FYI The Importance of an Atmosphere

An **atmosphere** is the layer of gases that may surround a planet or moon. There is no definite boundary between the atmosphere and outer space. Instead, the atmosphere simply becomes thinner and thinner as it gets farther from the world's surface.

Venus, Earth, Mars, Pluto, and one moon of Saturn, called Titan, all have significant atmospheres. Some of the moons in the solar system, such as Jupiter's Europa and Ganymede, have very thin atmospheres, called exospheres, that are almost, but not quite, a vacuum. For the gaseous planets, such as Jupiter, it is difficult to distinguish between what is planet and what is atmosphere. In fact, gaseous planets don't have a surface, their atmospheres just get denser toward the center of the planet until a solid state is reached.

Whether or not a world has an atmosphere is dependent on a number of factors, including surface gravitation. The gas that makes up the atmosphere has mass, and so it is attracted to the mass of Earth by gravitational force. The gravitational force on Jupiter is strong enough to hold really light gases, such as hydrogen or helium. The gravitational force on Earth is strong enough to hold on to an atmosphere, though one made primarily of the heavier gases nitrogen and oxygen. The gravitational force on Titan is very low; however, the temperature of this outer-world moon is also very cold. As a result, the gases in Titan's atmosphere have very little thermal energy and are moving slowly. Their velocity (speed with a direction) is low enough that they can't escape the gravitational force of their moon.

Atmosphere Affects a Planet's Temperature

A world's atmosphere reflects, absorbs, and transmits electromagnetic radiation.

- **Reflection** is the process of changing the direction of the electromagnetic radiation. The atmosphere reflects the electromagnetic radiation, meaning that it takes radiation that is entering the atmosphere and returns or gives back that radiation to space.
- **Absorption** is the process by which electromagnetic radiation is taken up or in by another entity, such as the gases of an atmosphere. The atmosphere absorbs the electromagnetic radiation, meaning that it takes in the radiation.
- **Transmission** is the process of passing electromagnetic radiation through a substance. The atmosphere transmits electromagnetic radiation, meaning that it allows the radiation to travel through to the world's surface.

Figure 1-19: Diagram showing the greenhouse effect

When an atmosphere absorbs electromagnetic radiation from the sun, it is absorbing energy. This energy directly relates to the temperature of the world. The more energy that is absorbed, the higher the temperature. The greenhouse effect is the process by which the electromagnetic radiation absorbed and trapped by a planet's atmosphere heats the planet. Thus, an atmosphere affects the temperature of a world by absorbing energy from the sun.

Much of the light reaching a world from the sun is visible light. On Earth, this light warms the surface, which reradiates much of this heat back toward space. However, the surface reradiates this heat as **infrared radiation**.

While visible light passes easily through Earth's atmosphere, infrared light does not. An atmosphere absorbs about 90% of the infrared light emitted by the surface. Thus, the nature of the atmosphere affects how much and what types of radiation are reflected, absorbed, and transmitted.

An atmosphere also affects the temperature of a world by reducing the temperature extremes. If a world doesn't have an atmosphere to absorb and hold energy from the sun, the side of that world that is toward the sun is much hotter than the side that is away from the sun. Also, if a world doesn't have an atmosphere, the temperature near the part of the world where the sun is directly overhead is much greater than at the parts of the world where the sun can never be directly overhead. Because of a world's spherical shape, the energy available per unit area decreases from the parts of the world where the sunlight comes straight down from directly overhead (such as near the equator on Earth) to the parts of the world where the sunlight comes in at a low angle (such as at poles on Earth). (See Figure 1-20.) Atmospheric gases can move, so an atmosphere is able to take energy from the warmer places to the cooler places, reducing the temperature differences. For example, the temperatures on Mercury range from about 467 °C near the planet's equator on the side facing the sun to about -183 °C near the poles and on the side of the planet away from the sun. In contrast, the temperatures on the surface of Venus are only a few degrees warmer at the equator than at the poles.

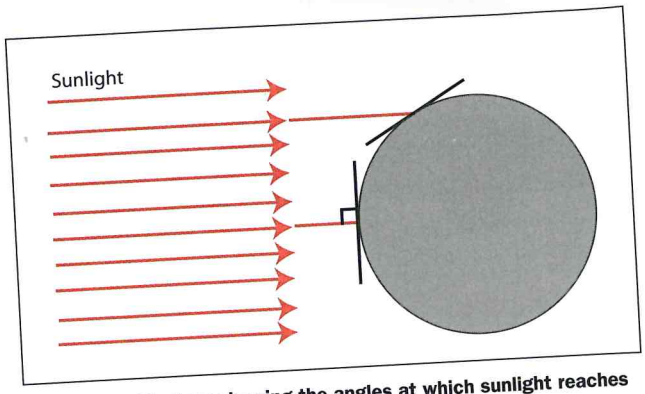

Figure 1-20: Diagram showing the angles at which sunlight reaches a world's surface. A world without an atmosphere or with only a very thin atmosphere will be hotter at the location where the sunlight is coming straight down, at a right angle to the surface, than at the locations where the sunlight is reaching the surface at a lower angle.

Other Features of a Planet's Atmosphere

In addition, an atmosphere helps protect a world's surface from dangerous electromagnetic radiation. Some forms of electromagnetic radiation can be harmful. For example, ultraviolet radiation causes sunburns, which are damaging to human skin. An atmosphere doesn't absorb or reflect all types of electromagnetic radiation equally—Earth's atmosphere transmits almost all the light from the sun but only some of the ultraviolet radiation. Thus, by reflecting and absorbing some of the electromagnetic radiation from the sun, an atmosphere can protect a world's surface.

An atmosphere also helps protect a world's surface from asteroids, meteoroids, and other bits and pieces of rock and materials traveling through the solar system. If a world has an atmosphere, this space debris may burn up in that atmosphere and never reach the surface. The thickness of the world's atmosphere, along with the size and nature of the debris, determines whether or not the debris burns up before reaching the surface. For example, little pieces burn up easily in Earth's atmosphere, resulting in meteors, which are commonly (though incorrectly) called falling or shooting stars. However, objects larger than a few meters in diameter zip almost unaffected through Earth's atmosphere. Even Venus's dense atmosphere only burns up objects less than 100 or so meters in diameter. Larger stuff goes right through. When pieces do reach the surface due to a thin or nonexistent atmosphere, the result is a **crater**, a circular depression or lowered area on a surface. In general, the larger the piece hitting the surface, the larger the crater. Therefore, a world without an atmosphere or with an insubstantial atmosphere will have many more small craters on its surface.

Finally, an atmosphere directly affects the surface of a planet or moon. For example, movement of the atmosphere, or wind, causes erosion— a wearing away or slow destruction of the surface. Wind also carries materials such as dust across a world's surface. An atmosphere therefore moves materials from one location to another.

Checking In

1. How does a planet's temperature depend upon its atmosphere?
2. How does a planet's atmosphere protect the planet?