
DAILY EARTHPOEM
EARTHPOEM ARCHIVES
SEARCH
ARTIST/NATURALISTS
SITE MAP
DONATE
TEACHER RESOURCES
LEARN ECOLOGY
KIDS' EARTH POEMS
KIDS' EARTH HEART
MEMBERS' WRITING
JOHN CADDY
ABOUT MORNINGEARTH
HOME
CONTACT
LINKS

## Yearning To Be Round 5

# Energy Flows From the Sun and Through the Biosphere

**For a graphics-rich treatment of this material, go Here.**

Solar Light drives Photosynthesis
the foundation of all life

Chlorophyll + Sun + Water + Carbon Dioxide
convert light into packaged sun energy called Food

Plant-packaged sun energy transfers from life to life

Solar Heat drives the water cycle, the winds, the ocean currents

# Introduction

This reading explores the work of life on earth, which is:

- **the transfer of energy from life to life**
- **the transformation of energy from form to form**

# What Is Energy?

As you know, our bodies are composed of billions of microscopic subwholes called cells. Each of these cells is contains little power plants called mitochondria. Cells take in food and oxygen and turn them into something called energy.

Energy is a word we hear a lot. How would you define it?

An energy source is whatever can be converted into heat or motion, for example wind in a sail, a log on a fire.

**Energy exists in several forms:**

- **Light,**
- **Electricity,**
- **Chemical energy,**
- **Motion, and**
- **Heat.**

People think of their own energy as going ‘up’ and ‘down,’ and think of energy as something they can increase or decrease.

Question: You increase energy by:

a) drinking coffee,
b) getting more sleep
c) eating a particular brand of candy bar.

You decrease energy through stress, hard work, and effort expended.
When your energy is low in everyday life you don't get your work done.
In science, energy and work are also closely related. In physical science, "work" means "a transfer of energy ."

## The Solar Shower

Every day as Earth rotates, her surface is entirely showered with light . Light is a form of energy that arrives on Earth in little packets called photons. The sun, of course, is a sphere that radiates light energy in every direction, and Earth only receives a tiny portion of what the sun gives off, yet that "tiny" portion is what makes all Earth-life possible.

**Mind-Experiment:** In a darkened room, turn on a flashlight and lay it on the edge of a table, so it shines across the room. The flashlight is the sun. Now take a tennis ball (or any ball) and hold it in the center of the flashlight's beam. The ball is Earth. Next, rotate the ball on its axis. Notice how the light illuminates all sides of the ball as it turns. Now look: what parts of the surface of the ball are getting the least light? Yes, the top and bottom. Now you know why the North Pole and South Pole are cold.

## Making a Living

To stay alive, every living thing has to have a way to make a living.
Life is endlessly inventive—it is always trying out new things.

Life's second great invention was to find a way to use light to make a living.

• Photosynthesis is what we call that invention. It means “putting together (*synthesis*) with light (*photo*)”

• The process of photosynthesis is complex, so we will simplify:

• Inside some living cells is a substance called Chlorophyll, which gives plants their green color

• Putting together **Chlorophyll + Light + Carbon Dioxide + Water** transforms light energy into chemical energy we call food, in the form of carbohydrates (made of carbon from the carbon dioxide; hydrogen from the water, and oxygen from both)

• photosynthesis is a way of packaging and storing energy that came from the sun.

## Ways of Making a Living: How lives get their energy

| Lifestyle | Notes | Dependencies |
|---|---|---|
| **Photosynthesis** | Plants **Producers** absorb sunlight and transform it into chemical energy. • Plants package the sunlight energy into food we call carbohydrates. | Plants depend on the sun. |
| **Grazing & browsing** | Animals such as deer, rabbits and grasshoppers, eat leaves and bark, usually without killing the plants.<br><br>These **primary consumers** package the sunlight energy as a mixture of proteins and fats we call meat. | Grazers & browsers depend on plants. |

| | | |
|---|---|---|
| **Predation** | Carnivorous animals such as frogs, shrews, snakes, owls, skunks, mink, and owls kill and eat other animals.<br><br>These **secondary consumers** package the sunlight energy as a mixture of proteins and fats we call meat. | Carnivores depend on grazers and browsers |
| **Parasitism** | Parasitic plants and animals, such as mistletoe and leeches, take food from other organisms, usually without killing them, but give nothing in return.<br>The parasite usually lives attached to or inside the host organism. | Most parasites depend on one or a few species they coevolved with. |
| **Symbiosis** | Symbiotic organisms combine to live mutually so that both benefit.<br><br>Lichens combine fungus and either algae or cyanobacteria.<br><br>95% of plants combine their roots with fungi to help them absorb nutrients.<br><br>Multicellular plant and animal cells began existence as combinations of different kinds of bacteria.<br><br>The largest symbiosis on Earth is between all plants and all animals: Plants breathe out oxygen and breathe in carbon dioxide, and animals breathe out carbon dioxide and breathe in oxygen. | Symbionts depend on each other. |

| | | |
|---|---|---|
| **Detritus–Feeding** | Detritus is organic particles left after plants or animals are partially decomposed.<br><br>Earthworms and many oceanic bottom-dwelling worms are detritus feeders and play a vital role in re-cycling organisms. | Detritus-feeders depend on dead organisms, mostly plants. |
| **Scavenging** | Scavengers such as vultures and jackals feed on dead animals—they are carnivores who wait until their prey are dead.<br><br>Scavengers prepare bodies for decomposers. | Scavengers depend on non-microscopic dead animals |
| **Decomposing** | Many bacteria and fungi feed on dead organisms and break them down into their chemical constituents.<br><br>Decomposers restore life-materials to the ecological nutrient pools and prepare them for re-cycling. | Decomposers depend on dead organisms. |

**FYI:**

Most plants are not grazed or browsed. Most animals are not eaten by predators; their energy and nutrients follow different, shorter paths through the ecosystem. Most just die; from winter, disease, age, disaster.

## Energy Transfer

As living things on Earth make their livings, chemical energy transfers from life to life to life.

The path of this transfer is called a **food chain**.

A food chain is a simplified description:
One pond community food chain might be **algae to snail to turtle**.

But real life is not quite that neat and orderly.
Instead, the lives in a pond are a complex community that creates many food chains and transfers energy from life to life in all sorts of ways. We call this complex combination of energy transfers a **food web**.

In the words of Biologist E. O. Wilson, *energy is carried as in a leaky bucket from one species to another through the food webs of organisms.*

Producers (plants) are partially eaten by grazing animals, which are eaten by meat-eating animals (sometimes), which, when they die are eaten by the decomposers.

At the end of all food chains the energy has been used up, and is replaced by new input of light from the sun.

So energy flows through a community and is lost, but is then restored to the community system by plants.

If you drew a picture of how energy travels through a community, you would draw a straight line, or a steady stream of drips from Dr. Wilson's leaky bucket.

**One clarification:** food chains sound dramatic, because they involve killing. We must bear in mind, when considering energy transfers, that many animals die from age and debility, not from being killed by a predator. Similarly most plantsare not eaten.
The result of these less dramatic food chains is a path of two or three links. Pathogens and parasites may be links in these chains. Scavengers may be links as well. With plants especially, fungi are links. The final link in these chains, like all others, are the decomposers, bacteria.

## Energy Sharing

When we see Life as a whole system (the Biosphere), we do not think in terms of its individual parts.

So when one mouse is eaten by one hawk, we can see that as an energy transfer, which it certainly is.

All lives stay alive on energy transfers and end in death.

When we look at the whole system of the Biosphere, how we see it is a choice we make:

- we can see it as a horrible tragedy, a slaughterhouse of “nature red in tooth and claw”, or
- we can see it as a system of energy sharing which is essentially cooperative.

All life on Earth survives by feeding on other lives. We live by eating each other. That is the way things are.

What is good for the health of the system is not necessarily good for single lives in that system.

Here we have to be cautious about imposing our human moral judgments onto other lives.
It is not especially ugly when a carrot dies.
But when the rabbit who ate the carrot dies, it can be ugly (to humans).

If the rabbit was smeared across a highway by a car, that is ugly.
If the energy the rabbit contains is not used by other lives, that may look ugly and wasteful.

But in fact life is so resourceful that living things always find a way to make a living off

whatever is available.
All the car did was to shorten the food chain.

The crow was happy with the meat she carried back to her nestlings, the sparrow was happy with the fur lining his nest, and forty billion bacteria were living the good life in what was left.

We live by eating each other simply means that Life on Earth is a system of Energy Sharing.

It is never eat **or** be eaten; it is always eat **and** be eaten.

## Energy Transformation

As living things transfer energy from life to life within a food web,
energy transforms from light energy (photons) that plants use, into chemical energy (food) into heat energy, which is its final form.

Energy changes form, from **Light to Chemical Energy to Heat.**

When animals eat, they use the chemical energy that was converted from sunlight by plants.
Digestion, or the process of breaking down and releasing chemical energy for use is part of metabolism.
Metabolism breaks down or burns our food (catabolism), but it also builds up new cells for replacement and growth (anabolism).

At each feeding level in a food chain, only about 10% of the available energy is used for growth and staying alive.
Ecologists call the unused energy (90%) ‘lost’ energy or ‘wasted’ energy. It is lost as heat, and dissapates into the atmosphere.

The radiated heat energy has escaped the system of Earth's biosphere—Life can't use it anymore.

## Energy Storage

Plants store chemical energy by growing larger bodies.
Animals store chemical energy similarly.

Earth as a whole has some processes which store large amounts of chemical energy just under her skin.

Earth stores transformed sunlight:

- for the short term, inside living organisms; much of this energy is stored in ocean algaes and in bacteria.
- for slightly longer, in the wood of trees and in seeds
- for the long term (millions of years) in fossil fuels: peat, coal, petroleum, and natural gas, which are stored chemical energy derived from sunlight which fell on Earth millions of years ago.

Now, coal, petroleum, and natural gas are our civilization's primary sources of energy, so we are, in fact, driving cars powered by ancient sunlight.

And we are heating our homes with ancient sunlight as well.
We are watching TV powered by burning ancient sunlight which was transformed into coal. And so on. We use up all the energy we can find.
We have learned how to tap stored energy through mining and drilling, but we humans have not learned much about storing energy. We can store food energy for some time as dried grain seeds. We can store electrical energy briefly in batteries. But we are not about to wait around for Earth to make more oil and gas.

In the words of Earth educator Steve van Matre,
*We are riding this great resurrected wave of old sunlight energy, refusing to believe it will*

*ever end.*

## Renewable and Non-renewable Energy Sources

At the beginning of this reading we said “an energy source is whatever can be converted into heat or motion, for example, a log on a fire, wind in a sail, ”

One way to look at energy sources is in terms of whether they are renewable, or whether once we’ve used them, they are lost as heat, or non-renewable.

The non-renewable sources are peat, coal, petroleum and natural gas.
Most renewable sources are renewed by the sun, just as plants are.

The seven Renewable energy sources are:

- direct solar heating, using infrared radiation, of dwellings and of water for dwellings.
  The use of solar heating requires only changing home design to collect sunlight properly.

- windpower (based on solar heating),

- hydropower, harnessing flowing water to turn wheels and to make electricity, also based on solar heating)

- photovoltaic cells directly convert light into electricity and are already competitive with fossil fuels in remote areas.

- Geothermal power is renewed not by the sun but by the heat from Earth’s mantle.

• Tidal power is renewed by the gravitational pull of the moon on Earth.

• Biomass conversion (the fermentation of plants into alcohol, and the decomposition of plants into methane gas, which are in turn based on solar light)).

We are looking for energy to use wherever we can find it. We need alternative sources of energy to supplement and eventually replace fossil fuels, which our civilization is rapidly using up.

## Solar Heating:
## Water Cycle, Wind, and Ocean Currents

Just as we animals are completely dependent on solar energy by way of plants, we and plants and all other life depend on water: nothing can live without it. Water can be liquid, or solid (ice), or gaseous (water vapor).

The change of water from phase to phase, and its circulation around the earth, is called the water cycle.
It is the largest physical process on earth, and it is powered by solar heating.
The primary sequence of the water cycle is evaporation followed by condensation, followed by precipitation (rain, snow) followed by flow into soil, rivers, lakes and the ocean, and evaporation again.

Solar heating also powers the winds, which create the weather that affects our every day.

The winds in the atmosphere circulate entirely around Earth.

The primary process of the winds is the unequal heating of Earth’s surface, which is the

result of the way light is absorbed.

Lighter colored areas of Earth's surface reflect more light; darker areas absorb more light, so they become warmer.
When air becomes warm, it expands and becomes lighter, and rises higher in the sky. When warm air rises, cooler air rushes in beneath it, and this rush is what we call wind. The global winds are a central part of the water cycle as well. Wind is water's delivery system.

Solar heating powers yet another enormous distribution system: the ocean currents. Heated fluids like water and air always become lighter and rise, so heat sets water in motion.

The ocean currents distribute heat and life materials around Earth.
Without the warming effects of the ocean currents, much of coastal Europe and North America would be too cold for us to live in.
They would be more like Greenland, covered with a permanent ice cap where nothing could grow.

## Summary

Let's summarize where we've been. We have been exploring Energy: what it is, what it does, and especially, how it travels and how it transforms. We have been exploring the first principle of ecology,: Life is powered by a flow of energy from the sun.

**Making a Living:** Plants capture sun energy using photosynthesis, and package it as food. Animal eat plants to use that food energy. Other animals eat them to use the food energy again. Decomposers end all food chains, and make the basic nutrients available to new lives.
By the time the decomposers are done, all of the original sun energy the plants captured has been used up. It has been released into the air as heat. (except…… Life is full of 'except'—sometimes Earth buries plants and animals before the decomposers can do

their job, so that energy gets stored as fossil fuels.)

Plants are energy **producers** and animals are energy **consumers.**

Plants feed themselves; they are **autotophs**. Animals feed on others; they are **heterotrophs**.

**Energy Transfer:** Sun-energy which has been re-packaged by plants as chemical energy is transferred from life to life to life within complex community food webs. Energy is rapidly lost as food moves through food chains.

Life-materials cycle, or circle, through the Biosphere. Energy flows in a straight line like an arrow and is used up, but is constantly renewed by sunlight.

**Energy Sharing:** The biosphere is a system of energy sharing. All organisms eat and all are eaten.

**Energy transformation:** The typical path of sunlight energy is a change of form from light to chemical energy to heat. Another energy path is from light to heat to the movement of wind and ocean currents and back to heat.

**Energy storage:** We know very little about how to store energy, but Earth does. She slowly makes fossil fuels which our way of life is completely dependent on, but we are rapidly using them up.

**Renewable and Non-renewable Energy Sources:**The non-renewable sources are peat, coal, petroleum and natural gas. The most important renewable energy sources are photovoltaics, solar heating, hydropower, and wind power. Others are geothermal, tidal, and biomass conversion.

Our civilization demands huge amounts of energy. Almost all of what we currently use is fossil energy—oil and gas, which are limited in quantity. We need alternative sources of energy to supplement and eventually replace fossil fuels. We may also need to change some of the ways we live, and focus on the quality of our lives rather than on the quantity

of our possessions.

**Solar Heating: Water Cycle, Wind, and Ocean Currents**: The global winds create weather, which delivers water to Life, and the global ocean currents distribute nutrients around the Earth and help create climate . Both are powered by the sun.

## Some Sources for Energy and How Lives Share It

Eliade, Mercia, *The Sacred and the Profane*
*Encyclopedia Britannica*
Odum, Eugene, *Fundamentals of Ecology*
Tester, John, *Minnesota's Natural Heritage*
Van Matre, Steve, *Earth Education, A New Beginning*
Vernadsky, Vladimir, *The Biosphere*
Wilson, E. O. *The Diversity of Life*

**Note: For a graphics-rich treatment of this material, go Here.**

Top of Page