The Unity of Opposites and the 2nd Law of Thermodynamics, with a biological outcome.

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"*Opposites are complementary*"
Neils Bohr (1885-1962)

"*To regulate something always requires two opposite factors*"
Albert Szent-Györgyi (1893-1986)

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1. Abstract

Difficulties with the 2nd Law of Thermodynamics have given reason to explore Fantappiè's (1944) 'syntropy' hypothesis[2]. Entropy and 'syntropy' are a pair of opposites that convert the 2nd Law into a duality. The negative entropy is linked to the positive 'syntropy' constituting a complementary opposite such that the 2nd Law becomes a duality in which opposite units attract one another. Fantappiè died prematurely and it was not until 2008 that Ludovico reworked and published Fantappiè's original mathematics. Fantappiè believed that his study of entropy and 'syntropy', created a link between physics and biology. In their duality there is the possibility proposed by Wicken (1987) that life emerged from the 2nd Law. The feasibility of such ideas is explored by Fantappiè, as here the 2nd Law as a duality involves the 'physical' (entropy) and the 'biological' (syntropy). Fantappiè's proposal was that entropy is an opposite of syntropy, such that the pair interact in a variety of ways. The pair then constitute the 2nd Law.

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[2] The hypothetical interpretation by Fantàppie (1944) who proposed that 'syntropy' is the complementary opposite to entropy.

2. Background

In an early study of particles, Einstein argued that the displacement of Brownian particles is not proportional to elapsed time but rather to its square root (Einstein, 1956). It was accepted that the most general equation for the energy of particles is the square of energy. Paul Dirac's (1928) theory was a development of the Schrödinger Equation (1926) for quantum mechanics, which dealt with slow-moving particles and required an equation that incorporated electron spin at relativistic speeds (Hussey in Close, 2009). The most general equation for the energy of particles requires that the square of energy (Farmelo, 2009) created an equation with two solutions. The opposing pair of the electron and positron is due to their opposite charges.

Dirac's formula for the energy of the free electron predicted that there were two sets of energy values, one positive and one negative, which both proved to be real. This meant that each complementary couple has a pair of opposites [2]. There followed the understanding that electrons have negative charges and positrons have positive charges, that are opposites[3] and equal in magnitude. The number of electrons is the same as the number of positrons, as the average charge is zero. This implies that every particle has an anti-particle which is the same, except for the opposite charge.

Fantappiè's account of his ideas was published in Italian in 1944 (reprinted in 1993), both were reprinted in Italy. He was a mathematician who became interested in Dirac's theory of the electron. Entropy reaches a physical equilibrium at a maximum, due to the dissipation of energy and matter. Fantappiè deduced that 'syntropy' behaved in the opposite way to entropy, such that energy and matter are concentrated, as indicated by the spherical output of the wave equation (Figure 1).

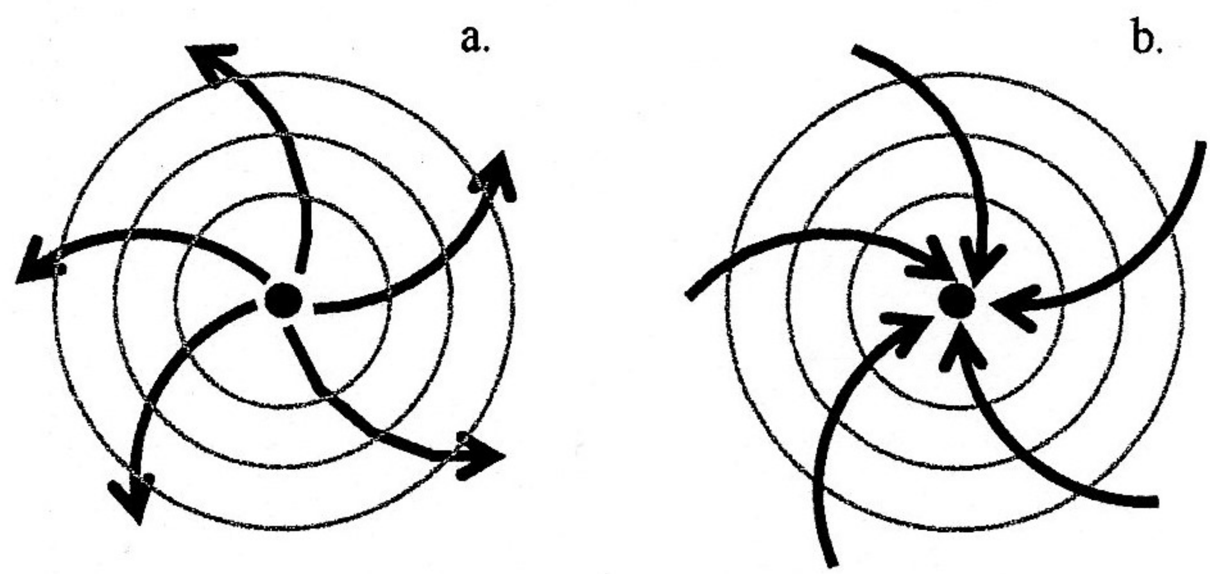

Figure 1. Wave equations are given as the positive and negative consequences, first the centrifugal diverging waves (a) and then the centripetal converging waves (b). Fantappiè interpreted these opposing results such that the divergent waves are due to entropy, and the convergent waves are due to syntropy. He appreciated that the converging waves could not accumulate indefinitely (b)

[3] Entropy and syntropy are complementary opposites originating from Schrödinger (1944). Here the latter are preferred as it explains the origin and the positive and negative are solutions of the Dirac equation

Returning to the Dirac equation, there are two solutions; one negative and the other positive, yet both are real. It is clear that Fantappiè linked his work to the Dirac equation. This included a Unity of Opposites in which the opposites nearby cancel one another out, resulting in zero. This idea was later expressed in an equation of Ludovico (2008). Fantappiè adopted the work of Dirac (1928), particularly his study on the electron and the positron, and applied it to his study of entropy. As the electron is a negative charge, syntropy as a positron has a positive charge.

For Fantappiè (1944) there was a problem which involved the reversal of the passage of time and future causality that was implied by 'advanced' waves. Quantum mechanics is probabilistic, and consists of populations of particles moving at great speed. Cramer (1986) proposed a mechanism by which 'retarded' waves due to the positive solution, became dominant and the negative solution became transient (quantum transition). This implies that any reversal of time would not be significant at an acroscopic level, nor would the logical pattern of causality (see Gribbin, 1995). Consequently quantum changes of large numbers of electrons driven by waves are not relevant at the macro-level. Although Fantappiè wrote of "causes located in the future", it is now acknowledged that the reversal of time is not an obstacle to acceptance of the syntropy hypothesis.

The Dirac equation, and its opposites in the positive and negative, are precursors to the wider application of such opposites, which were adopted by Fantappiè and the Unity of Opposites. It is relevant that entropy and syntropy constitute features akin to a Quadratic Equation, as entropy is negative and syntropy is positive, such that the sum of the parts is equal to zero. The implication is that the pair of opposites are linked and relate to one another.

3. Duality and a higher level of organization

Heraclitus (ca. 535 - 475 BC) first adopted the concept of the *Unity-in-opposites* (Hussey in Long (2006). The Unity of Opposites is a system of at least two opposite conditions, that depend upon each other[4]. A much later analysis of the Unity of Opposites was provided by Hegel (1812). Heraclitus and Hegel accepted the duality of a pair. The unity is succeeded by a duality, with a higher level of organization. This level is observed in Hegel's work. But crucially opposites are due to charges of positive or negative, related to otherwise similar particles. In this way the Unity of Opposites creates a duality more complex than either unity of the 2nd Law. This level is given from Hegel's work (with minor changes in wording),

1. A union of opposite units creates a duality by attracting one another,
2. Attraction draws the elements of the duality together and completion of the whole,
3. The opposing units interact with one another,
4. The forces of attraction by one unit, act directly on the parts of the other unit,
5. Contact between the units of a duality can act upon one another in the area of contact,
6. Opposites cancel one another, so that they result in zero, and the duality constitutes a unity of the whole.

Heraclitus also refers to 'opposites', as a duality in his unity of entropy, although Hegel (1812) wrote later of a 'duality'. Nevertheless, Clausius' (1865) saw 'entropy' as a negative process, that is

[4] Heraclitus is attributed to the concept of the Unity of Opposites, but the Taoists of the ancient Orient used opposites much earlier (c 550 BCE).

a unitary process in one direction. It was Boltzmann (1877) who made the definition of entropy (*S*) with his equation $S = k\ LogW$. But Fantappiè (1944) saw entropy as a duality that is one of a pair of opposites. He named 'syntropy' as the complementary opposite to entropy. The negative of syntropy is offset by the positive of entropy. This opened up the concept of a Unity of Opposites in thermodynamics, a new interpretation of the 2nd Law, and a duality of opposites.

In this way the Unity of Opposites was adopted in association with meta-physics, that lead to philosophy and biological properties. Later Penrose (2005) wrote of the physical status of entropy but he did not see it as an absolute' in a present day physical theory. This change was brought about by Fantappiè with his 'syntropy' which is the complementary opposite of entropy. This creates a Unity of Opposites and another level of organization, the processes of which relate to the functions in a dual system and put the 2nd Law in a new guise. More important are opposites that relate physics to biology.

4. Problems with respect to entropy.

Penrose (2005) studied entropy and the 2nd Law, by comparing them to the 1st Law. The 1st Law is *equal*, such that the total energy remains constant, despite the functioning of processes. He refered to the *equality* in relation to the total energy, which is conserved in an isolated system. Heat and temperature provide a measure of energy, such that they remain much the same. The value of something or energy remains constant, despite the fact that various kinds of processes take place, and the total energy after some processes becomes *equal*. According to Penrose the 1st Law has a 'kind of precision', such that it remains constant despite the variation of processes.

The 2nd Law is an *inequality*, due to processes that cause decay, degradation and dissipation. This tells of an increasing property, such that entropy always increases, due to its role of breaking matter down after the break down of particles to smaller elements, which tends to increase the degradation of matter. Entropy is an approximate measure of 'randomness' in the system, such that energy has a larger value and is a constant. Randomness also increases, and entropy increases. Entropy is an *inequality* due to the breakdown of matter[5].

According to Hegel's (1812) theoretical analysis, a duality is the product of two units, which in the right conditions, are attracted to one another, creating a duality to which they are drawn and interact with one another. Hegel's entropy is a unity, but syntropy together with entropy constitute a duality. This is due to the complementary opposites of entropy and syntropy, where entropy is negative and syntropy is positive. On contact, each eliminates the other. Ludovico (2008) understood that entropy plus syntropy is a constant, such that $dS + dP = 0,$ where entropy is *S* and syntropy is *P.* Fantappiè realised that a natural addition of opposites was provided by syntropy as the unique complementary opposite to entropy. The behaviour of entropy with syntropy and other properties are unique to the duality of the pair.

The overall consequence of this section, is that in negating one another, the pair of opposites creates an *equality.* It then becomes clear that entropy and syntropy are complementary opposites that work

[5] Although entropy (2nd Law) is widely used since the term was introduced by Clausius (1865), in the last 25 years there have been over 20 challenges which have appeared in the scientific literature. A review of relevant sources is given by Capek and Sheeham (2005).

together in creating a duality. This comes to the probability that entropy as an *inequality* requires syntropy as its complementary opposite within a duality that becomes *equal*. In this way the dual system of entropy and syntropy becomes a Unity of Opposites which is an opposing pair that relate with one another. Under entropy, the negative matter breaks down into properties that relate to dissipation, disorder and destruction, while with syntropy the positive properties build up into properties that relate to order, construction and complexity (Figure1,b). The properties of entropy with syntropy determine their dominance, as entropy has negative processes, and syntropy has positive processes.

'Order' is a specific property of syntropy, while 'disorder' of entropy has no specific state. Syntropy incorporates 'order' and has certainty in organization, while entropy creates disorder with the disorganization of matter. The outcome is that 'order', and other related properties, ensures the dominance of syntropy over entropy. In a Unity of Opposites syntropy and order are dominant over entropy and disorder. The tendency of syntropy's dominance and entropy's inferiority suggests that the pair create an adaptation that favours the property Fantappiè noted in the process of syntropy. In a duality the outcome is entropy and its negative properties create an *inequality*, but syntropy linked to entropy creates an *equal*, which serves the processes of both in a dual system in which entropy and syntropy interact. This comes about because the dual system which creates and serves the requirements that opposites attract, are constant to each other and serve mutual purposes.

	Entropy Negative	**Syntropy** Positive
i	energy dissipated (Clausius, 1865)	energy concentrated
ii	increase of disorder (Boltzmann, 1874)	increase in order
iii	increase in destruction (Fantappiè, 1944)	increase in construction
iv	increase in simplicity (Fantappiè, 1944)	increase in complexity
v	break down – catabolism (Fantappiè, 1944)	build up - anabolism
vi	loss of information (Shannon, 1948)	gain in information
vii	unable to do work (Daintith, 2005)	able to do work
viii	randomness increases (Penrose, 2005)	randomness decreases

Table 1. The properties of entropy (a) and syntropy (b) are given in two columns (i to viii); while the properties of entropy (a) are given by those who discovered them; those of syntropy (b) are given by the opposites of entropy. It is assumed that if entropy and syntropy are opposites, so the properties of syntropy can be given as the opposite of that of entropy, and vice versa. In this way, the opposites of syntropy (i to viii) can be given by the opposite of entropy. Each of the eight properties (i - iii) are given in negative properties of 'a. entropy'. The a. entropy becomes the b. syntropy as opposites of entropy. It follows that all the list also become opposites in the properties (i to viii). In this way the 'disorder' (ii) of entropy becomes 'order' of b. 'syntropy'. Similarly the 'inability to do work' (vii) becomes the ability to do work. Again each of the properties (a. entropy) becomes the opposite (b. syntropy). The remaining properties behave similarly in the same way. With the physical properties of entropy, the properties have Physical features (a. entropy). Fantappiè's opposite have properties that have Biological features (b. syntropy).

'Order' is always positive and tends to increase. The following examples suggest other adaptations that favour syntropy. Fantappiè indicated that entropy is averse to life and syntropy favours life. It is apparent that syntropy is available to do work (Table 1,b,vii). Morowitz (1979) provided examples of control mechanisms and cyclical systems that are both related to biological systems. The early students of entropy gave examples that were averse to life, but the polar opposites indicate that syntropy favours properties that incorporate life. Penrose added that entropy 'might acquire a more fundamental status in the future.' It is suggested that Fantappiè's 'syntropy' provides Penrose's (2005) addition to entropy, creating a pair of opposites.

5. Entropy plus syntropy as a Unity of Opposites.

Early entropy and syntropy constituted a pair of opposites, such that the concept of opposites was attributed to Heraclitus[6]. Later Fantappiè recognised that Dirac's equation for energy (E^2) yielded opposite solutions, such that entropy has a negative charge and syntropy has a positive charge. Dirac noted that there is a complete and perfect symmetry between positive and negative charges. Opposites are not only complementary, as Neils Bohr observed, but opposite exists in perfect symmetry. Fantappiè applied such symmetry accepting the two solutions of thermodynamics; the established negative entropy left the opposite solution, to which Fantappiè gave the term 'syntropy'. The pair of opposites are the complementary and opposite poles of entropy and syntropy, which become a Unity of Opposites. Entropy and syntropy are pairs of opposites in a field of tension that interact with one another (Capra,1982). Opposites interact between the pair and their polar extremities. The two opposites find intermediate optima, as they oscillate between two opposite points until dynamic stability is optimized (Figure 2).

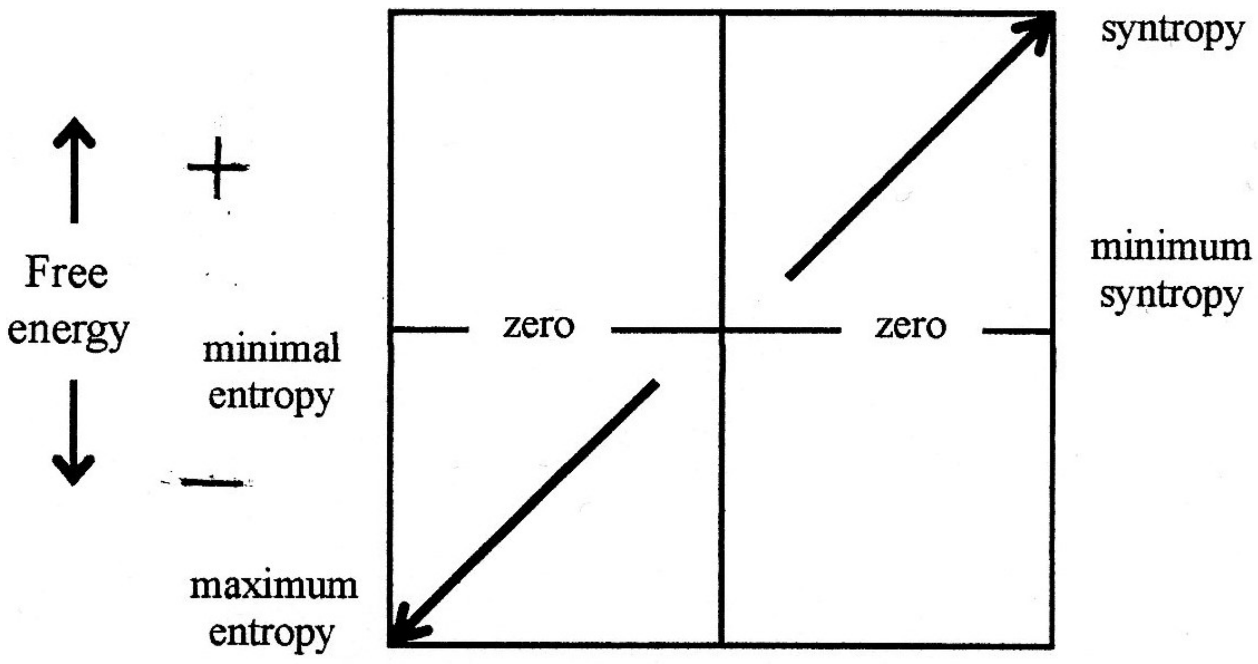

Figure 2. The diagram indicates the tendencies of entropy and syntropy (bold lines and arrows). The pairs function in the opposite directions such that entropy increases downward, and syntropy increase upward on the same axis. The horizontal indicates shared minima and the zero points for both entropy and syntropy, such that entropy is negative (-) and syntropy is positive (+).

[6] Heraclitus is attributed to the concept of the Unity of Opposites.

In a hypothetical control mechanism positives exhibit the concentration of energy, increase in order, and reflect properties in their range of oscillation (Figure 3).

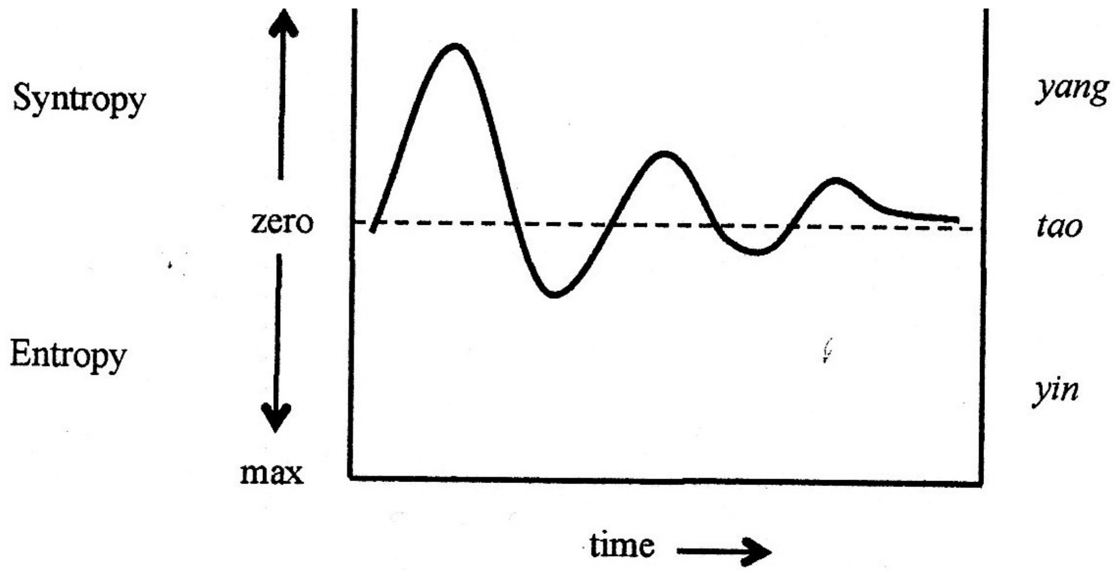

Figure 3. The output of a hypothetical control mechanism gives the oscillations regulated by syntropy (+) and entropy (-), which exhibits that are positive and negative over time. The zero point for each is also the point of equilibrium. The system oscillates over time to the points at which the processes reach an equilibrium which requires no energy due to syntropy and entropy.

Oscillation occurs at a maximum between the poles of syntropy and entropy, and at a minimum where their equilibrium approaches zero.

Fantappiè's work on wave fields confirm that entropy is negative and syntropy is positive. He found that in a spherical wave field, centrifugal waves disperse matter, while centripetal waves attract and concentrate matter (Figure 1). So entropy and syntropy have tendencies in opposite directions. Entropy declines from zero to a maximum, while syntropy increases from zero to a different maximum (Figure 2). The opposing properties co-operate due to the complementary opposites of entropy and syntropy, as they are the polar opposites. Entropy has properties that are in disorder, and cause dissipation and destruction, syntropy has properties that are orderly, concentrate matter and do work. Given only abstract properties to detect life, it is also necessary to measure that which is tangible. It seemed to Fantappiè that the existence of opposites indicates a positive solution, and suggested the possibility of the generation of biological systems. It seemed from the positive abstract terms of syntropy (see below), that it could have provided the conditions necessary for life. A system of two complementary opposites depend upon each other; with entropy as a negative and syntropy as a positive that emerged from the opposites of physical systems.

6. Control due to 'biological' and 'physical' in the Unity of Opposites.

Fantappiè (1944) identified and linked catabolism and anabolism. They are biological and metabolic processes, such that anabolism refers to processes that build-up molecules. Catabolism is a process that breaks-down complex molecules into smaller ones. The pair are metabolic processes. Matter is determined by entropy (-) with its negative property, syntropy has positive properties (+). The particles of entropy are dissipated, while syntropy concentrates and brings together the matter of biology. The important difference is normally that catabolism and anabolism are applied in biological systems, such that allow an organism to live , grow and adapt. In time organisms multiply and increase in numbers. The processes of catabolism are linked to the Physical processes of catabolism with the break-down of entropy. Anabolism refers to the biological processes that build-up molecules, the increase of biological systems, growth, life and numbers of organisms. This transition of the biological pair of anabolism and catabolism are linked with the physical pair of entropy and syntropy (Table 2).

Fantappiè apparently brought together the physical properties of entropy/syntropy and the biological properties of anabolism/catabolism, without explaining their different roles. Although Fantappiè considered 'biology' and 'physics', is not clear whether he considered them in two separate systems. It seems that anabolism/catabolism apply to biology alone, and the entropy/syntropy relates to physics.

	Biological	**Physical**
Positive	*anabolism (+)*	*syntropy (+)*
Negative	*catabolism (-)*	*entropy (-)*

Table 2. Biological and physical properties may contribute to biology. This suggests how the 'physical' and the 'biology' could co-exist in the same system, and support biological systems, and support biological systems.

Entropy is negative (E^-) and syntropy (P^+) is positive. It follows that only syntropy has positive consequences. Syntropy has various processes given in Table 1,b,i to viii, which are only given when entropy is active. The Unity of Opposites rests on circumstances in which the existence of a thing depends on two conditions that are opposite to each other. Pairs of complementary opposites depend on one another within a field of tension. In recent times complementary opposites depended on Dirac's Equation, which has two solutions. These opposing terms provide the basis of the Unity of Opposites. Entropy (and its properties) have processes that involve 'dissipation', 'disorder', 'destruction' and 'break down', such that the overall effect is negative. Syntropy has opposite properties 'that involve the increase in processes, gain and build up', with the overall effect that is positive. It is apparent that the properties of entropy have properties that relate to 'break down', while syntropy has properties that relate to 'build up' (Table 1, a,b). It is understood that entropy is negative and is unavailable to do work (Daintith, 2005). Entropy is a measure of the *unavailability* of a system's energy to do work. The opposite follows, such that syntropy requires an opposing definition that is a measure of the *availability* of energy to do work. Entropy with negative charges cannot do work as E^-, but syntropy with positive charges has energy that do work as P^+ , such that $E^- + P^+ = 0$. In this way entropy is negative and devoid of energy, while syntropy is positive and accumulates energy. The properties of syntropy include various positive traits (Table 1, b, i to viii).

There is a definitive distinction between the opposites of entropy and syntropy. Entropy and syntropy are opposites, and it follows that the opposites of one provide the opposites of the other. The properties of entropy (negative -) make it possible to determine the opposite which is syntropy (positive +). Put simply, the properties of entropy make it possible to determine the opposing properties of syntropy. Table 1,a gives the title of 'a. entropy', which are taken from those properties of entropy (Table 1,a), beginning with Clausius (1865) to Penrose (2005). Table 1,b gives the properties of 'b. syntropy' as the negative opposites of syntropy (i to viii), that are the opposites of the properties of 'a. entropy'. Table 1,b is given by the properties of entropy and syntropy, which creates the conversion of entropy to syntropy. In the process, entropy (Table 1a, i-viii) is converted to syntropy (Table 1b i-viii), such that negative entropy becomes the positive of syntropy, and includes the ability 'to do work'.

A pair of opposites is essential for a Unity of Opposites, that depend on the co-existence of two conditions, that are opposites to each other. They depend on each other, within of a "field of tension" and change. Syntropy is positive and generates energy that drives processes. Entropy is negative and has no energy, so the breakdown of particles is natural. Entropy is the base-point of reference in relation to change that has no energy.

Fantappiè (1944) adopted the Unity of Opposites as a pair of opposites that link the processes of entropy and syntropy, and are predominantly physical and biological. Unities of Opposites act in pairs and are essential in their interactions. They are given terms such as they 'depend upon each other', 'are opposite to each other' and 'presuppose each other' within a field of tension. As entropy and syntropy constitute a pair of opposites, it is expected that the opposite pair depend upon each other. Pairs of such opposites are used in control separating 'the negative and the positive', which depend on the opposite of entropy and syntropy. Hussey in Long (2006) refers to 'control' as an example of a function of duality.

7. Biological processes of syntropy

While entropy relates to physical properties and tends to the negative such as 'entropy dissipation', 'increase in dissipation', and 'increase of disorder' (Table 1,a), syntropy and entropy are both necessary for life, and organisms capture and apply energy for their various processes. The application of energy is a feature of syntropy, and applies energy in all of its positive properties (Table 1,b). Energy is used as a measure of a biological system to do work, and takes on the positive features of syntropy that favour biological systems. Examination of Table 1,b and syntropy indicate properties such as 'to build up, the 'ability to do work' and the 'increase of order', as well as others that favour biological systems. Systems relate to biological processes given the properties of a negative entropy and the positive syntropy, and create a division of opposites. Opposites separate a physical system from the biological, such that syntropy has the necessary properties that favour the activities and functions of biology, derived from the opposites of physical processes of entropy. The 'increase of dis-order', is attributed to entropy, and the opposite is the 'increase of order' which is attributed to syntropy. The duality of entropy and syntropy has different meanings and functions with respect to one another as the 2nd Law. The pair bring meaning to the consequences of their co-existence. Negative traits and their positive, are complementary opposites and constitute a Unity of Opposites.

Entropy and syntropy bring together a pair that links the physical properties with the biological pair of anabolism and catabolism. Fantappiè's 'physical' links entropy to its complement as the opposite 'syntropy'. This brings together the physical entropy and its opposite in 'syntropy' to the biological anabolism and catabolism (Table 2).

Fantappiè (1944) referred to 'counter-balancing' the destructive and the lethal effect of entropy', which he related to the breakdown of matter, information and energy, as changes from the complex to the simple. These examples are used to determine opposites as the properties of the complementary system (Table 1,b).

'Randomness' is a property of entropy. Syntropy is life-like, in a certainty of outcome that originated in the properties that are compatible with life. In this example we see the power of opposites, from the negative and inert features of entropy, to the biological features of syntropy. Fantappiè also noted that if entropy is 'missing information', then syntropy is information. Later Shannon (1948) established an equation for the 'loss of information' as a message. These examples from entropy are used to determine opposites as the properties of the complementary syntropy (Table 1,b). Only a few pairs of opposites are identified here, as it is assumed that the various properties of entropy (Wehrl, 1978) can be identified and their opposites attributable to syntropy.

8. Quadratic Equation and its application to the 2nd Law

In an enclosed system entropy creates a balance with syntropy, such that entropy plus syntropy is constant $dS + dP = 0$ where S is entropy and P is syntropy. Ludovico (2008) accepted that entropy and syntropy are opposites to one another. He wrote that 'syntropy is a necessary adjustment to entropy. He wrote that 'any increment in the disorder of the system corresponds to an equivalent decrease in the system's order, and vice versa'. Entropy is a measure of the *unavailability* of a systems energy to do work ($dS \geq 0$) (Table 1, a(i)), as entropy always increases. It follows that the opposite in syntropy is a measure of the *availability* of a systems energy to do work ($dP \geq 0$, where P is syntropy), while syntropy always increases (Table 1,b(i)), entropy loses energy in the dissipation of matter (Table 1,a,b). Such a link between entropy and syntropy suggests a direct link between physics and biology.

From a modern mathematical perspective, Dirac's equation was analogous to a Quadratic Equation, such that $ax+bx+c=0$. Here x represents an unknown, while a, b, and c equal are constants, with a not equal to 0. In the context of the 2nd Law, entropy is a single term. However Fantappiè (1944) put forward a complementary opposite to entropy, which he termed 'syntropy'. This pair relates to the Quadratic Equation, which incorporates a pair of opposites. The complementary opposite relates to the Dirac Equation, which has two solutions: a negative entropy and a positive syntropy. These pairs are features of a Quadratic Equation, which relate to the pair of the negative entropy and positive syntropy, which gives the pair a meaning as complementary opposites. It is apparent that entropy is a complementary opposite. Entropy requires the opposing features and application of entropy linked to syntropy as necessary opposites (Figure 4), from the Dirac Equation to the Quadratic Equation.

It is now possible to consider the negative of entropy (Table 1a) in relation to its positive (i to viii) from Clausius (1865) to Penrose (2005). The properties for positive syntropy can be deduced from entropy. The properties of syntropy can be determined (Table 1b) as the opposite of those of entropy (i to viii). Thus entropy tends to 'an increase of disorder' (Boltzmann, 1874), whilst syntropy becomes the tendency to 'an increase in order'.

These are related to the negative features of entropy, given by the properties of the original authors (Clausius to Penrose). From the eight properties are given the opposites of syntropy which are positive, and the positive features of syntropy. The outcome resembled the opposites of syntropy as converted from the opposites of entropy. It also resembled the probable properties of the biological features of living order.

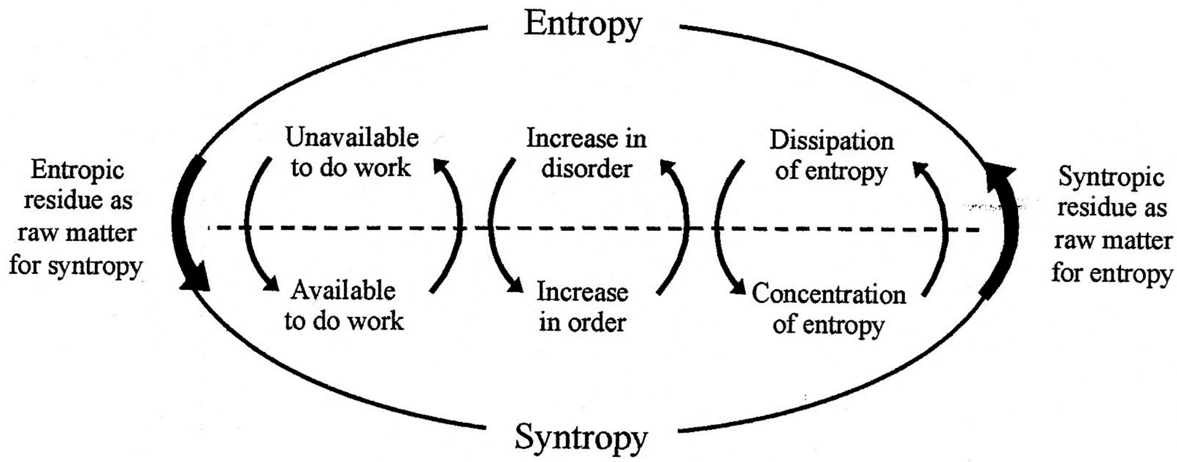

Figure 4. A hypothetical circular system involves entropy and syntropy in a system that involves opposing properties. The principal processes occur at the horizontal extremities (left and right), such that the residue of raw material due to entropy becomes the raw material taken up by syntropy. The system is circular such that the raw material of syntropy becomes the raw material for entropy. Similarly the residues of entropy becomes the raw material for syntropy. Other examples of the circularity of process are given in enclosed cycles are indicating properties including 'work', 'order' and 'concentration' (see Table 1). The cycling by entropy and syntropy creates an unending source of matter.

Entropy is averse to life, but syntropy is a system that has tendencies to the Biological rather than the Physical. This has the result that syntropy favours the living, and is contrary to entropy. Syntropy is a complementary opposite that thrives in the positive, in which its properties are favoured and the positive increases. Syntropy favours life and tends to concentrate energy. Fantappiè observed that entropy is attracted to the increase of disorder, and identifies the properties of syntropy that include the increase to order. Key to this study of entropy and syntropy is Fantappiè's study of syntropy and the activity and energy that indicate the Biological properties that point to Life.

Entropy is inert and dissipates matter, while syntropy favours life, and concentrates matter and favours biological systems. Clausius gave entropy to mean the increase of negative processes (Table 1a) which cause the dissipation of energy. Syntropy favours the increase of positive processes, including the concentration of energy, the increase of order, and the construction with increase in complexity. The implication is that the amount of entropy (disorder) always increases, and the amount of syntropy (order) always increases. The negative opposites that constitute entropy, and the positive opposites that constitute syntropy, create polar opposites. As opposites, the duality of entropy and syntropy have different meanings and functions with respect to one another and the 2nd Law. Entropy and syntropy interact and bring meaning to the consequence of their co-existence, and as complementary opposites, negative traits and their positive, constitute a Unity of Opposites.

Entropy and syntropy are opposites, with different conditions, such that they may change to one or the other. In this way the disorder of entropy, changes to syntropy to become order. Entropy becomes negative and disorder, while syntropy is positive and becomes order. Other properties (i to iii) may change due to the opposing properties of entropy or syntropy. The negative catabolism is linked to entropy, and the positive anabolism is linked to syntropy (Table 2). In Table 1 the properties of entropy indicate the properties of catabolism which relate to break-down in a. entropy (v) . Similarly the properties of syntropy indicate the properties, which relate to the build-up of anabolism (b,syntropy, (v). It seems that the properties of entropy become syntropy which has the properties of life (Table 1,b), which Fantappiè took to resemble biological systems.

9. Evidence of control processes and biological forms

Morowitz (1968, 1992) proposed a Principle of Continuity which was later elaborated by others. The principle states that every stage is connected with a previous stage. Opposites then can be referred to as a continuum of the physical with the biosphere. The origin of Life is a development of many forms which have radiated over 4 billion years. Morowitz (1968) suggested that the problem of the origin of life and the development of global ecosystems merged into one problem. He suggested a general notion of control theory, and the properties of servo networks, 'which must be characteristic of biological systems at the most fundamental level of operation'. Morowitz observed the general notions of control theory in control mechanisms and cyclical systems. He noted that they were both related to biological systems. Properties of servo networks are characteristic of biology, and have a biological purpose. The 'cyclic flow' of matter, is encountered in biology and requires an energy flow.

Control process are important in managing systems, and provide another influential process that relates to circular systems. They have the unique advantage of being perpetual. In a hypothetical example of a cyclical system, the residue of syntropy provides raw matter for entropy. The diagram indicates a hypothetical system that is cyclical in which entropy and syntropy co-exist within a single system (Figure 4). The upper half has negative properties which are responsible for dissipation and disorder (Table 1a). Syntropy occupies the lower half and has positive properties, which are responsible for concentration and order (Table 1b). Matter is decayed by entropy into elemental particles that pass into the lower half. The break-down products created by entropy are used by syntropy and build-up complex segments of organisms. Ultimately entropy breaks down into elemental particles. The outcome is that entropy is a state of disorder, and by implication syntropy is a state of order.

In this interpretation the system is perpetual, such that matter used by entropy to disintegrate catabolism is later used by syntropy in building up complex matter and life. The Conservation of Matter dissipates energy, while syntropy builds up and concentrates energy (Figure 4). In such circumstances, syntropy is superior to entropy, with the advantage of accumulating matter and energy. Morowitz (1979) again points out cyclical systems between the physical and the biological, such that, ''The flow of energy causes cyclic flow of matter". "The converse is also true; the cycle flow of matter such as is encountered in biology requires an energy flow in order to take place."

In a physical system, entropy is negative and syntropy is positive; but as a biological system, catabolism is negative and breaks matter down while anabolism builds matter up. It is relevant that the processes have similar opposing terms. The implication is that the similar opposite terms have passed from the physical and are converted to biological. This notion was suggested by Wicken (1987). These hypothetical systems suggest how entropy and syntropy may co-exist within an enclosed system (Figure 4), made possible because it is self-enclosed and infinite, as is the 1st Law (Penrose, 2005). Fantappiè (1944) anticipated that the properties of syntropy, which originated from the opposites of entropy, have provided tendencies that favour the emergence of biological forms.

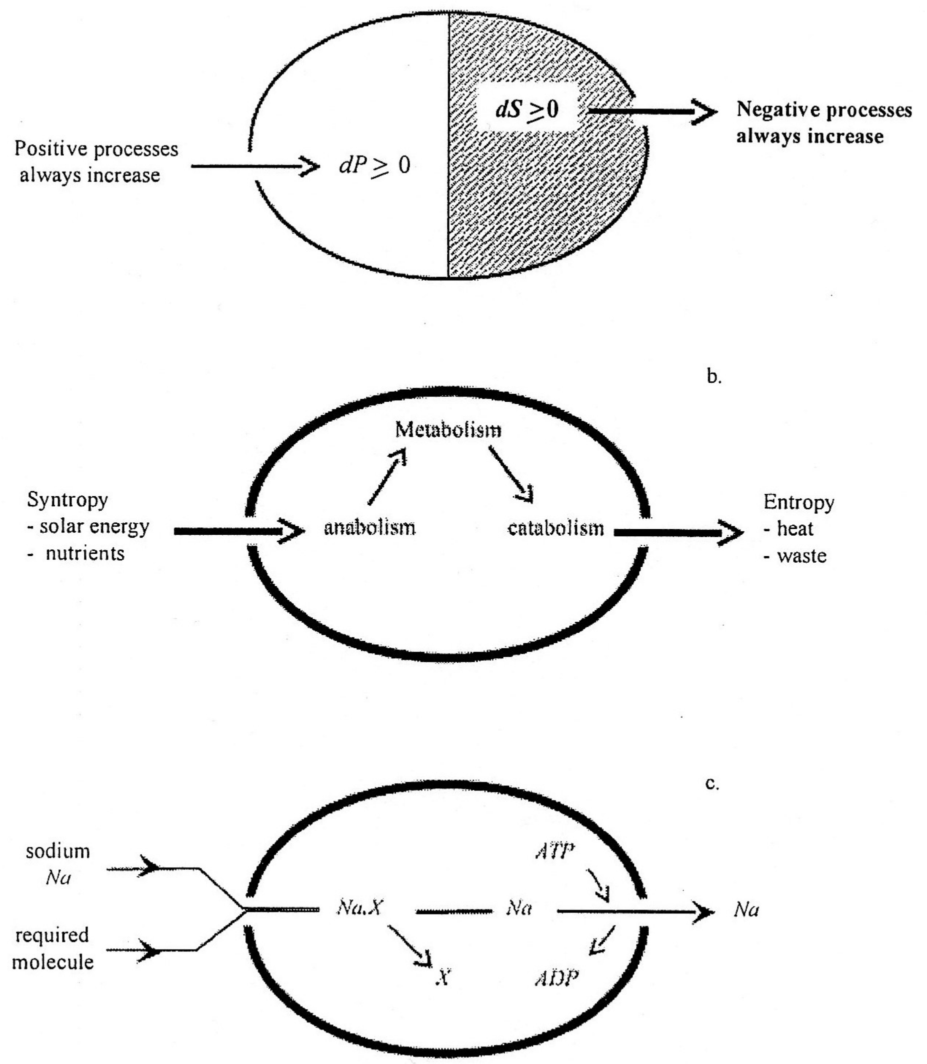

Figure 5. Three hypothetical and enclosed systems are proposed to have changed from physical to biological, with the same fundamental processes of uptake and disposal of waste. Their features are essentially the uptake of what it required and the rejection of what is no longer required. The first implies that the features of uptake and the expulsion of waste, originated in the physical system (a) and were passed on to biological systems (b). Some justification is provided in Figure 5a as the agent of entropy and the discharge of broken down matter (dS≥0), but here syntropy is rich in active positive processes (dP≥0) that provides the biological first noted by Fantappiè (see Table 1b).

In any circular system in which entropy and syntropy co-exist (Figure 4), there is an enclosed system. In a circular system the disorder of entropy becomes the order of syntropy and the biological systems are broken down and create disorder by entropic processes (Wicken, 1987). Hypothetical systems involve control (Figure 4) and cyclical systems (Figure 5), such that both these systems involve the interactions of opposing processes, that are equal, and their function is perpetual. Such systems are natural in respect to one another, as the sum of entry and exit must remain the same, with respect to the volume of each enclosure (Figure 5b). Wicken (1987) was convinced that life emerged from the 2nd Law. With the addition of syntropy as an addition to the 2nd Law, Wicken's proposal became much more probable. Syntropy is positive and has abstract properties that are much more amenable to biology than the features of entropy (Figure 2a).

10. Syntropy and entropy as a measure of energy and work

Here negative entropy and positive syntropy constitute a Unity of Opposites, that interact with each other as a pair of mutual terms. Their relationships have developed over time, and their dominant features are maintained from the Physical to the Biological. Three diagrams (Figure 5) depict a sequence of change that involves the *intake* of essentials and the *exit* of processes from the exterior to the interior, beginning in a physical system which depicts the take-up of useful matter of syntropy, and the exit of wasteful matter by entropy.

A sequence of evolutionary change (Figure 5) suggests that the physical processes of entropy (*S*) discharge the waste matter ($dS \geq 0$) to the exterior. The biological processes of syntropy (*P*) attract an intake of matter ($dP \geq 0$) and provide energy for living organisms, providing growth and replication. The energy of syntropy increases with its uptake, and the waste of entropy matches the output. The equation for syntropy is a complementary opposite, such that entropy (*S)* as a negative is replaced by syntropy (*P)* which is positive. The intake of syntropy and the discharge of waste syntropy, such that $P + S = 0$, as each is equal to the other. Such a system is indicated in a perpetual circular system (Figure 4) that operates indefinitely, in which entropy and syntropy depend upon each other. It is suggested that the processes of intake and output were likely to have been passed on to organisms (Figure 5b,c), as the same processes and requirements apply with refinements. The equation for entropy $dS \geq 0$ indicates that disorder always increases. Conversely syntropy is expressed as $dP \geq 0$ such that the amount of order always increases. This becomes a feature in processes that relate to syntropy as a biological system (Table 1b).

Entropy exits waste (to the right) and syntropy accepts matter (from the left). Pairs of opposites are assumed to constitute the extended 2nd Law, within a Unity of Opposites. Ludovico (2008) used the term $P+S = LnN$, for the sum of the pair of constants. He wrote that an "increment in the disorder (entropy) of the system corresponds to an equivalent increase in the system's order (syntropy) and vice versa". Daintith (2005) earlier showed entropy as a measure of the unavailability of the system's energy to do work. This would also have implications for the evolution of biological systems. This sequence of changes (Figure 5), process a physical system with uptake and exit (a), becomes a biological system that adopts a similar system of uptake and exit for nutrition (b). This is depicted in a complex biological system (c). It is essential that any enclosed system requires a system of uptake and output, whether physical or biological.

This persists in other evolutions of life, from the physical to the biological, and from the simple to the complex (Figure 5 a to c). Physical components of entropy link to syntropy and provide the raw material of biological systems. Syntropy ensures an input of sun-light and nutrients, and entropy provides an exit of heat and waste expelled to the exterior (Figure 5a). The dual system as a revised 2nd Law of entropy and syntropy, constitutes a unity of opposites that is part physics and part biology. The enclosed system has two connections as entries and exits in biology are similar to those in physical systems. They include an input that brings matter which is required, and an exit that rejects waste matter to the exterior. This simple system persists in other systems that follow it (Figure 5a) and in more complex systems (Figure 5 b and c).[7]

7. A hypothetical circular (Figure 4) system includes pairs of entropy and syntropy that each have up-takes and outputs, which each pass two routes of matter to the other.

The second diagram (Figure 5b) has the same properties of intake and exit of matter. The exchange of biological elements is due to the build-up of matter by anabolism, and the breakdown of waste matter by catabolism. This system provides essential features relating to intake and exit, that are necessary for metabolism. Overall, the enclosed biological system has a constant, such that the amount taken up, is the same as that expelled as waste from the cell. The concept of 'catabolism' means the destructive processes in living organisms (Figure 5b). The complementary opposite is 'anabolism' meaning the constructive processes of living organisms. The terms applied by Fantappiè echo the physical entropy, meaning the dissipation and destruction of matter; while syntropy means the biological construction and increase in orderliness. While a physical system is apparent in entropy, a biological system is also apparent in the same Unity of Opposites. Energy involves dissipation and disorder due to catabolism, while syntropy involves order and construction due to anabolism.

The implication of these opposites is that physical and biological processes have meanings that are opposites, yet relate to one another as complementary opposites (Table 1). Catabolism and anabolism are biological origins that have abbreviated forms of 'break-down' and 'build-up', which relate to the negative and positive of entropy and syntropy. The terms were adopted and applied here by Fantappiè (1944). The implication is that physical and biological processes have meanings that are opposite (Table 1), but together serve a range of functions with a variety of purposes.

11. The elaboration of uptake and output in a biological system.

The third diagram (Figure 5b) indicates that in an actual biological system, there maintains the principle feature of the first and second diagrams, in relating to uptake and output. In this instance, the system is drawn from a complex biological system, which is echoed in organisms in general. Input processes are achieved by 'coupling' described by Brown (2000). Biochemical molecules draw the influx of matter through the cell membrane and exit the cell against a density gradient (Figure 5c). This occurs due to a required molecule (*X*) attached to a sodium atom (*Na*), which pass down-gradient into the cell. The required molecule (*X*) cannot move up-gradient unaided, but does so when coupled with a sodium atom (*Na.X*). Once within the cell the sodium atom and the molecule separate, and the sodium atom returns up-gradient to the exterior (Figure 5c). Such processes involve selection to acquire the necessary molecule and increased order within the cell. The selection of energy and nutrients maintain the dominance of syntropy, while the elimination of entropy is a continuous feature of metabolism. Waste is released and increases the level of entropy in the surroundings. The system applies coupling to capture the required molecule which pass up-gradient into the cell, and sodium is expelled to the exterior by ADP. The essential intake and export remains the same, but have evolved into complex processes involving coupling for intake and energy for output.

Fantappiè (1944) observed that the properties of syntropy indicated biological systems. Those properties given here have been extended (see Table 1b), and become more apparent in a list of examples of syntropy that suggest biological processes, even though they are taken from physical entropic processes (Table 1a). In addition there have been a number of relevant observations due to Morowitz (1987) and others. Wicken (1987) was convinced that life emerged from the extended 2nd Law. Simple cellular systems are here derived from the 2nd Law which as properties of syntropy suggest biological terms (Brown, 2000), indicating that thermodynamic terms overlap at a low level (Figure 5c). Metabolism requires energy and matter for physical and chemical processes within living organisms. At this point in evolution there is a shift in the balance of syntropy over entropy; unlike entropy, syntropy has control over energy and its application. The concentration of energy gives meaning and the ability to do work (Table 1b). Here Fantappiè's syntropy provides order which answers the question that Brown proposed. Syntropy not only constructs order without violating the 2nd Law, but syntropy and entropy are complementary opposites that constitute a Unity of Opposites.

Metabolism is the sum of the chemical reactions of cells that require the co-ordinated processes of entropy and syntropy in the capture of nutrients in the interior and the evacuation of waste to the exterior. The kind of circular processes of entropy and syntropy in a hypothetical system are coupled to one another (eg. Figure 4). Brown (2000) observed that to increase its order, organisms must export disorder. But here syntropy, as a source of order, provides the natural solution with entropy and syntropy as complementary opposites (Figure 3). Ludovico (2008) established that entropy and syntropy interact with one another and remain constant in an enclosed system in which the sum of the opposites remains constant.

The acceptance of entropy and Fantappiè's syntropy are essential elements in the process of biological systems. These elements co-exist, in that entropy and syntropy are opposites to one another, but the sum is zero. The co-existence of a Unity of Opposites brings together their co-operation in a variety of ways. Syntropy persists in providing cells with essential nutrients and solar energy, while entropy has the role of expelling waste and heat to the exterior. As a pair, entropy has negative physical features, while syntropy has positive features that favour biological systems. The Unity of Opposites depend on the co-existence of two (or more) conditions which are opposite to each other and pre-suppose each other within a field that is under tension. (Szent-Györgi, 1961).

12. Single entities overtaken by the duality, of entropy and syntropy.

It has become apparent that entropy and syntropy constitute an entity with two processes. This is indicated as a pair of opposites in opposing directions. that create a single entity. Szent-Gyorgyi (1961) accepted that a single factor is not sufficient to control a unity of opposites. He realised that two opposing factors regulate a control system. It requires a duality of two opposing factors to control biological systems. This is apparent when entropy and syntropy come together (Figure 2). A control mechanism involves two opposing factors that control processes (Figure 3), and in a circular system (Figure 4).

This paper depends on the Unity of Opposites, based on opposing differences between negative (entropy) and positive (syntropy) that are opposites to one another. Entropy or syntropy can be converted to the other, as is the case of the properties of entropy, when they are converted to syntropy. This is the case in Table1,b where the properties of syntropy create the properties (i-viii) suggesting a biological system. Hence entropy is given the term 'physical' and syntropy is considered to be biological.

It was Szent-Györgyi (1961) who noted that a single factor cannot regulate, such that pairs become essential. Thus a simple control mechanism requires a pair of entropy and syntropy (Figure 3). Similarly a cyclical system requires a pair of entropy and syntropy to maintain rotation definitely (Figure 4). Within a cyclical function in a biological system syntropy requires the capture of nutrient and solar energy and entropy involves an equal exit of heat and waste. To maintain the volume of organisms and the volume of the cell (Figure 5), the uptake of matter and the exit of waste must be equal ($dD+dS=0$). These examples show that the pair of entropy and syntropy indicates natural pairs of opposites in life. Szent-Gyorgyi made clear that no process can function without two opposing terms.

There is another feature that is likely to apply to entropy and syntropy. A hypothetical feedback control mechanism oscillates with a declining amplitude to a stable state, that is likely to be involved in a control mechanism. It requires a duality of two opposing factors to control biological systems (Figure 3). This provided a reason for Fantappiè to create a duality of entropy and syntropy. This hypothetical system also suggests that opposites regulate change in a continuum from maximum syntropy to maximum entropy, stabilizing over time, with an equilibrium at zero. Although the controlled process may be applied to a variety of processes it is used here with respect to the input and output which control a variable input, producing an oscillatory output. If entropy is a measure of the unavailability to do work, it follows that syntropy is a measure of the availability to do work. This implies that syntropy provides energy to do work.

13 . Order, syntropy and biological organisms.

Peter Medawar (1982) wrote an essay in which he set himself the task of understanding ‘the relationship between biology and thermodynamic order’ [8]. This was the origin of this paper. Despite Medawar’s efforts, he was not satisfied, with recent knowledge and new interpretation was needed. It is demonstrated here that biology and thermodynamic order collaborate and co-exist.

The tendency to ‘increase in order’ provides a major source of ‘order’ in biological systems. ‘Order’ is one of a number of positive properties which include syntropy. Fantappiè observed that such properties which are required by life, led him to suggest syntropy as a link to biology. It is apparent that any source of ‘order’ is needed for life, as ‘order’ is abundant in biological systems. As Medawar noted, ‘order’ permeates biology ‘through and through’. It seems likely that the emergence of ‘order’ in syntropy is a product of thermodynamics, and also coincident with the emergence of biological forms. This is due to entropy and syntropy which are complementary opposites that, at the level of their duality relate to one another. This duality of entropy plus syntropy, keeps physics and biology as a link in a mutually positive interaction (see Figure 4, Ludovico, 2008 and other examples).

Lwoff (1962) had used ‘negentropy’ as his source of ‘order’, which is a term equivalent to syntropy. Cox and Cohen (2011) noted that there was abundant ‘order’ in the universe, but there seemed to be no known source of ‘order’. Other terms that had equivalent properties include construction, complexity and the ability to do work. ‘Order’ exists but there is no agreed source of its origin. Here the source of ‘order’ is given as syntropy which is not simply a location of order, but a source that increases perpetually (Table 1, bii). In the way entropy has negative processes, so syntropy has positive processes, including the increase of ‘order’.

Entropy is the negative of disorder (below) which was identified by Boltzmann (1878). Disorder is a product of entropy, while ‘order’ became a product of syntropy. If the products of entropy include ‘increases in disorder’, then the opposite of entropy is syntropy, which has the property of ‘increase in order’. If entropy is the source of disorder, then syntropy is the source of ‘order’ in life. Entropy is physical and syntropy is biological, which depend upon one another within a Unity of Opposites.

[8] There are accepted meanings of ‘order’ and ‘disorder’ in physics and biology. These and their comparison are dealt with in depth by Medawar (1983, pp 209-227) and were later discussed by Layzer (1990, pp 17-38).

For some time there has been a lack of understanding of 'order'. Schrödinger (1944) understood that *entropy* = *k log D* , where *D* is a measure of disorder. He then reasoned that, if *D* is a measure of disorder, its reciprocal *1/D* is a direct measure of order, such that *order* = *k log* (1/*D*) . If $dD \geq 0$ has the meaning that entropy always increases, and complies with the unity of opposites, then $dP \geq 0$ means syntropy and the 'increase in order' (Table 1b). The term includes increase of order, work, construction, complexity, and other properties that favour positive tendencies. The iteration of Schrödinger's origin of order was repeated by Lwoff (1960). The complementary opposites of physics and entropy, with syntropy and biology is apparent. Here entropy and syntropy constitute a Unity of Opposites.

Medawar saw order as 'thermodynamic and biological', as abstractions such that entropy is characterised by 'increase of disorder' (Table 1a, (ii)), and syntropy is characterised by 'increase in order' (Table 1b (ii)).

It is apparent that opposites may change from an 'increase of disorder' to an 'increase of order', and vice versa. It is also assumes that the negative entropy changes from disorder to order, and a reversal change from order to disorder. These reversals suggest that the abstraction changes from entropy or syntropy and, assumes properties that become positive and negative. In particular, syntropy has the trait of the 'increase of order', which provides sources of 'order' in life on earth. Sources of order in the universe are abundant, but there is no agreed source.

Fantappiè's syntropy (positive) is a complementary opposite to entropy (negative) that provides a variety of functions beyond those of entropy alone. A Unity of Opposites and a variety of functions in the duality of entropy and syntropy, constitute a high level of complexity. The opposites of entropy and syntropy co-exist (Figure 2), collaboration in control (Figure 3), and the functioning of circular systems (Figure 4). At variations, levels of entropy and syntropy are likely to join in functional links that create new links and processes.

Acknowledgements

I am grateful to Leslie Wyatt for his conversation and ideas. I also appreciate John Widdow's work on an early draft. I am grateful once more to Mary Brinsley and her work on the figures. Finally I could not have brought the paper to publication without the contribution of my wife Valerie, who helped bring the final state to completion.

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