ENERGY TRANSFER

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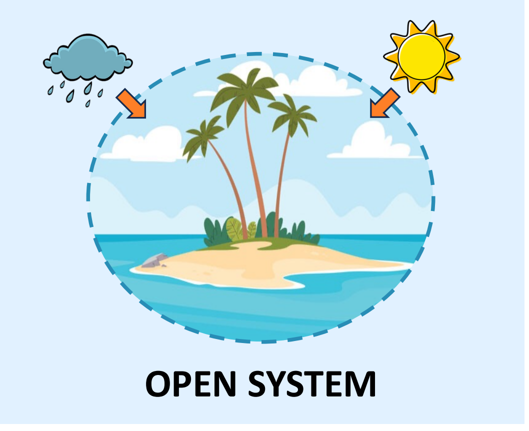
SOURCES OF ENERGY

Ecological systems can be described as open or closed according to the exchange of energy and matter. In an open system both energy and matter can enter and exit, whereas matter cannot enter a closed system. Individual ecosystems are considered to be **open systems** with energy being constantly introduced as **light**. Certain ecosystems may not be exposed to sunlight (such as underground caves and hydrothermal vents in the deep sea) and may instead rely on the **oxidation** of inorganic molecules as an alternative energy source. In ecosystems, each energy conversion results in a loss of some energy that must continuously be replaced.



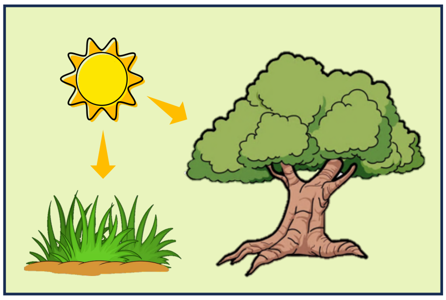
The entire Earth is considered a closed system. Single biomes are considered open systems as matter can enter or exit via rain, wind or animal migration

ENERGY CONVERSIONS

All living things require chemical energy to maintain the functions of life. In most ecosystems, this energy is supplied by sunlight and stored in organic compounds via **photosynthesis**. Alternatively, energy for making organic compounds can be derived from the oxidation of inorganic molecules (**chemosynthesis**). The stored chemical energy is released via **cell respiration** to produce ATP, which acts as an energy currency within the cells. The energy stored within the carbon compounds can be transferred between organisms via **feeding**.

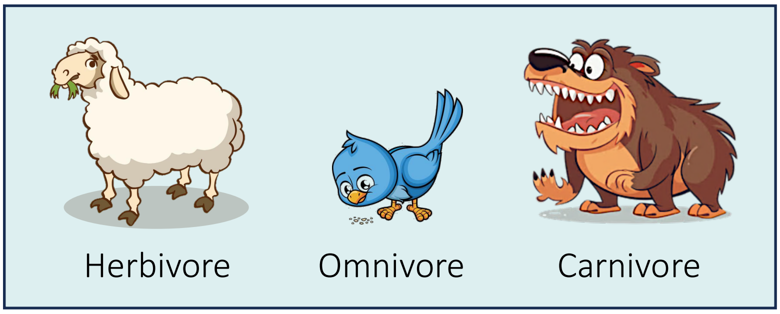
AUTOTROPHS

Autotrophs are organisms that synthesise organic compounds from simple inorganic substances. A photoautotroph sources the energy for this process from sunlight, while a chemoautotroph uses energy from the oxidation of inorganic materials. Because autotrophs make their own food without relying on any other organism, they are said to be **producers**. Autotrophs include plants, algae and cyanobacteria.



HETEROTROPHS

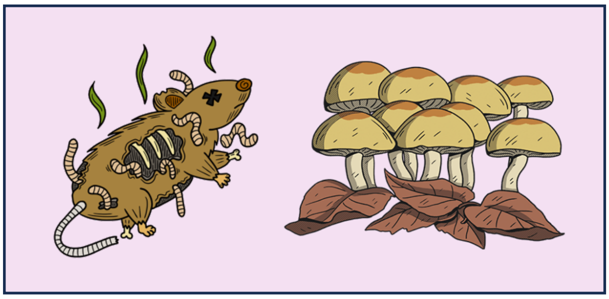
Heterotrophs are organisms that obtain carbon compounds from other organisms to synthesise the organic molecules that they require for survival. In other words, a heterotroph obtains organic material via feeding. Heterotrophs that gain nutrition via internal digestion (i.e. holozoic nutrition) are referred to as **consumers**.



Types of Consumers:
Consumers are classed as *herbivores* if they feed principally on plant material, *carnivores* if they feed on animal tissue or *omnivores* if the diet is composed of both plant and animal material.

SAPROTROPHS

Saprotrophs are heterotrophs that gain organic nutrients from dead organisms via external digestion. They live on (or in) non-living organic matter and secrete enzymes to break down organic material for subsequent absorption. Because digestion is external, they are commonly called **decomposers**. Examples include most bacteria and fungi.



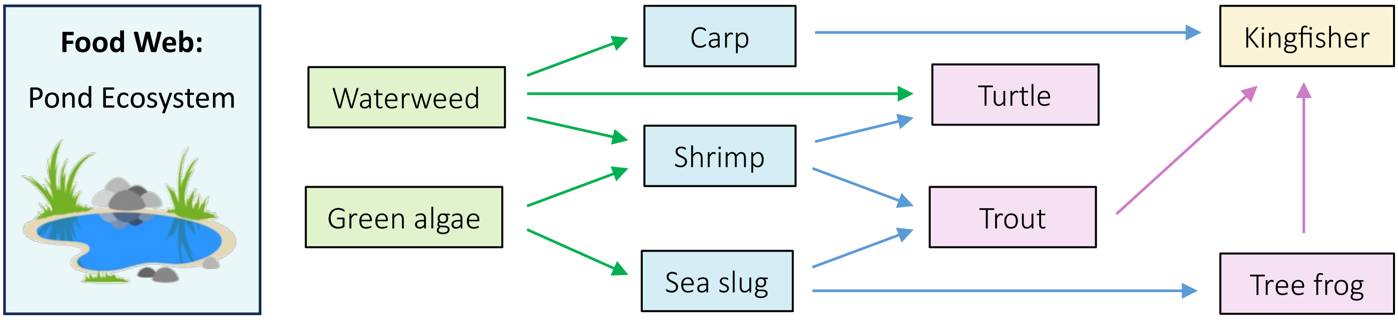
TROPHIC LEVELS

The position an organism occupies within a feeding sequence is known as a **trophic level**. Producers always occupy the first trophic level in a feeding sequence, while consumers are ordered sequentially (i.e. primary, secondary, etc.). As decomposers feed on all dead organisms, they are not usually assigned a trophic level.

	1	2	3	4
Position	Producer	Primary Consumer	Secondary Consumer	Tertiary Consumer
Example	Sunflower	Fruit fly	Green tree frog	Kookaburra

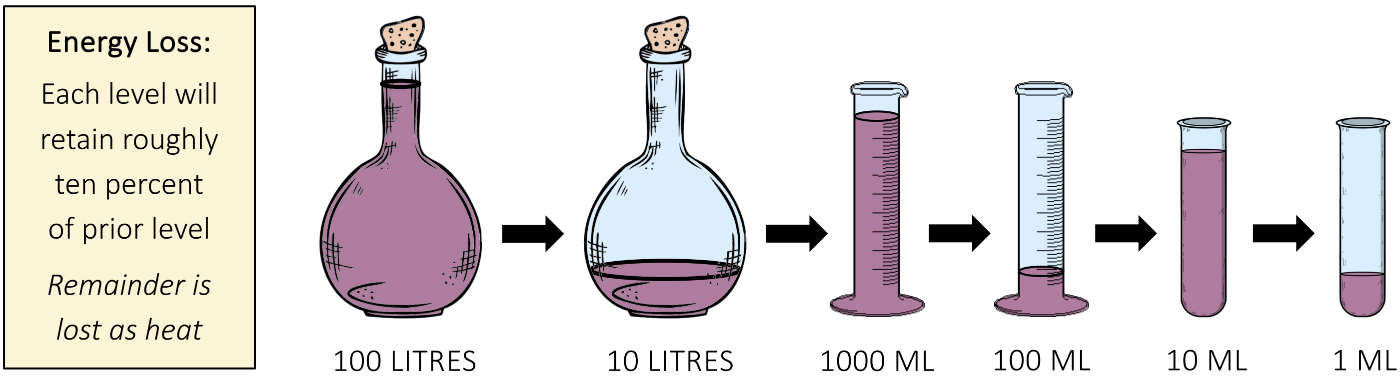
FEEDING PATHWAYS

The flow of chemical energy between trophic levels can be represented by a **food chain**. Arrows are used to represent the transfer of energy and biomass from a food source to a consumer. Food chains will only show linear feeding relationships between species in a community. A **food web** displays many food chains linked together to represent more complex feeding relationships. Organisms within a food web can have multiple food sources and many predators – so, unlike in food chains, they can occupy more than one trophic level.



ENERGY LOSS

Not all energy stored in organic molecules is transferred via heterotrophic feeding – some of the chemical energy remains undigested (either unconsumed or excreted as faeces). Additionally, the energy conversions that occur during cell respiration release thermal energy (**heat**) as a by-product. Living organisms cannot convert heat energy into other usable forms and the energy is subsequently lost from ecosystems. Typically, energy transformations are roughly **10% efficient**, with about 90% of available energy lost between trophic levels. As the energy content of a unit of mass does not change, the reduction in energy means that there will be less total biomass at higher trophic levels – leading to fewer organisms or smaller organisms at each successive stage in a food chain. With less biomass available, higher order consumers will need to eat larger quantities of prey to obtain sufficient energy, but will also require a greater expenditure of energy to hunt the requisite amount of prey. This restricts the number of trophic levels in an ecosystem (maximum 4 – 5).



ENERGY PYRAMIDS

A pyramid of energy is a graphical representation of the amount of energy at each trophic level of a food chain. They are expressed in units of energy per area per time (e.g. kJ m^{-2} $year^{-1}$). A pyramid of energy will never appear inverted as some of the energy stored in one source is always lost upon transfer – each level is roughly one tenth of the size of the preceding level, as energy transformations are ~10% efficient. The bottom level of an energy pyramid always displays the producer, with higher levels representing consumers.