Santa Fe BOTANICAL GARDEN

CELEBRATE • CULTIVATE • CONSERVE

Climate, Change, and Energy

Is it getting warm in here?

Name:_______________________________

What do you already know about climate and climate change?

What is the difference between climate and weather?

What is carbon dioxide?

What effect does carbon dioxide have on the temperature of the atmosphere?

What is electromagnetic radiation?

How does EM radiation impact the Earth?

Is it Climate or Weather?

Each color of m&m symbolizes a different type of water.

Color of m&m	Red	Orange	Yellow	Green	Blue	Light Brown	Dark Brown
Weather	Partly cloudy, 50° F	Cloudy 55° F	Sunny 65° F	Rainy 50° F	Snow 30° F	Sleet 40° F	Hail 45° F

You are going to start by finding the weather for March 1st for 30 years. Draw one m&m at a time and record the "weather" for that year.

Date	Weather
1-Mar-81	
1-Mar-82	
1-Mar-83	
1-Mar-84	
1-Mar-85	
1-Mar-86	
1-Mar-87	
1-Mar-88	
1-Mar-89	
1-Mar-90	
1-Mar-91	
1-Mar-92	
1-Mar-93	
1-Mar-94	
1-Mar-95	

Date	Weather
1-Mar-96	
1-Mar-97	
1-Mar-98	
1-Mar-99	
1-Mar-00	
1-Mar-01	
1-Mar-02	
1-Mar-03	
1-Mar-04	
1-Mar-05	
1-Mar-06	
1-Mar-07	
1-Mar-08	
1-Mar-09	
1-Mar-10	

The type of weather that was the most common was ______________________________.

If you look at March 1st in just one year, this is weather. If you look at the average weather over 30 years, this is the climate.

What would you call the climate of your city on March 1st? (Use temperature and precipitation, for example, cold and wet.)

____

____

Find the average temperature by adding up all of the temperatures and this number by 30.

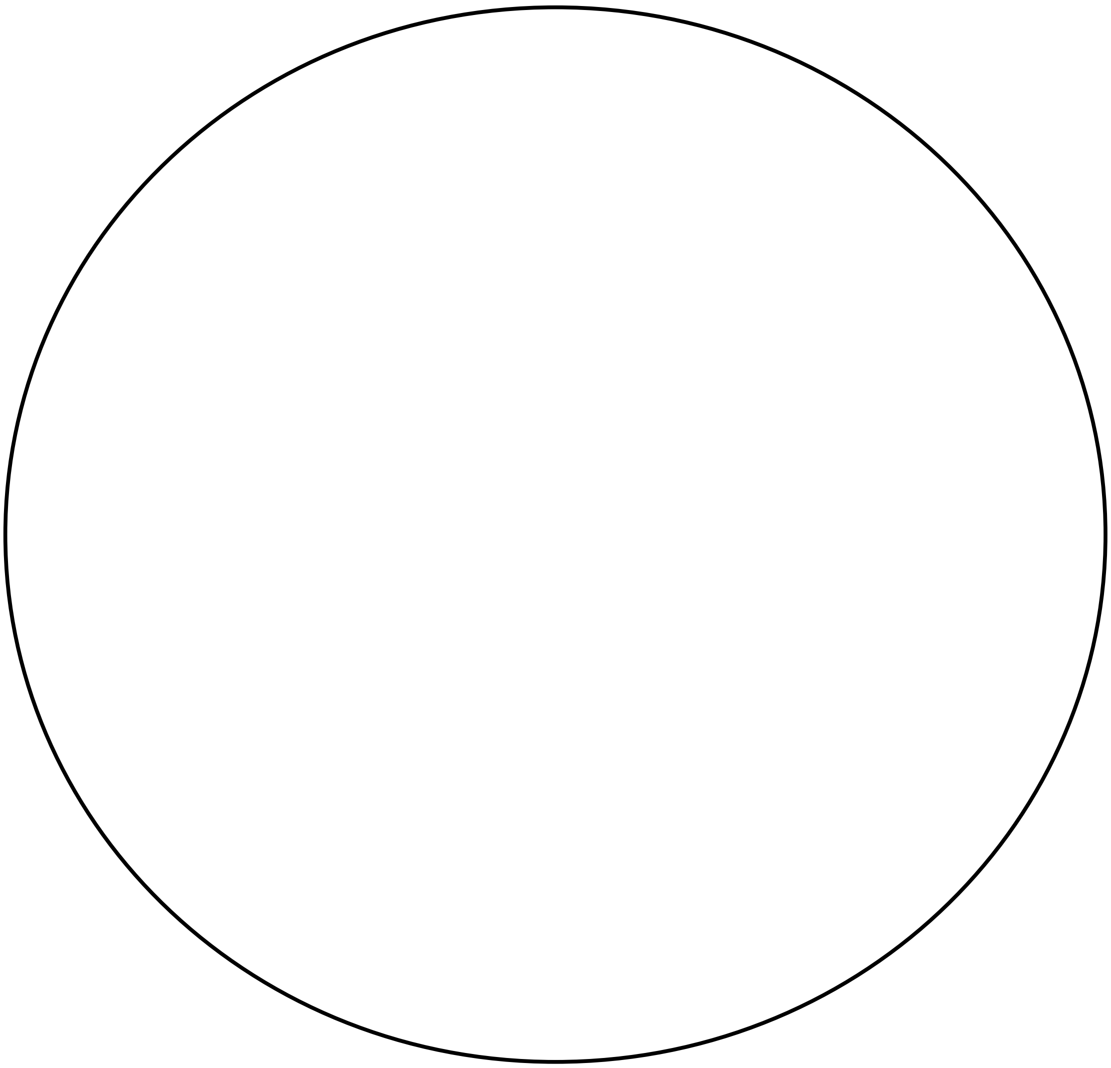
The average temperature is:___________________

Create a Pie Chart of Weather

Mmmmmm… Pie

Create a color-coded pie chart of the data you collected on 30 years of March 1st weather.

Color							
Weather	Partly cloudy, 50° F	Cloudy 55° F	Sunny 65° F	Rainy 50° F	Snow 30° F	Sleet 40° F	Hail 45° F



Interview Two Adults about Climate Change

<u>Interview 1</u>
Name or relationship with Adult 1:________________
What do you know about climate change?

____

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Do you think climate change is happening? Why do you say that?

____

____

____

If so, do humans or something else causes climate change? Why do you say that?

____

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____

<u>Interview 2</u>
Name or relationship with Adult 2:________________
What do you know about climate change?

____

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____

____

Do you think climate changes is happening? Why do you say that?

____

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____

If so, do humans or something else causes climate change? Why do you say that?

____

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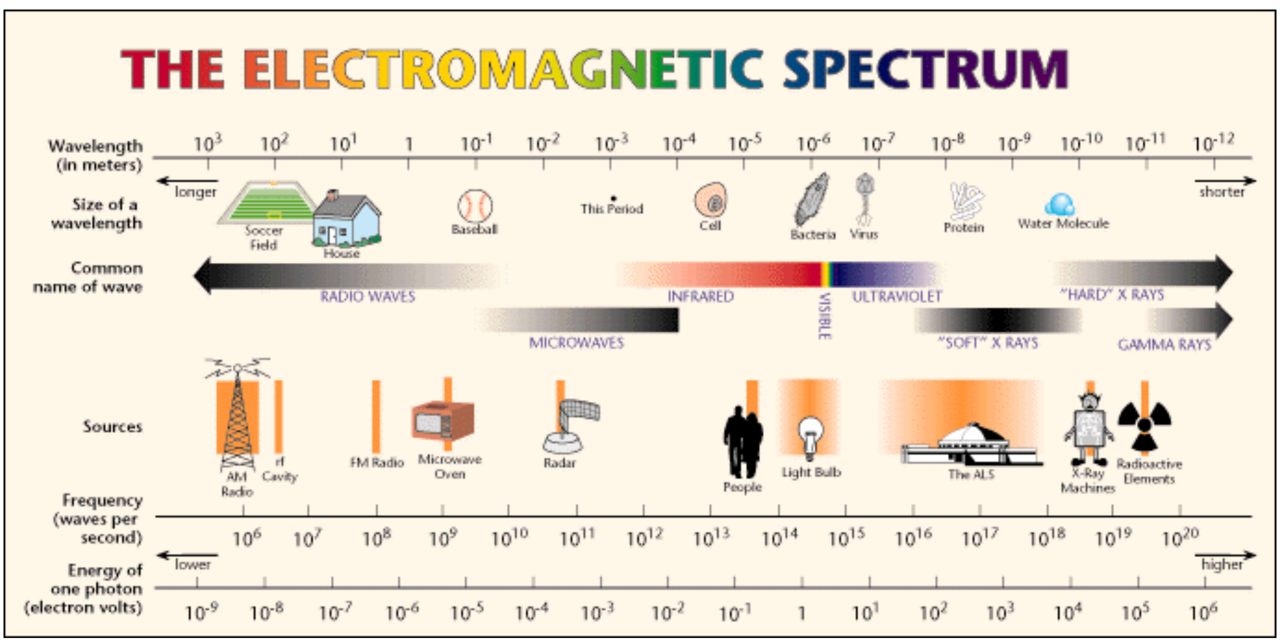
Electromagnetic Radiation
Moving from One Form of Energy to Another

Stars give off energy in the form of electromagnetic radiation. The closest star to the Earth, the sun, is the primary source of energy on Earth. When Santa Fe is faced towards the sun, we are receiving electromagnetic radiation. This is our daytime. At night we are faced away from the sun, into space and are not receiving direct radiation. Electromagnetic radiation comes in many wavelengths. The shorter the wavelength the more energy it carries with it. The longer wavelengths carry less energy.

The length of the wavelength determines what type of electromagnetic radiation is being emitted. The longest wavelengths are called radio waves. Every time you listen to the radio, you are using electromagnetic radiation. The more powerful and harmful types of radiation are from the other end of the spectrum. These are better known as x-rays or gamma rays. These are one cause of cancer and are emitted by a nuclear blast. Visible light is between these two extremes. Stars emit all of these wavelengths. Our atmosphere and the magnetic field around the Earth protect us from many of the more damaging forms of electromagnetic radiation.



Try it… Have a friend hold the other end of a jump rope. Slowly move your hand up and down, creating a wave. Now speed up. Which wave do you think carries more energy?

Temperature Variability

As outlined earlier, weather varies greatly from day to day and year to year. It is only when you take a step back and look at trends that you are able to begin to make sense of data. On the left is the year. On the right the amount that the global average temperature varies from the average temperature of the period between 1951 and 1980.

For example, the average temperature between 1951 and 1980 was 57.92 degrees Celsius. In 1951 the temperature was 0.07 degrees below this average. That means that in 1951 the annual global mean was 57.85. There is some natural variability in temperature, but even small changes can make a large impact on our environment.

When you graph this data, you will need to think carefully about what scale to use. Look for the smallest number and the largest, and use these as your limits.

Year	Deviation from Annual Global Mean, from 1951-1980
1959	0.03
1960	-0.04
1961	0.05
1962	0.04
1963	0.07
1964	-0.2
1965	-0.1
1966	-0.04
1967	-0.01
1968	-0.05
1969	0.06
1970	0.04
1971	-0.07
1972	0.02
1973	0.16
1974	-0.07
1975	-0.01
1976	-0.12
1977	0.15
1978	0.05
1979	0.12
1980	0.23
1981	0.28
1982	0.09
1983	0.27
1984	0.12
1985	0.08
1986	0.15
1987	0.29
1988	0.36
1989	0.24
1990	0.39
1991	0.38
1992	0.19
1993	0.21
1994	0.29
1995	0.43
1996	0.33
1997	0.46
1998	0.62
1999	0.41
2000	0.41
2001	0.53
2002	0.62
2003	0.6
2004	0.52
2005	0.66
2006	0.59
2007	0.62
2008	0.49
2009	0.6
2010	0.67
2011	0.55
2012	0.57

Graph CO2 from Mauna Loa

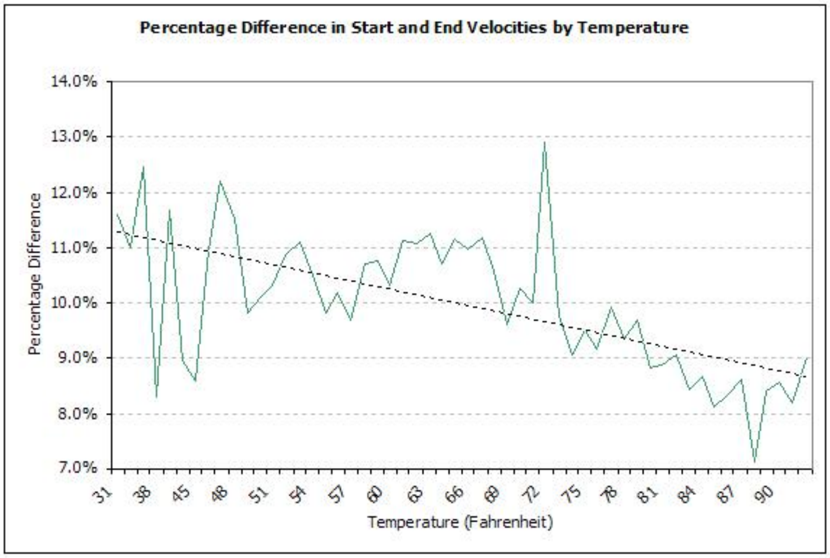
This is data that has been collected on Mauna Loa in Hawaii. The carbon dioxide is measured in the parts per million molecules of air in the atmosphere. For example, in 1959 there were 315.97 parts per million. The Mauna Loa data has been collected for over half a century. It has been incredibly important in looking at the impact of adding carbon dioxide to the atmosphere over time.

Year	**Carbon Dioxide**
1959	315.97
1960	316.91
1961	317.64
1962	318.45
1963	318.99
1964	319.62
1965	320.04
1966	321.38
1967	322.16
1968	323.04
1969	324.62
1970	325.68
1971	326.32
1972	327.45
1973	329.68
1974	330.18
1975	331.08
1976	332.05
1977	333.78
1978	335.41
1979	336.78
1980	338.68
1981	340.10
1982	341.44
1983	343.03
1984	344.58
1985	346.04
1986	347.39
1987	349.16
1988	351.56
1989	353.07
1990	354.35
1991	355.57
1992	356.38
1993	357.07
1994	358.82
1995	360.80
1996	362.59
1997	363.71
1998	366.65
1999	368.33
2000	369.52
2001	371.13
2002	373.22
2003	375.77
2004	377.49
2005	379.80
2006	381.90
2007	383.76
2008	385.59
2009	387.37
2010	389.85
2011	391.63
2012	393.82

What Can You Learn From This Data?

A trend line is a line that shows a general pattern in data. Although you might see a graph jumping up and down, the trend line is the general direction in which the pattern is moving.

This is a trend line graphing the percent decrease in speed of baseballs thrown in Coors Field in Denver versus the temperature. This graph says that as the temperature increases, the baseball do not lose as much speed, and might be harder to hit.



Go back to your two graphs and try to draw a trend line for each.

Compare graphs. What do you notice?

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____

What does this make you think about the connection between carbon dioxide in the atmosphere and the temperature on Earth?

____

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Learning at the Botanical Garden
Piñon Pine Exploration

Investigate this tree. What do you notice?

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What do you think killed this tree? Why do you say that?

____

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Survey: You will now conduct a survey on the health of the trees on our property.

Mark surveyed trees with chalk.

Look for:

- Piñon Ips Beetle
- Scale

Live and healthy	Live, evidence of Ips	Live, evidence of Scale	Live, evidence of Scale and Ips	Dead
Total:	Total:	Total:	Total:	Total:

Look at the handouts to learn what precipitation and temperature events are correlated with piñon die-off.

Learning at the Botanical Garden

What impact does Carbon Dioxide have on heating in the atmosphere?

Question: How does an increase in carbon dioxide change the rate of heating in a closed system?

Hypothesis: I think ____

____

____

because ____

____

Procedure:

1. In the shade, place two cups with equal amounts of water in open in two ziplock bags
2. Place both cups and bags on a flat surface, like a clipboard, that can be easily lifted and moved into direct sunlight
3. Place a thermometer in the bag, next to the water
4. Seal one bag with as much air as you can possibly keep in the bag. The air around us is primarily made of nitrogen (70%), so this is the primary gas in bag 1.
5. Drop an Alka-Seltzer in the other bag and quickly squeeze as much air as you can out of the bag and seal it. When Alka-Seltzer reacts with water, it releases carbon dioxide. This bag will have a high concentration of carbon dioxide in the bag.
6. Take an initial temperature reading and record the results
7. Place the two bags into direct sunlight
8. Every three minutes check the temperature and record your results below

Results:

	O minutes	3 minutes	6 minutes	9 minutes	12 min.	15 min.
Alka-Seltzer, *primarily* CO_2						
Santa Fe Air, *primarily* N_2						

Conclusion:
I think that these results tell me that____

What questions did this experiment make you want to answer next? How would your create a test to answer these questions?

What could these results tell you about our world and the impact of carbon dioxide on the temperature of the Earth? Remember, although the Earth is large, it is also a closed system

Learning at the Botanical Garden
Arid is Beautiful Too

Much of our garden is designed to be successful in an arid, or dry, land. Use this time to find three plants that you think gardeners should plant in their yards and use the art supplies to create three works of art that you think will convince people that they should plant them. These works will be photographed and put on the Botanical Garden Filed Book Website.

When you do field drawing, it is important to know what the weather is like and what time of year it is. This allows people to know what plants look like during different periods of time.

Date:___________________________

Time:___________________________

Temperature:_______________________________

Describe the weather:____

____

____

____

____

____

Plants that I drew: ____

____

____

____

____

Reflection

What are three things you learned today?

1.____

____

2.____

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3.____

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What are two questions that you have about something related to the fieldtrip?

1.____

____

2.____

____

What was your favorite activity today and why?

1.____

____

____

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Draw your favorite memory of today below.

Atmosphere Game Heating Rules

No Atmosphere

Begin with 10 units of "solar energy" off the board.

Turn 1: Place a unit of energy on the farthest left position on the game board.
Flip your coin. If it is heads, the energy is lost to outer space, if it is tails the energy stays on Earth, heating the surface. If it the energy is in outer space, you can no longer use it and it stays in space until the next game.
Record what happened on your score sheet.

Turn 2: Place a unit of energy on the second position.
If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is lost to outer space, if it is tails the energy stays on Earth, heating the surface. Repeat with the position 2 unit of energy.
Record what happened on your score sheet.

Turn 3: Place a unit of energy on the third position. If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is lost to outer space, if it is tails the energy stays on Earth, heating the surface. Repeat with the position 2 and 3 units of energy.
Record what happened on your score sheet.

Turns 4-10: Repeat the above steps, adding a new unit of energy on each turn.

After the 10^{th} turn, count how many units of energy are on Earth and how many are in space and record these in the total.

One Atmosphere

Begin with 10 units of "solar energy" off the board.

Turn 1: Place a unit of energy on the farthest left position on the game board.
Flip your coin. If it is heads, the energy is moved to the atmosphere, if it is tails the energy stays on Earth, heating the surface.
Record what happened on your score sheet.

Turn 2: Place a unit of energy on the second position.
If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is moved to the atmosphere, if it is tails the energy stays on Earth, heating the surface. If position 1 is in the atmosphere, flip your coin; if it is tails it radiates back to Earth, if it is heads it moves into space. Repeat with the position 2 unit of energy. If it the energy is in outer space, you can no longer use it, and it stays in space until the next game.
Record what happened on your score sheet.

Turn 3: Place a unit of energy in the third position. If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is moved to the atmosphere, if it is tails the energy stays on Earth, heating the surface. If position 1 is in the atmosphere, flip your coin; if it is tails it radiates back to Earth, if it is heads it moves into space. Repeat with the position 2 and 3 units of energy.
Record what happened on your score sheet.

Turns 4-10: Repeat the above steps, adding a new unit of energy on each turn.

After the 10^{th} turn, count how many units of energy are on Earth, in the atmosphere, and how many are in space and record these in the total.

Two Atmospheres

Begin with 10 units of "solar energy" off the board.

Turn 1: Place a unit of energy on the farthest left position on the game board.

Flip your coin. If it is heads, the energy is moved to the lower atmosphere, if it is tails the energy stays on Earth, heating the surface.

Record what happened on your score sheet.

Turn 2: Place a unit of energy on the second position.

If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is moved to the lower atmosphere, if it is tails the energy stays on Earth, heating the surface. If position 1 is in the atmosphere, flip your coin; if it is tails it radiates back to Earth, if it is heads it moves into the upper atmosphere.

Repeat with the position 2 unit of energy.

Record what happened on your score sheet.

Turn 3: Place a unit of energy in the third position. If you still have a unit of energy on Earth in position 1, flip your coin. If it is heads, the energy is moved to the lower atmosphere, if it is tails the energy stays on Earth, heating the surface. If it is still in the lower atmosphere in position 1, flip your coin. If heads, it is moved to the upper atmosphere, if tails, it goes back to Earth. If position 1 is in the upper atmosphere, flip your coin; if it is tails it radiates back to the lower atmosphere, if it is heads it moves into space. Repeat with the position 2 and 3 units of energy. Record what happened on your score sheet. If it the energy is in outer space, you can no longer use it, and it stays in space until the next game.

Turns 4-10: Repeat the above steps, adding a new unit of energy on each turn.

After the 10th turn, count how many units of energy are on Earth, in the lower atmosphere, in the upper atmosphere, and how many are in space and record these in the total.

Atmosphere Heating Score Sheet

No Atmosphere

Rounds	1	2	3	4	5	6	7	8	9	10	Final
On Earth											
In Space											

Total of the energy on Earth: _______________ units energy

One Atmosphere

Rounds	1	2	3	4	5	6	7	8	9	10	Final
On Earth											
In Atmosphere											
In Space											

Add the energy on Earth and in the Atmosphere:_____________ units energy

Two Atmospheres

Rounds	1	2	3	4	5	6	7	8	9	10	Final
On Earth											
Lower Atmosphere											
Upper Atmosphere											
In Space											

Add the energy on Earth, in the Lower Atmosphere, and in the Upper Atmosphere:_____________ units energy.

Experiment
Does all of the Earth's surface heat at the same rate in the sun?

Question: Do different materials heat at different rates when placed in the sun?

The three materials I will test are:

1.______________________________________

2.______________________________________

3.______________________________________

Hypothesis: I think that ____

____

____

because____

____

Procedure: These are the steps I will use to test my hypothesis.

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Results:

Conclusion: I think this tells me that

Next questions I think should be tested or changes I would make to this test:

Reflection:
What effect does changing the surface have on temperature?

What do you think would happen if we paved the entire Earth with blacktop?

What would happen if we painted the Earth white or covered it with ice?

What else does this test tell you about the Earth?

Reflection about Climate Data

What do you know about climate change?

Do you think climate change is happening? Why do you say that?

If yes, do you think it is caused by humans or something else? Why do you say that?

What do you think should be done about climate change? Why do you say that?

Glossary

Anthropogenic

Climate

Climate Change

Precipitation

Weather