Plausibility and Climate Change

Plausibility: A Refresher

How do scientists change their plausibility judgments?

Plausibility is a judgment we make about the potential truthfulness of one model compared to another. The judgment may be tentative (not certain). You do not have to be committed to that decision.

Scientists may change their plausibility judgments about scientific ideas.

Analysis of Evidence

Strongly supports

Contradicts

Supports

Has nothing to do with/unrelated

Falsifiability

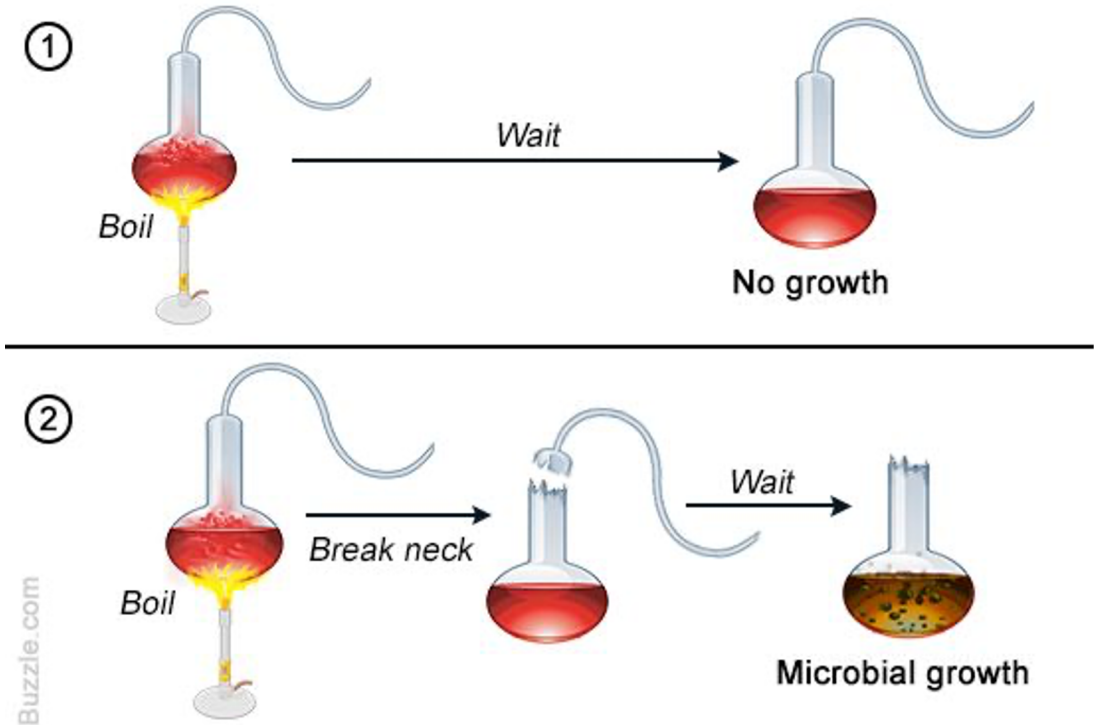
Scientific ideas must be *falsifiable*. In other words, scientific ideas can never be proven. But, ideas can be disproven by opposing evidence. When this happens, scientists must revise the idea or come up with another explanation. *Falsifiability* is a very important principle when evaluating scientific knowledge.

The True/False Strategy

Falsifiability Examples:

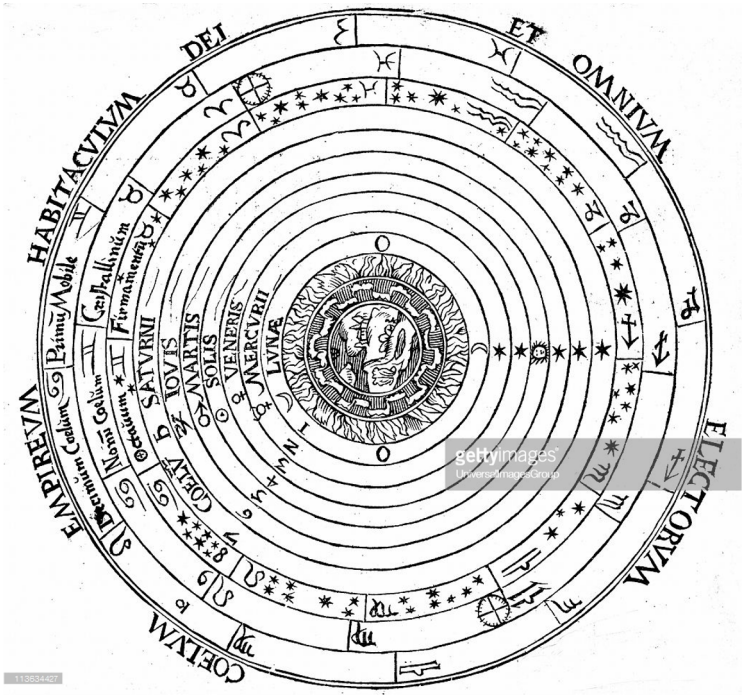
Spontaneous Generation

Univocal Generation

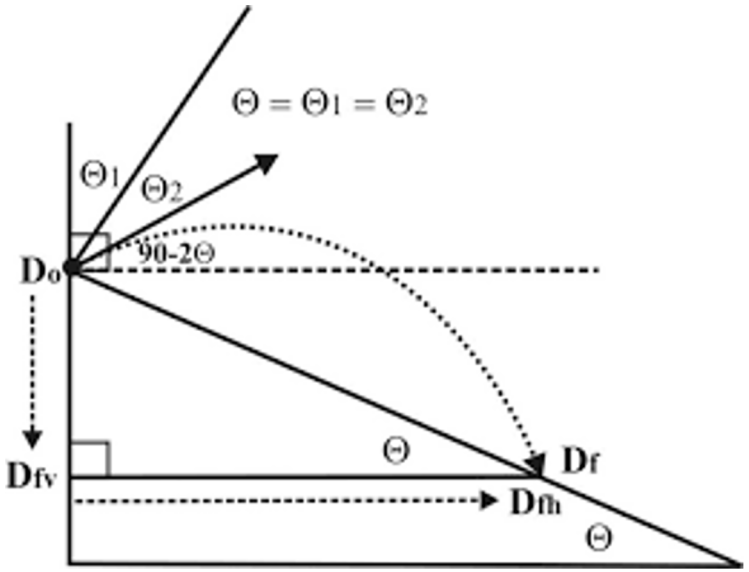


Falsifiability Examples:

Aristotelian Physics



Newtonian Physics



Plausibility
Non-Examples:

Avoid things like

- Miraculous
- Magical
- Supernatural

Realistic Choices

What do students do?

Goals:

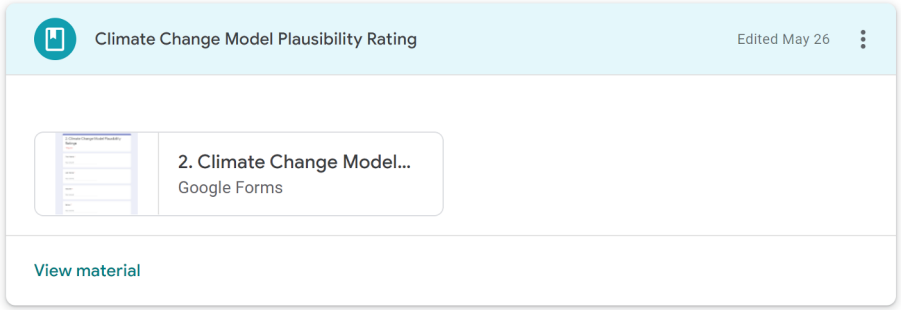
- Recognize that plausible competing models exist
- Evidence influences plausibility
- Falsifiability is an important scientific concept

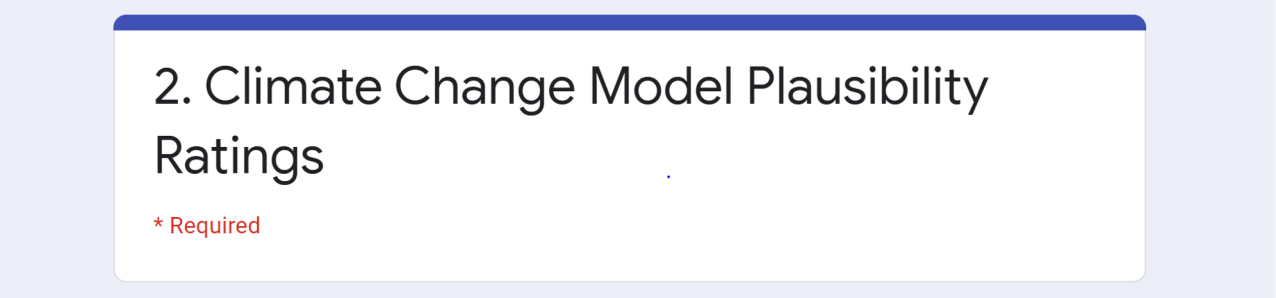
Discussion Points:

- Probability vs Plausibility
- Emphasize the importance of falsifiability- the null hypothesis

Climate Change MEL

Model Plausibility Ratings





If you are pretty sure a model might be true, that means the plausibility is high—7, 8, or 9 on the scale.

If you are pretty sure a model is false, that means the plausibility is low—1, 2, or 3.

Model Plausibility Ratings:
Causes of Current Climate Change

Circle the plausibility of each model. [Make two circles. One for each model.]

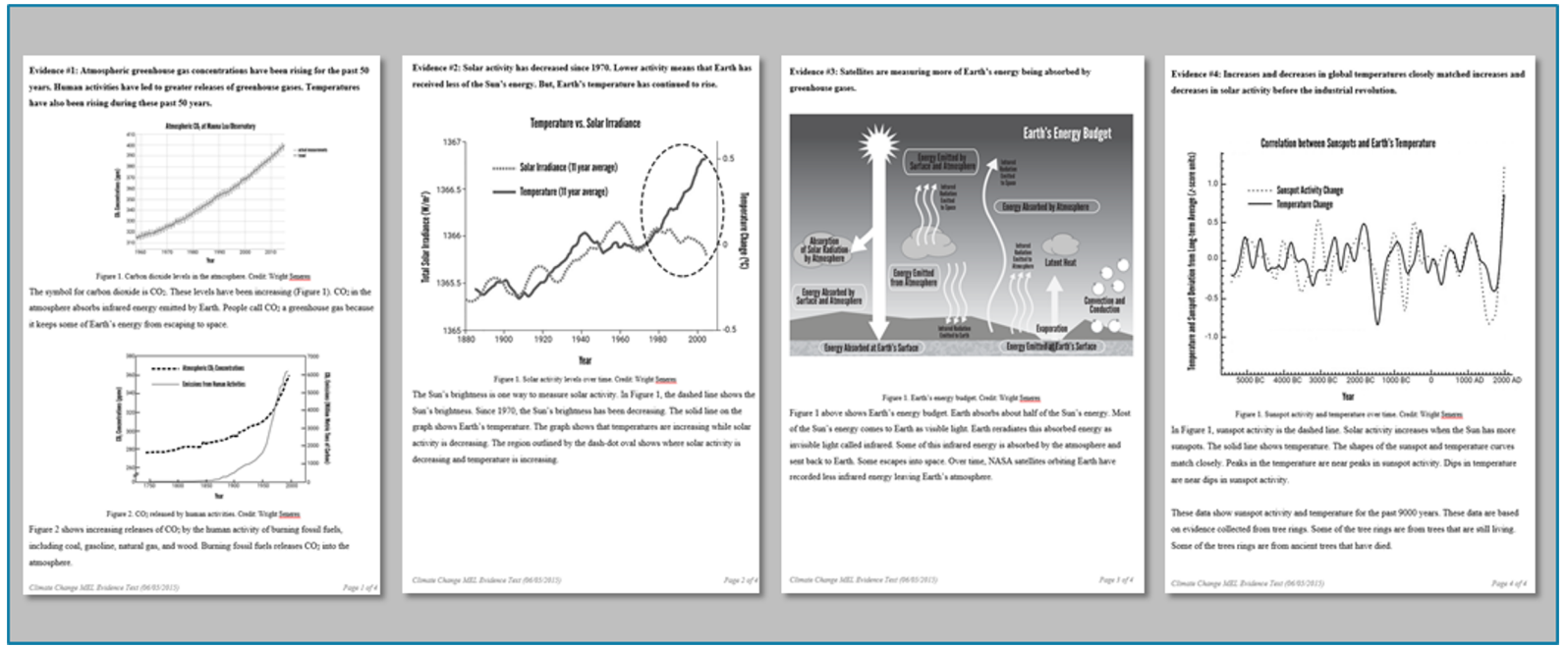
	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

Model A: Humans are the cause of current climate change.

Model B: Increasing amounts of energy from the sun are the cause of current climate change.

Please make a note of your ratings. You might want to refer to them later. We are working on making this better.

Evidence Texts



Evidence #1: Atmospheric greenhouse gas concentrations have been rising for the past 50 years. Human activities have led to greater releases of greenhouse gases. Temperatures have also been rising during these past 50 years.

Figure 1. Carbon dioxide levels in the atmosphere. Credit: Wright Smeets

The symbol for carbon dioxide is CO_2. These levels have been increasing (Figure 1). CO_2 in the atmosphere absorbs infrared energy emitted by Earth. People call CO_2 a greenhouse gas because it keeps some of Earth's energy from escaping to space.

Figure 2. CO_2 released by human activities. Credit: Wright Smeets

Figure 2 shows increasing releases of CO_2 by the human activity of burning fossil fuels, including coal, gasoline, natural gas, and wood. Burning fossil fuels releases CO_2 into the atmosphere.

Climate Change MEL Evidence Test (06/05/2015) *Page 1 of 4*

Evidence #2: Solar activity has decreased since 1970. Lower activity means that Earth has received less of the Sun's energy. But, Earth's temperature has continued to rise.

Figure 1. Solar activity levels over time. Credit: Wright Smeets

The Sun's brightness is one way to measure solar activity. In Figure 1, the dashed line shows the Sun's brightness. Since 1970, the Sun's brightness has been decreasing. The solid line on the graph shows Earth's temperature. The graph shows that temperatures are increasing while solar activity is decreasing. The region outlined by the dash-dot oval shows where solar activity is decreasing and temperature is increasing.

Climate Change MEL Evidence Test (06/05/2015) *Page 2 of 4*

Evidence #3: Satellites are measuring more of Earth's energy being absorbed by greenhouse gases.

Figure 1. Earth's energy budget. Credit: Wright Smeets

Figure 1 above shows Earth's energy budget. Earth absorbs about half of the Sun's energy. Most of the Sun's energy comes to Earth as visible light. Earth reradiates this absorbed energy as invisible light called infrared. Some of this infrared energy is absorbed by the atmosphere and sent back to Earth. Some escapes into space. Over time, NASA satellites orbiting Earth have recorded less infrared energy leaving Earth's atmosphere.

Climate Change MEL Evidence Test (06/05/2015) *Page 3 of 4*

Evidence #4: Increases and decreases in global temperatures closely matched increases and decreases in solar activity before the industrial revolution.

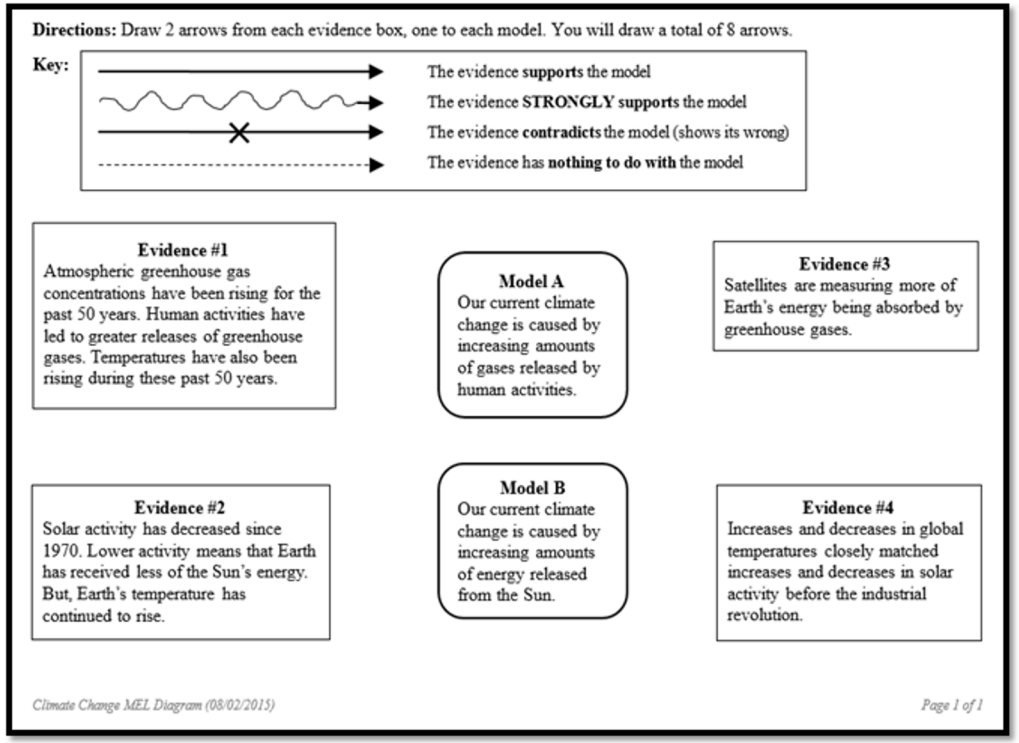
Figure 1. Sunspot activity and temperature over time. Credit: Wright Smeets

In Figure 1, sunspot activity is the dashed line. Solar activity increases when the Sun has more sunspots. The solid line shows temperature. The shapes of the sunspot and temperature curves match closely. Peaks in the temperature are near peaks in sunspot activity. Dips in temperature are near dips in sunspot activity.

These data show sunspot activity and temperature for the past 9000 years. These data are based on evidence collected from tree rings. Some of the tree rings are from trees that are still living. Some of the trees rings are from ancient trees that have died.

Climate Change MEL Evidence Test (06/05/2015) *Page 4 of 4*

Model-Evidence Link (MEL) Diagram: Causes of Current Climate Change



Directions: Draw 2 arrows from each evidence box, one to each model. You will draw a total of 8 arrows.

Key:

- The evidence **supports** the model
- The evidence **STRONGLY supports** the model
- The evidence **contradicts** the model (shows its wrong)
- The evidence has **nothing to do with** the model

Evidence #1
Atmospheric greenhouse gas concentrations have been rising for the past 50 years. Human activities have led to greater releases of greenhouse gases. Temperatures have also been rising during these past 50 years.

Model A
Our current climate change is caused by increasing amounts of gases released by human activities.

Evidence #3
Satellites are measuring more of Earth's energy being absorbed by greenhouse gases.

Evidence #2
Solar activity has decreased since 1970. Lower activity means that Earth has received less of the Sun's energy. But, Earth's temperature has continued to rise.

Model B
Our current climate change is caused by increasing amounts of energy released from the Sun.

Evidence #4
Increases and decreases in global temperatures closely matched increases and decreases in solar activity before the industrial revolution.

Climate Change MEL Diagram (08/02/2015) *Page 1 of 1*

Types of Arrows

Supports

Strongly Supports

Contradicts

Has nothing to do with

Evidence #1
Atmospheric greenhouse gas concentrations have been rising for the past 50 years. Human activities have led to greater releases of greenhouse gases. Temperatures have also been rising during these past 50 years.

Model A
Climate change is caused by humans who are releasing gases into the atmosphere.

Evidence #3
Satellites are measuring more of Earth's energy being absorbed by greenhouse gases.

Evidence #2
Solar activity has decreased since 1970. Lower activity means that Earth has received less of the Sun's energy. But, Earth's temperature has continued to rise.

Model B
Our current climate change is caused by increasing amounts of energy released from the Sun.

Evidence #4
Increases and decreases in global temperatures closely matched increases and decreases in solar activity before the industrial revolution.

THE MEL PROJECT

Generating Explanations

Name_____Date_____Teacher_____Period_____

1. Please work on this part individually after you complete your diagram. Now that you have completed the diagram, reconsider the plausibility of Models A and B (and C, if there is one). Circle the plausibility of each model. [Make one circle for each model.]

	Greatly implausible (or even impossible)									Highly plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10
Model C (if there is one)	1	2	3	4	5	6	7	8	9	10

What were your previous ratings? Model A: _____ Model B: _____ Model C (if there is one): _____

2. Did the plausibility of any of the models change after you completed the diagram? Yes or No [Circle One]

3. Which arrows changed your plausibility judgments about the models? If your plausibility judgments did not change, which arrows supported your original plausibility judgments? Use the following steps to provide an explanation for why your plausibility judgments did or did not change.

a) Write the number of the evidence you are writing about. [Note: it is okay to include more than one evidence.]
b) Circle the appropriate word (**strongly supports | supports | contradicts | has nothing to do with**).
c) Write which model you are writing about. [Note: it is okay to include more than one model.]
d) Then write your reason.

Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

4. In your final ranking, did you rank any Model as "1" or "10?" Yes or No [Circle One] Why? Why not?

THE MEL PROJECT

One the Website!

Model-Evidence Link Diagrams Project > Teaching Resources

Model-Evidence Link Diagrams Project

- About
- Teaching Resources
  - Climate Change MEL
  - Fracking MEL
  - Wetlands MEL
  - Moon MEL
  - Extreme Weather MEL
  - Fossils MEL
  - Freshwater MEL
  - Origins of the Universe MEL
  - Extreme Weather baMEL
  - Fossils baMEL
  - Freshwater baMEL
  - Origins of the Universe baMEL
- Professional Development

Teaching Resources

The MEL project has developed a set of teaching resources to support the teaching of controversial and/or complex Earth and space science topics. Previously developed MEL teaching resources include those for climate change, earthquakes and fracking, wetlands use, and the formation of the moon. Current baMEL teaching resources include extreme weather, fossils and Earth's past, freshwater availability, and origins of the universe. All materials are freely available under a Creative Commons Attribution-NonCommercial-ShareAlike license. You may reuse these materials for non-commercial purposes as long as you provide attribution and offer any derivative works under a similar license. Credit the Science Learning Research Group, University of Maryland, for the development of these materials.

MEL Teaching Resources

- Climate Change
- Earthquakes and Fracking
- Wetlands Use
- Formation of the Moon
- Extreme Weather
- Fossils
- Freshwater
- Origins of the Universe

ACKNOWLEDGEMENTS

This research project is supported by the US National Science Foundation (NSF) under Grant Nos. 1316057, 1721041, and 2027376. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not necessarily reflect the NSF's views.