1

A Warming World

TODAY PEOPLE TALK about the greenhouse effect as if it were something frightening and unnatural. But it is not. It is the natural atmospheric phenomenon that keeps the earth warm and life on it functioning. The greenhouse effect is the result of a delicate balance between life and the environment. That balance is not fixed. Life on earth can change the environment, and the environment can change life on earth.

It now appears that life on earth is indeed altering the balance that results in the greenhouse effect. The activities of human beings seem to be creating an imbalance in this natural system, an imbalance that could alter the world drastically. To understand the greenhouse effect and why humans have the power to change it, it is helpful to understand a little about the earth's atmosphere.

(Opposite page) The greenhouse effect helps to maintain the delicate balance between life and the environment. Some fear human activities have altered that balance.

The birth of an atmosphere

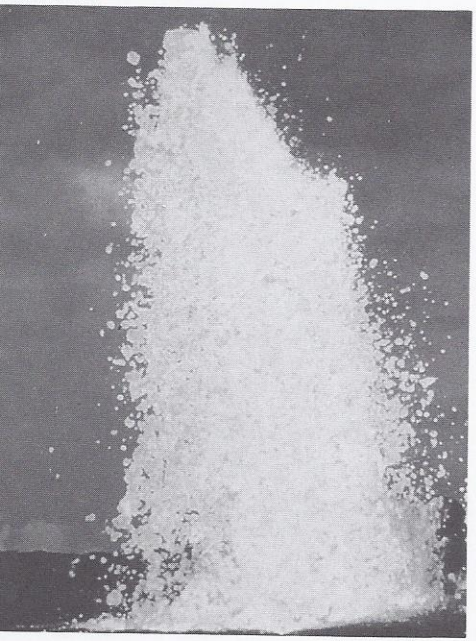
All living beings breathe every moment of every day. People rarely think about what they are breathing unless it is a smoggy day or they are hiking high in the mountains where the air is thin. But the air they take for granted did not come with the earth originally. In fact, 4.5 billion years

ago, the earth had no atmosphere. There was little but the vacuum of space around this molten ball of rock.

As the freezing temperatures of space began to cool the earth, a thin layer, or crust, of solid rock began to form. Beneath the crust, though, still-molten rock churned. Gases from below the surface escaped when volcanoes exploded through the earth's fragile skin. Meteors tore holes in the crust releasing more gases. Those gases were the earth's first atmosphere. They were probably much like the gases spit out by volcanoes today: 64 percent water vapor; 24 percent carbon dioxide; 10 percent sulfur; and 1.5 percent nitrogen.

As the planet continued to cool, the water vapor condensed and started the water cycle—rain, evaporation, condensation, and more rain. Carbon dioxide interacted with the other gases and formed methane and ammonia. There was little free oxygen or nitrogen around, and everything—earth and atmosphere—was bombarded by ultraviolet radiation that poured from the sun.

Lava fountain of a Hawaiian volcano. The gases in the earth's early atmosphere were much like those released by volcanoes today.



A change in the atmosphere

These are the conditions in which life is thought to have developed on earth more than three billion years ago. At that time, the bacteria and blue-green algae that made up most of the life on the planet lived in the ocean. There, somewhat protected from the sun's ultraviolet rays, the algae took carbon dioxide out of the water and emitted, or gave off, oxygen into the air.

These primitive plants released so much oxygen that after about a billion years, the atmosphere changed. The oxygen combined with the ammonia, methane, and other gases until the atmosphere filled with nitrogen and oxygen. The air that had once contained mostly carbon dioxide now contained very little. There was hardly any

methane or ammonia left at all.

This may have been the first case of massive air pollution in the earth's history. It was not good news for the bacteria and blue-green algae. Most of those organisms were used to an atmosphere rich in carbon dioxide; oxygen was poison to them. As a result, most life died. But fortunately, some organisms survived. They adapted and began making use of this strange new atmospheric gas: oxygen.

The abundance of oxygen also created the ozone layer that surrounds the earth today and that is so important to human survival. The ozone, a type of oxygen, blocked out the sun's harmful ultraviolet radiation so that eventually ocean life could crawl out on land without being burned to a crisp.

Other changes resulted from the new atmosphere. Because carbon dioxide made up so much of the early atmosphere and because carbon dioxide absorbs heat, the earth was very warm. When the amount of carbon dioxide in the air decreased, much of the heat trapped in the atmosphere was able to escape back into space. The average temperature of the planet cooled by about 20°F to what it is now—about 59°F. Just enough carbon dioxide was left to keep life on earth comfortable—like plants in a greenhouse.

Holding in the heat

Plants in a greenhouse stay warm even when there is snow on the ground outside because the glass walls and roof trap heat. Similarly, the earth stays warm even though space around it is freezing. The carbon dioxide in the earth's atmosphere traps heat around the earth.

Heat is generated by hot objects, such as the sun, the earth, a kitchen stove, which radiate, or send out, energy. This energy moves away from

the objects in waves. The hotter the object, the shorter the wavelength of energy it produces. Cooler objects produce energy with longer wavelengths.

When energy wavelengths strike an object, they can pass through the object, be reflected by it, or be absorbed by it. Much of the sun's short energy wavelengths pass through the earth's atmosphere and strike the ground. Light-colored areas, such as clouds or snow, reflect the sun's energy back toward space. But dark-colored areas, such as soil, plants, and the ocean, absorb the sun's energy. This absorption is what warms the earth's surface.

As the earth warms, it begins to radiate heat. Without anything to stop it, the heat would keep moving farther and farther out into space, and the earth—and everything on it—would freeze. The

The earth retains heat in much the same way the glass of a greenhouse traps heat.