# Thermodynamics and waste

The first law of thermodynamics says that materials are never lost, merely transformed into other materials. The second law ways that every materials transformation that increases order – or usefulness -- in some material reduces order and increases disorder in others. Perpetual motion is impossible. The life cycle of a material product reduces its usefulness and eventually becomes a waste unless it can be reused, repaired, remanufactures of recycled. Exergy (useful energy) from some external sources is required for all of these activities, especially for recycling. Since most useful energy (exergy) is derived from fossil fuels, and fuel combustion is an irreversible process that produces unrecyclable wastes, slogans like “zero waste” are extremely misleading. A more realistic goal is to recapture and recycle rare (but useful) elements for which there are no good substitutes. It is not true that nature produces no wastes. On the contrary, the oxygen in the atmosphere was a waste that only because useful after a mutation created a new type of organism to engage in respiration. Iron ore is the waste product of early anaerobic creatures in the sea. Limestone is a waste product. Fossil fuels were wastes. However nature does recycle certain valuable nutrient elements. Humans must learn to do the same, especially for important metals.