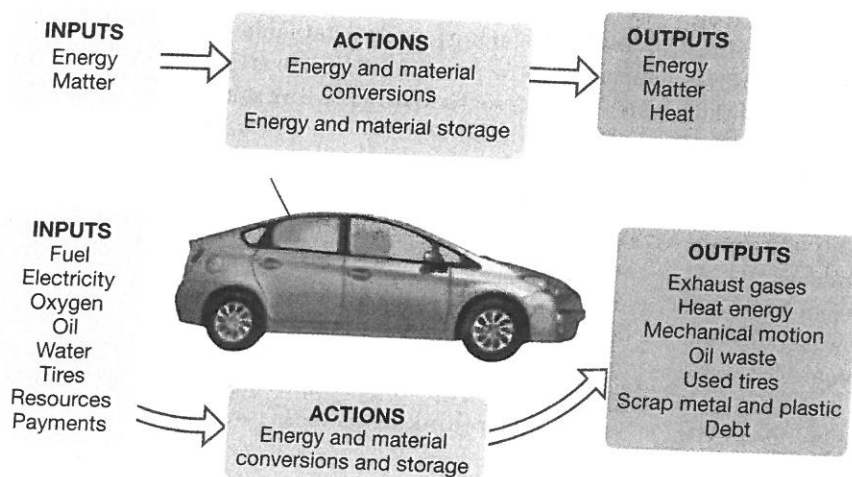




▲**Figure 1.5 An open system.** In an open system, inputs of energy and matter undergo conversions and are stored or released as the system operates. Outputs include energy, matter, and heat energy (waste). After considering how the various inputs and outputs listed here are related to the operation of the car, expand your thinking to the entire system of auto production, from raw materials to assembly to sales to car accidents to junkyards. Can you identify other open systems that you encounter in your daily life?

may be arranged in a series or intermingled. A system may comprise any number of subsystems. Within Earth's systems, both matter and energy are stored and retrieved, and energy is transformed from one type to another. (*Matter* is mass that assumes a physical shape and occupies space; *energy* is a capacity to change the motion of, or to do work on, matter.)

Open Systems Systems in nature are generally not self-contained: Inputs of energy and matter flow into the system, and outputs of energy and matter flow from the system. Such a system is an **open system** (Figure 1.5). Within a system, the parts function in an interrelated manner, acting together in a way that gives each system its operational character. Earth is an open system in terms of energy because solar energy enters freely and heat energy leaves, going back into space.

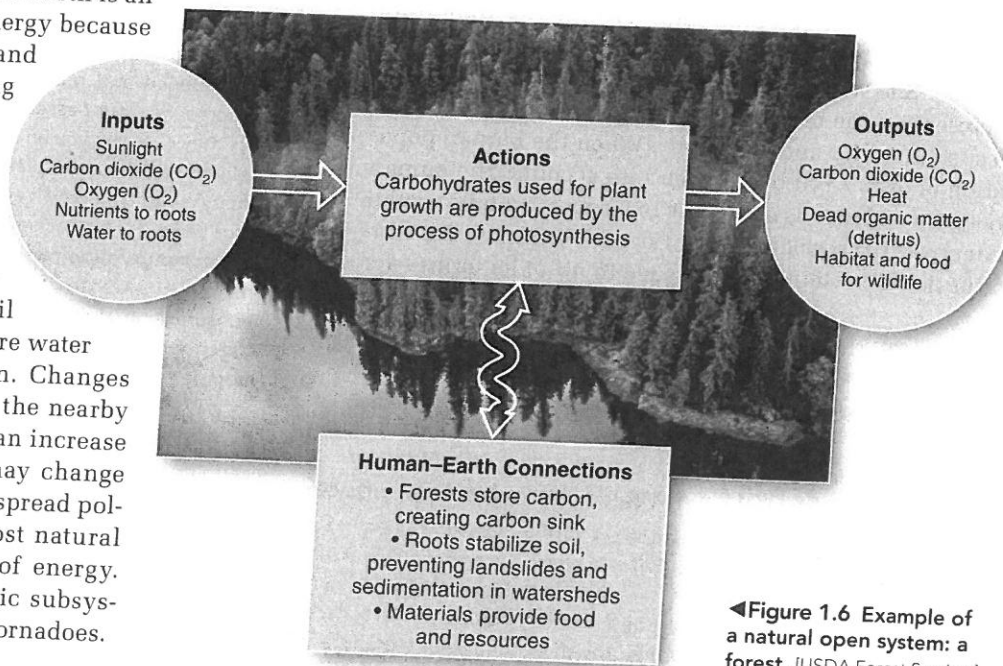
Within the Earth system, many subsystems are interconnected. Free-flowing rivers are open systems: Inputs consist of solar energy, precipitation, and soil and rock particles; outputs are water and sediments to the ocean. Changes to a river system may affect the nearby coastal system; for example, an increase in a river's sediment load may change the shape of a river mouth or spread pollutants along a coastline. Most natural systems are open in terms of energy. Examples of open atmospheric subsystems include hurricanes and tornadoes.

Earth systems are dynamic—active and energetic—because of the tremendous infusion of radiant energy from the Sun. As this energy passes through the outermost edge of Earth's atmosphere, it is transformed into various kinds of energy that power terrestrial systems, such as kinetic energy (of motion), potential energy (of position), and chemical or mechanical energy—setting the fluid atmosphere and ocean in motion. Eventually, Earth radiates this energy back to space as heat energy.

Closed Systems A system that is shut off from the surrounding environment so that it is self-contained is a **closed system**. Although such closed systems are rarely found in nature, Earth is essentially a closed system in terms of physical matter and resources—air, water, and material resources.

The only exceptions are the slow escape of lightweight gases (such as hydrogen) from the atmosphere into space and the input of frequent, but tiny, meteors and cosmic dust. The fact that Earth is a closed material system makes recycling efforts inevitable if we want a sustainable global economy.

Natural System Example A forest is an example of an open system (Figure 1.6). Through the process of photosynthesis, trees and other plants use sunlight as an energy input and water, nutrients, and carbon dioxide as material inputs. The photosynthetic process converts these inputs to stored chemical energy in the form of plant



◀**Figure 1.6 Example of a natural open system: a forest.** [USDA Forest Service.]