Kitchen Klimate Science

Climate Science Hands-On Learning Activity
Program Manual

Prepared by Friends of Blackwater's Allegheny Highlands Climate Change Impact Initiative
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Allegheny Highlands Climate Change Impacts Initiative
Friends of Blackwater
Because We Care.


EXIT
2100


2017
1850


PURSUIT OF
23

Welcome!

The five hands-on science learning Activities in this Manual have been successfully tested and enjoyed by hundreds of West Virginia students and teachers. They are based on proven atmospheric science and they illustrate fundamental natural processes. Understanding this basic science is an important part of finding solutions to the challenge of climate change.

On the cover of this manual is a drawing of "Ginny," the rare West Virginia Northern Flying Squirrel (drawing by Brad Basil of Elkins, WV). "Ginny's" cool, deep-woods habitat includes the Blackwater Canyon in Tucker County, West Virginia -- a region that is already feeling the impacts of global warming and climate change.

"Ginny" and all her friends are counting on us to protect their mountain home! You can find a copy of this Manual and PDFs of the graphics needed for these Activities at www.alleghenyclimate.org. We hope you enjoy these activities.

Tom Rodd, Director, Friends of Blackwater's Allegheny Highlands Climate Change Impacts Initiative

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General Instructions and Information

What is the goal of the Activities described in this Manual?

Studies show that hands-on learning activities are one of the best ways to meaningfully impart scientific information. The goal of these Activities is to help participants gain scientific knowledge and understanding about the role of greenhouse gases (GHGs) in the Earth's atmosphere, including the impacts of human-added gases.

How much time do the Activities in this Manual take?

The Activities are all related, but each has a discrete learning goal. We have presented all of the five Activities in this Manual in a class period of an hour, but it is pretty rushed. Activities One and Two or One through Three could be done in one period and Activities Three or Four through Five in another.

How many people can do these Activities?

The Activity Descriptions in this Manual are written for a classroom group of 26, with up to half the group as active participants and the rest as the audience. However, you can have from six to sixty (or more) active participants, depending on how many potential participants and Props you have. We have done Activity Four, "The Greenhouse Boogie" with one hundred people. There are suggestions at the end of each Activity Description for variations for different sized groups.

Who conducts/directs the KKS Activities and how? Who are the "Leader" and "Reader?"

Each Activity is designed to be conducted/directed by a "Leader," who can be a classroom teacher or anyone who will take on the task. At the beginning of a program of one or more Activities, the Leader ordinarily selects a "Reader," a person with a loud voice who when called on reads aloud from the "Activity Script," to remind the Leader and participants what to do and say.

At the beginning of each Activity, the Leader asks the Reader to read aloud the name of the Activity and the Activity goal (twice, so people get a clear statement of the Activity's purpose.) The Leader then asks the required number of active participants to stand and come forward. They are assigned their Parts, and they take up/put on their initial Props, and perform the Activity, all as directed in the Script. A Reader is not strictly necessary, especially if the Leader is familiar with the Script, but it helps and is more fun.

The Leader and Reader wear cardstock "chef hat" elastic headbands (and aprons or lab coats, if available) -- as befitting a "Kitchen Klimate Science" program. As an Activity proceeds, the Reader follows along in the Script as the Leader conducts the Activity. The Leader occasionally asks the Reader to offer assistance from the Script – for example, if the Leader forgets what is next, or if an explanation from the Script is needed, or just for fun. At designated points in the Script, the Reader shows/passes around the Posters that are called for by the Script and the Leader elicits/explains the information in the Posters.

What are "Parts," "Props," and "Posters?"

Each active participant in an Activity has a "Part," like a character in a play, and each participant wears and/or holds one or more "Props." For example, a participant in Activity One who has the Part of a "Photon" has one or two Props: (1) a cardstock symbol of a photon on an elastic headband, worn on their forehead; and (2) possibly an LED light, depending on how many people are Photons.
Before doing the Activities it is necessary to assemble/create the needed Props and Posters.

A list of Parts and Props for each Activity, calculated for a 26-person classroom group, is given at the beginning of the Activity description. There is also a Master List of materials for Props for all Activities, and directions for making them, in a separate section of this Manual.

Some Props and Posters require a color printer that can handle cardstock. There is overnight "drying time" for making Props like colored rice grains and tennis balls. Thumbnails of PDF graphics used for Props and Posters are included in this Manual, and PDFs are downloadable online at www.alleghenyclimate.org; or contact Friends of Blackwater.

The Posters are printable PDF graphics – tables, charts, and images – containing scientific information that helps participants and the audience to understand the Activity. Posters are printed out before the Activity, along with preparing the Props. The bigger that you print them the better - 8 ½" x 11" will work, but 11" x 17" is better. Heavier paper works better. Posters are shown to participants and audience at a point in the Activity that is directed by the Activity Script.

Once the Props and Posters are ready, lay them out on a table beside an open area where the active participants can stand and move around. A 10' X 15' area cleared of chairs will work well for a classroom group, or a bigger space for a larger group.

What does the "Activity Script" contain?

The Activity Script in a step-by-step fashion directs the behavior of the active participants in each Activity, telling them what to do with the Props, etc. The Script also describes the scientific content that should be elicited and/or explained in order to better understand the Activity. The Leader should review the Script for each Activity in advance – and if necessary edit the Activity Description to fit the size of the participant group, the numbers of Parts, Props, etc. There are suggestions for varying the Activity for different numbers of participants.

What does it mean when the Script calls for the Leader to "elicit/explain" certain information?

The idea of the elicit/explain distinction is for the Leader to first ask a question that tries to elicit some or all of the particular information from the group; and then to confirm and/or explain as needed. Example: "So the photons are generated in the Sun from the process called . . .?" (Hopefully someone says "fusion.") There are all sorts of ways to do this, and it is up to the Leader when and how to take this approach. In a classroom or smaller group, using a conversational structure works well. In larger groups, simply explaining is often more practical.

How does each Activity end?

At the end of an Activity, the Reader reads the goal aloud, and the Leader asks the group if the goal has been achieved. When they say "Yes" (we hope!), the Leader leads the group in applause for its work. The active participants then put their Props aside and retake their seats. This can be a good time for seeing who has questions. Assuming a large enough overall group, a new group of active participants is then recruited for the next activity; until the program is completed.

What about the music and singing in the Script?

During certain Activities, the Activity Script suggests that the Leader lead the participants in singing the songs -- "You Are My Sunshine;" "the Greenhouse Boogie;" and "Shake, Rattle, and Roll." This singing is to accompany the participants turning and moving around while they are being photons, atmospheric gas molecules, and the like. It's like a free-form square dance! Give a little group singing a try when the Script suggests it. It definitely adds to the fun!

What are the "Participant Response Forms"?

The Participant Response Form (a blank copy is in this Manual) is an important part of the KKS experience. The Form asks participants to express in a short-answer fashion what they have gotten out of the program. Completing this Response Form can help participants digest the Activity experience. The completed Forms can help the Leader see what parts of the program worked best. And the response data, when compiled, has scientific value. At the end of the program, please leave enough time (3-4 minutes) for people to fill out a Participant Response Form and please send copies of completed Forms to Friends of Blackwater.

What are the "Content Standards Information" and "Online Video" sections of this Manual?

The Content Standards Information section helps put the Activities' learning content into a recognized reporting and classification system. The Online Video section gives links to useful climate science online videos to complement the Activities.

KKS Activity One -- “You Are My Sunshine,” or “Here Come the Photons!”

Goal: Participants will better understand how the Sun heats the Earth.

Parts and Props

1 Leader
- 1 Cardstock chef hat on elastic headband – PG 0016
- Apron/labcoat if available

1 Reader
- 1 Cardstock chef hat on elastic headband – PG 0016
- Apron/labcoat if available
- Activity Script
- Posters listed below

1 Earth
- 1 cardstock frozen Earth disc w loop with no text – PG 0027
- 1 cardstock green Earth disc w loop with no text – PG 0007
- 1 cardstock Snowball Earth face elastic headband – PG 0026
- 1 cardstock Smiling Earth face elastic headband – PG 0028

1 Sun
- 1 cardstock Sun disc w/loop – PG 0014
- 1 cardstock Sun face elastic headband – PG 0011

4 Photons
- 4 cardstock Photon elastic headbands -- PG 0009
- 2-4 handheld lights preferably with white and red light

Posters
- 1 Poster showing the electromagnetic radiation spectrum – PG 1009

Activity Script:

The person playing the Earth puts on a frozen Earth disc with string loop (PG 0027) and a Snowball Earth headband (PG 0026) and stands to one side in the cleared area before the audience. The Leader explains that we are going to imagine that the Earth is alone in space, lifeless and cold. Get the Earth to shiver and look gloomy.

Then have the person playing the Sun put on a Sun disc (PG 0014) and a Sun face elastic headband (PG 0011) and hold a light (turned off), and stand facing the Earth. Have the Earth walk across and around the Sun and back, without the Sun turning on the light. The Leader tells the Earth to remain gloomy and shivering cold. Ask the audience “why?” The Leader elicits/explains that it’s because there is no sunlight striking the Earth. So, we say, we need some sunlight!

The Leader gets the people who are playing Photons to put on cardstock Photon elastic headbands (PG 0009) and hold lights (as many as you have), but not turned on yet. They stand behind the Sun in a semicircle, facing the Earth.

The Leader elicits/explains the genesis of photons in nuclear fusion inside the Sun, and their path to the surface of Sun, which can take 100,000 years. To show this continuous fusion process, the Photons turn on their white lights, and the Photons walk in a small circle behind the Sun a few times, rotating themselves as well. The Sun rotates, too, doing a little fusion dance!

The Leader shows the Electromagnetic Spectrum Poster (PG 1009), and elicits/explains that the multicolored Photons' headpieces and their lights represent the many frequencies of the EMR spectrum – visible light, radio waves, X-Rays, ultraviolet, infrared, etc. The Photons can switch back and forth between the red and white on their lights if they have both.

Then the Leader elicits/explains that the Photons, having finally reached the surface of the Sun, depart into space; the Photons stop circling and walk across toward the Earth.

The Leader can optionally tell the Photons to stop about halfway to the Earth, and do "the wave" in unison, which reflects that Photons have the properties of both particles and waves. This is a fundamental of quantum physics. Then they resume their trip. When the Photons get to the Earth (the Leader elicits/explains that this takes 8 minutes at the speed of light), the Photons stand in a circle around the Earth, and shine their lights on the Earth.

The Leader elicits/explains that many things happen when the EMR photons reach the Earth – such as (1) people get sunburn from UV radiation; and (2) photosynthesis occurs when Photons hit green leaves and give up some of their energy that the plants use to grow. Today, says the Leader, the main effect that we are concerned about is that some of the sunlight heats up the Earth's surface. This is the same effect that allows you to feel warmth on your skin standing outside on a sunny day, even when the air is cold.

Now, the participants model how the sunlight warms up the Earth and makes it happy and liveable. While the Photons circle the Earth, shining their lights on it, the Earth covers up the frozen Earth disc with a green Earth disc with no text (PG 0007), and also takes off the snowball Earth headpiece and puts on a Smiling Earth headband (PG 0028). Now the Earth, warmed and energized by the photons, is alive and happy, smiling and turning around, dancing and moving side to side.

The Leader elicits/explains that 99.99% of the Earth's surface temperature – the temperature of its air and land and water -- comes from sunlight. The Earth's molten core, although hot, contributes very little to surface temperature, because most of the heat in the core does not make it to the surface, except a little from volcanoes etc.

While the Earth is being warmed, the Leader sings and gets participants to sing along, "You are my sunshine, my only sunshine, you make me happy when skies are grey, you'll never know dear, how much I love you, please don't take my sunshine away."

The Leader elicits/explains that this is just the beginning of the story: we ask, what happens to all that heat energy that has arrived on the Earth? That's something we will learn in upcoming Activities – and especially we will learn about the role of the Earth's atmosphere interacting with the Photons.

That's it! – the Activity ends with this scene of the warmed Earth, surrounded by the Photons shining their white lights. Sing again if you like! Across the room, the Sun waves a friendly "Hello."

The Leader asks the Reader to read the goal, and ask the participants whether it was achieved. Applaud the active participants for their parts. They take off their regalia and return to the audience.

Variations: For a larger group, if you have enough props, you can have 2-4 Suns, who stand in a group facing outward. Inside the "space" they define can be the Sun's core, the birthplace of as many Photons as you have headbands (and if available, lights) for. Similarly you can have several Earths, also facing outward.

KKS Activity Two – "Let's Mix Up an Atmosphere!"

Goal: Participants will better understand the relative amounts of basic atmospheric gases.

Parts and Props

1 Leader

- Cardstock chef hat on elastic headband – PG 0016
- Apron/labcoat if available

1 Reader

- Cardstock chef hat on elastic headband -- PG 0016
- Apron/labcoat if available
- Activity Script
- Posters listed below

3 Atmosphere Chefs

- 3 Cardstock chef hats on elastic headbands – PG 0016
- 3 aprons or labcoats if available
- Pre-dyed colored rice grains representing atmospheric gases: 3 cups blue for N2; 1 cup green for O2; 8 tbsp. red for Ar; 8 tbsp. white for H2O; 8 tbsp. yellow for CO2 and CH4
- 6 12 oz. clear plastic bottles with caps
- Large mixing bowl
- Spoon for mixing and cup for pouring rice through funnel
- Funnel that allows rice grains to pass through and fits into 12 oz. plastic bottles
- 1 bottle label that says "2017 400 PPM 1/2500 CO2" – PG 0029
- Scotch tape

Posters

1 Poster showing Simplified Atmosphere in Table Form – PG 1001
1 Poster showing Complete Atmosphere in Pie Chart Form – PG 1002

Activity Script

Three Atmosphere Chefs put on their chef hat headbands (PG 0016) and with the Leader and group they examine the two posters (PG 1001, PG 1002), which show both simplified and complete gas amounts/percentages. The Leader elicits/explains the information on both Posters and explains that we will use the simplified Table as a recipe.

Then the Chefs mix up a simplified atmosphere in the mixing bowl from the colored rice grains. It is helpful if the rice has been pre-measured, but you can do the measuring in the activity, too. They mix the grains according to the following recipe: 4 cups of blue nitrogen molecules; 1 cup of green oxygen molecules; 1/4 cup red argon molecules; 1/4 cup white water vapor molecules.

DO NOT add the yellow grains for CO_2 and CH_4 (methane) to the mix in the bowl.

Next, the Chefs divide the mixture among the six bottles, using the funnel. The Leader elicits/explains that this mixture represents the Earth's long-term atmospheric gas concentrations, except for the trace gases CO_2 and methane. Set five of the bottles aside; they will be used in Activity Five, “Shake, Rattle, and Roll with the Five Earths.”

Then, tape the “2017” label (PG 0029) on one bottle. Add TWO pinches of yellow rice grains to this bottle and put the cap on the bottle. The Leader elicits/explains that this is the CURRENT concentration of CO_2 and Methane in the atmosphere. Pass it around the group.

Ask participants to breathe in and out and think about the mixture of gases that are flowing in and out of their lungs. Review the Posters again, and see if people have comments. Ask Reader to read goal and ask if the goal was met. Applause to the chefs for showing the simplified rough concentrations of basic atmospheric gases.

Variations: Larger groups can make more bottles using more rice.

KKS Activity Three -- "Make Mine More Molecules!"

Goal: Participants will better understand the molecular structure of common atmospheric gases.

Parts and Props

1 Leader
- Cardstock chef hat on elastic headband – PG 0016
- Apron/labcoat if available

1 Reader
- Cardstock chef hat on elastic headband -- PG 0016
- Apron/labcoat if available
- Activity Script
- Posters listed below

11 Atmospheric Gas Molecules -- 4 Nitrogen; 2 Oxygen; 1 Argon; 1 Water Vapor; 1 Methane; 2 Carbon Dioxide
- 11 gas molecule models (as above)
- 11 gas molecule elastic headbands (as above) – PG 0019, PG0020, PG 0021, PG 0022, PG 0023, PG 0024

Posters

1 Poster showing Simplified Atmosphere in Table Form – PG 1001
1 Poster showing Complete Atmosphere in Pie Chart Form – PG 1002

Activity Script:

Eleven participants each hold one molecule model of a basic atmospheric gas, and put on the appropriate headband. The Leader elicits/explains that, as with the colored rice grains, for simplicity a number of "trace gases" that are present in very small atmospheric concentrations are omitted in this set of molecule models. Examine Posters PG 1001 and POG 1002 showing simplified and complete gases.

Have Participants identify the gases represented by the models. Have them swirl around as when the winds blow, lightly bumping each other, reflecting the atmosphere's mixture of gases. Maybe it's time to do a little hurricane action! Ask Reader to read the goal- was the goal met? Applause for modeling a simplified Earth atmosphere.

Variations: If you have more props you can involve more people. With less people, each participant can hold more than one molecule!

KKS Activity Four – "Do the Greenhouse Boogie!"

Goal: Participants will understand how different atmospheric gases react to infrared radiation emitted by the Earth, and why some atmospheric gases are called "greenhouse gases."

Parts and Props

1 Leader

  Cardstock chef hat on elastic headband – PG 0016
  Apron/labcoat if available

1 Reader

  Cardstock chef hat on elastic headband – PG 0016
  Apron/labcoat if available
  Activity Script
  Posters listed below

1 Earth

  1 cardstock green Earth disc (with no lettering) on a string loop – PG 0007
  1 cardstock Smiling Earth elastic headband – PG 0028
  1 red/white light

4 Photons

  4 cardstock Photon elastic headbands – PG 0009
  2-4 red/white lights

6 people holding a total of 11 atmospheric gas molecule models

  2 hold 2 Nitrogen each; 1 holds 2 Oxygen and 1 Argon; 1 holds 1 Water Vapor; 1 holds 1 Methane and 1 Carbon Dioxide; 1 holds 1 Carbon Dioxide.
  11 cardstock gas molecule elastic headbands worn as above (two people wear two headpieces each, one wearing O2 and Ar, and one wearing CH4 and CO2) -- PG 0019, PG 0020, PG 0021, PG 0022, PG 0023, PG 0024

Posters

1 Poster showing the Basic Greenhouse Effect – PG 1010
1 Poster showing the Electromagnetic Radiation Spectrum – PG 1009
1 Poster showing the Natural and Human-Caused Greenhouse Effect – PG 1005

Activity Script

One participant wearing a green Earth disc (PG 0007) and a Smiling Earth headband (PH 0028) stands surrounded by four Photons (PG 0009), at one end of the cleared space. Six people holding 11 atmospheric gas molecules and wearing corresponding headbands stand in a line about ten feet from and facing the Earth and the Photons.

The Leader elicits/explains that we have seen that the Earth has been previously energized and warmed by the Sun, and now we are going to explore what happens to some of that energy that came from the Sun.

The Leader elicits/explains that the Photons we are looking at now are not the entire electromagnetic spectrum. They are the long-wave invisible infrared heat radiation, the same that you feel when you hold your hand next to a hot pan as it is cooling on the stove, or that can be picked up by infrared cameras. Show the Poster that has the electromagnetic spectrum (PG 1009) again and point out the area of long-wave infrared.

The Leader elicits/explains that the Earth, once warmed by sunlight, radiates heat outward into the atmosphere as infrared energy in the form of photons -- like at night, when a hot asphalt parking lot cools down. To illustrate this process, the Leader explains that the infrared Photons are going move away from the Earth toward and through the atmospheric gas molecules, shining their lights. The Earth will shine its light toward the gases, too.

At this point, have the N2 and O2/Argon molecule people come closer to the Earth while the other molecules remain in place. The Leader goes up to the closer gases and tells them privately that when the Photons pass close to them, they are to remain motionless, and show no reaction. The Photons will try to impress and energize the gases, but to no effect, so the Photons eventually head out into space.

Then have the Photons move away from the Earth and pass through and close to the N2 and O2/Ar, and those gases act out their indifference. They are not impressed, no matter how persistently the Photons shine their light or how close they come. The Leader elicits the lack of any reaction, and elicits/explains it is because of their rigid molecular bonds that are unaffected by the infrared.

Then the Leader has the Photons return to the Earth, and the N2 and O2/Argon molecules move back from the Earth. The H20, CH4, and the CO2s come forward and stand in a line closer to the Earth. The Leader tells these gases privately that when the infrared Photons pass near them, they are to wiggle their molecules, holding the central atom and getting the flexible blades to move up and down, and move side to side turn around and around.

Then have the Photons move out as they did before, shining their lights, and move close to and around the atmospheric molecules, which react and wiggle and turn around. The Leader asks the audience what the difference is from the previous situation, and elicits/explains that these gases -- CO2, CH4, and H2O -- are energized by the Photons because unlike the O2 and N2, their “springy” molecular bonds resonate with the infrared energy and pick up some of its energy. That’s why we call these gases “greenhouse gases,” because their molecular bonds trap some of the heat energy leaving the Earth, like a greenhouse cover traps heat.

Now have the Photons return to the Earth again, and ALL of the atmospheric gases EXCEPT ONE HOLDING ONE CO2 MOLECULE stand in a line facing the Earth, mixed together/alternating. The Leader elicits/explains that this time when the Photons come out from the Earth shining their lights, they will energize the greenhouse gases, which will wiggle their models, and they will turn around and bump into the other gases, which will start to turn around, until all are turning around. Tell the photons to hang around the atmosphere and not disappear into space.

Now send those Photons out to encounter the entire atmosphere, which warms up -- all the gases. The move side to side and turn around, and this is where we can sing "The Greenhouse Boogie." Sing: "You put your gases in, put your gases out, put your gases in, and you shake it all about – do the Greenhouse Boogie and turn yourself around -- that's what it's all about."

The Leader elicits/explains that if we did not have any GHGs, the Earth and its atmosphere would be much, much colder. We need greenhouse gases in our atmosphere to keep the planet warm and support life. Now HAVE THE PERSON HOLDING THE 1 REMAINING CO_2 JOIN THE LINE. Have everyone increase the speed of their turning around -- and sing the song faster.

After this "finale," participants can take off their gear and sit down. The Leader elicits/explains that by adding more CO_2 to the atmosphere, more infrared energy is absorbed, and the atmosphere becomes warmer.

Show and discuss the Poster (PG 1005) that explains the difference between natural and human-caused greenhouse effect, and compare to the Poster showing the Basic Greenhouse Effect – PG 1010. These show the basic mechanisms by which GHGs "trap" heat from the incoming sunlight and earth-emitted infrared energy. Have the Reader ask if the goal was met. Applause for demonstrating the effect of GHGs in the atmosphere.

Variations: If you have enough props you can have a group of 100 people do this one! There can be a square of Earths inside two concentric circles of non-GHGs and GHGs, and the Photons can interact with the inner circle, and then the outer circle, and then a mixed circle. With enthusiastic leadership, quite a dancing atmosphere can result.

KKS Activity Five: "Shake, Rattle, and Roll with the Five Earths!"

Goal: Participants will better understand the effects on the atmosphere of humans adding greenhouse gases.

Parts and Props

1 Leader

- Chef hat on elastic headband – PG 0016
- Apron/labcoat if available

1 Reader

- Chef hat on elastic headband – PG 0016
- Apron/labcoat if available
- Activity Script
- Posters listed below

2 Atmosphere Chefs

- 2 chef hat elastic headbands – PG 0016
- 5 12 oz. plastic bottles, each about 1/3 filled with the basic atmospheric mixture made up in Activity Three, with no yellow grains added
- 5 different text labels for the plastic bottles -- PG 0008
- ¼ cup yellow rice grains
- Funnel that fits into bottles and passes rice
- 5 different cardstock Earth Faces on elastic headbands – PG 0004
- 5 different cardstock Earth temperature discs w string loops – PG 0002
- 5 different Earth Face cardstock bottle headpieces – PG 0004

  NOTE: SEE PROP INSTRUCTIONS LEAVE A 2 X 2 "NECK" ON EACH CUT-OUT BOTTLE HEAD
- 1 large thermometer cardstock cutout – PG 0001
- 2 lights
- Scotch tape
- Scissors

5 Earths

- 5 different Earth discs on string -- PG 0003

1 Photon

- 1 Photon elastic headband – PG 0009
- 1 light that preferably shines red and white.

Posters

- 1 Poster showing the Simplified Atmosphere in Table Form – PG 1001
- 1 Poster showing the Complete Atmosphere in Pie Chart Form – PG 1002
- 1 Poster showing the Natural and Human-Caused Greenhouse Effect – PG 1005
- 1 Poster showing CO2 and Temperature Fluctuations over 400 Thousand Years – PG 1003
- 1 Poster showing Future Temperatures under Different CO2 Emissions – PG 1008

Activity Script

Have the five Earths stand in a line; each wearing a different date-labelled Earth disc (except no date on the "Imaginary" text disc) (PG 0003).

The Atmosphere Chefs, wearing chef hat headbands (PG 0016), stand at a table with the props for this Activity – yellow rice grains, bottles with rice grains, cardstock thermometer (PG 0001), headbands (PG 004), and temperature discs (PG 0002). The Leader explains/elicits that we are going to look at the effect of different amounts of atmospheric greenhouse gas CO2 on the Earth's temperature at different times in the Earth's past and future.

The Leader explains/elicits that although H2O and CH4 are also GHGs, we are focusing on the effects of CO2 because humans are mostly affecting CO2 levels and it lasts so long in the atmosphere – hundreds of years or more. CH4 lasts about ten years, and it degrades into CO2. While H20 or water vapor is also a greenhouse gas, if there were no CO2 the temperature would be so cold that the water would remain frozen and there would hardly be any water vapor in the atmosphere.

First call forward the Imaginary Snowball Earth. The Leader has the Atmosphere Chefs hold up one of the five bottles from Activity Two that have not had any yellow rice grains added, and elicits/explains that this is the simplified Earth atmosphere without any of the greenhouse gas CO2. The Leader reminds them what the different colored rice grains stand for, using the Poster of the simplified atmosphere (PG 1001).

Now have the Atmosphere Chefs put a cap on the bottle, and tape the Snowball Earth cardstock head on the bottle, and hand it to the Snowball Earth who puts the Snowball Earth headband on. The Chefs then mime taking the Earth's temperature with the big thermometer. They bring out the disc with the temperature info for the Snowball Earth and put it on the Earth. The Leader elicits/explains the temperature, and the fact that an Earth without CO2 is frozen and lifeless. Then this Snowball Earth steps aside, with applause of course.

The Leader then brings forward the 1850 Earth. The Atmosphere Chefs bring out another bottle, and hand it to this Earth. The Leader explains that we are going to add one pinch of yellow rice grains to represent the CO2 in the atmosphere before humans started adding CO2 through burning fossil fuels like oil, natural gas, and coal.

At this point the Leader has the audience look at the past temperatures Poster (PG 1003) and elicits/explains the CO2 and temperature fluctuations over the past 400,000 years, fluctuating from ice ages with 180 PPM CO2 to the normal for the past 10,000 years at 280 PPM CO2 or 1/2500.

The Atmosphere Chefs add one pinch of yellow grains, and then put the cap on, and tape the cardstock head on the 1850 Earth, and put the 1850 "Good Old Earth" face headband on the Earth Then then they take the 1850 Earth's temperature, and put the temperature disc on the 1850 Earth. The 1850 Earth steps aside to applause and the Leader calls up the 2017 Earth.

Next call up the 2017 Earth. The Chefs bring out another bottle, and this time they add 3 pinches of yellow grains and put the cap on. They take this Earth's temperature, and put on the 2017 "feeling the Heat" Earth temperature disc and headband. The Leader elicits/explains that this represents the current concentration of CO_2, and points to the increase in average global temperature reflected in the temperature discs. Applause for the 2017 Earth.

Now the two 2100 Earths are called up, and each gets a bottle. The Leader asks the audience why we have two 2100 Earths, and gets a number of responses. It's good to agree with all offered answers, and solicit as many more as you can –say "Sounds good – how else could you say why we have two 2100 Earths?" Our suggested summary of the reasons is: "we have choices."

The Atmosphere Chefs add 4 pinches of yellow grains to the 2100 Low Emission bottle, and 8 pinches to 2100 High Emission. Then they put caps on and tape the cardstock heads on the bottles, and put the Low-E "Earth with a Fever" and High-E "Raging Heat" headbands on the 2100 Earths. They then take temperatures, and put the temperature discs on.

The Leader explains the range of possible futures, depending on how soon we cut back our emissions. The Leader shows the possible futures scenarios Poster (PG 1008) and points to where the two 2100 Earths are on the chart -- one Low-Emission and one High-Emission.

Now the Leader has all the Five Earths all stand in a line, and the Atmosphere Chefs complete their work by taping the bottle labels on the bottles. The Atmosphere Chefs take out lights and shine light (red if you have it) on the Earths, one at a time, and in order of increasing concentration of CO_2. The Imaginary Earth shakes its bottle hardly at all and barely moves. The following Earths shake their bottles more, and turn around, each shaking and turning around faster than the predecessor that had less CO_2.

As the Chefs shine their light on all of the Earths at once, and all shake and turn around at their respective speeds, the group sings "Shake Rattle, and Roll – and do the Greenhouse Boogie!"

Applause for all the Earths and all participants.

Variations: for a big group, you can lead the Earths one at a time around a circle of seated people, after they have been adorned with temperatures, etc., and have them say "hello" and shake their bottles. "Meet your past and future!"

Prop and Posters List for All Activities – 26-person Classroom

Prop List

1 cardstock green Earth disc (with no lettering) on string – PG 0007
1 Smiling Earth no text elastic headband – PG 0028
5 Chef hats on elastic headband – PG 0016
4+ Photons on elastic headband – PG 0009
5 different Earth Faces with text on elastic headbands – PG 0004
5 different Earth temperature discs on string loops – PG 0002
5 different Earth discs with dates on string loops -- PG 0003
1 large thermometer cardstock cutout – PG 0001
7 gas molecule elastic headbands – 2 N_2, 1 O_2, 1 Ar, 1 H_2O, 1 CH_4, 2 CO_2 -- PG 0019, PG 0020, PG 0021, PG 0022, PG 0023, PG 0024
5 different text labels for plastic bottles -- PG 0008

2-5 Aprons/labcoats if available
6 12 oz. plastic bottles with caps
Funnel that fits into bottles and passes rice
Large mixing bowl
Spoon for mixing
Cup for pouring rice through funnel
2 - 4+ handheld lights preferably white and red
Scotch tape
Scissors
Pre-dyed colored rice grains representing atmospheric gases: 3 cups blue; 1 cup green; 8 tbsp. red; 8 tbsp. white; 8 tbsp. yellow

11 Atmospheric Gas Molecules -- 4 Nitrogen; 2 Oxygen; 1 Argon; 1 Water Vapor; 1 Methane; 2 Carbon Dioxide

Poster List

1 Poster showing the Simplified Atmosphere in Table Form – PG 1001
1 Poster showing the Complete Atmosphere in Pie Chart Form – PG 1002
1 Poster showing the Natural and Human-Caused Greenhouse Effect – PG 1005
1 Poster showing CO_2 and Temperature Fluctuations over 400 Thousand Years – PG 1003
1 Poster showing Future Temperatures under Different CO_2 Emissions – PG 1008
1 Poster showing the Basic Greenhouse Effect – PG 1010
1 Poster showing the Electromagnetic Radiation Spectrum – PG 1009

26 Participant Response Forms – PG 1006

Prop Instructions

This section tells how to make or obtain the Props used in the Activities in this Manual. Each Activity Description has a list of the Props that are used by the participants in the Activity. The "PG" numbers refer to individual PDF files posted online for the graphics that are used to create the props.

Lights

Many stores sell inexpensive LED headlamps that can shine both white and red light. White light flashlights will also work, as the color is not crucial, but the idea of infrared radiation is reinforced when red light is available.

Atmospheric Gas Molecule Models

For a basic/minimum classroom set of 11 molecule models used to present the Activities described in this Manual, you need 27 colored tennis balls to represent different elements as atoms. You need 8 blue (N) atoms; 9 green (O); 1 red (Ar); 6 white (H); and 3 yellow (C). These 27 atoms are made into 4 N2 models; 2 O2 models; 1 H20 model; 1 CH4 model; 1 Argon model; and 2 CO2 models. Having more models can be helpful and fun, especially if there are a larger number of participants. You can buy cheap non-pressurized yellow tennis balls in bags of a dozen.

Our practice is usually to spray-paint the tennis balls in groups of a certain color before using a sharp, strong serrated steak knife to put slits in the balls, and then assemble the model molecules. We put the balls outside on newspaper on trays and spray with cheap spray paint, rolling them with a stick to get even coverage.   Several coats are usually necessary. Use good ventilation. Yellow balls need a good dose of paint to show blue, green, and especially white distinctly.

You can also assemble the models first and then paint the balls, as long as you have room to separate and spread them out and move them around while you are painting. And you can try other painting methods beside spray paint.

The bonds between the atoms are created using 10-12" long, 3/8" or so wooden dowels and flexible 12" hacksaw blades with small teeth. For the basic classroom set described in this Manual you need 6 rigid dowel bonds and 5 flexible blade bonds. In both cases you wrap each dowel or blade with an overlapping layer of electrician's tape for a consistent appearance and to protect against the teeth on the blade.

The flexible blades on the H2O, CO2, and CH4 models represent molecular bonds that are "springy" and can resonate with and absorb energy from infrared radiation. The rigid wooden bonds on N2 and O2 are unaffected by infrared radiation.

After wrapping the bonds with tape, put a "bump" on both ends of each bond by wrapping the tape about three times around the end, creating a thicker area. Then put a bump in the middle of each of the flexible blades. The bump will catch and hold the atom when the blade or dowel is stuck into an atom or or all the way through the central atom in the model.

To join the bonds with the atoms, the atoms are punctured and the punctures are opened by slightly sawing 1” slits for the bonds to go into, or in the case of a central atom as in CO_2, for the bond to go completely through. The exception is Argon, a single-atom molecule.

For CO_2, a central yellow carbon atom gets two slits on opposite sides of the ball, and a wrapped hacksaw blade is put through the ball, and an O atom (with one slit) is forced onto each end of the blade. H_2O is constructed the same way, with two opposing slits and the bond/blade sticking out of both sides of an O atom, and a one-slit H atoms on the ends. For CH_4, put four opposing slits on four sides of a C atom, with two blades passing at right angles through the central ball, forming a plus sign, and then H atoms at the end of the blades, with one slit each. If the bumps will not go in the slits, open them a bit with the knife.

For N_2 and O_2, a slit in one direction on each atom can be further opened slightly with another smaller slit at right angles, to create a crossed opening that the end of the dowel, larger than the flexible blade bond, can be forced into. The atoms/balls will usually grip the bonds well enough for all of the activities; if one should fall off during some active Greenhouse Boogieing, well, that’s chemistry!

To finish the models, use a dark black magic marker to write the element symbol on each atom. Congratulations, you have a simplified atmosphere!

Colored Rice Grains to Model Atmospheric Gases

Five pounds of uncooked white rice grains will be enough for a classroom program: you will need 3 cups of blue rice for N_2; 1 cup green for O_2; 8 tbsp. red for Ar; 8 tbsp. white for H_2O; 8 tbsp. yellow for CO_2 and CH_4. Small bottles of food coloring are sold in four-color sets at supermarkets; one set is enough for a classroom presentation. Single-color larger bottles are also sold.

Rice grains need to be dyed and dried before doing the Activity. For each color, put undyed rice in a large mixing bowl and stir in a very little water to just moisten the grains. Add drops of food coloring as needed and stir well to get complete coverage and a strong color.

Put the dyed grains in a flat metal or ceramic pan or tray and spread them out and set it aside to air-dry – or put it in a low oven to avoid scorching the rice. Stirring the grains will promote even drying. Store colored grains in sturdy bags.

Rice Bottle Labels

These are at PDF PG 0008. Print out the label sheets on cardstock and cut them into labels; they are taped with clear scotch tape onto the bottles in Activity Five.

Cardstock Rice Bottle Earth Face Headpieces

Cut out the heads, leaving as careful a margin as you wish; be sure to *leave a 2” X 2“ “neck” coming down from the bottom of each cut-out head,* so you can tape them easily to the plastic bottle full of colored rice, after it has the cap put on.

Cardstock Image Discs with String Loops

Print the graphic for the disc image on a piece of either cardstock or other paper, as heavy as is available and that will work in your printer. Or draw the image on cardstock yourself. Cut the image out with scissors. Make a loop of string or cord about 36 inches long. Tie the ends together, then place the knot in the end of a small loop of the string and lie the disc on a table face down, and staple the loop to the backside of the disc at the top of the image. Check to see that the loop goes over one's head easily.

Cardstock Image Headpieces on Elastic Headbands

Print the Prop graphics for headband images on a piece of cardstock or other heavy paper; or draw the images on cardstock. Cut the images out with scissors. Fasten a piece of elastic tape or cord or even a large rubber band to the image that will go around the wearer's head, so that the image is supported snugly and is upstanding and visible, centered on the wearer's forehead, but does not block their vision.

You can attach the elastic to the left and right lower sides of the image using holes or tape or staples, but this may lead to the cardstock tearing, etc. What follows is a suggested method that makes the headband a bit more rigid and durable.

Cut a 30" long strip of flat elastic fabric tape, sold in sewing departments. 3/8" tape works well but ¼" and ½" will also work. Overlap the ends of the elastic tape by an inch or two and staple them together in two places to form a loop that will stretch and fit snugly over the average head. You can also tie the tape ends to make a loop.

Secure the loop to the cardstock image by placing the cut-out image face down on a table and placing a 6" portion of the loop on the image, and then placing a 1.5" x 6" cover strip cut from heavy cardstock over the tape, forming a sandwich with the tape held between the image and the strip. The cover strip should be located in the middle of the image and slightly to the bottom so the wearer can see clearly with the headband on their forehead. Use four or so staples along the cover strip -- stapling through the image, tape, and strip -- to secure the elastic loop to the image.

Test your first headband and see if there are any adjustments needed as you make the rest.

Thermometer

Print out cardstock, cut around image parts, and assemble with tape.

Online Video Resources

“A Warming Climate Takes Its Toll on the Polar Bears of Hudson Bay” by Daniel Cox (5:00 minutes)
https://vimeo.com/17469748

“CO2 Trapping of Earth’s Heat” by Ian Stewart (2:35 minutes)
http://www.bbc.co.uk/programmes/b00djvq9/episodes/guide

“Climate Change Denial Disorder” by Brianne Trosie (1:42 minutes)
http://www.funnyordie.com/videos/9bd64b041b/climate-change-denial-disorder?_cc=__d___&_ccid=a22vvc.nvut34

“Death of a Forest” by Michael Pellegatti (14:46 minutes)
www.wildvisions.net/myportfolio/death-of-a-forest/

“Facing Climate Change Series” featuring “Oyster Farmers”, “Coastal Tribes”, “Potato Farmers”, and “Plateau Tribes.” All four short films are by Benjamin Drummond and Sara Joy Steele (4:35, 4:16, 4:47 and 4:28 minutes respectively). https://vimeo.com/bdsjs

“Forest Man” by William Douglas McMaster (16:34 minutes)
https://www.youtube.com/watch?v=HkZDSqyE1do

“Harnessing the Sun to Keep the Lights on in India” by Andrew Satter (8:46 minutes)
https://vimeo.com/95475289

“A Higher Calling” by Clif Bar (6:10 minutes)
https://www.youtube.com/watch?v=GMXoMilsCXY

“How Whales Change Climate” by Chris Agnos (4:51 minutes)
http://www.filmsforaction.org/watch/how-whales-change-climate/

“NASA: A Year in the Life of Earth’s CO2” by Leslie McCarthy (3:10 minutes)
https://www.nasa.gov/press/goddard/2014/november/nasa-computer-model-provides-a-new-portrait-of-carbon-dioxide/#.VhUrw_lViko

“NASA Temperature Data from 1880-2011” by Leslie McCarthy (0:25 minutes)
http://www.nasa.gov/topics/earth/features/2011-temps.html

“Our Pale Blue Dot” by Victoria Weeks (7:42 minutes)
http://verglasmedia.com/ourpalebluedot/

“Permafrost: The Tipping Time Bomb” by Peter Sinclair (6:04 minutes)
http://www.yaleclimateconnections.org/type/video/

“Requiem of Ice” by John Waller and Ben Canalles (7:05 minutes) https://vimeo.com/111161365

“Rising Seas Threaten Wildlife” by the Center for Biological Diversity (1:07 minutes) http://www.biologicaldiversity.org/about/creative_media/videos/index.html

"Science Bulletins Shrinking Glaciers" by the American Museum of Natural History (8:11 minutes)
http://www.amnh.org/explore/science-bulletins/(watch)/earth/documentaries/shrinking-glaciers-a-chronology-of-climate-change

"Small Scale Farmers Cool the Planet" by Ryan Fletcher (17:32 minutes)
http://fairworldproject.org/cool/

"The History of Climate Change Negotiation" by Center for Climate and Environmental Reseach (1:23)
http://www.climate-cryosphere.org/media-gallery/599-the-history-of-climate-change-negotiations-in-83-seconds

"The Price of Carbon" by Climate Reality Project (2:23 minutes)
https://www.climaterealityproject.org/video/cost-carbon

-"Tribute to the Ocean" by Martin Colognoli and Guillame Holzer (2:21 minutes)
https://www.youtube.com/watch?v=_bTRedQIYO0

"What's More Precious?" by Nadia Asfour, Selina Chaouki, and Elias El Hage (0:32 minutes)
https://www.youtube.com/user/Connect4Climate

"What's the Deal with Carbon?" by Jared Williams (3:04 minutes)
http://ed.ted.com/on/7rUeDQKz

Content Standards Information – Based On WV State Standards

Activity 1: "You Are My Sunshine" or "Here Come the Photons!"

Goal: Participants will better understand how the Sun heats the Earth

Elementary School Standards	Middle School Standards	High School Standards
S.K.GS.9 "Students will make observations to determine the effect of sunlight on the Earth's surface." **Explanation:** In this activity, participants are invited to suggest how photons/electromagnetic energy affect the Earth. **S.3.GS.3** "Students will ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other." **Explanation:** In this activity, participants engage in inquiry about the interactions between the sun, electromagnetic radiation, and the earth. **S.4.GS.2** "Students will make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents." **Explanation:** In this activity, participants are invited to use prior experiences with the effects of sunlight to reach the conclusion that energy is being transferred from the sun to the earth's surface and atmosphere.	**S.6.PS.2** "Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials." **Explanation:** In this activity, participants will act out a model that demonstrates how electromagnetic radiation interacts with atmospheric gases and the earth's surface, and will become familiar with concepts including reflection, absorption and re-radiation.	**S.9.ESS.1** "Students will develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation." **Explanation:** In this activity, students participate in an explanatory model of solar radiation, which will include discussion of nuclear fusion and radiation. **S.9-10.L.4** "Students will determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 tests and topics." **Explanation:** In this activity, participants become familiar with and use the terminology of electromagnetic radiation and subatomic particles.

Activity 2: “Let’s Mix Up an Atmosphere”

Goal: Participants will better understand the relative amounts of basic atmospheric gases

Elementary School Standards	Middle School Standards	High School Standards
S.5.GS.1 “Students will develop a model to describe that matter is made of particles too small to be seen.” **Explanation:** In this activity, participants create a model of atmospheric composition, using rice as a stand in for particles of atmospheric gas.	**S. 6-8.L.7**: “Students will integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph, or table).” **Explanation:** In this activity, participants are drawing conclusions based on information in a variety of media, including a table, a pie chart, and the rice-bottle models.	**S.9-10.L.4** “Students will determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 tests and topics.” **Explanation:** In this activity, participants use the terminology of atmospheric composition, inert and reactive gases.

Activity 3: “Make Mine More Molecules!”

Goal: Participants will better understand the molecular structure of common atmospheric gases.

Elementary School Standards	Middle School Standards	High School Standards
S.5.GS.1 “Students will develop a model to describe that matter is made of particles too small to be seen” **Explanation:** In this activity, participants classify, evaluate and describe model molecules.	**S.8.PS.1** “Students will develop models to describe the atomic composition of simple molecules and extended structures.” **Explanation:** In this activity, participants classify, evaluate, and describe model molecules. This includes an understanding of the differing number and types of bonds that form the molecules.	**S.9-10.L.4** “Students will determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 tests and topics.” **Explanation:** In this activity, participants use the terminology of atmopheric composition, inert and reactive gases, types of bonds, and the greenhouse effect.

Activity 4: "Do the Greenhouse Boogie!"

Goal: Participants will understand how different atmospheric gases react to infrared radiation emitted by the Earth and why some atmospheric gases are called "greenhouse gases".

Elementary School Standards	Middle School Standards	High School Standards
S.K.GS.9 "Students will make observations to determine the effect of sunlight on the Earth's surface." **Explanation:** Participants are invited to suggest how photons/electromagnetic energy affect the Earth. **S.3.GS.3** "Students will ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other." **Explanation:** In this activity, participants engage in inquiry about the interactions between the sun, electromagnetic radiation, and the earth. **S.4.GS.2** "Students will make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents." **Explanation:** In this activity, participant's prior experiences, as well as their observations of the skit, will help them to understand the transfer of energy between the sun and earth's atmosphere.	**S.6.PS.2** "Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials." **Explanation:** In this activity, participants will act out a model that demonstrates how electromagnetic radiation interacts with atmospheric gases and the earth's surface, including reflection, absorption and re-radiation. **S.7.ESS.1** "Students will develop a model to describe the cycling of earth's material's and the flow of energy that drives this process." **Explanation:** In this activity, participants will discuss the carbon cycle, in particular the exhange between atmospheric carbon and carbon contained within the earth. **S.8.PS.1** "Students will develop models to describe the atomic composition of simple molecules and extended structures." **Explanation:** In this activity, participants evaluate the relationship between the structure of model molecules, and their behavior when exposed to electromagnetic radiation.	**S.9.ESS.1** "Students will develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation." **Explanation:** In this activity, students participate in an explanatory model of solar radiation, which will include discussion of nuclear fusion and radiation. **S.9.ESS.13** "Students will use a model to describe how variations in the flow of energy into and out of earth's systems result in changes in climate **Explanation:** In this activity, participants learn about the patterns of energy flow that result in the greenhouse effect. **S.9-10.L.4** "Students will determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 tests and topics." **Explanation:** In this activity, participants will become familiar with and use terminology and concepts related to molecular bonds, transfer of energy, and electromagnetic radiation.

Activity 5: “Shake, Rattle, and Roll with the Five Earths!”

Goals: Participants will better understand the effects on the atmosphere of humans adding greenhouse gases.

Elementary School Standards	Middle School Standards	High School Standards
S.K-2.ETS.1: “Students will ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.” **Explanation:** In this activity, participants use information about the change in atmospheric composition over time to define the problem posed by the greenhouse effect. **S.K.GS.6** “Students will communicate solutions that will reduce the impact of humans on the land, water, air and/or other living things in the local environment.” **Explanation:** Participants consider two possible atmospheric scenarios for the year 2100, which they would rather live in, and what factors affect that outcome. **S.2.GS.8** “Students will use information from several sources to provide evidence that Earth events can occur slowly or quickly.” **Explanation:** In this activity, participants use information from charts, models, and lecture to consider how the pace of atmospheric change has accelerated over the past 150 years.	**S.6.ESS.6** “Students will ask questions to clarify evidence of the factors that have caused the change in global temperature over the past century.” **Explanation:** Discussion during this activity will explore the relationship between human actions, atmospheric composition, and climate. **S.7.ESS.1** “Students will develop a model to describe the cycling of earth’s material’s and the flow of energy that drives this process.” **Explanation:** In this activity, participants will discuss the carbon cycle, in particular the exhange between atmospheric carbon and carbon contained within the earth. **S.8.ESS.1** “Students will construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.” **Explanation:** Drawing on charts, models, and activities, participants draw connections between human activities, CO2 emissions, and changes in global climate.	**S.9.ESS.13** “Students will use a model to describe how variations in the flow of energy into and out of earth’s systems result in changes in climate **Explanation:** In this activity, participants learn about the patterns of energy flow that result in the greenhouse effect. **S.9.ESS.14** “Students will analyze geoscience data and the results from the global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associate future impacts on the earth.” **Explanation:** In this activity, participants will model the historical shifts in climate, and hypothsize about the possible future climate trajectories.

"KITCHEN KLIMATE SCIENCE"
PARTICIPANT RESPONSE FORM

Please respond to these short questions. You do not have to give your name. Your responses will help improve the program.

1. **What is the most important thing that you learned in this program?**

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2. **Which activity was the most interesting and why?**

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3. **How can we improve the program?**

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4. **Other comments, questions, and/or suggestions:**

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5. Are you interested in receiving more information and/or possibly doing a research project about global warming and climate change? If so, give your name and e-mail address (we do not share this information.)

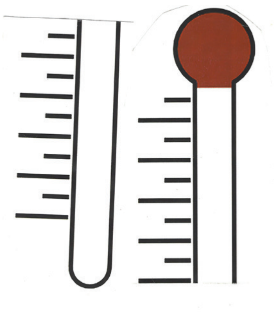
Name: ___________________________ E-mail:_______________________________________

Please return to Friends of Blackwater, PO Box 247 Thomas, WV 26292 (304) 345-7663 info@saveblackwater.org

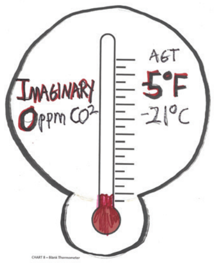
ONLINE PDFS OF PROPS AND POSTERS

PG 0001 Thermometer Large.pdf
PG 0002 Five Earths Temperature discs.pdf
PG 0003 Five Earth dated discs w string.pdf
PG 0004 Five Earths full page Faces for Headbands.pdf
PG 0007 Green Earth disc no lettering.pdf
PG 0008 Five Earths Bottle Text Labels.pdf
PG 0009 Multicolor photons EMR.pdf
PG 0011 Psychedelic Sun Headband Image.pdf
PG 0013 Five Earths smaller faces for bottles.pdf
PG 0014 Blank Sun Disc.pdf
PG 0016 Cartoon Chef Hat Headgear.pdf
PG 0019 Molecule Headgear AR.pdf
PG 0020 Molecule Headgear CO2.pdf
PG 0021 Molecule Headgear H2O.pdf
PG 0022 Molecule Headgear N2.pdf
PG 0023 Molecule Headgear O2.pdf
PG 0024 Molecule Headgear CH4.pdf
PG 0026 Snowball Earth face full page for headband no text.pdf
PG 0027 Frozen Earth disc no text.pdf
PG 0028 Smiling Earth face full page for Headband no text.pdf
PG 0029 Label for Bottle 2017.pdf

PG 1001 Simplified Table of Atmosphere 2017 Poster.pdf
PG 1002 Pie Charts of All Gases in Earth's Atmosphere 2017 Poster.pdf
PG 1003 CO2 and Temperature Chart 400K Years.pdf
PG 1005 Natural and Human-caused Greenhouse Effect Poster.pdf
PG 1006 Participant Response Form.pdf
PG 1008 Recent and Future CO2 and Temperature Increase Poster.pdf
PG 1009 Electromagnetic Spectrum.pdf
PG 1010 Basic Greenhouse Effect Poster.pdf



PG 0001

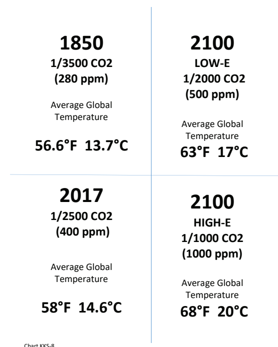


PG 0002

PG 0003

PG 0004

PG 0007



PG 0008

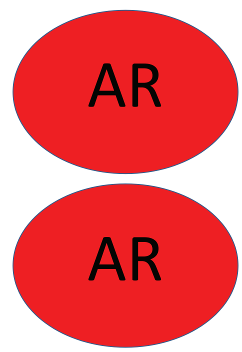
PG 0009

PG 0011

PG 0013

PG 0014

PG 0016



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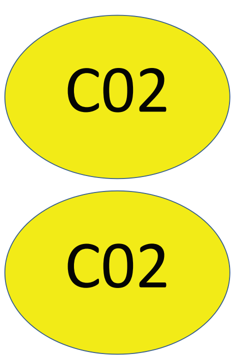
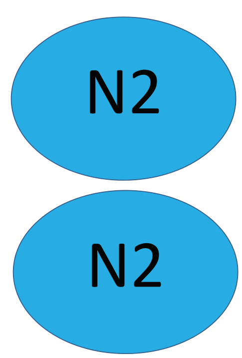


PG 0020

PG 0021



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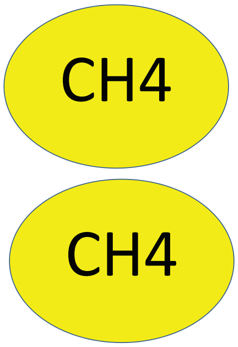
PG 0023



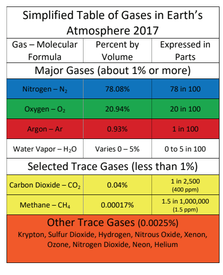
PG 0024

PG 0011

PG 0026

PG 0027

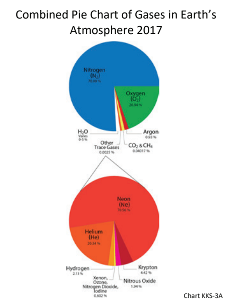
PG 0028



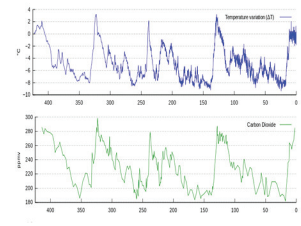
Simplified Table of Gases in Earth's Atmosphere 2017		
Gas – Molecular Formula	Percent by Volume	Expressed in Parts
Major Gases (about 1% or more)		
Nitrogen – N_2	78.08%	78 in 100
Oxygen – O_2	20.94%	20 in 100
Argon – Ar	0.93%	1 in 100
Water Vapor – H_2O	Varies 0 – 5%	0 to 5 in 100
Selected Trace Gases (less than 1%)		
Carbon Dioxide – CO_2	0.04%	1 in 2,500 (400 ppm)
Methane – CH_4	0.00017%	1.5 in 1,000,000 (1.5 ppm)
Other Trace Gases (0.0025%) Krypton, Sulfur Dioxide, Hydrogen, Nitrous Oxide, Xenon, Ozone, Nitrogen Dioxide, Neon, Helium		

ChartKKS-1a

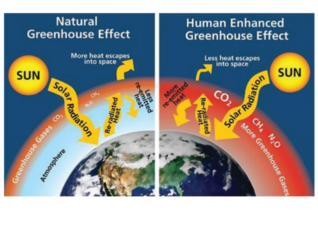
PG 1001



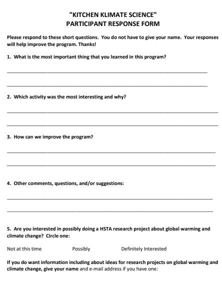
PG 1002



PG 1003



PG 1005



"KITCHEN KLIMATE SCIENCE"
PARTICIPANT RESPONSE FORM

Please respond to these short questions. You do not have to give your name. Your responses will help improve the program. Thanks!

1. What is the most important thing that you learned in this program?

____

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2. Which activity was the most interesting and why?

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3. How can we improve the program?

____

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4. Other comments, questions, and/or suggestions:

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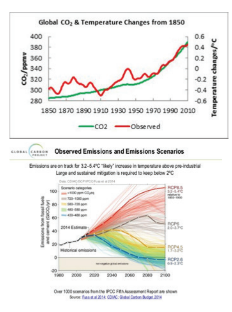
5. Are you interested in possibly doing a HSTA research project about global warming and climate change? Circle one:

Not at this time Possibly Definitely Interested

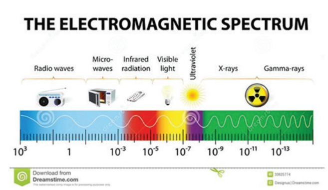
If you do want information including about ideas for research projects on global warming and climate change, give your name and e-mail address if you have one:

Name: ____________________ E-mail: ______________________

PG 1006



PG 1008



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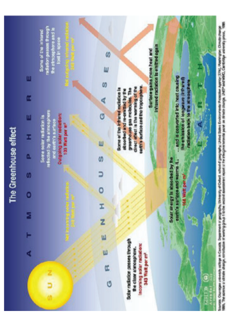

PG 1010