

Holistic Reasoning and Generalization of the Second Law of Energy Degradation and Entropy Generation

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Even today, the *Second Law of Thermodynamics* remains obscure, due to the lack of its holistic and subtle comprehension, and it continues to attract new efforts at clarification, including this one. The theory of classical Thermodynamics was originally based on thermal and mechanical energy transformations, but it has been expended to all different types of work and heat interactions and thus effectively became Thermo(*multi*)dynamics, the general energy science, considered by some to be “the *Mather of all sciences*.”

Any change/process is caused/requires mass-energy flux exchange, i.e., it is a forced displacement of non-uniform mass-energy in space, ultimately resulting in equilibrium. Therefore, the force concept is the cause-and-effect force-flux phenomena. In that regard the *Newton's Laws* of motion and forces, which overlap each other, are special cases of more general Thermodynamic Laws, the latter have much wider, including philosophical significance and implication, than their simple expressions based on the experimental observations – they are *The Fundamental Laws of Nature: The Zeroth* (equilibrium existentialism), *The First* (conservational transformationalism), *The Second* (forced-directional, irreversible transformationalism), and *The Third* (unattainability of emptiness). They are defining and unifying our comprehension of all existence and transformations in the *Universe*.

The second law of Thermodynamics is among the most fundamental principles of engineering, science and nature. Since its discovery about one-and-a-half century ago, its status is generally considered supreme. However, the Second Law has come under unprecedented scrutiny during the last couple of decades by research groups worldwide. It caused some proponents of the Law to unnecessarily take defensive by restricting its validity to the isolated systems and global physical processes.

It is reasoned and deduced here that the Second Law is universally valid for all space and time scales, and without exceptions. During forced interactions (thus all processes) the momentum and energy are conserved at local scale and therefore at any integral space and time scales. However the momentum and energy are spatially redistributed in time and directionally equi-partitioned into ‘randomized’ thermal energy (dissipated via heat) giving rise to *irreversible generation* of thermal energy per absolute temperature, known as *entropy*. In reality entropy is always generated (in part or in whole) within locality of system structure, while otherwise and in limit it is conserved during reversible processes (without energy dissipation), but it cannot be destroyed since it will imply creation of non-equilibrium from nowhere or from within an equilibrium alone (without required non-equilibrium forcing).

The Second Law is often challenged in biology, life and social sciences, including evolution and information sciences, all with history rich in confusion. Organization/creation of technical (man-made) and natural (including life) structures and thus ‘creation of local non-equilibrium’ is possible and is always happening in many processes while entropy is generated (never destroyed), using another functional structures (channeling/filtering, pumping, with tools, hardware/software templates, information-knowledge-“intelligent” templates, DNAs, etc.). However, the mass-energy flow/transfer within those structures will always and everywhere dissipate energy and generate entropy (*according to the 2nd Law!*), i.e. on the expense of internal and/or surrounding/boundary systems' non-equilibrium. It may appear that the created non-equilibrium structures are self-organizing from nowhere, from within an equilibrium (thus *violating the 2nd Law*), due to the lack of proper observations and ‘accounting’ of all mass-energy flows, the latter maybe in ‘stealth’ form or undetected rate at our state of technology and comprehension (as the science history has though us many times). *The miracles are until we comprehend and explain them!*