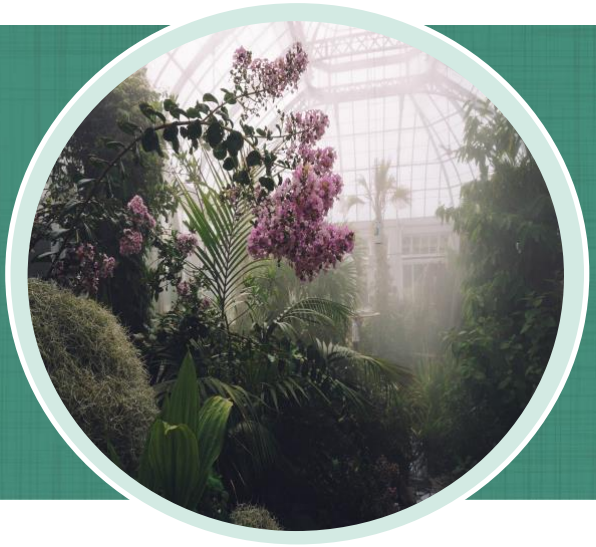
Energy Transfer in Nature



Real World Energy
Backgrounder
Grade Level: 9-12

Metabolism

So far you have learned about the energy that makes individual organisms go. You have discovered that all living things need glucose as their energy supply, and that only plants can make their own glucose. Because animals can't make glucose, they must eat other living things to get it.

You have also learned about metabolism, which is all about how energy is converted from one form to another inside an organism. You have learned that there are anabolic and catabolic processes that build up or break down molecules, that energy can be stored for future use, and that other molecules such as proteins and fats can become energy sources when needed. The bottom line is that any single organism can be thought of as a highly complex energy conversion system.

Ecosystem Energy

An ecosystem is a physical space inhabited by a few or many different kinds of organisms that must all live together, sharing the same basic resources such as sunlight, water, soil, and air. That physical space might be as small as a single rock, or it might be as large as a whole lake, or even an ocean. So if you thought organisms are complex, they are nothing compared to whole ecosystems. Not only can there be hundreds if not millions of individual organisms, but there can be thousands of different species within that ecosystem. *That's complexity!*

An ecosystem is also an energy conversion system, albeit a very complex one. An ecosystem receives energy from the sun, plus water, air, minerals from the soil, and other basic ingredients for life. Green plants use the sunlight to convert simple carbon dioxide and water into vegetation. Almost every last bit of the vegetation becomes food for something else in the ecosystem. Plants are therefore called **producers**, and the organisms that eat them are all called **consumers**.

Most ecosystems have many kinds of consumers. Some eat only plants. Others eat both plants and animals, while there are some animals that only eat other animals. All of these organisms have names that describe how they live:

You will notice that some animals fit under more than one category. For instance, grizzly bears eat mostly plants such as roots and grasses. But when they can, they catch and kill salmon, caribou calves, moose, and other sources of meat. Grizzlies also feed on dead animal remains, such as dead whales washed up on the beach, or those that have died from starvation over winter.

Energy transfer in an ecosystem begins with plants using sunlight to convert water and carbon dioxide to glucose. The glucose is then available to other organisms in the rest of the ecosystem, and it is passed along when organisms are eaten by others. All the energy originally captured by plants is eventually converted to heat and released back to the environment.

Green Thumb: Fossilized Ecosystem Energy

Occasionally, the energy being passed around the ecosystem does NOT get converted to heat and dumped into the environment. Sometimes, plant and animal matter, still with plenty of energy stored in it, gets put into long-term storage. This is the case with coal, peat, natural gas, oil, and other "fossil" fuels. Millions of years ago, huge deposits of plant matter were buried under mud and sand, and the process of decomposition was halted. These materials then were compressed and heated, and over millions of years they changed into energy-rich minerals. We now depend heavily on these minerals to power our cars, heat our homes, and provide most of our electricity. In other words, our modern society runs on ancient "ecosystem energy." This is a convenient source of energy, but it comes at a cost: we risk changing the composition of the atmosphere by adding huge volumes of greenhouse gases to it. This could make the atmosphere warmer, leading to global-scale climate change.

Solar-Powered Planet

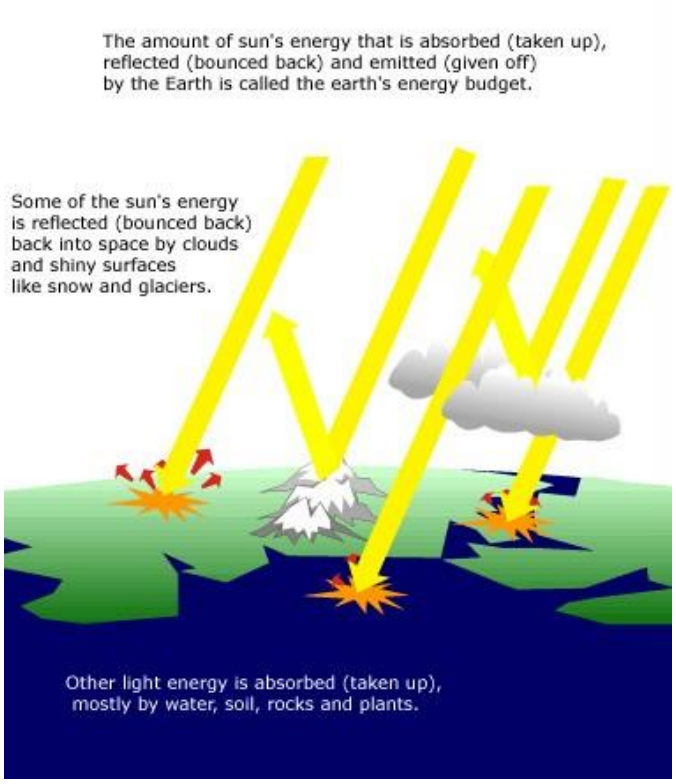
The entire surface of the Earth is covered with living ecosystems. We call this "layer of life" the **biosphere**. The biosphere is so complex that in hundreds of years of studying it, we are only just begun to understand how it works and as you might expect, the Earth is an energy conversion system, but on a grand scale. Our planet is bathed in energy from the sun. Solar energy powers all of the Earth's ecosystems and gives life to the trillions of organisms that live in the oceans, air, and land. Solar energy also powers the winds, ocean currents, and weather systems that help control our planet's climate system. In fact, you can think of the Earth as a solar-powered spaceship, in orbit around a star!

The Earth's Solar Energy Budget

The amount of sunlight the Earth receives from the sun is fairly constant. One of the challenges for scientists has been to understand how the limited solar energy is shared among oceans, soil, plants, rocks, the atmosphere, and other parts of the Earth's surface. This helps to explain how climate and weather work, and what makes ocean currents and winds behave the way they do.

The diagram below explains the Earth's "energy budget."

How the Earth "spends" its energy budget.

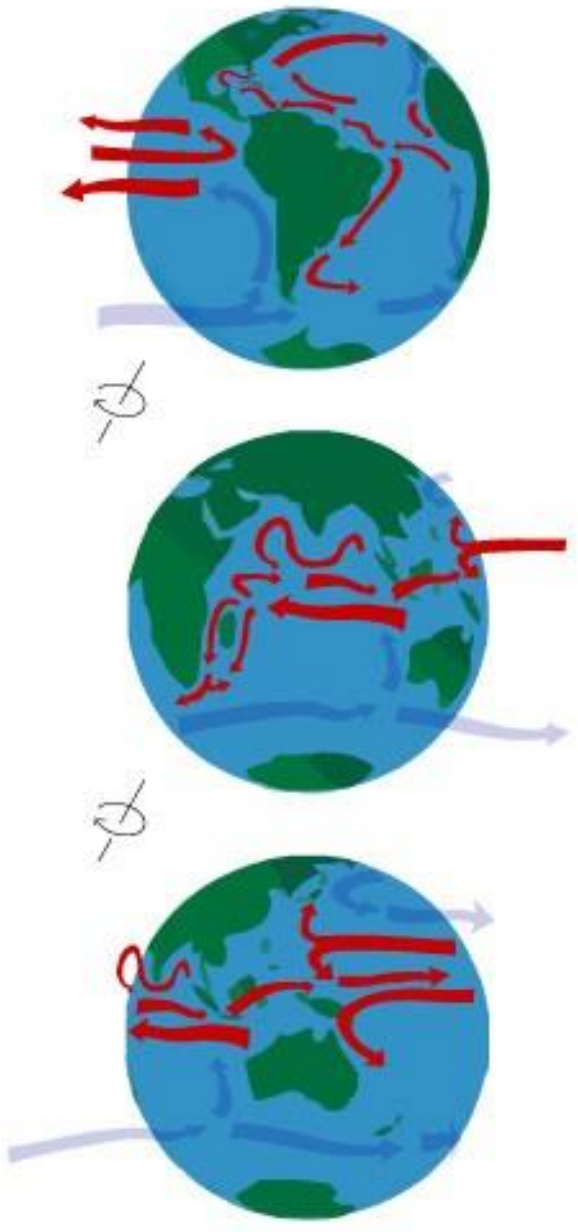


Looking at the diagram, you'll notice that about half of the energy is reflected (bounced back) into space by clouds and shiny surfaces such as snow and glaciers. The rest is absorbed. Some of this energy is captured by plants and turned into food for other organisms. Some heats up oceans, while yet more of it is used to evaporate and lift water vapour from oceans, rivers, and lakes.

Because the Earth is round, the equator gets more direct sunlight than the polar regions. For this reason, the equator must absorb more sunlight than the polar regions, and therefore gets hotter. The oceans and atmosphere are able to carry this heat away from the equator and bring it to the polar regions of the planet. If it were not for this process, the equator would be too hot to support life, and the poles would be too cold! Thankfully, the heat gets spread around

the planet fairly well, and ecosystems thrive in almost every part, except perhaps the very centre of the Antarctic and Greenland ice caps.

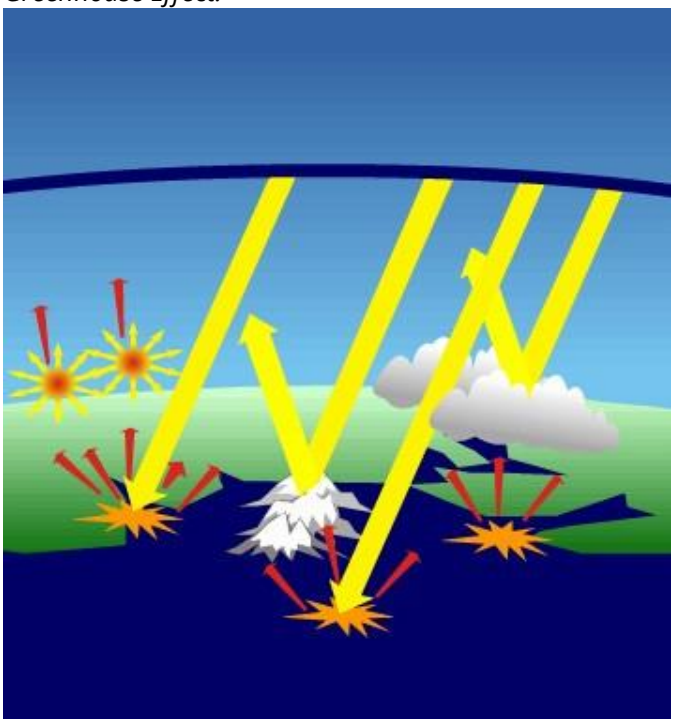
Ocean currents. Ocean currents and winds carry heat from the equator to the poles.



The Greenhouse Effect

The atmosphere contains gases that have the ability to absorb heat. These gases are called **greenhouse gases**. The atmosphere's main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapor (H_2O). Together they make up less than one-tenth of one percent of the atmosphere's total volume. The rest of the atmosphere contains mostly nitrogen (78 percent) and oxygen (21 per cent), neither of which capture much heat.

Greenhouse Effect Diagram. Caption: The Earth's Greenhouse Effect.



The greenhouse gases are present in the atmosphere in just trace amounts. Even so, they have an extremely important role in determining climate. By trapping heat, they help maintain Earth's average temperature at about +15 degrees Celsius (°C). Without greenhouse gases, the average temperature would be 33°C colder than it is now, and Earth would be a lot more like Mars, a frozen, dusty, lifeless planet.

Green Thumb: Climate Change

Humans are messing with the Earth's climate system! Each day, billions of tonnes of carbon dioxide and other pollutants into the atmosphere from cities, towns, and farms. Mostly, the carbon dioxide is released from things that burn gasoline, diesel, coal, and other fossil fuels. Human activities such as transportation have increased the amount of carbon dioxide in the atmosphere by about 30 percent. Another important greenhouse gas, methane, has more than doubled in the atmosphere from human activities. Scientists believe these changes to the atmosphere are making the atmosphere warmer, adding up to global-scale change in the Earth's climate.

Key Points to Remember

- Ecosystems absorb and convert energy just like organisms do, but are much more complex.
- Energy in ecosystems is released back to the environment as heat.
- The Earth is a planet-sized energy conversion system, with ecosystems, oceans, an atmosphere, and other components that absorb and release energy.
- Parts of the Earth receive more energy than other parts because of the Earth's shape.
- Winds and currents carry heat from the equator to the poles.
- Most scientists believe human activities are changing the Earth's atmosphere, contributing to a warming of global climates.