Entropy and Applied Energy

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Abstract

Creationists have long used the second law of thermodynamics in arguments against evolution. The response has been that a system's entropy can decrease if energy is applied to that system and that the earth is such an open system. The problem is that there seems to be no general principle that shows how applied energy affects entropy. Even the most casual of observations shows that applying energy to a system can either increase or decrease entropy, depending on the nature of the application. This fact is best illustrated by the difference between construction work and a bomb. Despite this, there seems to be no general principle describing this difference. It turns out that statistical analysis of the problem provides this needed general principle. Herein it is shown that when energy is applied to a system, it tends to move the system's degree of randomness toward that of the applied energy. The result is that energy applied in an organized manner will decrease entropy, while energy applied in a random manner will increase entropy.

Introduction

The second law of thermodynamics has long been used by creationists to argue against evolution, particularly in the case of abiogenesis. This is because the second law shows that, left to itself, a system's entropy will always increase. However, it is known that the entropy of a system can be decreased by applying energy to that system, but there seems to be no general principle that addresses how applied energy will affect entropy. Even from the most casual of observations, it is clear that how energy is applied to a system determines how it affects the system's entropy. Energy can be applied in an organized manner, such as construction work, resulting in a decrease in the system's entropy; or it can be applied in a random manner, such as a bomb, resulting in an increase in the system's entropy. A statistical analysis of the problem provides this needed general principle.

Background

Statistically, entropy is logarithmically related to the randomness of a system (Bromberg, 1984), as shown in formula 1.

$$S = k \ln \Omega \tag{1}$$

where:
S = entropy

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k = Boltzmann constant = 1.380662×10^{-23} J K^{-1}
Ω = the number of equivalent micro states (possible arrangements) of a system.

Now the change in the entropy of a system is:

$$\Delta S = S_2 - S_1 \tag{2}$$

Now, plugging formula 1 into formula 2 produces:

$$\Delta S = k \ln \Omega_2 - k \ln \Omega_1 = k \ln \Omega_2 / \Omega_1$$

Such that:

$$\Delta S = k \ln \Omega_2 / \Omega_1 \tag{3}$$

Because of these relationships, the problem of applied energy is best dealt with statistically. Furthermore, any system consists of smaller parts with their own independent equivalent microstates resulting in formula 4.

$$\Omega_s = \Omega_1\, \Omega_2\, \Omega_3\, \Omega_4 \ldots \Omega_N = \prod_{n=1}^{N} \Omega_n$$

$$\Omega_S = \prod_{n=1}^{N} \Omega_n \tag{4}$$

where Ω_s is the total number of equivalent microstates, the product of the number Ω_n of microstates of each of the distinct smaller parts. Plugging formula 4 into formula 1 results in: $S_s = k \ln \Omega_s$, such that:

$$S_S = k\ \mathrm{h} \prod_{n=1}^{N} \Omega_n \tag{5}$$

This forms the bases for analyzing what happens to the entropy of a system when energy is applied to it.

Analysis

The simplest possible system to analyze is one consisting of a single particle that is moved to a targeted location by the applied energy. The entropy of the applied energy (S_e) is related to the accuracy with which it can place the particle, such that Ω_e equals the number of locations (equivalent states) where the applied energy could actually place the particle. The result would be that entropy of the single particle system after the energy is applied would equal the entropy of the applied energy, such that: $S_s = S_e$.

In a complex system, the entropy of the applied energy would be the sum of the entropy of the energy applied to each component part of the system in accordance with formula 5, such that:

$$S_e = k\ \mathrm{h} \prod_{n=1}^{N} \Omega_e \tag{6}$$

If the energy were applied to each component part of the system perfectly, then the entropy of the system after the energy is applied would be equal to the entropy of the applied energy, resulting in $S_s = S_e$. In the real world, this would not be the case, since some energy is lost.

However, at some level this process could be modeled such that some individual components of the system get energy applied to them while others do not. In such a model, each component would have one of two possible outcomes.

1. Component gets energy applied: $\Omega_{2n} = \Omega_{en}$.
2. Component does not get energy applied: $\Omega_{2n} = \Omega_{1n}$.

So when S_{s2} is calculated by formula 5, the total entropy of the system moves toward the entropy of the applied energy such that $\Delta S_{max} = S_e - S_s$. Applying formula 3 to this produces formula 7.

$$\Delta S_{max} = k \ln \Omega_e / \Omega_s \tag{7}$$

In general, this indicates that applying energy to a system will move the entropy of that system. However, the actual change in entropy is a result of the amount of energy applied to the system. The amount of energy applied to a system is measured in the number of component parts of the system to which it is actually applied (σ), which is less than or equal to the total number of component parts of the system (N).

In systems with a variable Ω where energy is applied such that $\sigma << N$ and $\Omega_1 < \Omega_s < \Omega_2$, an anomaly can occur when $\Omega_1 < \Omega_e < \Omega_s$ or $\Omega_s < \Omega_e < \Omega_2$. A small increase in entropy can occur when $\Omega_e < \Omega_s$, or a small decrease in entropy can occur when $\Omega_s < \Omega_e$. In such cases, the change in Ω is limited to the range of Ω already within the system. This is because the anomalous change occurs only because the energy is affecting parts of the system with a $|\Omega_s - \Omega_n| > |\Omega_s - \Omega_e|$.

Discussion

The entropy change formula 7 shows the difference between construction work and a bomb. Construction work has a Ω_e smaller than the Ω_s of the raw material, while in a bomb a Ω_e is larger than the Ω_s of the raw material.

A good illustration is to consider what happens when a system is heated or cooled. It is known that heating a system produces a $\Delta S > 0$, while cooling a system produces a $\Delta S < 0$, and formula 7 shows why this occurs.

At the molecular level, heat energy is applied randomly such that $\Omega_e = \Omega_{s(Max)}$ for any system where $\Omega_s < \Omega_{s(Max)}$, and then heating the system produces a $\Delta S > 0$. This result is shown by $\Delta S_{max} = k \ln \Omega_e / \Omega_s = k \ln \Omega_{s(Max)} / \Omega_s$.

When a system is cooled, the electromagnetic forces between molecules are better able to guide the molecular motion such that the energy of these electromagnetic forces are applied to the system as a whole with $\Omega_e = \Omega_{s0}$ where $\Omega_{s0} = \Omega_s$ at absolute zero, so that for any system when $\Omega_s > \Omega_{s0}$, then cooling the system produces $\Delta S < 0$. This result is shown by $\Delta S_{max} = k \ln \Omega_e / \Omega_s = k \ln \Omega_{s0} / \Omega_s$.

This principle can be shown to apply to all systems, since the analysis is both system and path independent. The basic principle is that adding more randomness to a system makes it more random and adding more order to a system makes it more organized.

Prediction 1: The general application of energy to a system in a manner more random than that system will increase the entropy of that system.

Prediction 2: The general application of energy to a system in a manner less random than that system will decrease the entropy of that system.

It is already known that conservation and degeneration are observed in natural process, while the improvement processes needed for the evolutionary model are not observed (Williams, 1976). The present principle goes beyond the earlier concept, not only explaining this observation, but also providing the basic thermodynamic principles that set the process types apart. It shows that degeneration results from energy being applied to a system in a random manner, such as heat and radiation. Conservation of order and complexity can occur because it requires no net change. Also, such a conservation system already possesses the order and complexity it needs to maintain itself. A spontaneous improvement process would, by definition, require order and complexity to be produced where none exists. Thus, the present principle indicates that this is impossible, which explains why such processes are not observed.

Implications for the Origin of Life

This principle has profound implications for the idea of a naturalistic origin of life. The simplest possible living cell has a $\Omega_c = \Omega_s$. Energy can be applied to a nonliving system in three natural ways: molecular motion (heat), where $\Omega_e = \Omega_h$; radiation, where $\Omega_e = \Omega_r$; and molecular forces, where $\Omega_e = \Omega_m$.

Since both molecular motion and radiation interact with molecular systems like that of a living cell in essentially a totally random manner, then $\Omega_c << \Omega_h \approx \Omega_r$. Furthermore, while molecular forces do have a degree of order to them, it is far short of the order and complexity of the simplest possible living cell, so the result is that $\Omega_c << \Omega_m$.

This means that all of the naturally occurring forces that could be involved in the origin of life would drive any nonliving system, even those near the degree of order of a living cell, toward increased disorganization. As such, this would prevent any natural process from originating life. This is illustrated by the fact that when even the simplest cell dies, the cell's molecular structure breaks down and eventually disintegrates entirely.

Implications for Information Theory

Since information is a system that encodes and represents an abstract description of something else (Gitt, 1997, p. 85), then an information system would have an extremely low Ω_s. *Noise*, on the other hand, being defined as random changes in an information system, has a vary high Ω_e, such that $\Omega_s << \Omega_e$. The result is that noise always destroys and distorts information and never creates it, as is actually observed in information systems.

Implications for DNA

Deoxyribonucleic Acid (DNA) is the information storage medium for living things (Gitt, 1997, p. 90). Like any information system, it has an extremely low $\Omega_{DNA} = \Omega_s$. Likewise, mutations apply energy to DNA such that $\Omega_m = \Omega_e$. This application of energy has an extremely high Ω_m so that $\Omega_{DNA} << \Omega_m$. This can only result in the information in the DNA being damaged or destroyed, and thus these entropy change equations reinforce the observation that genetic mutations are very harmful (Sanford, 2005).

These results mean the total collapse of all naturalistic methods for producing information in the DNA of living things. Evolutionists often invoke natural selection as a solution. To qualify as an adequate solution, however, natural selection would have to apply energy to DNA with an $\Omega_{ns} = \Omega_e < \Omega_{DNA}$.

As it turns out, natural selection is incapable of meeting the above requirement. Natural selection does not have a well-defined objective, which would be needed to have $\Omega_{ns} < \Omega_{DNA}$ since each DNA instruction has a well-defined meaning within the cell. Furthermore, natural selection does not apply energy to the DNA under consideration. In fact, it does not act directly on DNA; it only reacts to the traits that information of existing DNA produces. As a result there is no Ω_{ns} to be applied to the DNA, meaning that natural selection is totally incapable of increasing genetic information.

Implications for Living Systems

It has been previously shown that living systems are generally conservation systems in that the increase of their entropy over time is slower than that of nonliving systems. This applies not only to individual organisms, but to entire created kinds as well (Williams, 1971). The present principle not only applies to both living and nonliving systems, but also allows the earlier concept to be more clearly explained. The reason living systems are generally conservative is that they apply energy to maintain themselves against degeneration such that $\Omega_e \approx \Omega_s$. However, they increase their entropy because Ω_e is always a little greater than Ω_s. As such, living systems will always increase their entropy over time, even if at a slower rate than a nonliving system.

Summary

It has been shown herein that when energy is applied to a system, the degree of randomness of the system moves toward the degree of randomness of the applied energy. When energy is applied in a manner more random than the system to which it is applied, the system's entropy increases. When energy is applied in a manner less random than the system to which it is applied, the system's entropy decreases. This represents a general concept of how applied energy affects a system's entropy in any application of energy to any system. Furthermore, this provides a solid answer to the argument that a naturalistic origin of life is consistent with the laws of thermodynamics because the earth is an open system. The argument fails because that energy is applied in a manner far more random than the high degree of organized complexity of even the simplest living cell.

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