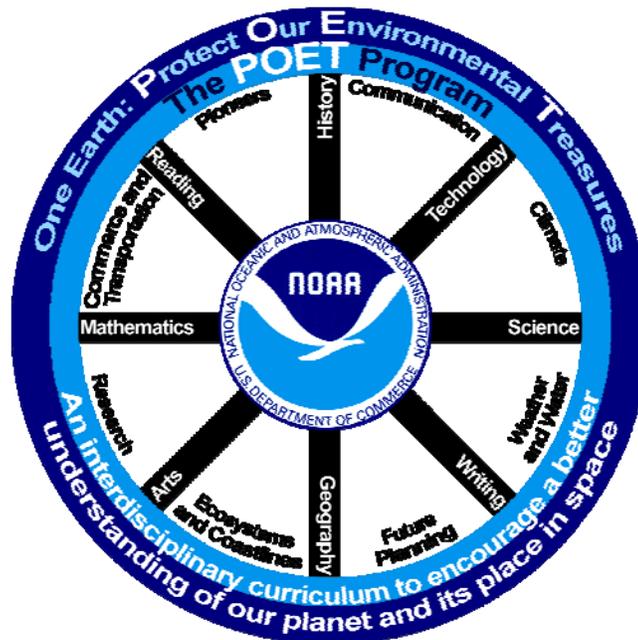


Answer Keys and Conclusions for POET Activities



Activity 1 – “Nighttime Lights of the World – Part 1”

Check to see that students properly label locations on the map.

Activity 1 – “Nighttime Lights of the World – Part 2”

(Accept any logical answers and encourage accurate observations and inferences.)

1. South Korea is either more populated, more prosperous, or both, compared to North Korea. There are more night lights (electricity).
2. Western Europe, around the perimeter, near oceans and seas. There are more night lights.
3. Probably not. Since it appears dark, there are fewer lights and probably fewer people.
4. Around the eastern perimeter. There are more night lights.
5. An absolute answer to this question is complex. There are huge populations in India and China, and lots of lights distributed over large areas. Of these two, the guess is that China uses more power. Then there's Japan, where the lights are as bright as over the eastern U.S. or western Europe. Per capita, Japan is likely the biggest electric power user. For total power consumed, the winner is difficult to determine without more information.

Conclusion – Activity 1 – “Nighttime Lights of the World”

Nighttime lights show population density, as well as economic prosperity.

Developed countries use more energy in the form of electric power that shows up in the nighttime sky. For example, Japan has many bright lights and North Korea has few. Japan is economically prosperous, while in North Korea, people are starving.

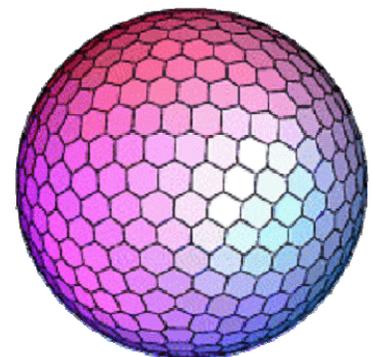
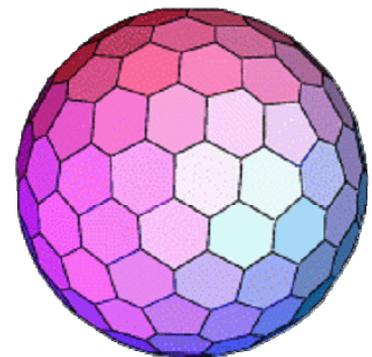
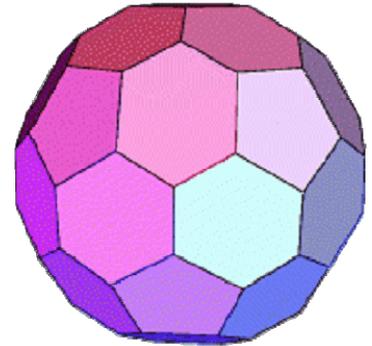
Activity 2 – “Using Different Models of Earth”

(Accept any logical answers and encourage accurate observations and inferences.)

1. An icosahedron is more like a sphere. The Miller map projection is flat. The globe (map) is a sphere. On the Miller projection, polar areas are spread out and distorted. Yet, a flat map is more convenient to carry around.
2. Antarctica looks long and narrow on a flat map and more like a circle on an icosahedron.
3. Greenland looks larger on a flat map than it does on an icosahedron.
4. Shape and size on an icosahedron are closer to the actual measurements. They are more distorted on a flat map.
5. Since an icosahedron is more like a globe, it is more true to scale.
6. An icosahedron is easier than a sphere to construct and its shape is almost a globe. Important to note is that the icosahedron, with 20 faces, each a perfect polygon (pentagon or hexagon), is the 3-D figure with the maximum number of faces that one can cut out and assemble from a flat piece of paper. For purposes of weather prediction by computer, each face can be subdivided further. The two figures to the right, in the middle and bottom, could **not** be assembled from a cutout.
7. A circle route across Antarctica. Icosahedron.
8. A circle route across the Arctic Ocean. Icosahedron.
9. Sizes, shapes, and distances are more distorted on a flat map, especially around the poles. For example, Antarctica looks long and narrow on a flat map; whereas Antarctica is more rounded on an icosahedron or globe.
10. Indian Ocean.
11. Arctic Ocean.
12. Nova Scotia.
13. The icosahedron because it more accurately represents distances and directions. More direct routes are easier to identify on an icosahedron or a globe than on a flat map.

FYI

An icosahedron is a polyhedron with 20 faces.



Conclusion – Activity 2 – “Using Different Models of Earth”

Shapes, sizes, and distances are distorted on a flat map, especially around the poles. Antarctica looks long and narrow on a flat map; whereas Antarctica is more rounded on an icosahedron or globe.

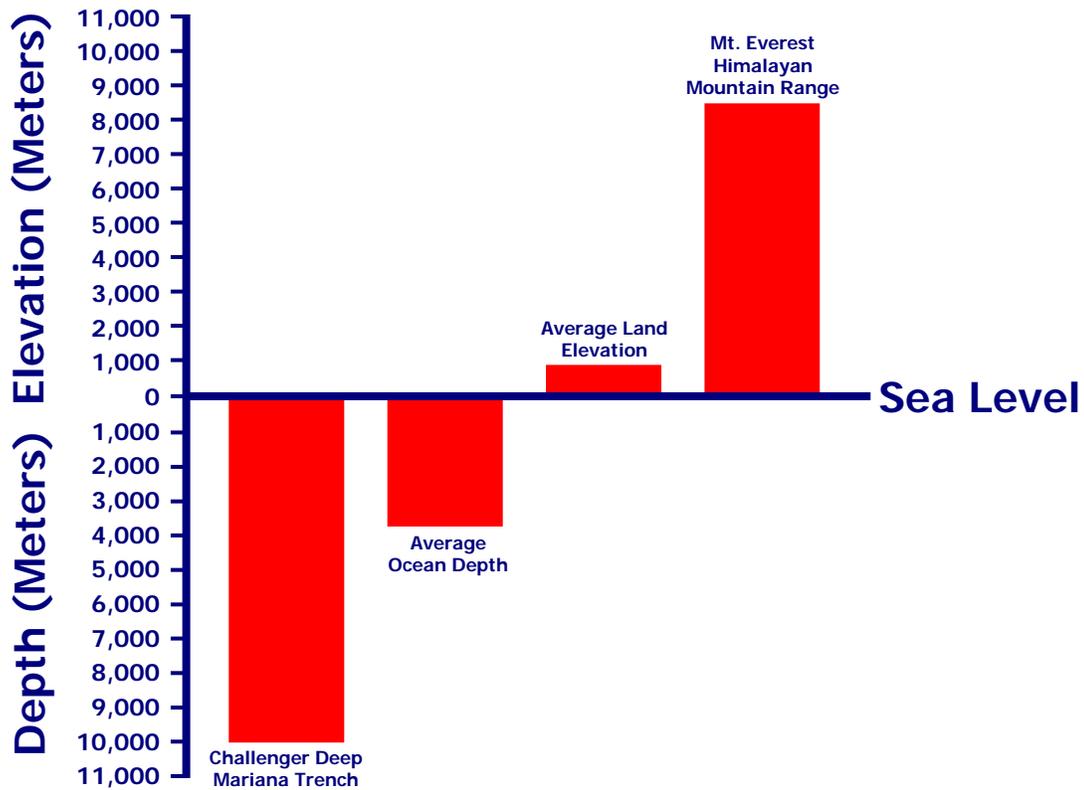
The shortest route between two locations is a Great Circle. For example, going from Seattle, Washington to Kazakhstan is shorter over the Arctic Ocean than across the Pacific Ocean. More direct routes are easier to identify on an icosahedron.

Activity 3 – “ Topography and Bathymetry”

1. **Topography** - Surface features of a place or region that show relative positions or elevations.

Bathymetry – The study of Earth’s underwater features that show relative positions or elevations.

2. Lowest depth in the ocean.
3. The Challenger Deep - Mariana Trench is 1594 meters deeper than Mt. Everest - Himalayan Mountain Range is high.
4. Accept any reasonable bar graph that accurately shows the relative distances. Similar to the following...



Conclusion – Activity 3 – “ Topography and Bathymetry”

The ocean depth is greater by 1594 meters. Since Earth is dynamic and always moving, the distances change over time.

The average ocean depth is greater than the average land elevation.

Activity 4 – “The USCGS to the Rescue”

Answers to this activity will vary.

Conclusion – Activity 4 – “The USCGS to the Rescue”

Summarize the "To Reach" section of the procedure.

Activity 5 – “Tornado Over Kansas - Parts 1 and 2”

(Accept any reasonable response.)

Artist and Scientist

must know more than one subject; how to use tools and chemicals including paint; must go through a process like the scientific method when producing a work of art or doing research, etc.

Art and Science Cross Paths

Often unexpected, both art and science involve study, preparation, insight, and inspiration. An artist uses a studio and a scientist uses a laboratory in order to prepare. Both are creative and both are seeking to discover something, heretofore unknown. Both use tools of their trade: A scientist might seek a new treatment for an illness; likewise, an artist might look for a new way to use color or shape. Artists often have a science background and scientists often use art in their investigations.

There are more observations and inferences in this key than the students are required to fill in.

<i>People</i>	
<i>Observations</i>	<i>Inferences</i>
Man, Woman, Two Young Boys, and a Girl	Family
Moving In One Direction	Staying Together
Door to the Shelter is Open	Running to the Shelter
Boy carrying Cat, Mom carrying Blanket and Baby, Boy carrying Boxes, Dad Holding Girl's Hand	Family Planned and Practiced
Expressions of Fear on Faces	Have Experienced a Tornado Before
Looking Toward the Chicken	Wondering Whether to Take the Time to Catch the Chicken
Running Toward Cellar	Underground is Safe
Mother and Father Looking Behind	Making Sure that all the Children are Close
Tornado Approaches Without Warning	Only the Most Dear Possessions are With the Family – the Pets
Economically Poor	House is Weather-beaten, Few Toys, a Cart but No Auto

<i>Weather</i>	
<i>Observations</i>	<i>Inferences</i>
Green Sky	Hail
Funnel-Shaped Cloud	Tornado
Flat Land	Prairie
Clouds	Rain
Expressions of Fear on Faces	Weather Can Be Dangerous

<i>The Artist – John Steuart Curry</i>	
<i>Observations</i>	<i>Inferences</i>
Color and Form of Clouds, Sky, Tornado	Knows Weather
Form of People, Muscle, Angles of Limbs	Knows Physiology
Color and Form of Land	Knows Seasonal Variation
Colors Realistic	Knows Chemistry to Mix Paint
Realistic Look of Fear on Faces	Probably Has Personal Experience of Tornado
Picture Conveys Motion	Reflects Drama of the Experience
Included People, Animals, House	In Severe Weather, the Goal is to Save Lives and Protect Property

Conclusion – Activity 5 – “Tornado Over Kansas - Parts 1 and 2”

Answers vary, but should include information from the Activity. (Refer to the tables in this Key.)

Activity 6 – “Hurricanes: Environmental Satellites – Part 1”

1. Background

- Geostationary Satellite: (acronym) **G**eostationary **O**perational **E**nvironmental **S**atellite (**GOES**)
- Use of satellites began in the 1970's for weather observations and space research
- Equipment includes infrared sensors, cameras, and monitors to gather data
- Data sensors include proton detectors, seismic detectors, rain and river gauges

2. Current Uses

- Continue weather observations and space research
- Volcano monitoring
- Fire detection
- Search and rescue

3. How GOES Works

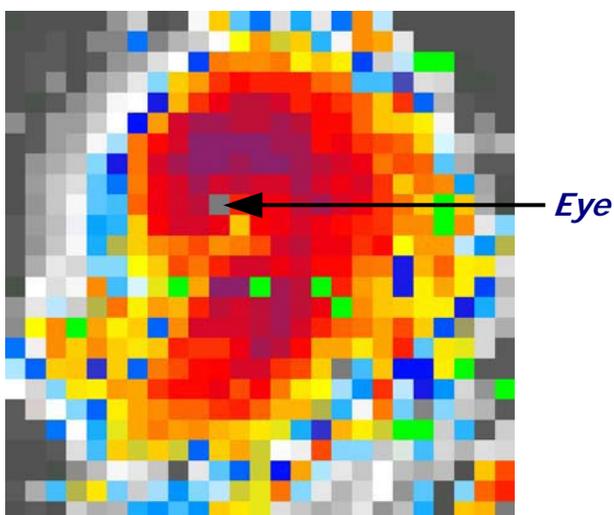
- Satellite orbits in a geosynchronous orbit: from Earth the satellite appears to remain in the same location, but is really revolving around Earth at the same rate that Earth is rotating - Orbits at altitude of 22,300 miles - Orbits Earth in 24 hours
- Collects data form Earth like snowfall, precipitation stream flow, around the globe, and sends data back to Earth to be processed
- The large antenna at lower left in Figure 6-1 (Page 6-3) - Receives data from the GOES satellite.
- Almost directly below the satellite in the drawing is the CDA, a Command and Data Acquisition Facility, which controls what the satellite does.

4. Why should we learn about satellites and satellite images?

- We use satellite-related conveniences daily, such as cell phones, TV, radio, GPS, etc.
- We depend on satellite data to forecast events, such as floods, hurricanes, earthquakes, etc.

Activity 6 – “Hurricanes: Creating a Satellite Image Using Pixels – Part 2”

- Part of the electromagnetic spectrum that lies at a band of wavelengths just longer than those for visible light. We use it to measure and detect heat energy.
- Like a spiral or a “comma”. Accept any reasonable description.
- Approximately 800 x 800 kilometers.
- Approximately 32 kilometers.
- Purple and red.
- Black and gray.
- Similarities
 - Eye is visible
 - Counterclockwise motion
 - Over water
 - Coldest temperature is in the center
 - Warmer temperatures are closer to the edge
 - Similar shape in general



A detailed portion of the center and eye of Hurricane Georges.

Differences

- Different details within the similar shape
 - Different eye size
 - Hurricane image on the left is less compact
 - Hurricane image on the left has more higher and colder clouds
 - Hurricane image on the left has high cold clouds encircling the eye
- We can observe or infer hurricane size and shape, temperature at cloud top, relative amount of rainfall, and location.

Activity 6 – “Hurricanes: A Cross-Section Through the “Eye” of a Hurricane – Part 3”

1. Center of the hurricane is partially clear with light winds.
2. Moving west to east, clouds get higher and colder, then suddenly disappear, then reappear with thick high clouds and gradually become thinner.
3. Where the cloud height is zero toward the center of the graph.
4. Beneath the higher clouds around the “eye”.
5. Beneath the higher clouds.
6. All the arrows should indicate wind movement in a counterclockwise direction (cyclonic low).

Conclusion - Activity 6 – “Hurricanes: Parts 1 – 3”

Part 1

Students should summarize the information in the answer key.

Part 2

Enlarged pixels

- contains small blocks of different colors that indicate different temperatures
- swirling in a counterclockwise direction
- different colors represent different temperatures
- hurricane shaped like a spiral
- open area in the center

Observe or Infer

- hurricane size and shape, temperature at cloud top, relative amount of rainfall, location
- the coldest clouds are also the highest
- the high clouds near the eye are also the thickest clouds and probably contain the heaviest rain

Part 3

- Moving west to east, clouds get higher and colder, suddenly disappear
- The cloud height is zero toward the center of the graph
- High clouds reappear and get lower and lower

Activity 7 – “Winter at the South Pole”

1. 50 degrees below zero Fahrenheit
2. 20 pounds
3. 89.99 degrees south. 00.01 degrees difference between the NOAA station and the geographic South Pole
4. To track trends of atmospheric gases, particles, etc. Examples include greenhouse gases, ozone depleting substances, etc.
5. Ozone balloon: sends data to Boulder, Colorado, monitors the “ozone hole”

Conclusion – Activity 7 – “Winter at the South Pole”

- Cold!
- An opportunity to be a pioneer.
- A great research experience.
- Six months of dark and six months of light upsets biological rhythms.
- Stargazing is good during the South pole night – generally clear skies.
- Very social.
- Lots of people living closely together.
- You might have a unsuitable roommate.
- There is not much “self” time alone.
- You cannot leave on a whim.
- You can see auroras (Aurora Australis) during the South Pole night.
- You can explore.
- Exposure to UV and light could be hazardous.
- Sleep and meal times could be random.
- You can see unusual creatures on the journey.
- Uncomfortable outdoor clothes.
- **Excitement in having an adventure that not many people have!!**

Activity 8 – “Carbon Dioxide and Seasons”

1. An increase followed by a decrease creating a repeating pattern of peaks and troughs much like a wave, with an increase in heights of both peaks and troughs over time. Said differently: A year over year increasing trend superimposed on an annual cycle of increases and decreases. (Reasons are discussed in the final question.)
2. 10.63 parts per million (ppm).

3.

Year	Mean CO ₂ Concentration (ppm)	Amount of CO ₂ Change (ppm)	Change Since the Previous Year (Increase, Decrease, Unchanged)
2002	372.31		
2003	374.94	2.63	Increase
2004	376.76	1.82	Increase
2005	378.77	2.01	Increase
2006	380.97	2.20	Increase
2007			
2008			

4. Highest: March, April, May – Spring / Lowest: August, September – Fall

Activity 8 – “Carbon Dioxide and Seasons” (Continued)

5. April – Because the CO₂ concentration during the winter builds up over time

The variations within each year are the result of the annual cycles of photosynthesis and respiration. Photosynthesis, in which plants take up carbon dioxide from the atmosphere and release oxygen, dominates during the warmer part of the year; respiration, by which plants and animals take up oxygen and release carbon dioxide, occurs all the time but dominates during the colder part of the year. Overall, then, carbon dioxide in the atmosphere decreases during the growing season and increases during the rest of the year.

Because the seasons in the northern and southern hemispheres are opposite, carbon dioxide in the atmosphere is increasing in the north while decreasing in the south, and vice versa. The magnitude of this cycle is strongest nearer the poles and approaches zero towards the Equator, where it reverses sign. The cycle is more pronounced in the northern hemisphere (which has relatively more land mass and terrestrial vegetation) than in the southern hemisphere (which is more dominated by oceans).

6. Approximately 384.0 ppm

7. See Number 5

8. Annual cycles with increasing slope due to CO₂ additions to the atmosphere

9. Need Answer

10. Need Answer

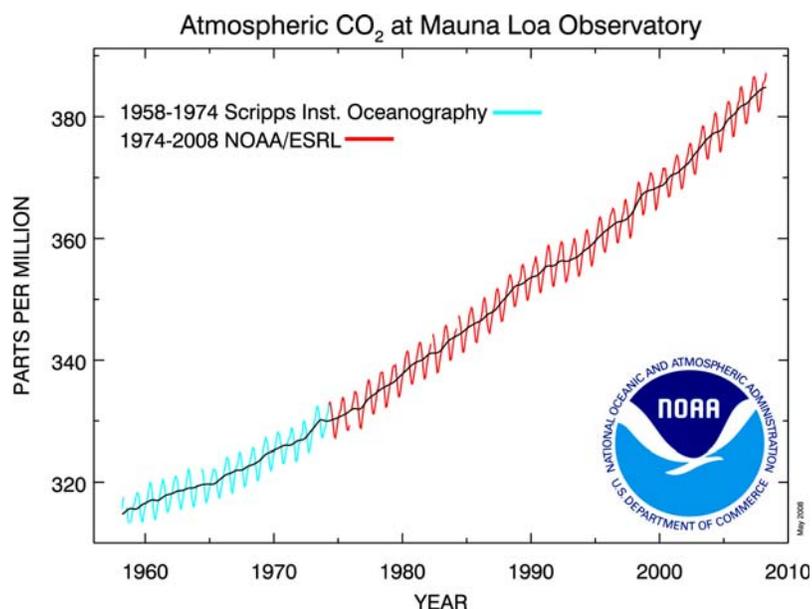
Conclusion – Activity 8 – “Carbon Dioxide and Seasons”

The variations of carbon dioxide within each year are the result of the annual cycles of photosynthesis and respiration.

Photosynthesis, in which plants take up carbon dioxide from the atmosphere and release oxygen, dominates during the warmer part of the year; respiration, by which plants and animals take up oxygen and release carbon oxygen, occurs all the time but dominates during the colder part of the year. Overall, then, carbon dioxide in the atmosphere decreases during the growing season and increases during the rest of the year.

Because the seasons in the northern and southern hemispheres are opposite, carbon dioxide in the atmosphere is increasing in the north while decreasing in the south, and vice versa. The magnitude of this cycle is strongest nearer the poles and approaches zero towards the Equator, where it reverses sign.

The cycle is more pronounced in the northern hemisphere (which has relatively more land mass and terrestrial vegetation) than in the southern hemisphere (which is more dominated by oceans).



Activity 9 – “Global Warming”

Thousands of Years Before Present	CO₂ Concentration (ppm)	CO₂ Concentration Rounded to Nearest Whole Number	Temperature Anomaly (Degrees C)	Temperature Anomaly (Degrees C) Rounded to Nearest Tenth Degree
2.34	284.7	285	-0.00	-0.0
10	261.6	262	-0.28	-0.3
20	189.2	189	-7.62	-7.6
30	205.4	205	-7.95	-8.0
40	209.1	209	-6.91	-6.9
50	190.4	190	-5.18	-5.2
60	210.4	210	-6.53	-6.5
70	227.4	227	-7.84	-7.8
80	221.8	222	-3.66	-3.7
90	208.0	208	-4.69	-4.7
100	225.9	226	-3.45	-3.5
110	245.7	246	-5.53	-5.5
120	265.2	265	-0.86	-0.9
130	263.4	263	+1.47	+1.5
140	192.3	192	-8.99	-9.0
150	191.9	192	-7.34	-7.3
160	204.4	204	-6.25	-6.3
170	197.9	198	-7.01	-7.0
180	213.2	213	-6.34	-6.3
190	231.4	231	-6.49	-6.5
200	242.6	243	-2.68	-2.7
210	244.6	245	-3.07	-3.1
220	212.2	212	-4.31	-4.3
230	245.2	245	-6.15	-6.2
240	230.4	230	-2.12	-2.1
250	203.9	204	-6.52	-6.5
260	184.7	185	-8.30	-8.3
270	231.4	231	-5.95	-6.0
280	207.7	208	-6.17	-6.2
290	240.2	240	-6.00	-6.0
300	241.9	242	-3.08	-3.1
310	256.3	256	-3.32	-3.3
320	271.8	272	-0.12	-0.1
330	234.2	234	-4.90	-4.9
340	220.4	220	-7.44	-7.4
350	193.0	193	-7.64	-7.6
360	206.4	206	-5.80	-5.8
370	229.7	230	-5.42	-5.4
380	245.9	246	-4.88	-4.9
390	255.2	255	-5.34	-5.3
400	278.0	278	-1.64	-1.6

Activity 9 – “Global Warming” (Continued)

1. A repeating cycle. When the carbon dioxide concentration goes up, temperature goes up. When the carbon dioxide concentration goes down, temperature goes down.
2. Five peaks and four troughs, although we do not know the year of the most recent peak (we are currently living in the most recent) nor do we know the oldest peak (drilling ice core samples continues).
3. Approximately 100,000 years.
4. Troughs because the temperature is at its lowest.
- 5.

CO₂ Concentration and Temperature Rate of Change (50,000 – 2000 Years Before Present [BP])

Category Data Parameter	Beginning Year	Ending Year	Difference Between Beginning and Ending Year	For the Beginning Year	For the Ending Year	Difference Between Beginning and Ending Year = Change	Difference Divided by Mathematical Time Range = Rate of Change
Carbon Dioxide Concentration (CO ₂ – ppm)	50,000 BP	2000 BP	? 48,000 Years	CO ₂ Concent. is ? 190 ppm	CO ₂ Concent. is 285.0 ppm	CO ₂ Change is ? 95 ppm	CO ₂ Rate of Change is ? 95/48,000 = 0.0012 ppm per year
Temperature Anomaly (Degrees C)	50,000 BP	2000 BP	? 48,000 Years	Temp. Anomaly is ? -5.18° C	Temp. Anomaly is -0.45° C	Temperature Anomaly Change is ? 4.73° C	Temperature Anomaly Rate of Change is ? 4.73/48,000 = 0.0000985° C per year

6.

CO₂ Concentration and Temperature Rate of Change (1880 to Present)

Category Data Parameter	Beginning Year	Ending Year	Difference Between Beginning and Ending Year	For the Beginning Year	For the Ending Year	Difference Between Beginning and Ending Year = Change	Difference Divided by Mathematical Time Range = Rate of Change
Carbon Dioxide Concentration (CO ₂ – ppm)	1880	Present (2000)	? 120 Years	CO ₂ Concent. is 291.0 ppm	CO ₂ Concent. is 384.0 ppm	CO ₂ Change is ? 93 ppm	CO ₂ Rate of Change is ? 93/120 = 0.78 ppm per year
Temperature Anomaly (Degrees C)	1880	Present (2000)	? 120 Years	Temp. Anomaly is -0.15° C	Temp. Anomaly is +0.36° C	Temperature Anomaly Change is ? +0.51° C	Temperature Anomaly Rate of Change is ? +0.51/120 = 0.00425° C per year

Activity 9 – “Global Warming” (Continued)

7. About 48,000 Years – About 120 Years
8. Both – CO₂ concentration increases and temperature anomaly increases – Both increase at a greater rate more recently
9. Upward for both CO₂ concentration increases and temperature anomaly increases
10. Approximately 0.51° C
11. Approximately 1.5 ppm per year
12. The rate of change increases
13. Internet Research – Volcanic eruptions and aerosols; Changes in Earth's orbit, axis tilt, and axis precession; Changes in energy from the Sun; Ocean current changes

Conclusion – Activity 9 – “Global Warming”

- > CO₂ concentrations and surface temperatures from present to thousands of years ago can be determined from polar ice core samples
- > Both temperature anomaly and CO₂ concentration follow a similar pattern over the period of time from 400,000 BP to present - rising and falling almost simultaneously
- > The time between two peaks or two troughs shows one cycle
- > One cycle occurs approximately every 100,000 years (example: 120,000 BP to 240,000 BP)
- > Both CO₂ concentration and temperature anomaly show a repeating natural cycle
- > Temperature troughs represent ice ages; temperature peaks represent interglacial periods
- > The rate of increase for temperature anomaly and CO₂ concentration is rising.

Activity 10 – “Arctic Sea Ice” – Parts 1 and 2

1. 2006 and 2007.
2. 6.7 million square miles.
3. 6.8 million square miles.
4. 7.5 million square miles.
5. The minimum ice extent occurs at the end of summer melting (i.e. September) each year.
6. Approximately 3.5 million square miles.
7. 2050.
8. Retreat of sea ice is a sign of global warming.

Ocean water absorbs sunlight that would otherwise be reflected back into space by bright snow and ice, accelerating warming in a "positive feedback". Political boundaries are not clearly established and therefore, ownership of natural resources and shipping routes.

Note that floating ice melting does not affect sea level. It's the same amount of water, solid or liquid.

Conclusion – Activity 10 – “Arctic Sea Ice”

- > Between 1979 and 2007, arctic ice has decreased from 7.2 million square mile to 4.3 million square miles.
- > The greatest decrease in arctic was between 2006 and 2007.
- > Decreasing arctic ice could result in the following changes: Climate and weather; political repercussions when countries scramble to claim the opening seaways; plant and animal habitat.

Activity 11 – “The Carbon Cycle – How It Works”

No questions need answers in this activity. The students play the game and in the process learn about elements of the carbon cycle.

Conclusion – Activity 11 – “The Carbon Cycle – How It Works”

Carbon...

- > is essential for life, a building block of matter
- > moves in a cycle through Earth's atmosphere, oceans, surface, plants and animals (called carbon reservoirs)
- > is stored in reservoirs until released or absorbed
- > can be released or absorbed by processes like burning, weathering and erosion, matter taken in as food or absorbed into cells, photosynthesis and respiration volcanoes, dissolving in water, death and decomposition

Carbon Dioxide (CO₂)...

- > is a colorless, odorless gas formed by one atom of carbon and two atoms of oxygen
- > is released into the atmosphere by burning fossil fuels
- > concentration is increasing in Earth's atmosphere as fossil fuel use increases world-wide
- > absorbs infrared radiation and other rays from the Sun
- > acts like a blanket covering Earth when it is in Earth's atmosphere
- > causes global warming

The Carbon Cycle summarized...

- > process of carbon moving among Earth's atmosphere, oceans, surface and living organisms
- > plants take in CO₂ and give off oxygen (O₂)
- > animals use O₂ and give off CO₂
- > sea plants use CO₂ for photosynthesis and sea animals use CO₂ to build shells (CaCO₃)

Activity 12 – “The Carbon Cycle – CarbonTracker”

No questions need answers in this activity. The students play the game and in the process learn about the CarbonTracker.

Conclusion – Activity 12 – “The Carbon Cycle – CarbonTracker”

CarbonTracker...

- > is a tool to keep track of carbon dioxide and other greenhouse gases around the globe
- > can collect data regarding carbon reservoirs, which are described as uptake (sometimes called a sink) and release (sometimes called a source) of CO₂ for many places on Earth
- > data will help to better understand how the uptake and release of greenhouse gases affect land, ocean, atmospheric, and living ecosystems
- > data will help to predict future changes in the amount and location of greenhouse gases
- > is important because atmospheric temperature increases when the CO₂ concentration increases
- > will help world leaders to have reliable data when planning for the future

Activity 13 – “The Carbon Cycle – The Annual Greenhouse Gas Index”

Students calculations may differ from the official results depending on how the steps leading to the results are rounded off.

Global Radiative Forcing 1979 – 2006 ($W\ m^{-2}$)								AGGI 1990=1	% Change
Year	CO ₂	CH ₄	N ₂ O	CFC12	CFC11	Halocarbons	Total		
1979	1.026	0.412	0.101	0.090	0.039	0.029	1.697	0.782	---
1980	1.056	0.418	0.102	0.094	0.041	0.032	1.744	0.803	2.69
1981	1.075	0.425	0.106	0.100	0.043	0.034	1.784	0.821	2.30
1982	1.086	0.432	0.109	0.106	0.045	0.036	1.814	0.835	1.71
1983	1.111	0.438	0.111	0.111	0.048	0.039	1.858	0.855	2.40
1984	1.137	0.446	0.113	0.116	0.050	0.041	1.902	0.876	2.41
1985	1.159	0.451	0.114	0.121	0.053	0.044	1.943	0.895	2.13
1986	1.181	0.456	0.118	0.128	0.055	0.048	1.987	0.915	2.28
1987	1.209	0.460	0.118	0.134	0.058	0.051	2.031	0.935	2.20
1988	1.246	0.464	0.122	0.140	0.061	0.055	2.088	0.961	2.81
1989	1.271	0.469	0.125	0.146	0.063	0.059	2.134	0.983	2.20
1990	1.291	0.472	0.129	0.153	0.066	0.062	2.172	1.000	1.78
1991	1.311	0.476	0.131	0.156	0.067	0.064	2.206	1.016	1.57
1992	1.321	0.480	0.133	0.160	0.067	0.069	2.230	1.027	1.10
1993	1.332	0.481	0.135	0.162	0.068	0.071	2.249	1.035	0.84
1994	1.353	0.483	0.137	0.164	0.068	0.072	2.277	1.049	1.26
1995	1.380	0.485	0.139	0.166	0.068	0.073	2.311	1.064	1.50
1996	1.407	0.486	0.142	0.168	0.067	0.075	2.344	1.080	1.43
1997	1.423	0.487	0.144	0.169	0.067	0.076	2.366	1.090	0.94
1998	1.463	0.491	0.147	0.170	0.067	0.077	2.415	1.112	2.04
1999	1.494	0.494	0.151	0.171	0.066	0.078	2.454	1.130	1.63
2000	1.511	0.494	0.151	0.171	0.066	0.079	2.473	1.139	0.76
2001	1.534	0.494	0.153	0.171	0.065	0.081	2.499	1.151	1.05
2002	1.564	0.494	0.156	0.171	0.065	0.082	2.532	1.166	1.35
2003	1.600	0.496	0.158	0.172	0.064	0.084	2.574	1.185	1.64
2004	1.626	0.496	0.160	0.171	0.064	0.085	2.602	1.198	1.09
2005	1.655	0.496	0.162	0.171	0.063	0.086	2.633	1.212	1.18
2006	1.685	0.495	0.165	0.170	0.062	0.087	2.665	1.227	1.23

Think About This...

Earth's energy balance is important because it determines Earth's average temperature, and therefore, affects our climate. List examples of how a change in Earth's energy balance might affect us.

Accept any reasonable answer. For example...

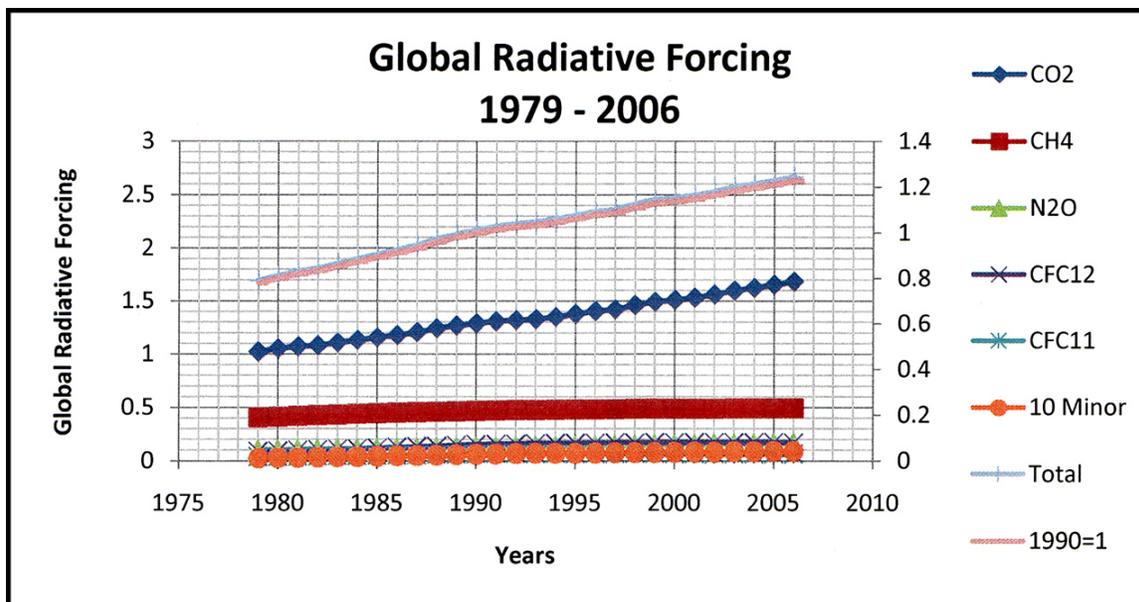
- Change – more rain/less rain – flood/drought
- Food crops will grow in different locations

Activity 13 – “The Carbon Cycle – The Annual Greenhouse Gas Index (Continued)”

1. Sun
2. Earth’s temperature changes causing changes in climate.
3. It would decrease so that life as we know it would cease.

	Name the six major greenhouse gases.	Write the chemical symbol for each of the six major greenhouse gases.	Write the trend (increasing, decreasing, remain the same) for each of the five major greenhouse gases.
4.	Carbon Dioxide	CO ₂	Increasing
5.	Chlorofluorocarbon 12	CFC12	Decreasing or Remaining the Same
6.	Chlorofluorocarbon 11	CFC11	Decreasing or Remaining the Same
7.	Methane	CH ₄	Decreasing or Remaining the Same
8.	Nitrous Oxide	N ₂ O	Increasing
9.	Halocarbons	Group of gases containing carbon, chlorine, fluorine, and iodine (C, Cl, F, and I)	Increasing

10. CO₂ and N₂O
11. CFCs and CH₄
12. 1999 and 2000
13. CO₂
14. Decreasing in recent years
15. Steady in recent years
16. Continuing increase
17. You do not need to know what W/m² means. It is a comparison between different years.
18. 1.23
19. 23% higher than in 1990.
20. Warming because the AGGI is positive.
21. 1990 – because it is the baseline year of the Montreal Protocol



Conclusion – Activity 13 – “The Carbon Cycle – The Annual Greenhouse Gas Index”

How can data be presented so that people understand whether or not the Earth's atmosphere is warming?

- > Create a scale that uses the number one as a baseline and has no units
- > Call the new scale by an easy name to remember - AGGI (pronounced agh-ee) - Annual Greenhouse Gas Index
- > Let a positive AGGI mean that Earth's surface has a tendency to warm and a negative AGGI to cool
- > Recalculate the new scale once a year to keep current
- > For example, the AGGI for 2004 is 1.198, which means that climate forcing in 2004 was 1.198 times as strong as (or 19.8% stronger than) in 1990
- > Since the AGGI is higher than the number one, Earth's atmosphere has a stronger tendency to warm compared to 1990.

How has the (radiative) heat balance of greenhouse gases in Earth's atmosphere changed since 1979?

- > The main greenhouse gases include carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), chlorofluorocarbon 11 (CFC 11), chlorofluorocarbon 12 CFC(12)
- > Out of the five main long-lived greenhouse gases, the gases that continue to increase in atmospheric concentration are CO₂ and N₂O
- > The greenhouse gases that remain approximately unchanged or are decreasing in atmospheric concentration are CFC's and CH₄
- > The smallest annual change was between 1999 and 2000
- > The gas that has the highest rate of change is CO₂
- > Between 1990 and 2006, the sum of greenhouse gases increased by 23%

Optional

- > Most of the energy that affects Earth's weather and climate comes from the Sun
- > On Earth there is a **balance** between the amount of energy that is absorbed from the Sun and the amount of energy radiated back into space
- > **This balance determines Earth's average temperature**
- > NOTE: Earth radiates energy back into space as heat energy, called infrared energy
- > When incoming and outgoing energy from the sun are balanced, Earth's temperature is steady, therefore, climate is stable
- > When the earth absorbs more radiation than it emits to space, the atmosphere and oceans will warm
- > A new balance will be established when the earth has warmed enough to once again give off exactly the same amount of energy to space as it absorbs from the sun

Activity 14 – “The Carbon Cycle – Students Help to Control Their Carbon Footprint”

Background – Student Activities

- > Percent CO₂ concentration increase between 1914 and 1960 – **4.98%**
- > The **second half century** (1961 – 2007) has the highest percent increase of CO₂
- > **4.24 times greater** is the percent of CO₂ increase in the second half century over the first

Typical Electricity Use Per Appliance

Total

(Students – Find the Totals)

107 W

1955 W

Questions – Part 1

1. Microwave – Computer – Different appliances have different power requirements for optimal performance
2. Refer to the “Typical Electricity Use Per Appliance” section above.
3. 40.5 kWh per day
4. 5.2%
5. \$0.26 per day – \$1.80 per week – \$93.73 per year (based on 107 Watt total)
6. Answers vary – accept any reasonable explanation

How Much Energy is Used by Appliances in Stand-By Mode?

Accept any reasonable answer that includes examples of "on" and "stand-by" from the Typical Electricity Use Per Appliance Table

Appliances that have a remote control need electric power to function with a "stand-by" option.

Questions – Part 2

1. Accept any reasonable answer
2. Accept any reasonable answer
3. Accept any reasonable answer
4. Accept any reasonable answer
5. Strategies to reduce your personal carbon footprint
 - > turn off appliances when not in use
 - > turn off remote controls
 - > turn off lights
6. Accept any reasonable answer
7. Accept any reasonable answer

Conclusion – Activity 14 – “The Carbon Cycle – Students Help to Control Their Carbon Footprint”

How Can a Student Help to Control Greenhouse Gas Emissions?

- > Choose actions that can be done by a student, without depending on someone else. For example, a student can control the use of certain electrical appliances, but not control the household temperature (thermostat).
- > Collect baseline data for future comparison by keeping a record of the amount of electricity used for a definite period of time.
- > Calculate the estimated amount of CO₂ contributed (carbon footprint) to the atmosphere.
- > Collect data for the same amount of time using as little electricity as possible.
- > Calculate the estimated amount of CO₂ contributed by reducing the use of electricity.
- > Find the difference between the amount of CO₂ contributed during the baseline data collection and the amount used during the reduction of electricity used.
- > List the actions taken to reduce the amount of electricity used, and decide which actions to continue in the future.
- > Create a plan for the future, based on personal data.
 1. Set a goal to reduce use of electricity.
 2. List actions to take.
 3. Calculate the reduction in CO₂.
- > Identify and practice other ways to reduce the amount of energy that you use. For example:
 1. At home use less electric power, heating and air conditioning;
 2. For transportation, ride a bike, walk, carpool, or use public transportation;
 3. Reduce air travel.

Activity 15 – “Life Zones Reflect Climate – Part 1”

Note: because of changes in proportions during photocopying, measurements such as latitude extent are approximate.

1. Leslie Holdridge.
2. Alpine and subalpine.
3. Polar.
4. Answers vary.
5. 13 plants.
6. 62.5 mm to 16,000 mm.
7. Potatoes, mushrooms, and ferns.
8. Up to 15,000 mm.
9. In a wide range of life zones, but not in any extreme life zone.
10. Superarid to humid.
11. Knowledge provides an opportunity to plan ahead. For example, irrigate or change crops.
12. Climate determines life zones.
13. Planning for the future. Since climate determines the type of vegetation that grows in an area, governments can plan ahead for both expected and unexpected events to ensure that citizens can thrive and survive. For example, as climate changes, the type of crop that once grew in a certain location may not survive. Planners can refer to the Holdridge Diagram to find a replacement plant that will survive.

Activity 15 – “Life Zones Reflect Climate – Part 2”

1.

Letter Key (to the Holdridge Ecosystem Maps)	Life Zone Class (Use the Key – Fig. 11-5)	Holdridge Present CO ₂ ppm Latitude Extent (Measured South to North in Degrees)	Holdridge Doubled CO ₂ ppm Latitude Extent (Measured South to North in Degrees)	Size Change (Increase, Decrease, Remain The Same)	Direction of Life Zone Movement (Use Cardinal Directions)	Humidity Provenance (See Holdridge Life Zone Diagram)
A	Subtropical moist forest	26° to 36° = 10°	29° to 38° = 9°	Decrease	North	Subhumid
B	Subpolar rain tundra and subpolar wet tundra	52° to 59° = 7°	53° to 57° = 4°	Decrease	North	Semiarid to Subhumid to Humid
C	Subpolar rain tundra and subpolar wet tundra	54° to 59° = 5°	51° to 53° = 2°	Decrease (Almost Disappeared)	Almost Disappeared	Semiarid to Subhumid to Humid
D	Boreal wet forest	44° to 57° = 13°	47° to 57° = 10°	Decrease	North	Subhumid

Table 15-1.

- North – the latitude increases.
- Decreases – the number of degrees latitude decreased in each case.
- Precipitation either remains the same or decreases. The maps show a northern movement of subtropical moist forest (for present CO₂ concentration), a subtropical dry forest established in northern Florida, and a tropical dry forest invading the southern peninsula (for doubling CO₂ concentration).
- Answers vary.

Activity 15 – “Life Zones Reflect Climate – Part 3”

- Africa.
- Present CO₂ concentration – between 34° N and 30° S ... Doubled CO₂ concentration – between 40° N and 40° S.
- It appears to decrease.
- To predict climate change and plan for the future. The goal is to save lives and prevent property damage. Examples include: prepare for drought and food shortages; prepare for changing weather patterns including severe storms; and prepare for flooding.

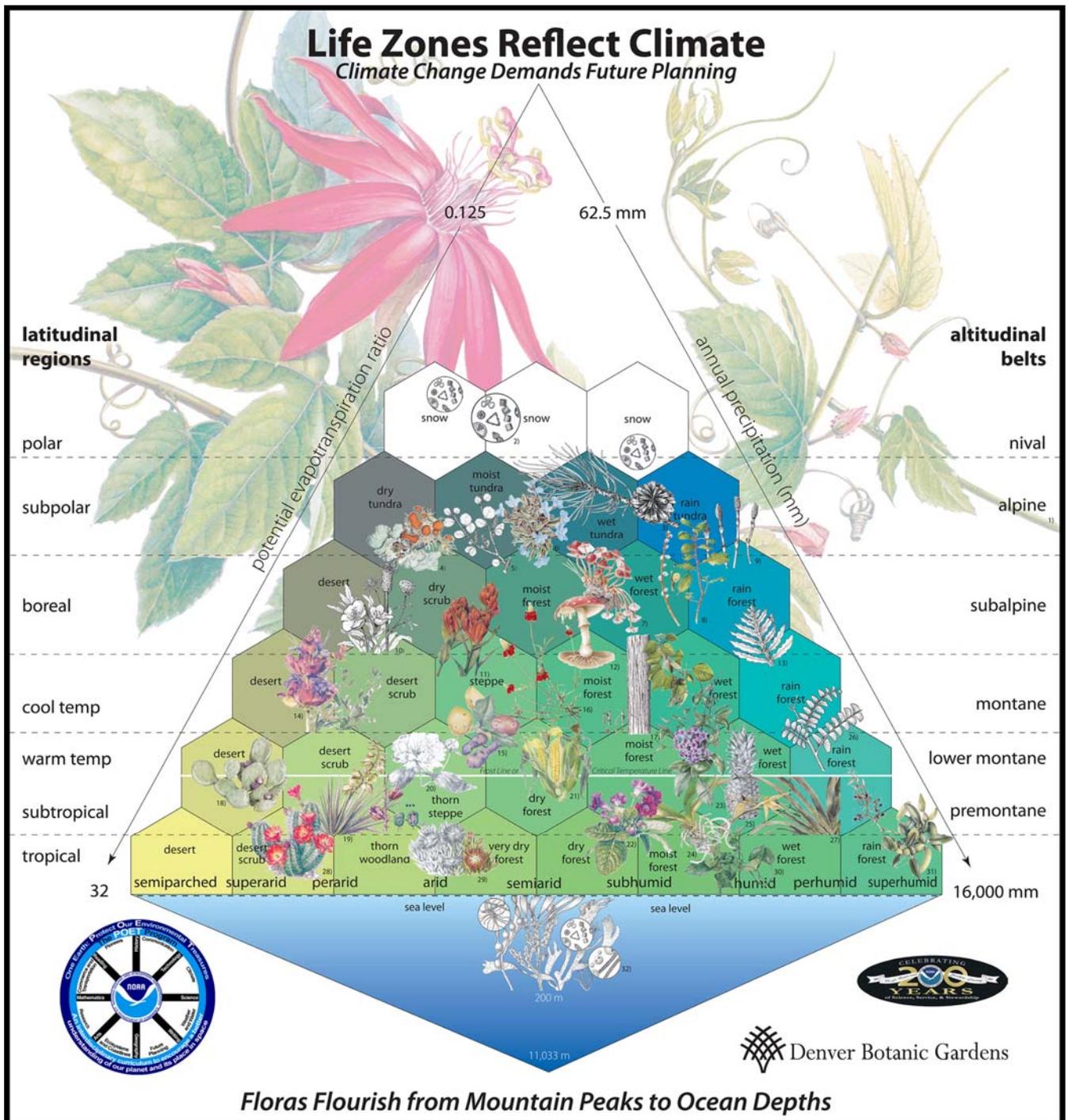
Conclusion – Activity 15 – “Life Zones Reflect Climate – Parts 1, 2, and 3”

Accept any reasonable answer.

- Knowing of possible changes allows time for planning
- Avoid food shortages or starvation
- Farmers can change crops or move to a new location
- Develop hybrid plants
- Prepare for changing weather patterns

The URL address for the ECOSYSTEMS Holdridge Life Zones

> <http://ingrid.ldgo.columbia.edu/SOURCES/.ECOSYSTEMS/.Holdridge/.doubleCO2/figviewer.html?plottype=colors>



Addendum

To Teachers:

If you have the capability to project computer images from the Internet onto a screen in class or if students have access to the Internet, there are exciting motion pictures that accompany most of the POET activities. Here is a partial list and access information.

1. Using your web browser, type **noaa science on a sphere**.
2. Click on **NOAA Science On a Sphere**.
3. Use the banner on the top, click on **Download**.
4. Using the side bar, click on **Data Pics/Movies**.
5. Dataset pictures and Movies appears, click on **one of your choice**.

For Example:

Land

- Topography and Bathymetry with Nighttime Lights Movie (37 mb)
- Arc Science Plate Tectonics and Paleo Animation Movie (8 mb)
- PALEOMAP Plate Tectonics and Paleo Animation Movie (2 mb)
- Blue Marble Movie (37 mb)
- Seasonal Blue Marble N/A
- Earth with Vegetation N/A
- Earth Topography Movie (9 mb)
- Earth Color Movie (6 mb)
- Earth Shaded Movie (9 mb)
- Earth at Night Movie (5 mb)
- Day Night Terminator Movie (36 mb)

