



This is the print version of the [Skeptical Science](http://sks.to/thermo) article '[2nd law of thermodynamics contradicts greenhouse theory](http://sks.to/thermo)', which can be found at <http://sks.to/thermo>.

The greenhouse effect and the 2nd law of thermodynamics

What The Science Says:

The 2nd law of thermodynamics is consistent with the greenhouse effect which is directly observed.

Climate Myth: 2nd law of thermodynamics contradicts greenhouse theory

"The atmospheric greenhouse effect, an idea that many authors trace back to the traditional works of Fourier 1824, Tyndall 1861, and Arrhenius 1896, and which is still supported in global climatology, essentially describes a fictitious mechanism, in which a planetary atmosphere acts as a heat pump driven by an environment that is radiatively interacting with but radiatively equilibrated to the atmospheric system. According to the second law of thermodynamics such a planetary machine can never exist." ([Gerhard Gerlich](#))

Skeptics sometimes claim that the explanation for global warming contradicts the second law of thermodynamics. But does it? To answer that, first, we need to know how global warming works. Then, we need to know what the second law of thermodynamics is, and how it applies to global warming. Global warming, in a nutshell, works like this:

The sun warms the Earth. The Earth and its atmosphere radiate heat away into space. They radiate most of the heat that is received from the sun, so the average temperature of the Earth stays more or less constant. Greenhouse gases trap some of the escaping heat closer to the Earth's surface, making it harder for it to shed that heat, so the Earth warms up in order to radiate the heat more effectively. So the greenhouse gases make the Earth warmer - like a blanket conserving body heat - and *voilà*, you have global warming. See [What is Global Warming and the Greenhouse Effect](#) for a more detailed explanation.

The second law of thermodynamics has been stated in many ways. For us, [Rudolf Clausius](#) said it best:

"Heat generally cannot flow spontaneously from a material at lower temperature to a material at higher temperature."

So if you put something hot next to something cold, the hot thing won't get hotter, and the cold thing won't get colder. That's so obvious that it hardly needs a scientist to say it, we know this from our daily lives. If you put an ice-cube into your drink, the drink doesn't boil!

The skeptic tells us that, because the air, including the greenhouse gasses, is cooler than the surface of the Earth, it cannot warm the Earth. If it did, they say, that means heat would have to flow from cold to hot, in apparent violation of the second law of thermodynamics.

So have climate scientists made an elementary mistake? Of course not! The skeptic is ignoring the fact that the Earth is being warmed by the sun, which makes all the difference.

To see why, consider that blanket that keeps you warm. If your skin feels cold, wrapping yourself in a blanket can make you warmer. Why? Because your body is generating heat, and that heat is escaping from your body into the environment. When you wrap yourself in a blanket, the loss of heat is reduced, some is retained at the

surface of your body, and you warm up. You get warmer because the heat that your body is generating cannot escape as fast as before.

If you put the blanket on a tailors dummy, which does not generate heat, it will have no effect. The dummy will not spontaneously get warmer. That's obvious too!

Is using a blanket an accurate model for global warming by greenhouse gases? Certainly there are differences in how the heat is created and lost, and our body can produce varying amounts of heat, unlike the near-constant heat we receive from the sun. But as far as the second law of thermodynamics goes, where we are only talking about the flow of heat, the comparison is good. The second law says nothing about how the heat is produced, only about how it flows between things.

To summarise: Heat from the sun warms the Earth, as heat from your body keeps you warm. The Earth loses heat to space, and your body loses heat to the environment. Greenhouse gases slow down the rate of heat-loss from the surface of the Earth, like a blanket that slows down the rate at which your body loses heat. The result is the same in both cases, the surface of the Earth, or of your body, gets warmer.

So global warming does not violate the second law of thermodynamics. And if someone tells you otherwise, just remember that you're a warm human being, and certainly nobody's dummy.

Basic rebuttal written by Tony Wildish

Update July 2015:

Here is the relevant lecture-video from [Denial101x - Making Sense of Climate Science Denial](#)

Update October 2017:

[Here](#) is a walk-through explanation of the Greenhouse Effect for bunnies, by none other than Eli, over at Rabbit Run.



Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a [college textbook on climate change](#) and the book [Climate Change Denial: Heads in the Sand](#). Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.



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