Teaching Activity: Where and How Is Atmospheric Carbon Dioxide Monitored by NOAA/CMDL?

Introduction: In an effort to improve our understanding of what determines the concentrations in the atmosphere of the major greenhouse gases, the National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory (NOAA/CMDL) implemented a global monitoring network.

Monitoring of these gases is done at remote locations around the world. There are four baseline observatories: Mauna Loa, Hawaii, Tutuila, American Samoa, Barrow Alaska and South Pole, Antarctica. In addition, the cooperative air sampling network includes approximately 50 fixed sites and 3 commercial ships taking measurements in the Pacific Ocean. An additional measurement program was instituted in 1992 using very tall towers and aircraft flights to obtain information on gas concentrations. Except for those taken at the baseline sites, air samples are sent back to the laboratories in Boulder, CO for analysis. Altogether, NOAA scientists are measuring carbon dioxide, methane, carbon monoxide, hydrogen, nitrous oxide, sulfur hexafluoride and the stable isotopes of carbon dioxide ($^{13}C/^{12}C$).

The global air samples provide an important resource for narrowing the uncertainties about future atmospheric problems. It also allows scientists to study and evaluate the effects of regional contributions to the dilemma of the enhanced greenhouse effect.

Objectives:

- To locate the NOAA/CMDL Cooperative Air Sampling sites around the world;
- To learn how concentrations of CO_2 and other greenhouse gases are measured at the Mauna Loa Observatory, HA;

Important Terms: NOAA/CMDL Cooperative Air Sampling Network, Northern/ Southern Hemisphere, baseline site, stable isotopes, greenhouse gases, infrared. ppm;

Materials: Map of the Earth, List of NOAA/CMDL Monitoring Station sites, Diagram of the NOAA/CMDL Monitoring Station at Mauna Loa, Hawaii, butcher paper/ pencil, markers/colored pencils, **Student Activity Sheets;**

Procedure:

PART I: The NOAA/CMDL Network:

1. Read over and discuss the **Introduction** and call attention to specific locations on the world map.

2. Review how to locate sites on a map using latitude and longitude coordinates.
   - Use two-three of the NOAA/CMDL sites as examples and help students locate them on their maps.
   - Students should indicate type of locations using the following symbols:
     -Baseline observatories --- Red square
     -Cooperative network sites--- Green circle
     -Tall Towers - Orange triangle
     -Ships -- Purple lines
     -Aircraft --- Black *
   - Instruct students to go ahead and complete the map by placing a symbol for each monitoring location.

3. Instruct students to complete the **Analysis and Comprehension** questions for **PART I** when they are done with the map activity.

PART II: Monitoring CO_2 at Mauna Loa, Hawaii

1. Make an overhead transparency of the monitoring set up at Mauna Loa from the black-line copy included in this activity packet.
   - Go over the diagram with the class.
   - Instruct students to compile a list of the steps in the diagram of the Mauna Loa procedure. (There are 8 steps which should be included. See attached list.)

2. Instruct students to work with a partner and to create a simple step by step diagram of the procedure on butcher paper.
   - Students should use arrows to show the direction of flow of the gases.
   - Students should draw boxes, circles or other shapes to indicate chambers, tanks, and freezer units.
   - Students should label the steps in the diagram explaining what is happening at each step.

3. Student should display completed diagrams in the front of the room.
   - Students should compare theirs with diagrams made by other groups.
   - Students should make any corrections on their diagrams they feel are needed.

4. Students should them complete the **Analysis and Comprehension** questions for **PART II.**

NOTES:

How CO_2 Is Measured at Mauna Loa

Step #1. Air comes into the lab from the top of a 130 foot tower that is above the level where it would be contaminated by people and machines at the lab.

Step #2. A pump draws the air in through tubes and forces it through the various pieces of lab equipment.

Step #3. The air then enters a freezer trap where the water vapor is frozen out of the sample.

Step #4. The air goes into a dry test chamber.

Step #5. The gas is warmed in the test chamber by a heating coil.

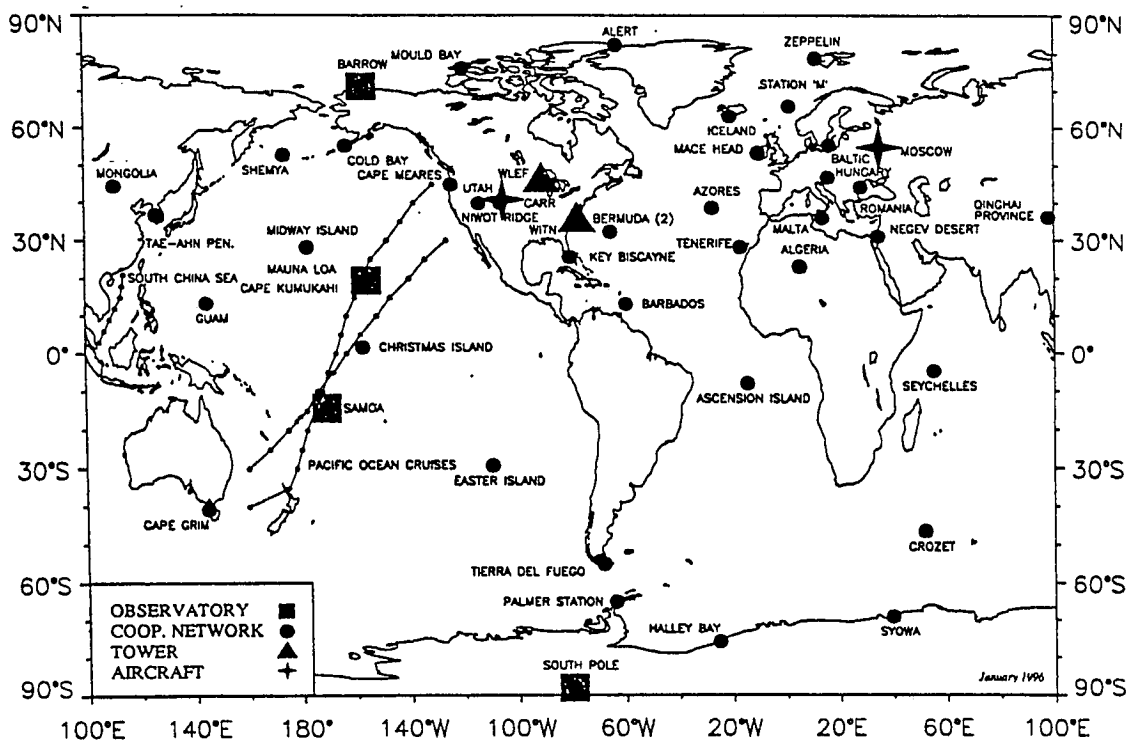
Step #6. A thermometer in the test chamber measures the temperature of the gas. The warmer the gas, the more CO_2 it must contain.

Step #7. Two tanks containing known concentrations of CO_2 are connected to the test chamber for adjusted measurements.

Step #8. Valves open and close the tanks and control the movement of the air into and out of the chamber.

Step #9. A computer readout is made available to scientists with the recorded levels of CO_2 in the samples tested.

THE NOAA/CMDL MEASUREMENT PROGRAMS



Student Activity Sheet: Where and How is Atmospheric Carbon Dioxide Monitored by NOAA/CMDL?

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Procedure:

PART I: THE NOAA/CMDL Network:

1. Read over and discuss the **Introduction** with your teacher.
   Pay attention as specific locations on the world map are identified.

2. Take review notes on locating sites on a map using latitude and lognitude coordinates.
   - Fill in two- or three of the locations on the map along with the teacher.
   - Indicates the type of location a site is using the symbols your teacher assigns.
   - Go ahead and complete the map once you are sure of the procedure.

3. Complete the **Analysis and Comprehension** questions for **PART I.**

PART II: Monitoring CO_2 at Mauna Loa, Hawaii:

1. Takes notes on the monitoring procedure at Mauna Loa from the overhead transparency shown to the class.

2. Work with a partner and create a diagram on butcher paper of the monitoring procedure used at Mauna Loa.
   - Use arrows to show the flow of the gases.
   - Draw boxes, circles, or other shapes to indicate the chambers, tanks, and freezer units.
   - Label each of the steps in the monitoring process on the diagram.

3. Display your completed drawing on the wall in front of the room.
   - Compare your drawing with those of other groups.
   - Make any corrections on yours that you think are needed.

4. Complete the **Analysis and Comprehension** questions for **PART II**.

Student Activity Sheet #1

ANALYSIS AND COMPREHENSION:

PART I: The NOAA/CMDL Network:

1. How many air sampling sites are there in the CMDL network? _____

2. How many sites are in the Northern Hemisphere? The Southern Hemisphere?
_____

3. Which of the sites are full operational baseline observatories? _____
_____
_____

4. Why do you think the monitoring sites are in remote locations? _____
_____
_____
_____

5. What type of training would people who work at Mauna Loa and Barrow need to do their jobs well? _____
_____
_____

6. Why is it necessary to use air samples with known concentrations of CO_2 in the chamber before the sampling process begins? _____
_____
_____
_____

7. Why do you think that tall towers have been added to the measurement program?_____
_____
_____

PART II: Monitoring CO_2 at Mauna Loa, Hawaii

1. Why is the air sample collected from a tower 130 feet high? _____
_____
_____

Student Activity Sheet #1

2. Why is the water vapor taken out of the air sample? _____

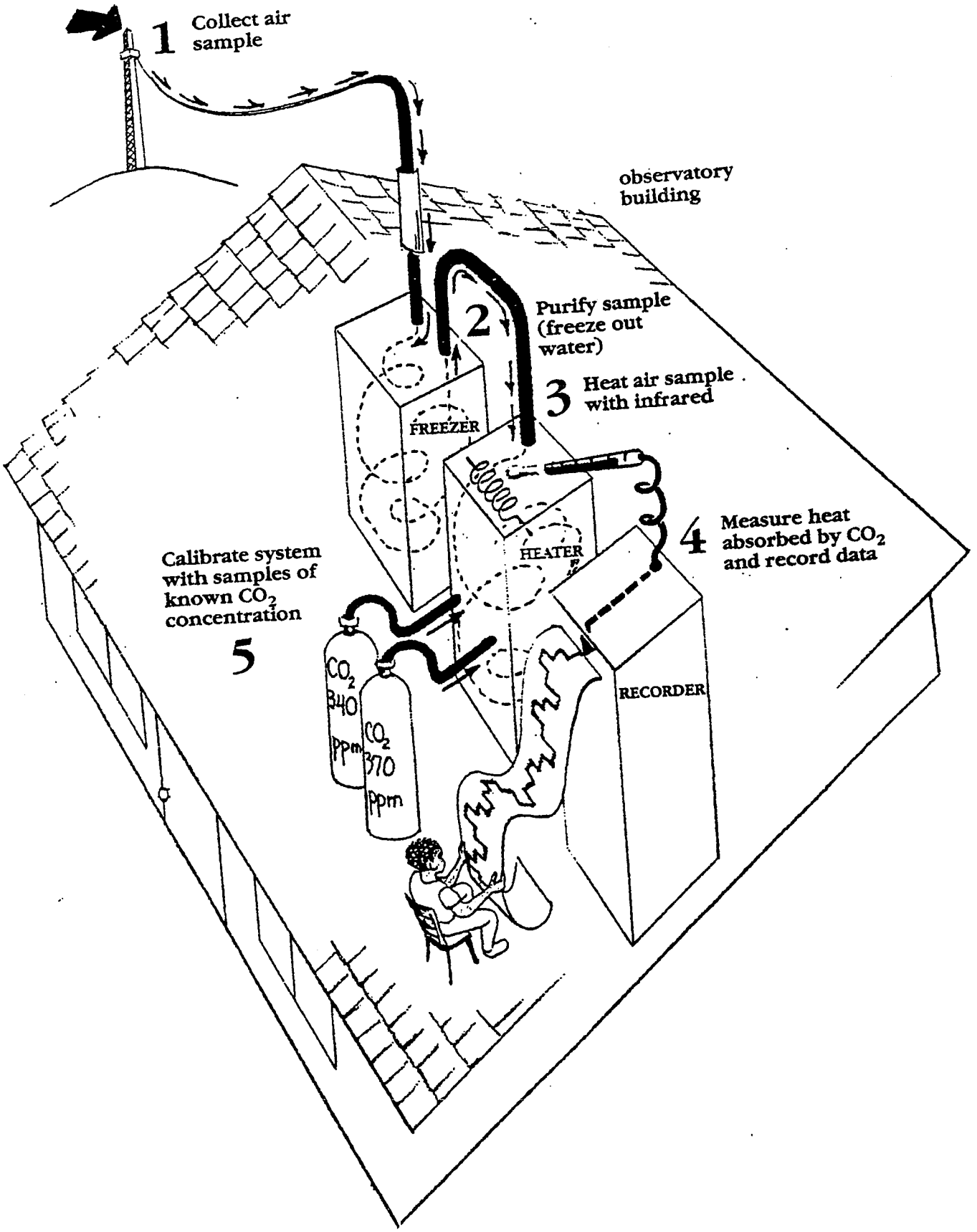
3. Why is infrared energy used to heat the gas sample? _____

4. What is the purpose of the heat sensor going from the heater to the recorder? _____

5. How should computer readouts for CO_2 levels from 1997 compare with those from 1958? _____

6. Mauna Loa is an active volcano. How could this prove to be a problem ? What could be done to clear up the problem? _____

THE CO_2 MONITORING PROCESS at the MAUNA LOA OBSERVATORY



1997 NOAA/CMDL COOPERATIVE AIR SAMPLING NETWORK

CODE	STATION	LATITUDE	LONGITUDE
ALT	ALERT, NORTH WEST TERRITORIES	82N	63W
ASC	ASCENCION IS., ATLANTIC OCEAN	8S	14W
ASK	ASSEKREM, ALGERIA	23N	6E
AZR	TERCEIRA ISLAND, AZORES	39N	27W
BAL	BALTIC SEA (BALANGA SISTER)	56N	17E
BME	ST. DAVID'S HEAD, BERMUDA	32N	65W
BMW	SOUTHHAMPTON, BERMUDA	32N	66W
BRW	BARROW, ALASKA	71N	157W
BSC	BLACK SEA, ROMANIA	44N	29E
CBA	COLD BAY, ALASKA	55N	163W
CGO	CAPE GRIM, TASMANIA	41S	145E
CHR	CHRISTMAS IS.,PACIFIC OCEAN	2N	157W
CMO	CAPE MEARES, OREGON	45N	124W
CRZ	CROZET, INDIAN OCEAN	46S	52E
EIC	EASTER ISLAND, PACIFIC OCEAN	29S	109W
GMI	GUAM, MARIANA ISLANDS	13N	145E
GOZ	DWEJRA POINT, GOZO, MALTA	36N	14E
HBA	HALLEY BAY, ANTARCTICA	76S	26W
HUN	HEGYHATSAL, HUNGARY	47N	15W
ICE	STORHOFDI, ICELAND	63N	20W
ITN	GRIFTON, NORTH CAROLINA	35N	77W
IZO	TENERIFE, CANARY ISLANDS	28N	16W
KEY	KEY BISCAYNE, FLORIDA	26N	80W
KUM	CAPE KUMUKAHI, HAWAII	20N	155W
LEF	PARK FALLS, WISCONSIN	46N	90W
MBC	MOULD BAY, NORTH WEST TERR.	76N	119W
MHT	MACE HEAD, IRELAND	53N	10W
MID	SAND ISLAND, MIDWAY	28N	177W
MLO	MAUNA LOA, HAWAII	20N	155W
NMB	BOBABEB, NAMIBIA	24S	15E
NWR	NIWOT RIDGE, COLORADO	76N	106W
OPB	PACIFIC OCEAN (Brisbane Star)	--	--
OPC	PACIFIC OCEAN (California Star)	--	--
PSA	PALMER STATION,ANTARCTICA	65S	64W
QPG	QINGHAI PROVINCE, CHINA	36N	101E
RPB	RAGGED POINT. BARBADOS	13N	59W
SCS	SOUTH CHINA SEA (Great Promise)	--	--
SEY	MAHE ISLAND, SEYCHELLES	5S	55E
SGI	BIRD ISLAND,ATLANTIC OCEAN	54S	38W
SHM	SHEMYA ISLAND, ALASKA	53N	174E
SMO	TUTUILA, AMERICAN SAMOA	15S	171W
SPO	SOUTH POLE, ANTARCTICA	90S	25W