to the opposite corners (like a big x in where the cardboard strips cross). The point where these two lines cross is the center.
   d. Use a marker to color the outside of one of the paper cups.
   e. Staple the cups to the ends of the cardboard strips. Make sure that the cups face the same direction.
   f. Push the pin through the center of the strips and into the eraser.
   g. Take everything outside.
   h. Place a small lump of modeling clay on a flat surface.
   i. Stick the unsharpened point of the pencil into the clay so that it stands up straight.
   j. As the wind blows, count the number of times the colored cup spins past you in one minute.
9. The wind should push all the cups in the same direction, making the wheel turn. Have students make an approximation of the force of the wind based on the Beaufort scale.
10. Have students return to the classroom and record the definition of anemometer in their Meteorology journals.
11. The strongest wind that has been recorded was at the summit of Mount Washington (elevation 6,262 feet). On April 12, 1934 the wind blew 230 miles per hour.
12. **Extension Activity:** Have students create a wind vane that has significant meaning to the student or represents something from the local area, state, or school.

E. *Assessment/Evaluation*
1. Collects students' Meteorology Journals. Use Appendix A to evaluate students' understanding of vocabulary from this lesson.

**Lesson Five: Water Cycle (approximately 50 minutes)**

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
      b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
   2. Lesson Content
      a. The water cycle (review from grade 2): evaporation, condensation, precipitation
   3. Skill Objective(s)
      a. Students will learn and illustrate the process of the Earth's water cycle.

B. *Materials*
   1. Students' Meteorology Journals
   2. Electric teakettle
   3. Cold plate or metal tin
   4. Appendix A (one copy per student)

C. *Key Vocabulary*
   1. Water cycle – the recycling system of Earth's water, in which water evaporates out of the oceans, forms clouds, falls as rain or snow and drains back into the oceans through rivers
   2. Evaporation – the process of adding heat energy changes liquid to gas
   3. Condensation – the process of vapor changing into a liquid when there is removal of heat energy
   4. Precipitation – liquid or solid particles that form in the atmosphere and then fall to the Earth's surface
   5. Humidity – the presence of water or water vapor in the air
   6. Hygrometer – an instrument used to measure relative humidity

D. *Procedures/Activities*
   1. Begin today's lesson by conducting the following teacher directed water cycle experiment:
      a. Heat an electric tea kettle filled with water.
      b. When the steam begins to come from the spout, hold a cold plate or metal tin about the steam.
      c. The water vapor will condense and eventually precipitate.
   2. Discuss with students the process they just watched. Have students recall the parts of the water cycle from 2nd grade.
   3. Have students design their own Water Cycle in their Meteorology Journal labeling evaporation, condensation, precipitation
   4. Ask students what causes water to evaporate (heat and moving air). Solicit examples of evaporation from the students (puddle drying up, laundry on a clothes line, when a student gets out of the pool on a hot day).
   5. Discuss with students what happens during condensation (water vapor changes from the state of a gas to a liquid when its temperature becomes colder). Have students suggest times in which they see condensation taking place (on the outside of a glass filled with a cold beverage on a warm summer day, on the mirror in the bathroom when the shower is running). Remind students that condensation occurs in clouds and when the water vapor collects and becomes too heavy, the vapor turns into precipitation and falls as rain.

6. Briefly discuss precipitation and have students brainstorm different types of precipitation and their characteristics.
7. Have students divide one page of their Meteorology Journal into four sections and then have students draw and label four forms of precipitation.
8. Discuss water conservation and it importance. Brainstorm ways in which students can help the process of water conservation.
9. At the end of this day's lesson take students outside to draw the clouds they see in the sky. This is a preview for tomorrow's lesson. They will need to take their Meteorology Journals, pencil, something hard to write on. Have them lie down and watch the clouds for a few minutes and then in their journals have them draw and give a short description of some of the clouds that they see.

E. *Assessment/Evaluation*

1. Collect students' Meteorology Journals and check to verify that their drawings of the water cycle include evaporation, condensation, and precipitation. Use Appendix A to evaluate students' work.

**Lesson Six: Cloud Types (approximately 50 minutes)**

A. *Daily Objectives*

1. Concept Objective(s)
   a. Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
   b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
2. Lesson Content
   a. Clouds: cirrus, stratus, cumulus (review from grade 2)
3. Skill Objective(s)
   a. Students will identify and recognize the three main types of clouds; cirrus, stratus, cumulus and the properties of each.

B. *Materials*

1. Students' Meteorology Journals
2. Clean, clear bottle with a small mouth
3. Small amount of very hot water (to be used by the teacher only)
4. Large ice cube
5. Appendix C: Cloud Formations (one transparency)
6. Appendix D: What's My Name (one copy per student)

C. *Key Vocabulary*

1. Cloud – a collection of water droplets or ice crystals in the atmosphere
2. Cirrus – a cloud that forms in wispy strands high in the sky
3. Stratus – horizontal layers of clouds that blanket the sky
4. Cumulus – a puffy white cloud formed by rising air heated by the sun

D. *Procedures/Activities*

1. Have students get out their Meteorology Journals and look over the drawings of the clouds they created yesterday. Have a class discussion on the students' discoveries.
2. Review from yesterday the process of condensation and precipitation from the water cycle.
3. Discuss how clouds are formed and what clouds are (condensed water droplets in the air).
4. Demonstrate how a cloud forms. Pour about ½ inch of very hot water into a clear bottle. Immediately cover the mouth of the bottle with an ice cube. Ask students

to observe what happens (inside the bottle, the sides of the bottle cloud up). Have students explain what is happening (the hot water evaporates and rises, then collides with cold air and condenses). Explain that this is what happens when a cloud forms.

5. Tell the students that there are three basic categories of clouds: cumulus, stratus, and cirrus. However, there are 10 types clouds all based on of combinations of three types.
6. Write the following affixes on the board with their definitions: "alto-mid-level clouds; cirro-high clouds; stratus-spread out or layered clouds; cumulus-mounds of clouds; cirrus-curly, wispy clouds; nimbus-rainstorm or rain cloud
7. Explain to students that when two names are combined, such as cumulonimbus or cirrostratus, the cloud has properties of both.
8. Use a transparency of Appendix C-Cloud Formations to discuss the 10 cloud types.
    a. Cumulus-are puffy white clouds, often flat on the bottom and dome shaped on top; about 1 mile above the Earth
    b. Stratus-flat layers, or blankets, of gray clouds, which often carry drizzle or steady rain; low clouds; stratus clouds at ground level are fog
    c. Cirrus-feathery wisps and curls made of ice crystals; high above the Earth
    d. Nimbostratus-dark gray clouds that produce hours of rain or snow; they start near the ground, but can extend high into the sky
    e. Altostratus-are neither high nor low in the sky; they form a cloud layer made of water droplets
    f. Cirrostratus-made of ice crystals; very high in the sky
    g. Cumulonimbus-billow upward eight to ten miles into the atmosphere, but they are flat and dark on the bottom; they are storm clouds called thunderheads, often associated with rain, thunder, lightning, and tornadoes
    h. Altocumulus-medium in elevation that look like flattened cumulus clouds almost joined together
    i. Cirrocumulus-produce a clouds that look like the scales of a mackerel fish; the clouds appear as rows of tiny icy clouds
    j. Stratocumulus-occur when cumulus clouds spread into layers; long rolls of stratocumulus clouds indicate the coming of fair weather
9. Have students look back in their Meteorology Journals and see if they can identify the scientific names for any of the clouds they drew.

E. *Assessment/Evaluation*

1. Students will complete the Name that Cloud (Appendix D) identifying the names of clouds based on their characteristics. Answers to Appendix D:
    a. altocumulus
    b. cirrus
    c. cirrocumulus
    d. stratus
    e. cirrostratus
    f. stratocumulus
    g. cumulonimbus
    h. nimbostratus
    i. cumulus
    j. altostratus

**Lesson Seven: Cold and Warm Fronts (approximately 50 minutes)**

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
      b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
   2. Lesson Content
      a. Cold and warm fronts
      b. Occluded fronts (not in *Core Knowledge Sequence)*
      c. Stationary front (not in *Core Knowledge Sequence)*
   3. Skill Objective(s)
      a. Students will recognize and label different fronts and their characteristics.

B. *Materials*
   1. Weather front worksheet – Appendix E (one copy per student and one overhead transparency for teacher)
   2. Weather Front Worksheet key – Appendix F (one copy for the teacher)
   3. Meteorology Journal (one per student)
   4. Newspaper weather map (one teacher copy and one copy per student or they can share if necessary)
   5. Drawings of the different kinds of fronts – Appendix G (one copy for the teacher)
   6. Rubric for Meteorology Journal – Appendix A (one copy for each student)
   7. *NOTE:* The *Mark Twain Media Science Activity Book: Meteorology* is a great resource to use to create transparencies for this lesson

C. *Key Vocabulary*
   1. Front – a transition between two temperatures, or air density zones
   2. Cold front – where a cold air mass meets up with a warm air mass and there is a sharp change in the weather
   3. Warm front – where a warm air mass meets up with a cold air mass and there is a gradual change in the weather
   4. Occluded front – when a cold front collides with a warm front and the warm front is pushed up over the cooler air in front of it, causing weather with characteristics of both a warm and cold front (one right after another)
   5. Stationary front – when a warm front and a cold front meet but move very little

D. *Procedures/Activities*
   1. Begin with a review of the water cycle lesson by asking one or two students to describe to the class the water cycle by using their drawings from their Meteorology Journal.
   2. Start a discussion with the students on what they know about what causes weather change. Some possible questions are: How many different types of weather are there? What patterns do you notice before the weather changes? What do you already know about cold and warm fronts? T ell the students that they are going to learn about the different types of weather fronts and how they affect the weather.
   3. Pass out a copy of a weather map from the newspaper. Have the students take a couple of minutes to notice some of the different things they see on this map. Direct the students' attention toward the different kinds of fronts (cold, warm, stationary, and occluded). Tell the students they will learn more about the rest of

the map later, but today they will be learning about these fronts and how they affect the weather.

4. Pass out the Weather Front Worksheet (Appendix E). Begin by explaining the vocabulary word: **front**. Write the definition on worksheet on the overhead and have the students fill in their worksheets along with you. Tell the students that fronts are formed by a contrast between temperatures in the ocean and on land or by pressure differences in the upper wind flow. When either of these two things happens, it causes cold air to sink and warm air to rise. Explain to the students that when the cold and warm air masses meet they do not mix but instead edge along side of each other and where they meet is where the front is (note: a great explanation is given in *What Your Fourth Grader Needs to Know)*. Tell the students that there are four different kinds of fronts.
5. Start explaining a **cold front**. Tell the students that a **cold front** is when a mass of cold air meets up with a mass of warm air and there is a sharp change in the weather. When the cold air mass pushes under the warm air mass it creates a cold front (see Appendix G, page 1). Explain to the students that before a cold front comes in the wind is coming from the south-southwest. The temperature is warm and mild but the barometric pressure is dropping. There is usually an increase in cirrus and cirrostratus clouds or towering cumulus or cumulonimbus clouds. The precipitation is usually a short period of showers. While the cold front is passing through the wind is gusty and shifting. There is a sudden drop in temperature, there is a sharp rise in the barometric pressure, and there are towering cumulus or cumulonimbus clouds, and usually heavy rain or snow showers sometimes with hail, thunder, and lightning. After the cold front passes the wind comes from the west-northwest. The temperature is colder and the barometric pressure is steadily rising. The clouds seen are often cumulus clouds. The precipitation is decreasing with less showers and some clearing. Point out on the newspaper weather map what the symbol for the cold front looks like (see Appendix G, page 1) and that it is usually blue in color. Explain that cold fronts usually bring storms because they force the warm air to rise quickly. As a result of this rapid rise, the warm air cools more quickly causing this cooler weather (adapted from *What Your Fourth Grader Needs to Know)*. Together with the students, fill out the section on the worksheet for cold fronts.
6. Next explain to the students a **warm front**. Tell the students that a **warm front** is when a mass of warm air meets up with a mass of cold air and there is a gradual change in the weather. When a warm air mass moves over a cold air mass, a warm front is formed and the warm air gradually starts to cool (see Appendix G, page 2). Explain to the students that before a warm front comes in the wind is coming from the south-southwest. The temperature is cool or cold and the barometric pressure is dropping. There is usually an increase in cirrus, cirrostratus, altostratus, nimbostratus, and stratus clouds. If it is summer time, there are usually fog and cumulonimbus clouds. The precipitation is light rain, snow, sleet, or drizzle. While the warm front is passing through there is no set wind pattern. There is a steady rise in temperature, the barometric pressure levels off and stays steady, there are stratus-type clouds in the skies, and there is usually only drizzle. After the warm front passes the wind flows south-southwest. The temperature is warmer and the barometric pressure slightly rises and then drops. There is a clearing in the clouds with some stratocumulus and cumulonimbus in the summer. There is usually no precipitation but there can be occasional light showers. Point out on the newspaper weather map what the symbol for the warm

front looks like (see Appendix G, page 2) and that it is usually red in color. Together with the students, fill out the worksheet for warm fronts.

7. Ask the students if they think it is possible to have both a cold front and a warm front at the same time. Explain to the students that cold fronts move faster than warm fronts and sometimes the cold fronts catch up and collide with a warm front. When this happens, an **occluded front** is formed. Tell the students that the definition of an occluded front is when a cold front collides with a warm front and pushes the warm air up over the cool air that is in front of this warm front (see Appendix G, page 3 for a drawing). When an occluded front occurs, the weather tends to have characteristics of both a cold and warm front. The weather produced can include periods of light rain or snow followed by heavy thunderstorms and snow.
8. Finally, explain to the students that a **stationary front** is when a warm front and a cold front meet but move very little (see Appendix G, page 4). When a stationary front occurs, the weather is usually very temperate and calm. This weather remains for several days.
9. Have the students take out their Meteorology Journals and write each of these four fronts and their symbols. Have the students in their own words write down a definition of each front that will help them remember what that front is. Once the students finish, have them draw a picture of what a day would look like during each of these fronts. (For example, a day during a cold front would have gusty winds with a dropping temperature, towering cumulus or cumulonimbus clouds, and heavy rain or snow showers.) **Accommodations:** For special education students, have these students only pick one or two fronts to draw pictures for.

E. *Assessment/Evaluation*

1. Collect each of the students' Meteorology Journals to see if each student has an understanding of these different fronts. Use Appendix A to grade.

**Lesson Eight: Tornadoes, Hurricanes, Thunder and Lightning (approximately 50 minutes)**

A. *Daily Objectives*

1. Concept Objective(s)
   a. Students recognize and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
   b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
2. Lesson Content
   a. Cold and warm fronts: thunderheads. lightening and electric charge, thunder, tornadoes, hurricanes
3. Skill Objective(s)
   a. Students will investigate different weather conditions caused by cold and warm fronts.
   b. Students will summarize how and why each weather condition is caused.
   c. Students will investigate the occurrence of storms.

B. *Materials*

1. For Lightning Experiment ( taken from Web Weather for Kids - www.ucar.edu)
   a. Styrofoam plate (one)
   b. Thumbtack (one)
   c. Pencil with new eraser (one)
   d. Aluminum pie pan (one)
   e. Small piece of wool fabric (one)

2. For Tornado/Hurricane Experiment (adapted from *Experiments with Weather*, by Salvatore Tocci)
    a. 1-liter plastic soda bottle (two)
    b. food coloring (any color)
    c. masking tape
3. Experiment worksheet, Appendix H (one per student)
4. Experiment Worksheet Key, Appendix I (one for teacher)
5. Meteorology Journals (one per student)
6. Meteorology Journal Rubric – Appendix A (one per student)

C. *Key Vocabulary*
1. Lightning – a flash of electricity through the atmosphere
2. Thunder – the noise created from lightning moving through a cloud and causes air to expand
3. Thunderhead – a special type of cumulus cloud that is formed when a cold front bringing storms forces the warm air to rise quickly and the warm air cools rapidly forming ; thunderheads often lead to violent thunderstorms
4. Tornado – an intense, rotating funnel or rope of air that descends from a cumulonimbus cloud and touches the ground
5. Hurricane – a severe tropical storm containing winds above 74 miles per hour

D. *Procedures/Activities*
1. **Note:** Teachers need to set up the two experiments before beginning this lesson.
2. Setting up the Lightning Experiment:
    a. Push the thumbtack through the center of the aluminum pie pan from the bottom.
    b. Push the eraser end of the pencil into the thumbtack making the pencil a handle to lift the pan.
    c. Put the Styrofoam plate upside down on a table. Rub the underside of the plate with the wool for one minute (be sure to rub hard and fast).
    d. Pick up the pie pan with your finger. If you don't feel anything when you touched the pan, try rubbing the plate again.
    e. Try turning the lights out before touching the pan.
3. Setting up the Tornado/ Hurricane Experiment:
    a. Fill one soda bottle 3/4 the way full with water. Add several drops of food coloring and swirl the bottle to mix the color.
    b. Place the second empty liter bottle over the bottle with the water. With the masking tape, tape the two bottles together by their mouths.
    c. Flip the bottles over so the bottle with the water is on top. Hold the bottles where they are taped together and gently swirl the water for five seconds. Watch as the tornado forms.
4. Begin with a review of yesterday's lesson by asking four students to explain one of their drawings of what a day during each front would look like and why.
5. Explain to the students that today they are going to learn about some specific storms that occur as a result of cold and warm fronts (hurricanes, tornadoes, thunderstorms).
6. Explain each of the experiments to the students. Begin by telling the students that they are going to create a hurricane, tornado and also lightning. Split the class into two different groups and assign one group to the lightning experiment and the other to the hurricane and tornado experiment. Pass out the Experiment worksheet (Appendix H) to each student. Go over with the students what needs to happen at each experiment. Tell the students at the lightning experiment they need to rub the underside of the plate with the wool for one minute (be sure to

rub hard and fast). Then they should pick up the pie pan with your finger. If they don't feel anything when they touched the pan, they need to try rubbing the plate again. The students at the tornado/hurricane experiment need to hold the bottles where they are taped together and gently swirl the water for five seconds. Watch as the tornado/hurricane forms. Have each group of students conduct each of the experiments, switching after about five to ten minutes. The students need to fill out each section of their worksheet (Appendix H) as they complete each experiment.

7. Explain to the students that **lightning** is a flash of electricity through the atmosphere. Lightning is caused by tiny drops of water and ice crystals being pushed around in a cloud, causing friction. When this friction is created, static electricity is formed. This static electricity is when positively charged droplets gather at the top of the cloud with a negative charge at the bottom of the cloud. When the difference in the electrical energy in the cloud becomes too great, a spark of electricity leaves the cloud and heads toward the oppositely charged point on the ground. For example when a negative charge leaves the cloud in the form of a lightning bolt, it will strike the highest positively charged object on the ground that it finds. This lightning and thunder will continue until the charge in the cloud is evened out.
8. Explain to the students that lightning travels in a cloud that is called a **thunderhead**. A **thunderhead** is special type of cumulus cloud that is formed when a cold front bringing storms forces the warm air to rise quickly and the warm air cools rapidly forming. Thunderheads often lead to violent thunderstorms. The most common season for thunderstorms is in the summer. This is due to the warmer air that is present during the summer. These warmer updrafts are necessary for a thunderstorm to occur.
9. Tell the students that it is the movement of the lightning through the cloud that produces thunder. **Thunder** is defined as the noise created from lightning moving through a cloud and causes air to expand. This expanding air gives off a sound we call thunder. Ask the student if they can tell you why we see the lightning before we hear the thunder. Explain to them that the speed of light moves faster than the speed of sound. So when a storm is further away from where you are located, you see the lightning first and then hear the thunder.
10. Next, discuss with the students what happened in the tornado/hurricane experiment. Define **tornado** as an intense, rotating funnel or rope of air that descends from a cumulonimbus cloud and touches the ground. Explain to the students that tornadoes form in thunderclouds. Explain to the students that scientists do not full understand why a tornadoes funnels begin to rotate but one reason for the rotation is due to the winds. When there is wind at two different altitudes, blowing at different speeds a wind shear is created. This wind shear causes the funnel cloud of the tornado to rotate horizontally. If this horizontal funnel gets caught in an updraft of wind, the funnel is tightened and the rotation speeds up. The rain and the hail of a thunderstorm cause this funnel to leave the cloud and touch down. At this point, the funnel cloud becomes a tornado. Mention to the student that the area in the United States where the most tornadoes are record (due to the weather conditions) is called Tornado Alley. Tornado Alley stretches across the plains between Texas and Illinois.
11. Finally, ask the students what the difference between a tornado and a hurricane is. Some of the students might think that a hurricane is a tornado over the water. Be sure to explain to the students that this is not the case. A tornado over the water is called a waterspout. Explain to the students that **hurricanes** are tropical

storms that occur only over warm water. This is why there are rarely hurricanes that can survive in the Pacific Ocean. In order for a hurricane to exist, the water temperature must fall between 75 – 80 degrees Fahrenheit and the winds on the surface of the water must come together to create the vortex (swirl) of the hurricane. Ask the students to observe the tornado experiment again from the top (walk around the room and show the students the tornado in the bottle). Explain to the students that viewing this tornado from the top is similar to looking at a hurricane. Point out that the eye of the hurricane is in the middle and is the calmest part of the hurricane. As the hurricane swirls outwards the winds and waves become more violent and destructive. A good example to use to help the students understand this concept is the crack the whip game. Explain that the one person standing in the middle during this game is stationary without much happening around them (eye of the hurricane). As more and more students join hands and begin rotating around this central student, the faster and more out of control the students are closer to the end of the whip (I would not recommend actually playing this game with the students). Tell the students that it is not the actual hurricane that causes the large amounts of damage. It is the winds and the waves created by the hurricane that cause this destruction. Explain to the students that the vortex of the hurricane swirls in different directions depending on which part of the world it occurs in. When a hurricane is in the northern hemisphere, the vortex swirls counter-clockwise (this happens in the United States). When a hurricane is in the southern hemisphere, the vortex swirls clockwise.

12. Go over the answers for the worksheet together (use Appendix I).
13. Have the students take out their Meteorology Journal and write definitions for lightning, thunder, thunderhead, tornado, and hurricane.

E. *Assessment/Evaluation*

1. Collect the student's Meteorology Journals and use Appendix A as a rubric to grade the vocabulary in this lesson.

**Lesson Nine: Forecasting the Weather (approximately 50 minutes, forecasting project will extend into Culminating Activity)**

A. *Daily Objectives*

1. Concept Objective(s)
   a. Students recognize and understand the process and interaction of Earth's systems and the structure and dynamics of Earth objects in space.
   b. Students recognize and understand interrelationships among science, technology, and human activity and how they can affect the world.
   c. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines.
2. Lesson Content
   a. Forecasting the weather: barometers (relation between changes in atmospheric pressure and weather), weather maps, weather satellites
3. Skill Objective(s)
   a. Students will investigate and construct a weather forecast.
   b. Students will demonstrate their knowledge of weather through a formal assessment.

B. *Materials*

1. Meteorology Test – Appendix J, pages 1 and 2 (one copy per student)
2. Meteorology Test Key – Appendix K, pages 1 and 2 (one for teacher)
3. Meteorology Journal (one per student)

4. Guidelines for Forecasting project – Appendix L (one per student and one transparency)
5. Rubric for Forecasting Project – Appendix M (one per student and one transparency)
6. Weather maps from the newspaper (multiple copies)
7. Computer with the internet (at least one)

C. *Key Vocabulary*

1. Forecaster – anyone who predicts something (in this case someone who predicts the weather)
2. Weather maps – maps that locate and identify fronts, areas of high and low pressure, and temperatures
3. Weather satellite – a tool equipped with television cameras that are used to take pictures of cloud patterns, snow, and ice

D. *Procedures/Activities*

1. Start this lesson out by giving the students the Meteorology Test (Appendix J). Tell the students they need to complete this test by using their Meteorology Journal to help them (this assessment can be used as a quiz or a test, you decide).
2. Once the students are finished with the Meteorology Test, explain to the students that their final project for this unit will be to create their own forecast. Ask the students if anyone know what a **forecaster** does (predicts the weather). Ask why is it important to be able to predict the weather (it can help us plan ahead in our daily activities, it helps keep us safe). Ask them what a **weather map** is (maps that locate and identify fronts, areas of high and low pressure, and temperatures). Explain to the students that there is a national weather map, a continental weather map, and a global weather map. These are used to help us keep up with the weather around the world.
3. Explain to the students that different tools that are used in helping forecast the weather. Some of the different tools are radar and satellites. A **weather satellite** is a tool equipped with television cameras that are used to take pictures of cloud patterns, snow, and ice. There are two different types of satellites: polar-orbiting satellites and geosynchronous satellites. The polar-orbiting satellites are used at an altitude of 500-900 miles above the surface of the Earth and the geosynchronous satellites orbit at an altitude of 22,300 mile and move along with the Earth.
4. Pass out the guidelines for the forecasting project (Appendix L). Place a copy of the guideline on the overhead. Read through these guide lines with the students, clarifying any questions that might come up. Next place a copy of the rubric for the forecasting project (Appendix M) on the overhead and explain to the students how you will be grading these projects.
5. Split the students into partners and assign a state to each set of students. Briefly explain the use of the internet to find weather maps (teachers you may want to have someone working with the students who choose to use the internet). Also quickly show the students where they can find copies of a weather map in the newspaper and review with them how to read it (the fronts, the highs and lows, the precipitation).
6. For the remaining class time, allow the students to work on their forecasts. Remind the students that they will be forecasting in front of the class tomorrow.

E. *Assessment/Evaluation*

1. There is no formal assessment or evaluation for this lesson because it goes together with the culminating activity.

2. The teacher should check the progress of each group, making sure they understand the forecasting project.

## VI. CULMINATING ACTIVITY

A. Have the students, with their partner; present their weather forecast that they created. On the day of the presentation, give the students an additional 15-20 minutes to finalize their forecast. Make sure the students have a script of what they are going to say during their forecast. Encourage the students to use prompts and even costumes if they want. Allow two to three minutes for each of the presentations. Before the presentations begin, remind the students of the rubric (Appendix M) you will use to grade the presentations. If available, use a video camera to film each of the forecasts.

## VII. HANDOUTS/WORKSHEETS

A. Appendix A: Meteorology Journal Evaluation Rubric
B. Appendix B: Pressing On
C. Appendix C: Cloud Formations
D. Appendix D: What's My Name (two pages)
E. Appendix E: Weather Fronts
F. Appendix F: Weather Fronts worksheet key
G. Appendix G: Weather Front Illustrations (four pages)
H. Appendix H: Lightning Tornadoes, and Hurricanes experiment
I. Appendix I: Lightning, Tornadoes, and Hurricanes experiment key
J. Appendix J: Meteorology Test (two pages)
K. Appendix K: Meteorology Test Key (two pages)
L. Appendix L: Guidelines for Forecasting Project
M. Appendix M: Forecasting Project Rubric

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**Appendix A**

# Meteorology Journal Rubric

| | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|
| **Content** | All information is accurate. | There is one error in the information. | There are two errors in the information. | There are three or more errors in the content. | _____ |
| **Pictures** | Picture is colored and neat. | Picture is colored, but slightly messy. | Picture is not completely colored, and is messy. | Picture is not colored. Work is illegible. | _____ |
| **Mechanics** | There are no errors in mechanics. | There is only one mistake in mechanics. | There are two mistakes in mechanics. | There are three or more errors in mechanics. | _____ |
| | | | | **TOTAL** | _____ |

**Teacher Comments:**

**Appendix B**

# Pressing On

Name:_____

1. What will the classroom barometer be measuring?

2. What should happen to level of the water in the bottle when the air pressure increases?

3. What should happen to the level of the water in the bottle when the air pressure decreases?

4. Could the location of the barometer affect the results of this activity? How?

5. Fill in the blanks using the words from the word bank:

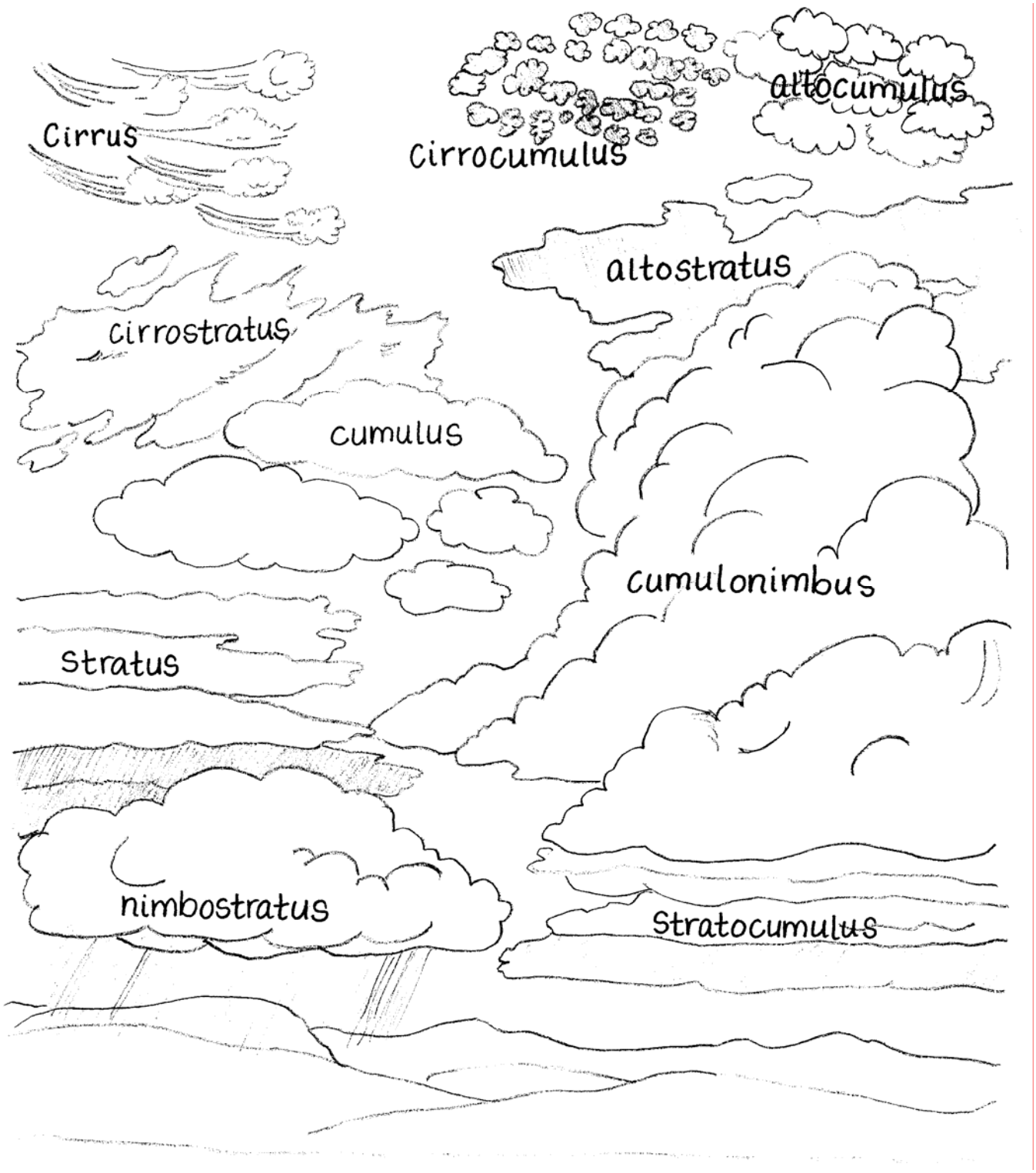
| cold | hot | low | high |
|---|---|---|---|

_____ air rises, causing _____pressure on the earth.

_____ air drops, causing _____pressure on the earth.

**Appendix C**

# Cloud Formations



**Appendix D, page 1**

# What's My Name?

Name:_____

Identify each of the cloud types by writing the correct cloud name for the given description. Then in the space provided above the cloud name, draw what the cloud would look like in the sky. There is a word bank at the end of this page to help you.

| | |
|---|---|
| 1.<br><br>Cloud name: _____<br><br>These clouds are medium in elevation and look like flattened cumulus clouds almost joined together. | 2.<br><br>Cloud name: _____<br><br>These clouds are feathery wisps and curls made or ice crystals and are located high in the sky. |
| 3.<br><br>Cloud name: _____<br><br>These clouds look like the scales or a mackerel fish and appear as rows of tiny icy clouds. | 4.<br><br>Cloud name: _____<br><br>These clouds are flat layers of gray clouds, which often carry drizzle or steady rain and are low to the Earth's surface. |
| 5.<br><br>Cloud name: _____<br><br>These clouds are very high in the sky and are made of ice crystals. | 6.<br><br>Cloud name: _____<br><br>These clouds form when cumulus clouds spread into layers and indicate the coming of fair weather. |

# What's My Name?

| | |
|---|---|
| 7.<br><br>Cloud name: _____<br><br>These clouds can billow upward eight to ten miles into the atmosphere, but are flat and dark on the bottom. These clouds are also referred to as thunderheads. | 8.<br><br>Cloud name: _____<br><br>These clouds are dark gray in color and produce a lot of rain or snow. They start near the ground, but can extend high into the sky. |
| 9.<br><br>Cloud name: _____<br><br>These clouds are puffy and white and are located usually about one mile above the earth. | 10.<br><br>Cloud name: _____<br><br>These clouds are neither high nor low in the sky. They form a cloud layer made of water droplets. |

## Word Bank

| | | | |
|---|---|---|---|
| Cumulus | Stratus | Cirrus | Nimbostratus |
| Altostratus | Cumulonimbus | Cirrostratus | Altocumulus |
| Cirrocumulus | Stratocumulus | | |

**Appendix E**

# Weather Fronts Worksheet

**Name**_____

| Type of Front | Definition of Front | Clouds seen with front | Speed of front | Temperature of front | Density of front | Weather conditions during front | Symbol of front |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

## Appendix F

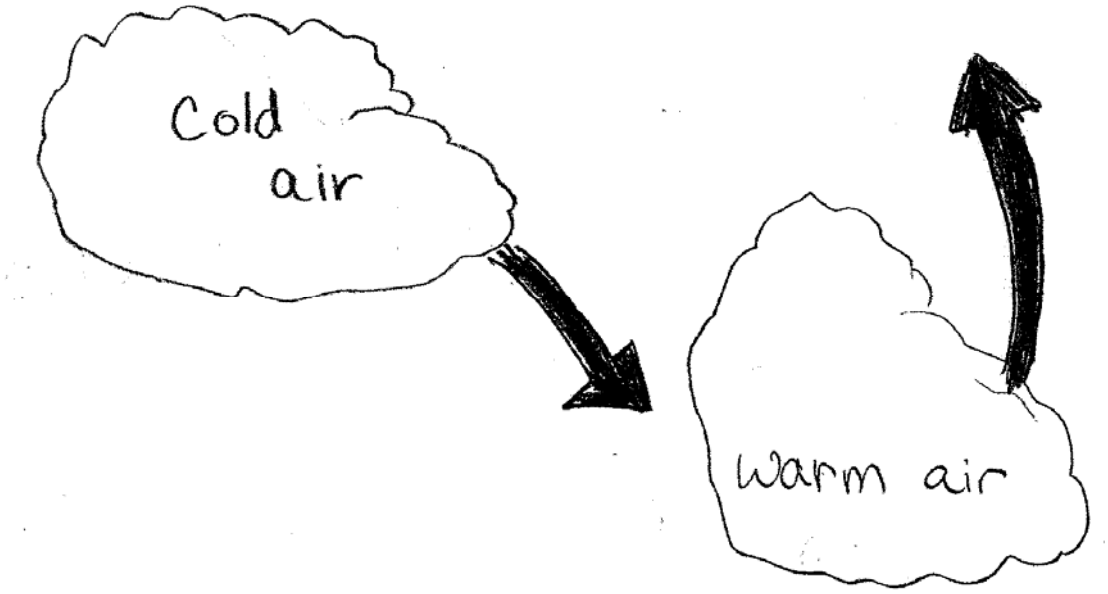
# Weather Fronts Key

| Type of Front | Definition of Front | Clouds seen during the front | Speed of front | Temperature of front | Density of front | Weather conditions during front | Symbol of front |
|---|---|---|---|---|---|---|---|
| **Cold front** | **Where a cold air mass meets up with a warm air mass and there is a sharp change in the weather** | **Cumulus and Cumulonimulus** | **Faster than a warm front** | **Drop in the temperature** | **More dense (lower in the sky)** | **Gusty winds, heavy rain or snow showers, possible hail, thunder and lightning** | **(See Appendix G)** |
| **Warm front** | **Where a warm air mass meets up with a cold air mass and there is a gradual change in the weather** | **Cirrus** | **Two times slower than a cold front** | **Rise in the temperature** | **Less dense (higher in the sky)** | **No set wind pattern and usually only a light drizzle** | **(see Appendix G)** |

**Appendix G, page 1**

# Cold Fronts

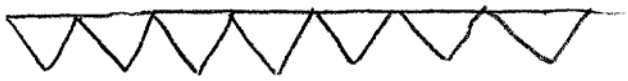
**Movement of front ------→**




**Cold air meets under the warm air, forcing the warm air to quickly rise.**

## Symbol for cold front

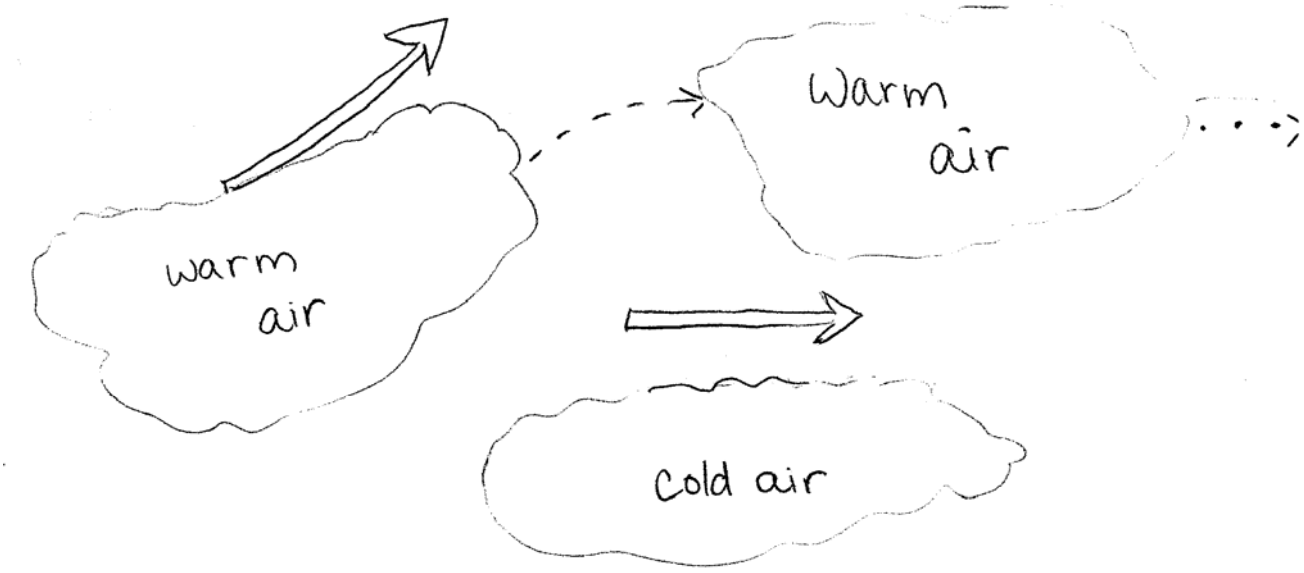
**(usually blue in color)**



**Appendix G, page 2**

# Warm Front

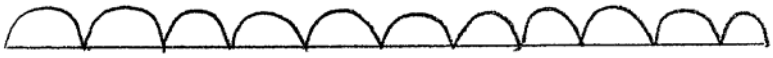
**Movement of front -------→**




**Warm air pushes up over the cold air, gradually cooling the air**

## Symbol for warm front

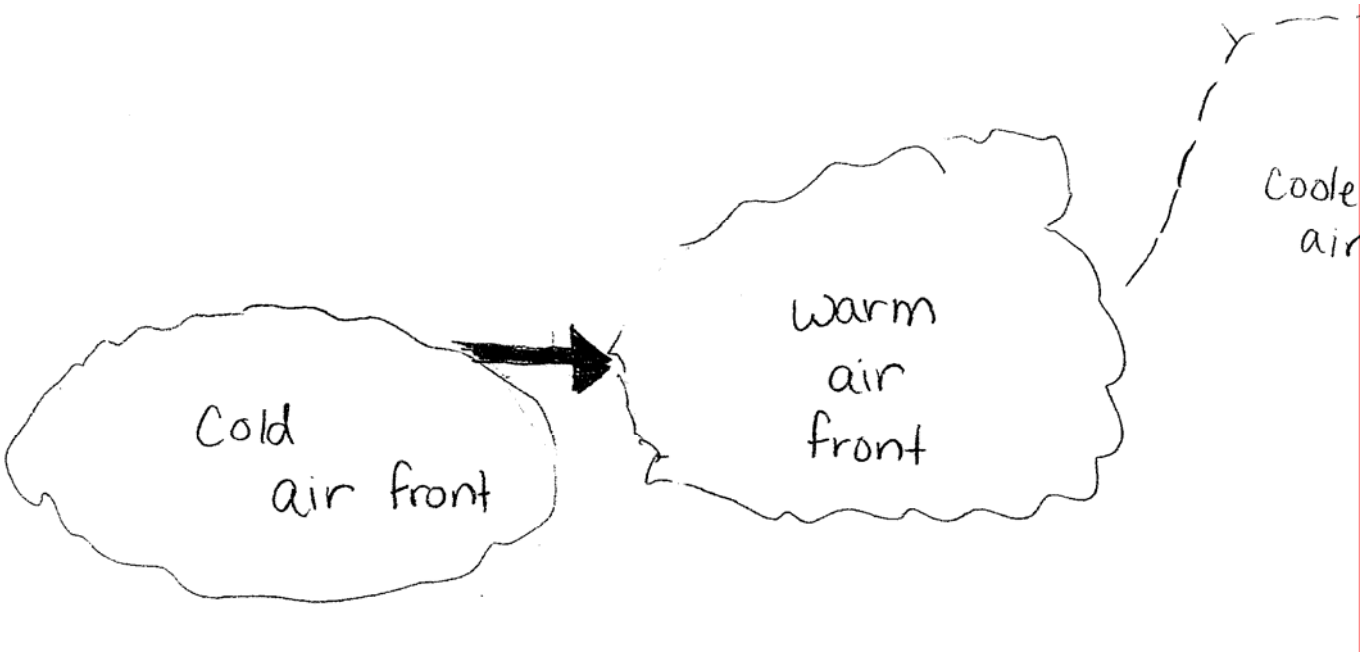
**(usually red in color)**



**Appendix G, page 3**

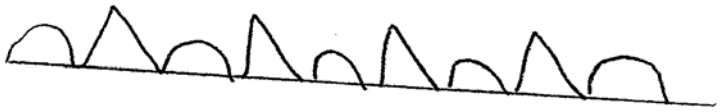
# Occluded Front

**Movement of front ------→**



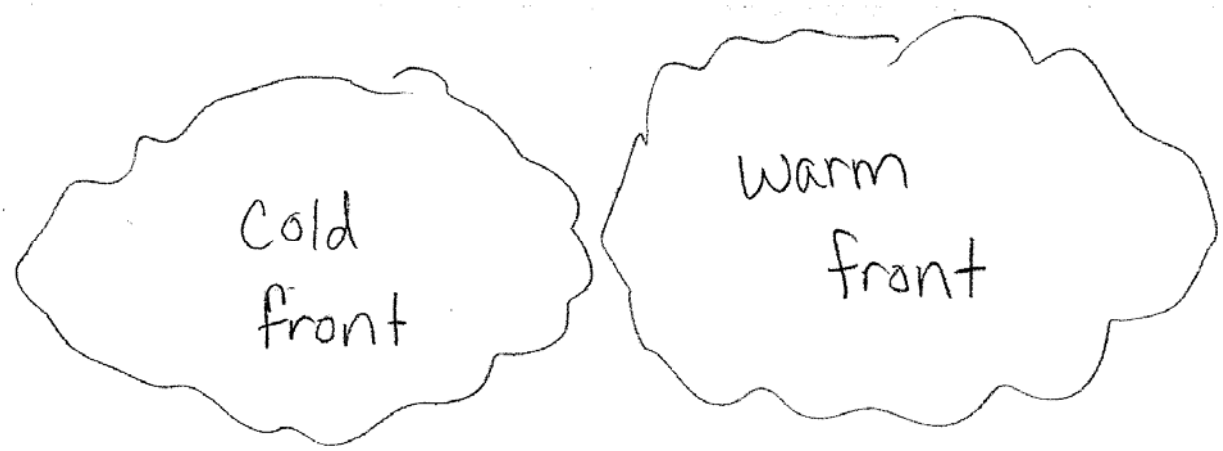

**The quickly moving cold air collides with the warm air masses.**

## Symbol for occluded front



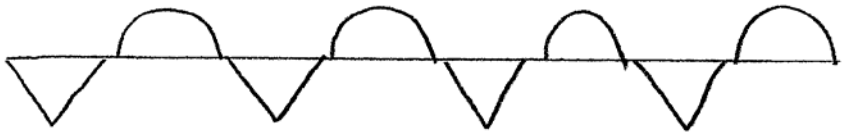
# Stationary Front

**Little movement of fronts**




**When a warm front and a cold front meet and move very little**

## Symbol for stationary front



**Appendix H**

# Lightning, Tornadoes, and Hurricanes

**Name_____**

## Lightning Experiment

**1. What happened when you touched the metal pie pan? What did you see and feel?**

**2. What do you think caused this (what you saw and felt when you touched the pie pan)?**

**3. How do you think the experiment with the pie pan is related to lightning?**

## Tornado and Hurricane Experiment

**1. What happens to the water in the bottles when you swirl it?**

**2. How is this experiment similar to a tornado? How is it similar to a hurricane?**

**3. How are tornadoes and hurricanes similar? How are tornadoes and hurricanes different?**

**Appendix I**

# Key for Lightning, Tornadoes, and Hurricanes

## Lightning Experiment (answers adapted from www.ucar.edu)

**1. What happened when you touched the metal pie pan? What did you see and feel?**

*When you touch the pie pan you should feel a shock and might be able to see a spark. This is similar to static electricity. Negatively charged electrons (similar to what is at the bottom of a cloud and in this case your finger) are attracted to positively charged protons (found on the ground and in this case the metal pie pan). This static electricity or spark is similar to a bolt of lightning.*

**2. What do you think caused this (what you saw and felt when you touched the pie pan)?**

*When the balance of electrons and protons is unbalanced in a cloud, the unbalanced charge causes the negatively charged electrons in the cloud to be released. This release of negatively charged electrons comes in the form of lightning. In this experiment, the rubbing of the wool causes the movement and pressure of the electrons and protons. Once your finger touches the metal pie pan, this built up force is released in the form of a spark.*

**3. How do you think the experiment with the pie pan is related to lightning?**

*Lightning is formed in the same way, through this electrical charge. This experiment is a simulation of a mini bolt of lightning.*

## Tornado and Hurricane Experiment

**1. What happens to the water in the bottles when you swirl it?**

*The colored water in the bottle, when swirled around, creates a funnel between the bottles.*

**2. How is this experiment similar to a tornado? How is it similar to a hurricane?**

*This experiment is similar to a tornado because it looks similar and a funnel is caused, similar to a funnel cloud in a tornado, due to the force of swirling the bottle. This experiment is similar to a hurricane because if you where to look at the top of this funnel, what you would see is similar to what a hurricane looks like. Also the swirling water has the same characteristics to those of the vortex of a hurricane.*

**3. How are tornadoes and hurricanes similar? How are tornadoes and hurricanes different?**

*A tornado and hurricane are similar because of their swirling motion each one has. Both tornadoes and hurricanes swirl with such a great force that it causes huge amounts of damage. Tornadoes and hurricane differ because of a couple of different reasons. First hurricane will only survive on water. Second tornadoes have an actual funnel cloud that spirals down from the sky. The actual funnel is what causes the damage of a tornado. Hurricanes don't have a funnel that extends down. The majority of the damage during the hurricane is from the winds and waves created during this storm, not from the actual hurricane itself.*

# Meteorology Test

**Name**_____

## Choose the best of the following answers for the questions below.

precipitation radar Tornado Alley ionosphere
exosphere occluded satellites

**1.** The area of the U.S. where most tornadoes occur is called_____.

**2.** The _____ and _____ make up the thermosphere.

**3.** _____ may be in the form of rain, sleet, hail, or snow.

**4.** An _____ front occurs when a warm and cold front collide.

**5.** _____ and _____ are used to forecast the weather.

## Circle the best answer for each question below.

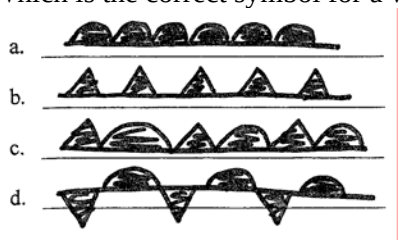
**6.** Most thunderstorms happen during which season?
a. Spring c. Fall
b. Summer d. Winter

**7.** Which level of the atmosphere is where most planes fly?
a. troposphere c. mesosphere
b. stratosphere d. thermosphere

**8.** The speed of the wind is measured by a(n)
a. anemometer c. hygrometer
b. barometer d. thermometer

**9.** What causes the different seasons to occur?
a. unequal heating of the earth
b. rotation of the earth
c. wind
d. the tilt of the earth

**10.** Which is the correct symbol for a warm front?



# Meteorology Test, continued

## Put a T in front of the following questions that are True and an F in front of the questions that are False.

**11.** _____ A cold front moves faster than a warm front.

**12.** _____ All of the sun's heat reaches the ground.

**13.** _____ The eye of a hurricane is the calmest place during this type of storm.

**14.** _____ Cumulus clouds indicate fair weather.

**15.** _____ The sound of thunder moves through the air faster than the speed of light from the lightning.

## Fill in the blanks with your best answer.

**16.** _____ refers to daily changes in the temperature, rainfall, sunshine, etc.

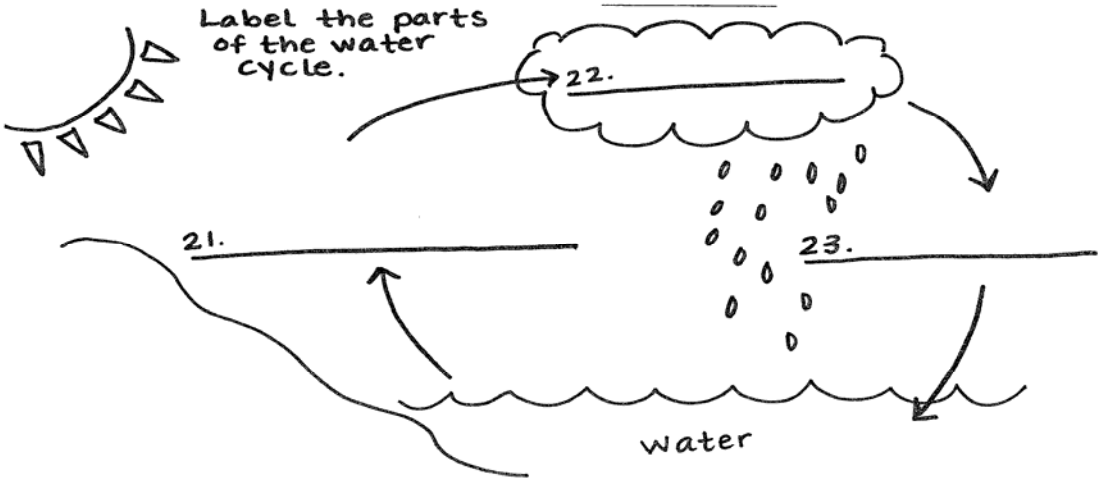
**17.** A scientist who studies weather is called a _____.

**18.** The _____ is the level of the atmosphere where most weather occurs.

**19.** The instrument that is used to measure air pressure is the _____.

**20.** A rain cloud or storm cloud can also be called a _____ cloud.

## Label the parts of the water cycle.



**Appendix K**

# Meteorology Test – Key

**Name**_____

## Choose the best of the following answers for the questions below.

precipitation radar Tornado Alley ionosphere
exosphere occluded satellites

**1.** The area of the U.S. where most tornadoes occur is called _____**Tornado Alley**_____.

**2.** The ____**ionosphere**_____ and _____**exosphere**_____ make up the thermosphere.

**3.** _____**Precipitation**_____ may be in the form of rain, sleet, hail, or snow.

**4.** An _____**occluded**_____ front occurs when a warm and cold front collide.

**5.** _____**Satellites**_____ and _____**radar**_____ are used to forecast the weather.

## Circle the best answer for each question below.

**6.** Most thunderstorms happen during which season?
a. Spring c. Fall
b. **Summer** d. Winter

**7.** Which level of the atmosphere is where most planes fly?
a. troposphere c. mesosphere
b. **stratosphere** d. thermosphere

**8.** The speed of the wind is measured by a(n)
a. **anemometer** c. hygrometer
b. barometer d. thermometer

**9.** What causes the different seasons to occur?
a. unequal heating of the earth
b. rotation of the earth
c. wind
d. **the tilt of the earth**

**10.** Which is the correct symbol for a warm front?
**a.**

# Meteorology Test – Key, continued

## Put a T in front of the following questions that are True and an F in front of the questions that are False.

**11.** __**T**___ A cold front moves faster than a warm front.

**12.** __**F**___ All of the sun's heat reaches the ground.

**13.** __**T**__ The eye of a hurricane is the calmest place during this type of storm.

**14.** __**T**__ Cumulus clouds indicate fair weather.

**15.** __**F**___ The sound of thunder moves through the air faster than the speed of light from the lightning.

## Fill in the blanks with your best answer.

**16.** _____**Weather**_____ refers to daily changes in the temperature, rainfall, sunshine, etc.

**17.** A scientist who studies weather is called a _____**meteorologist**_____.

**18.** The _____**troposphere**_____ is the level of the atmosphere where most weather occurs.

**19.** The instrument that is used to measure air pressure is the _____**barometer**_____.

**20.** A rain cloud or storm cloud can also be called a ___**nimbus**_____ cloud.

## Label the parts of the water cycle.

**21.** Evaporation
**22.** Condensation
**23.** Precipitation

**Appendix L**

# Guidelines for Forecasting Project

Welcome future meteorologists! For this project you will become weather forecasting experts. Ok, here's what you need to do:

- **Step One**: You and your partner will be given a state that you will have to forecast the weather for.
- **Step Two**: You and your partner will need to decide what resources you're going to us to obtain this weather information – some possible options are weather maps from the newspaper or weather maps found on the internet.
- **Step Three**: Work with your partner to come up with a two – three minute forecast of what the weather might look like tomorrow in the state you were assigned. Remember the weather might change around the state, so be sure to include the weather for each part of the state. Be sure to include weather terms you have learned during our study of meteorology. Your Meteorology Journal is a great place to review these terms.
- **Step Four**: Create a script for your forecast. Be sure to check the copy of the rubric I gave you to make sure you have included everything I am looking for.
- **Step Five**: Prepare for your presentation. You and your partner will be presenting a two –three minute presentation tomorrow for the class. Be sure that each of you has a speaking part in the forecast. You are encouraged to bring props and costumes for this presentation.

**Appendix M**

# Rubric for Forecasting Project

| | 4 | 3 | 2 | 1 | Score |
|---|---|---|---|---|---|
| **Content** | All information is accurate. The student uses at least five weather terms are used correctly | There is one error in the information and the student uses only three-four weather terms are used correctly | There are two errors in the information and the student uses one-two weather terms are used correctly | There are three or more errors in the content and no weather terms are used correctly | _____ |
| **Pictures** | Weather map is displayed and referred to at least three times | Weather map is displayed and referred to two-three times | Weather map is displayed and referred to only one time | Weather map is not displayed | _____ |
| **Mechanics** | The script was turned in completed and was neatly done | The script was turned in and was completed but was not written neatly | The script was turned in, but was not complete. | There was no script done | _____ |
| **Presentation** | Both students spoke and used eye contact | Both of the students spoke but only one used eye contact | Both of the students spoke but their was no eye contact | Only one of the students spoke and there was no eye contact | _____ |
| | | | | **TOTAL** | _____ |

**Teacher Comments:**