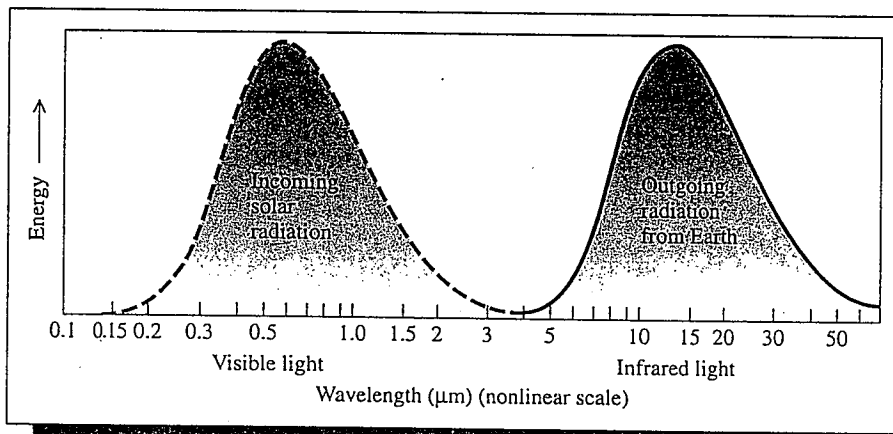
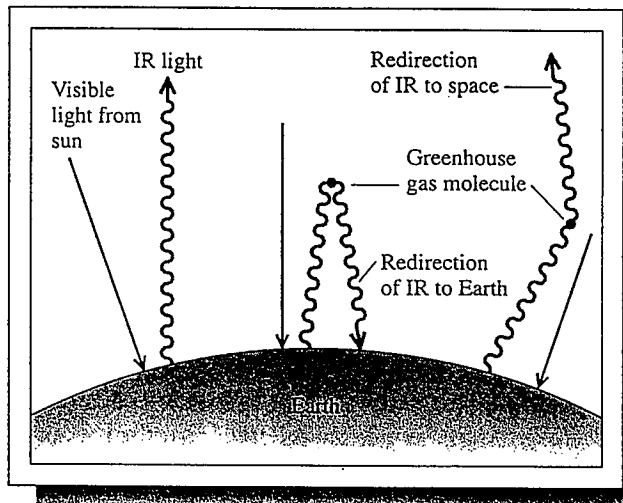


Teacher Background Information: The Greenhouse Effect

Some gases in the Earth's atmosphere can temporarily absorb thermal infrared energy of specific wavelengths, and so, not all the IR emitted from the Earth's surface and the atmosphere escaped directly to space. Shortly after its absorption by airborne molecules such as CO_2 and water vapor, this infrared energy is re-emitted in all direction - completely randomly. Some of the thermal IR (infrared) is redirected back towards the Earth's surface, is reabsorbed and consequently further heats both the surface and the air. This phenomenon, the redirection of thermal IR towards the Earth, as shown below, is called the *greenhouse effect*, and is responsible for the average temperature at the Earth's surface being +15 degrees C rather than -15 degrees C, the temperature it would be if there were no atmosphere. The very fact that our planet is not entirely covered by a thick sheet of ice is due to the *natural* operation of the greenhouse effect. The surface is as much warmed by this mechanism as it is by the solar energy it receives directly! The atmosphere operates in much the same way as a blanket, retaining within the immediate region some of the heat released by a body and thereby increasing the local temperature.

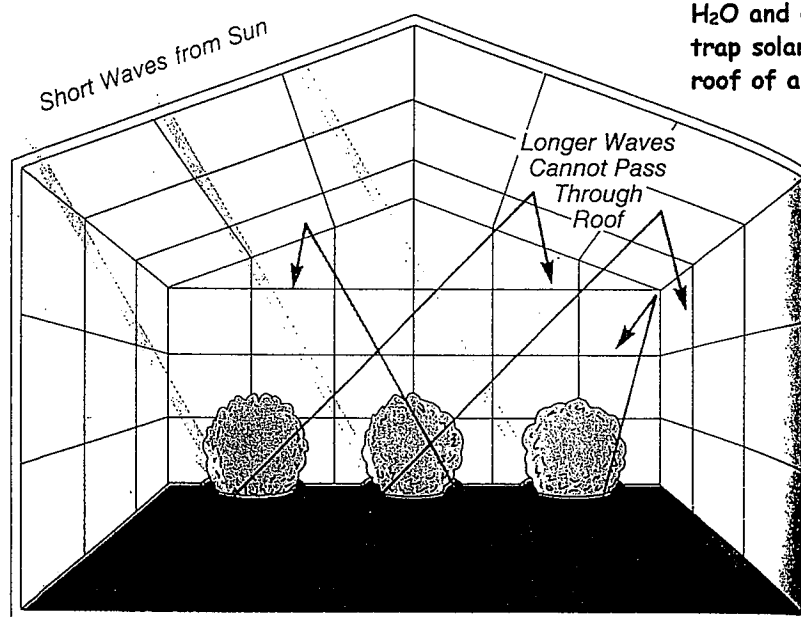


Wavelength distributions for light emitted by the Sun (dashed line) and by the Earth's surface and troposphere (solid line)



Schema of the operation of the greenhouse effect in Earth's atmosphere

The term *greenhouse effect* arises from the classic analogy to a greenhouse in which the glass allows the solar radiation in and traps much of the heat. It was first used back in the 1800's by the French scientist, Jean Fourier, who realized that the Earth's atmosphere had heat-trapping properties. In 1896, Svante Arrhenius, a Swedish chemist, who knew about Fourier's ideas, published an article in which he pointed to carbon dioxide as a principal heat trapping gas in the atmosphere. The mechanisms involved in the atmosphere are quite different from those involved in the heating of a greenhouse, where the glass primarily prevents convection currents of air from taking heat away from the interior. Greenhouse glass is not really keeping the enclosure warm by blocking or reradiating infrared radiation; rather it is constraining the physical transport of heat by air motion. The atmosphere, like the glass walls, concentrates heat near the surface, but the term greenhouse effect applied to a planetary atmosphere refers solely to the role of the atmosphere in preventing some of the infrared radiation from escaping to space. Despite the differences in mechanisms, the analogy is appropriate for popular use when referring to the heat trapping capability of the Earth's atmosphere.



H₂O and CO₂ in the atmosphere trap solar energy much as the glass roof of a greenhouse does.

The principal constituents of the atmosphere, N₂, O₂ and Ar, are incapable of absorbing infrared energy. The atmospheric gases that in the past have produced most of the greenhouse warming are water vapor (responsible for about two-thirds of the greenhouse effect) and carbon dioxide (which is responsible for about one-quarter). A good example is the absence of water in the dry air of desert areas which leads to low nighttime temperatures even though the daytime temperatures are quite high on account of direct absorption of solar energy. More familiar to people living in temperate climates is the crisp chill in winter air on cloudless days and nights.

The phenomenon that worries environmental scientists is that increasing the concentrations of the trace gases in the air that absorb thermal infrared energy (like piling on more blankets!) would result in the redirection of more of the outgoing thermal infrared energy and would thereby increase the average surface temperature of the Earth beyond 15 degrees C. This phenomenon is referred to as the *enhanced greenhouse effect*, to distinguish it from the one that has been operating naturally for millennia.