Process thought, teleology and thermodynamics
- a reinterpretation of the Second Law of Thermodynamics.

This article suggests a new interpretation of the Second Law of Thermodynamics (referred to as *2LT* in the following) through a radical application of process metaphysics. It involves an argument showing that *2LT* follows logically from the basic principles of the process scheme of thought as formulated by Alfred North Whitehead (1861-1947) in his late works, particularly in *Process and Reality* (1929, *PR* in the following). Curiously, the possibility of such a derivation doesn't seem to have been discovered by Whitehead himself or by any of his followers, although it solves a major difficulty which faces Whitehead's system (and many other lines of thought involving some sort of self-organizing or evolving cosmos).

The difficulty is the apparent contradiction between *2LT* and one of Whitehead's central postulates concerning the general nature of a process: the claim that all processes — not only life processes — are spontaneously self-organizing, i.e. they have an inherent teleological tendency towards the realization of order and complexity. This teleological claim seems to be impossible to support without implying the falsehood of *2LT* — a central and well corrobated law of modern physics. *2LT* introduces temporal asymmetry into the system of physical laws by requiring a quantity called entropy to increase in every spontaneous physical process — where entropy can be expressed, in modern standard interpretations through statistical mechanics, as a measure of *disorder*. In the language of classical thermodynamics, the requirement of increasing entropy is rather expressed in terms of *diffusion* of heat or *degradation* of energy, towards the state of thermodynamic equilibrium. In any case the requirement of increasing disorder can be characterized as universal dysteleology, or poetically as "the heat death of the universe". Thus, Whitehead's teleological claim seems to agree with *2LT* about the *existence* of a universal temporal asymmetry, but to claim it to have a completely incompatible or even the reverse *content*. Such a contradiction would hardly weaken *2LT*'s position as a law of physics, but it would be a problem for Whitehead's philosophical system — a particularly serious problem because much of the system's strength is its power in construing and reproducing well-known geometric and physical concepts on the basis of a simple concept of process. For example, Whitehead developed an elegant way of constructing metrical and topological properties of time and space from relational properties of processes (the "method of extensive abstraction"). Furthermore, Whitehead's concept of process seems to have been designed to systematically incorporate theoretical structures of modern natural science, including

biological evolution, quantum mechanics and relativity (This is all the more impressive since Whitehead's philosophy was developed simultaneously with these basic theories of modern physics, during the first decades of the 20th century). In Whitehead's own days his system's merits were acknowledged mainly by biologists, but recently Bohm, Prigogine and other theoretical physicists have found it useful in the discussion of interpretations of quantum mechanics[1]. It seems strange then that the laws of thermodynamics — which were well established by the turn of the century — should have been largely ignored by Whitehead. He may have shared the prevailing 19th century notion of thermodynamics as an inferior field of impure physics and engineering — but this does not fit with his critical attitude towards contemporary ideals of mathematical and logical purity — or he may have been discouraged by the apparent contradiction which is the theme of the present article. It is also possible that he was aware of the basic idea of the solution suggested here, but regarded it as an consequence of his work which did not have to be pointed out explicitly[2].

The new application of the process scheme presented here can be read as an extension or completion of Whitehead's applications; i.e. as a piece of Whitehead scholarship. But even without the assumption of an explicit process metaphysical framework such as Whitehead's system, the basic idea in the derivation of *2LT* can be suggested as a radical philosophical reinterpretation of the relationship between *2LT* and the obvious spontaneous order-generating activity of at least some kinds of natural processes.

A few technical notes and references: For a more comprehensive introduction to philosophically relevant aspects of thermodynamics and statistical mechanics, I refer to an earlier article (now Chp. 2 of this collection) which includes a discussion of classical metaphysical problems of interpretations of thermodynamics and the “arrow of time”. For a comparatively accessible introduction to technicalities of thermodynamics and statistical mechanics I refer to the elegant *Feynman Lectures*[3]. For an introduction to Whitehead’s philosophy and the idea of a processual metaphysics I refer to another earlier article (now Chp. 3 of this collection, previously part 1 of the present paper). At this point I shall just briefly state what it means to derive 2lt from something. A physical regularity is sometimes said to follow from something else. I can think of 3 kinds of things it could be: a) a more general principle not confined to physics, as when Newton’s First Law could be said to be an instance of the principle of Sufficient Reason, given the modern understanding of a “state” as a state of motion, or b) another physical law at a more general level,

1) For example, see articles by Bohm, Prigogine and others in *Physics and the Ultimate Significance of Time* (ed. D.R. Griffin), SUNY 1986.

2) I am grateful to David Ray Griffin for pointing out that Whitehead actually does discuss the clash of constructive self-organizing processes and destructive or dissolving tendencies in *The Function of Reason* (1929), and gives an account somewhat similar to the argument presented here. But Whitehead focuses on cultural and scientific processes of organization and decay, and he treats them very much through aesthetic terms. I think Griffin is right that the present article simply makes explicit what is implicit in Whitehead's own writings. In any case it is beyond the scope of this article to assess exactly how close the argument is to various stages of Whitehead's thought - rather I wish to open the discussion of a generally unrecognized potential of process thought in radically reinterpreting *2LT*

3) R. Feynman: *Lectures on Physics*, Vol 1, Chp. 39-46.

as when laws of optics can be said to be particular effects of of electromagnetism, or c) local border conditions which happen to hold throughout the field of application of the law. For some very general laws there is rarely a question of deriving them from something, except when discussing possibilities of theoretically "unifying" forces or fields. For 2lt this is different, it is very often taken to be in need of derivation or explanation in one of these ways. However, the derviations proposed are not unproblematic or without metaphysical assumptions. Nor is the a) type derivation proposed here without problems and assumptions.

Teleology and Entropy

Process metaphysics, in the radical form developed by Whitehead and introduced in my previous paper here, makes *teleology* inseparable from its concept of process. Spontaneous natural processes are held to build up order. But *2LT* seems to imply a universal decay of order, particularly when the entropy definitions of statistical mechanics and information theory are used to interpret *2LT*'s requirement of increasing entropy. If we want to get beyond the mere contradiction between teleology and dysteleology with respect to order, the obvious place to start looking is the concept of order which is used in a different — but not unconnected — sense. The important difference is that between static and dynamic form. The order referred to in statistical mechanics is basically a stable ideal that actual states and systems may comply with to varying degrees, as a function of time. In contrast, the process view implies that the mode of application of such an ideal or measure of order, and even the ideal itself, can only have quasi-permanent status. This has interesting consequences for the representation of self-organized order through basically extensive concepts such as the language of statistical mechanics.

The measure of order (or negative entropy) in statistical mechanics can be described as a two-step procedure. First, the state of the system is identified with one member of a set of possible macro-states given some border condition. Second, each macro-state is identified with a subset of all the micro-states (i.e. all the configurations of microscopic parts) which are possible given a theory of the system as composed of microscopic units. Essentially, statistical mechanical order is then expressed quantitatively as a simple measure of the size of this subset. The several different microscopic, statistical and information theoretical entropy analogues[4] are all such measures of subsets. The simple logic behind their various mathematical expressions is that low entropy (high degree of order) is equivalent to narrow constraints on the system in question. Just as ordered messages, like e.g. reasonable philosophical articles, correspond to a small subset of the space of random letter strings of the same length — a very small subset regardless whether borderline cases as the present one are counted in or out. And just as ordered states with all particles confined to one half of a container correspond to a very small subset of all random distributions of particles in the container. If the space of micro-states in the microscopic theory is discrete and all microstates have equal apriori probability, the measure of entropy can be expressed as a simple increasing function of the count of microstates:

$$S = k \log W$$

where W is the count of micro-states and k is a constant. This makes S a measure of a generalized kind of extension, and *2LT* a law of generalized diffusion: it is not just that heat of concrete bodies spontaneously diffuses according to classical thermodynamics, but in the translations into statistical mechanics and information theory entropy increase also corresponds to diffusion: diffusion of the points representing the system's microstate in generalized spaces (phase spaces etc.) of various microscopic theories. In the following argument the further physical and mathematical details of the micro-theory can be bracketed out, so we stay with the simple formula for the discrete case.

Similarly, we can express very simply the hub of traditional attempts of deriving *2LT* from basic physics through statistical mechanics. The state of thermodynamic equilibrium corresponds to maximal entropy (if the entropy analogue functions reasonably) and accordingly to the largest set of the possible microstates. Now, if the point representing the system's microstate in some generalized space is situated in a more constrained subset of states at some point of time, and if the point moves randomly though the generalized space, it is highly probable that after a while the point will have moved into a less constrained subset — and consequently the system will have gained entropy or lost order. If the ratio of extension measures is very large — as it is in typical cases — this probability approaches certainty. This is the solid and intuitive logic behind, for example, Boltzmann's H-theorem. However, as several authors have pointed out, this kind of derivation relies on a hidden asymmetry in the use of the parameter of time, in order to produce an asymmetric result on the basis

4) K. Denbigh (*How Subjective is Entropy*, Chemistry in Britain, Vol.17 (1981), p.168-185) has advocated the use of the term entropy *analogue* originally used by Gibbs, because none of the statistically defined candidates have been shown to be completely identical with entropy as originally defined through thermodynamic differentials. Also, the statistical analogues have an absolute magnitude while the differential only gives us relative magnitudes (entropy changes). Furthermore, Denbigh points out that entropy analogues are generally only definable in equilibrium or states very close to equilibrium, and that they rest on the assumption of a static layer of micro-units which are stable and non-interacting (e.g. negligibility of entropy in atomic nuclei, protons, or on some other level). I follow Denbigh's advice and use the term entropy analogue whenever I explicitly refer to statistical or information theoretical notions of entropy. However, the basic connection between order and entropy discussed in the following is not restricted to entropy analogues as opposed to "classical" entropy — which also measures order in the sense that a non-diffused and exploitable amount of energy is more ordered than the same amount of energy in a diffused and useless form. This measure of order would have the same fundamental limitations as that of statistical entropy analogues, and would allow an argument analogous with the following.

of otherwise symmetric laws[5][6]. The asymmetry obviously is introduced by considering a system found in an improbable state at t=0 and then considering the probable history of the system in only one temporal direction (future). Therefore, this kind of attempt fails as a derivation *2LT* and its "arrow of time", however enlightening statistical and information-based concepts of entropy may be in other respects. Several distinguished philosophers of science, including Popper and Whitrow[7], have argued that temporally asymmetric behaviour can be shown even in simple non-statistical physical systems — a single wavefront in an electromagnetic field, or the unaccelerated movement of two particles with different velocities. But again, the asymmetric behaviour in these examples rests on the addition of some asymmetric premises — border conditions or selection rules — to the symmetric laws of basic physics. Some intuitively obvious aspect of the process character of the real world has to slip into the argument and provide the asymmetry. Just as in statistical mechanics, the asymmetry does not follow from mechanics in the strict formal sense. If Whitrow and Popper are right that such systems display asymmetric behaviour, we have to say that the formal laws of fundamental physics are somehow not complete.

Now consider another limitation of the definition of order through statistical mechanics. It would seem that once we know how to make an effective substance scheme analysis of physical objects into configurations of microscopic substances, the measure of order and entropy would be objective, universally applicable and context-independent. But in fact, if we want to use some such extensive measure of order through a statistical entropy analogue, on some concrete ordered system

5) I. Prigogine & I. Stengers: *Order out of Chaos*, N.Y. 1984 gives a detailed analysis and history of the relationship between temporally symmetric mechanics and asymmetric thermodynamics. Prigogine also quotes Boltzmann's beautiful solution of the problem: entropy gradients are a self-selection effect of the kind which is now generally termed "anthropic" (Cf. Barrow & Tipler: *The Anthropic Cosmological Principle* Oxford 1986), because they are necessary for the existence of observers; and the universe is immense enough to contain random entropy fluctuations as large as our observable "cosmos". But Bolzmann's solution — and maybe many other instances of anthropic argument — seems to have the problem of entailing complete scepticism regarding the existence of a world outside, before and after Bolzmann's brain at the moment of thinking this thought — or even a simpler encoding of the thinking act — since such a fluctuation would apparently be much more economical (i.e., require a smaller and less improbable deviation from thermodynamic equilibrium) than an entire cosmos and its history. I plan to investigate the relation between anthropic arguments, time's arrow and Whitehead's and Hegel's philosophy of nature in a following article.

6) The equations describing the fundamental forces of nature are temporally symmetric, just as classical mechanics was — except for the "small" anisotropy ascribed to the weak nuclear force, in the sense that these interactions can only be time reversed if some properties of some particles are reversed. But this modification of the symmetry of basic physics is only relevant in exotic nuclear processes, and even if this kind of asymmetry did play a significant role it would not really change anything essential in the present family of arguments, because the idea of deterministic trajectories forward as well as backwards in time would be conserved, and because the reversal of properties in question contributes nothing to the explanation of temporal asymmetry in respect to general entropy, diffusion or order. For the detailed discussion of temporal symmetry in basic physics, see R.G. Sachs: *The Physics of Time Reversal*, Chicago 1987.

7) G.J. Whitrow: *The Natural Philosophy of Time*, Oxford 1980, p.8-12.

produced in natural processes or engineering, we need to know a finite number of ways it may be partitioned and organized in physical space or some generalized space. This is not impossible, if we know a posteriori something about the relevant forms and shapes — for example, if the measure of entropy in an organ or organelle is to make sense, it should rest on partitions according to intricate biochemical patterns specific to its biological function. In simple mechanical systems, particularly in machines built by ourselves, the relevant partitions and subsystems for such an analysis are readily available. But as we saw the process metaphysical claim is that there is no apriori formal limit to the forms of order coming up, particularly in complex processes. This can be expressed as the dropping of the assumption that there exists a finite formalism covering the whole variety of forms and order types resulting from self-organizing systems. What we can do in practice is to identify and measure many of them, by analysing phenomena with recourse to processes of development and to function (teleological analyses)[8].

The first consequence of these limitations of the measures of order offered by statistical entropy analogues is that they cannot give us a *generally* adequate measure of self-organized order. There may be no limitation to the precision with which we may measure the degree of order of a particular structure produced, once we have reached a sufficient understanding of that product, but a series of such a posteriori measures of states of a system would not be comparable, as they depend on different measures. (An ad hoc measure combining all the forms in such a series may of course be constructed a posteriori, and may be applicable with some precision to similar

8) What is argued here is not that statistical measures of entropy are subjective in the strong sense suggested by Gibbs, Einstein and others, namely that it only reflects human ignorance (of the true physical microstate). Clearly such a total scepticism would follow if we assumed not only the existence of an unambiguous layer of micro-substances making up the system in question but also the real possibility of knowing the exact microstate the system actually inhabits. With such a knowledge we could always simply define a macro-state corresponding to only the actual microstate, and thus obtain the maximal measure of order no matter what state the system is in. This possibility corresponds closely to the thought experiment of Maxwell's demon who, by virtue of precise knowledge of the system's microstate, would be able to turn any system, whatever its beginning condition, into a state of maximal order and maximal available energy. (Maxwell's demon is recently waking up to new life in information theoretical entropy analogues, see for example *Complexity, Entropy and the Physics of Information*, ed. W.H. Zurek, 1990.) This total scepticism towards the objectivity of entropy rests on the metaphysical ideal that knowledge and form can be separated from the actual phenomena they are embodied in; an ideal which is, as we saw, rejected in process metaphysics. Maxwell's demon is a precise illustration of what must be excluded for traditional statistical mechanics to work: the micro-level and the macro-level must be completely distinct in the sense that our knowledge of and interactions with the actual system are only described on the macro-level, while the micro-level is precisely described as ensembles. But, the argument here is that living organisms and (if Whitehead is right) other complexity-building processes in a sense do what should thus be forbidden. They don't manipulate microstates directly, by owning a demon-like map of them, nor are they free to bundle arbitrary sets of microstates into macrostates, but they do evolve new exotic macrostates which would not previously have been thought of as potential interesting cases of order. Even if we were to accept the basic mechanical premise that there is a bottom level of truly elementary facts, or of particles and configurations (as we saw, this is not necessary in process metaphysics) strong creativity on this intermediary level would destroy the possibility of an absolute or context-free count of states as least as ordered as the actual one. Such a count is local to a context where certain types of order are assumed — because they are objectively important.

self-organizing systems — the same biological species, for example — but if the process view is correct, no fixed combination of forms is generally applicable.)

But secondly: while the teleological and creative tendency of order production inherent in the suggested concept of process would not be positively measurable as the growth of any formally determined type of order, it would have a well defined *negative* consequence: the degree of realization of any relevant fixed ideal of order will decline. Process order, as we saw, is connected with a telos (loosely speaking, an interest in acquiring generality and dominance), and the point can be expressed by saying that the striving towards realization of any fixed ideal of order will be subject to a certain resistance, increasing with its degree of dominance, due to striving towards an infinity of other potential forms some of which will ultimately seize the dominant role. Quantitatively, the order defined by a fixed set of ideals will be realized through ever weaker instances, that is, through macro-states corresponding to ever larger sets of possible micro-states. This means an increasing number W in the simple formula above, and consequently an increase of S. This trivial result amounts to nothing less than a derivation of *2LT* as a consequence of Whitehead's concept of process. It should be noted that this derivation is not supposed to be local to a particular brand of strongly self-organizing processes — if we accept the process metaphysical premise that all processes are self-organizing in the strong creative sense, the result should be global.

The argument is very simple and hardly consists in much more than a single appeal to the process character of reality — which is at least in part the same agency that statistical derivations of *2LT* from mechanics depend upon, as stated above — but now it is part of the explicit premises, if not the only significant premise. We could state the argument more simply by staying within the framework of "genetic" process metaphysics: every order strives towards universality, and because particular patterns of order are not universal they decay — possibly with long periods of equilibrium or relatively good adaptation. On the other hand some steps of the argument may be given a more strictly general formulation, such as an expression of W allowing for continuous sets of microstates and uneven probability distributions, and such as a discussion of the relation between the physical time parameter referred to in *2LT* and the genetic chain of processes over which process order is growing. But these technical discussions would be wordy without changing the essence or power of the argument.

We could also ask if a derivation could proceed directly from Whiteheadian principles of process metaphysics to the classical, macroscopic form of 2LT. This does not connect in the same immediate way as the microscopic formulation in terms of phase state volume. As we saw the latter, the statistical entropy definition, is connected because it is in terms of a generalized kind of extension, and because extension is generally accounted for by Whitehead as relational patterns in societies

of processes, patterns held to be not ultimately stable but dynamically produced, we found that the teleological order-producing aspect of strong processuality implies the “dysteleological” tendency of generalized diffusion from smaller to larger sections. But there seems to be no such way of deriving anything to do with macroscopic properties such as heat and temperature, or at least that this would require that we first manage to construct such properties from our “first principle” of process metaphysics — that is, in fact, that we manage to perform a somewhat detailed construction of the range of properties of observable nature. Whether or not such a range of derivations is feasible, however, I think what is relevant here is something much less. In fact, it must be sufficient to account for the particular aspect of the classical version of 2LT which relates to the problems of interpretation associated with traditional attempts to derive 2LT from something else. It must be sufficient to derive the tendency of diffusion of heat, from inhomogenous to more homogenous distributions, and to do so it must be unnecessary in the first place to ask further questions of the nature off heat, if heat can just be treated as a kind of intensity, analogous to the system points or particles that moved in our generalized spaces before. We have already seen that since any distribution of intensity in a space will be constructed, in the process acount, as a dynamic relational buisiness, and that any fixing of a spatial confine that it is *in* implies a striving to come *out* and posit other patterns, other spatialities, hence we already have what we need: the intensity, heat is rising where it was low before and decreasing where it was high, so that the sum or integral of $dS = dQ/T$ is bound to increase. Under the traditional requirement of closedness of the system, of course.

There is another more interesting discussion left. We should ask what the relationship is between the entropy-like expression whose spontaneous increase we have argued for, and the use of entropy concepts and *2LT* in concrete scientific and technical practice. It must be emphasised that although the process metaphysical main premise for this new construal of *2LT* is of a completely different kind than the statistical mechanical analysis through microscopic subsystems and fundamental physical laws, it should not be taken to contradict statistical physics or its connection with thermodynamics. The combination of the process metaphysical reconstruction of concepts of extension and its dynamic-teleological theses amounts to a reconstruction of this connection too, with an account of why and how far the reduction to statistical physics works. The reduction works in systems close to equilibrium and with controllable border conditions. The limits of this successful function are of two kinds: borders outside the mechanical system (low-entropy beginning conditions) and borders within it (phenomena too complex to fit into the patterns used to measure order). The source of the broken symmetry — the arrow of time — is thus pushed beyond the system considered. But with the suggested reconstruction of *2LT* we can see how this is just what allows accurate description in terms of statistical mechanics.

Thus, the suggested derivation reconstructs orthodox practical use of statistical entropy analogues, just as Whitehead reconstructs the use of measures of time and space.

The fact that such a derivation is possible is extremely interesting. Its merit is not, of course, that the well-corrobated physical principle of *2LT* can gain much further authority through such an affirmation from speculative philosophy, nor that the validity of Whitehead's concept of process can be established by deriving known truths from it. But the possibility of the derivation shows that the apparent contradiction between thermodynamic "dysteleology" and the teleological moment in Whitehead's organic concept of process can be understood as expressing a coherence on a deeper level. The analysis of this apparent problem for process metaphysics discloses a strength of process thought in exactly this area of philosophy of science: the attempts of giving a coherent understanding of the two general classes of natural phenomena that have given rise to the two sets of concepts: the thermodynamic decay of low-entropic (i.e. exploitable) states and energy forms on the one hand, and the human and organic production of order on the other. It has proven extremely difficult to give such a coherent understanding on the basis of the metaphors and concepts developed in the manipulation of inorganic nature — thus, Monod[9] and many others have concluded, on the basis of such an "inorganic" or mechanical concept of nature in its totality, that the life processes in our immediate environment must be extremely atypical physical phenomena, consequences of simple coincidences with an almost infinitesimally small probability of occurring. In spite of the obvious difficulties in explaining notorious aspects of our immediate environment, the inorganic view has been able to maintain dominance — at least in those inevitably growing segments of culture and philosophy which have to deal with natural science — just because alternative views seemed to be in even greater metaphysical trouble. Thus, if the apparent order production in living phenomena were to be taken as a physical reality, it would either have to be local — a vitalist view according to which certain sectors of the universe obeys special laws of nature and in which the problem of limits and conversion between sectors of nature is unanswered — or it would have to be universal — but then we face the apparent clash with thermodynamics. However, Whitehead's concept of process can be used to dissolve this contradiction, as we have just seen, making a coherent organic account much more feasible.

9) J.Monod: *Chance and Necessity*, New York 1972.

Some further reflections on the "derivation" of 2LT.

The possibility of deriving 2LT from the concept of process represents a radical reinterpretation of the law. Rather than a mysterious condition with a dubious status somewhere between physical law and contingent border condition — appearing in macroscopic or statistical systems of many particles but unrelated to more basic physical laws — the process interpretation suggests *2LT* to be a basic consequence of the way (semi-) permanent structures emerge in a world of flux and self-organization. I will sketch some implications of this suggestion.

Firstly, it offers new alleys for the increasingly frequent *cosmological* speculations involving thermodynamics and evolution. One key question here is the reason for or nature of the extreme low-entropy state which must have existed at "the beginning" of our universe if entropy has been monotonously rising. The process view enables us to add a new kind of hypothetical answer: the whole range of thermodynamic phenomena of diffusion may express the decaying relevance of the dominant pattern of extensive division. Admittedly, this is just as speculative as other candidate answers to the same question, but — if we tentatively accept the process metaphysical view of spatiotemporal extension as bound to a particular mode of division whose dominance and relevance is local to a large family of processes, it would seem that the relevance and power of such a pattern of division must be closely connected with a high degree of difference between the contents of the spatiotemporal cells or regions it results in, and conversely that the decreasing relevance of the pattern expresses itself in a decreasing degree of difference. But this gives rise to the prediction that uneven distributions of heat, particles, intensity, energy, probability density, or whatever we look at the distribution of, are gradually replaced by more even distributions — or in other words, diffusion and growing chaos — while new kinds of order are spontaneously growing, eventually to make a whole new pattern of extensive division dominant. The other cosmological key question is the apparent extreme improbability of the evolution of life and higher organisms, according to recent attempts at summarizing the scientific knowledge of the phenomenon. It is now almost universally accepted that this evolution should be understood as made up entirely of spontaneous natural processes, but the detailed mapping of these makes it look more and more as a coincidence of coincidences of such immense degrees of improbability that it may deserve the term miraculous as well as divine creation has ever done. The various versions of the anthropic principle seek to explain the fact that we observe this phenomenon in spite of its infinitesimal probability, as an effect of a sort of passive transcendental self-selection[10], but as I will

10) Barrow and Tipler: *The Anthropic Cosmological Principle*, Oxford 1986. F. Bertola and U. Uri (eds.): *The Anthropic Principle*, Cambridge 1993.

show in another article[11] the invocation of the Anthropic Principle rather amounts to an undermining of any attempt at understanding evolution or anything else in terms of natural causes. On the other hand, if the process view is correct, it may instead be the improbability which is a perspective effect, resulting from the attempt of accounting for self-organization — which is, in Whitehead's words, "incurably atomic" — through extensive division. Self-organization, instability and complexity would then be the "typical" natural phenomena, but their representation into a fixed substance scheme would produce improbabilities as well as entropic decay — as a kind of side effect to the effective control of a large range of natural phenomena made possible by this kind of representation.

So, secondly, the connection of teleology and dysteleology can be interpreted *epistemologically*: the teleological nature of the knowing process — the subject or collective of subjects — shapes cognition along the lines of its projects. States and structures of the environment are measured and compared according to ideals and interests of the knowing process. Therefore, the dysteleological character of processes in the environment would seem to be an inescapable consequence of the subject's project of achieving a particular type of order — a kind of shadow of the subject's own telos. However, if Whitehead is right, processes, and particularly complex organisms, have the power of creatively integrating "negative" (apparently dysteleological) phenomena into "contrasts" and syntheses, thereby modifying their own telos into a richer or "higher" one. Epistemologically this would mean that entropic dysteleology is a transcendental condition of practical knowing, but only within the perspective of a subject holding on to a fixed telos. Generally, the shift from considering the subject as a being existing with a given structure to considering it as a becoming — a striving towards existence and consistent structure, a process in which "broken teleologies" play a central role — corresponds very closely to the shift from Kantian to Hegelian epistemology. The further discussion of process epistemology will have to be pursued elsewhere.

Instead I will conclude this article with a closely related consideration of an *ecological* kind. We have been losing traditional religious visions of nature as meaningful and valuable in itself, alongside the recent fast development of effective technical methods for certain kinds of manipulation and control. (The degree to which either of these historical changes is conditioned by the other is outside the scope here.) Controlling and manipulating the environment and using it as material for realizing goals, in the process view, is what all natural processes do — but it can be done in one-sided and inflexible ways which renders it inefficient in the sense that too many valuable potentialities are lost, by suppressing rather than integrating, with Whitehead's terms. Such a one-sidedness, I suggest, shows in the dichotomy

11) *Anthropic Principles and Human Natures* — forthcoming

between human activity seen as eminently teleological and productive of value, and natural activity seen as valueless. If thermodynamic decay of order is becoming a dominant feature of our understanding of nature, this could be a dangerous sign that we are becoming blind to nature's spontaneous production of order and value — in our own bodies as well as in the rain forests. What we need is perhaps not so much a "protection" of natural orders and values against our interaction, or even the ascription of moral rights to them (≈"deep ecology") — but rather a creative vision allowing us to see these orders and values, and a caring and creative style of engineering making them part of ours.

Finally, all of this does not imply that *2LT* is anything less than true. If the process construal suggested here were true, *2LT* would be an exact statement of conditions which hold whenever a natural process is met in the controlling mode. It would not be subjective in the sense suggested by Gibbs and many others (as a consequence of our limited knowledge of the true reality of microstates) but it would be local because control is always dependent on something uncontrollable. We may have to balance the "modern" knowledge of control with the "traditional" knowledge of how to live with the uncontrollable[12].

12) Cf. B.Latour: *We have never been modern*, 1993