The scope and limitations of Von Bertalanffy's systems theory

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Abstract
The Systems Theory is a *complex theory* (yet it is not identical to recent theories of complexity). The intention of this qualification is to demonstrate that the concept of a *system* is a *complex basic concept* of scientific thinking. This means that it is defined in terms of various *elementary basic concepts* brought together in its explication. The definition given by Von Bertalanffy to the concept of a system employs conceptual elements coming from at least *five* prominent conceptual clusters. In order to highlight the nature and interrelations between these clusters this article focuses upon perennial philosophical issues which present themselves within the definition of a system. They are those of *stability* and *change*, the *one* and the *many* (*unity* and *multiplicity*), the *whole* and its *parts*, and the relation between the *material* and the *vital*. An analysis of the interrelations between these clusters provides the basis for an assessment of the scope and limitations Von Bertalanffy's concept of a system.

Introduction

The invitation to participate in the *Forty-Sixth Meeting of the International Society for the Systems Sciences* contains three significant statements:

(i) Stability and change are frequently identified as the two most significant (and obviously interrelated) features of twenty-first century operations, organisations, communities and societies, and their environments.
(ii) Systems thinking promotes holism as its primary intellectual strategy for handling complexity.
(iii) Systems thinking has been fascinated by the tensions between stability and change, and has embraced a process philosophy in order to grasp the way systems develop over time.

The serious reaction of Modern Systems Theory to all *atomistic* modes of thought may serve as a starting-point for our discussion (cf. Strauss, 1999). Since Democritus introduced his *atomistic* philosophy of nature in Ancient Greece the term *atomism* acquired both a narrow and a broader sense. In its *narrow* sense it indicates the attempt to explain the material world in terms of last *indivisible material elements* ("atoms"). In the

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broader (ontological) sense it is employed to designate different forms of *pluralism*, or specific ways of understanding reality from its supposed last *units*, *building blocks* or – in the case of human society – *individuals*. Since 1825 Saint-Simon and his followers (amongst them Auguste Comte) started to employ the term *individualism* to designate the general approach of social philosophy during the 18th century. According to this view society was first broken apart into isolated individuals and only afterwards it was once again *rationally reconstructed* in terms of the *theory of a social contract*. Of course there are also other variants of atomism. Just like the *empiricistic* legacy of Locke, Berkeley and Hume proceed from the "atoms" of sensation, called *perceptions*, *logical atomism* (a phrase coined by Russell in 1920) considers elementary propositions to be basic and not further analysable – they are the *logical atoms* of the world.

Since all views of reality proceeding from such (supposedly) basic (or: ultimate) *elements*, however much they are considered to be in interaction, eventually are faced with the presence of genuine *wholes* or *totalities*, so-called *methodological individualism* attempts to side-step their reality methodically. Modern Systems Theory, however, was not satisfied with this move and chose to take as its starting-point *wholes* or genuine *totalities*. The fear of some "static" approach in addition added a further qualification: systems deal with *dynamic* realities. The combination of wholeness and dynamic changes explains the emphasis on the *interdependence* between the different *parts* of a system as a *whole*.

In their mutual interrelationships these parts dynamically constitute the whole. One of the key-concepts of all prominent variants of systems theory is therefore given in the relationship of the concept of a *whole with its parts* – irrespective of the way in which the interaction between these parts are conceived of, or concerning how the interaction between the *whole* and its (external) *environment* is envisaged.

Thus far we have highlighted different conceptual clusters. The first one relates to the fact that we deal with a *united multiplicity*. Secondly, we discern the idea of a *whole* with it *parts*. Thirdly, prominence is given to the idea of *stability* (the relative constancy of an enduring or persistent whole/system) and fourthly, the idea of *dynamic interaction* surfaces – which refers to the known interactions of the world we live in. Finally, Von Bertalanffy also adds the dimension of *being organised* to his circumscription of a system. We now embark on a closer look at Von Bertalanffy's systems theory.

Exploring the "System Concept" of Von Bertalanffy

According to Von Bertalanffy a system is a "set of elements in interaction" (1973:84, cf. 36, 37). The original arithmetical cluster of the one and the many, aptly captured by the phrase chosen for the "Festschrift" dedicated to Von Bertalanffy: *Unity through Diversity*, clearly manifests itself in this idea of "elements in interaction." He also refers to systems as "complexes of elements standing in interaction" and in the introduction of this work the term "complexities" is employed as a substitute for the idea of "systems" or "wholes" (Von Bertalanffy, 1973:3). Sometimes the adjective "holistic" is used as a synonym for the term *system* (1973:xvii).

Von Bertalanffy relates this approach to his biological standpoint which is also known as that of *organismic biology*:

> The "organismic" trend essentially starts from the trite consideration that "an organism is an organised thing" (the same applies to systems below and above

> the living individual); and we must look for principles and laws concerning "organisation," "wholeness," "order of parts and processes," "multivariable interaction" and so forth, to be elaborated by a "general system theory" (Von Bertalanffy, 1968:40).

Conceptual clusters involved in the definition of a system

At least five important and undeniable conceptual clusters are therefore recognisable in the description provided by Von Bertalanffy:

(i) an arithmetical cluster: the one and the many;
(ii) a spatial cluster: mutually connected parts within a whole or totality;
(iii) a kinematic cluster: we shall argue below that it is implicit in the issue of stability and change;
(iv) a physical cluster: dynamic interactions (thermodynamic open systems); and
(v) a biotic cluster: a system is organised (amongst other things it requires adaptation to its environment).

The interconnections between these clusters will now occupy our attention. Before we start our analysis of the *whole-parts relation* we have to ponder for a moment about the very nature of *definition* and *concept-formation*.

The nature and limits of definition and concept-formation

In everyday parlance as well as in scientific discussions and writings it seems natural to speak about *concepts*. Yet, as soon as one is asked to explain what concept-formation entails, that which initially appears to be self-evident suddenly turns out to be extremely complicated. Does the employment of concepts furnish us with a *concept of a concept*?

When we look at the classical legacy of reflection in this regard, two perspectives emerge:

(a) a concept is seen as the unity within a multiplicity, and
(b) concept formation is dependent on universal traits.

Taken together these two perspectives imply that the multiplicity which is united refers to universal properties encompassed by the concept. As soon as these implied elements (universal properties) of a concept is explained (explicated), they have to be *designated*. That is to say, they have to receive *names*, making it possible to understand and communicate them as *terms* which are constitutive of sentences and more encompassing texts.

For example, the concept of a triangle unites the following properties, designated by appropriate terms: a flat surface enclosed by three (intersecting) lines (and therefore three angles). The terms employed are: "three," "flat," "surface," "lines," and "angles." The question is now whether these terms, employed in the definition of a triangle, can be defined once more? And if so, what about the terms used to define them? Do we enter on the path of an infinite regress, or do we have to *terminate* the process at the basic level of *indefinable terms*?

The latter indeed seems to be the case, for as we know the antique axiomatic spirit which we have inherited from the Greeks received its modern rigorous shape in 1899 when David Hilbert, after the death of Poincaré in 1912 known as the foremost mathematician of the world, published his *Grundlagen der Geometrie* (Foundations of Geometry). In this work he abstracts from the contents of his axioms, based upon three undefined terms: "point," "lies on," and "line" – all of them related to our intuition of space, an intuition also underlying the relationship between a whole and its parts.

The whole-parts relation

It seems difficult to define the meaning of *continuous extension*. Dantzig did realise this with an astonishing lucidity:

> From time immemorial the term continuous has been applied to space, ..., something that is of the same nature in its smallest parts as it is in its entirety, something singly connected, in short something continuous! don't you know .... any attempt to formulate it in a precise definition invariably ends in an impatient: 'Well, you know what I mean!' (1947:167).

Synonyms like "uninterrupted," "connected," "coherent," and so on, simply repeat what is meant with continuity, instead of defining it!

Aristotle, in following up certain insights of Anaxagoras, holds it to be self-evident that "everything continuous is divisible into divisible parts which are infinitely divisible" (*Physica*, 231b15 ff.). Already the way in which Parmenides characterised *being* illuminates important features of continuity and the whole-parts relation. The B Fragments 2 and 3 of Parmenides contained in Diels-Kranz (1959-1960) says that being "... was not and will never be because it is connected in the present as an indivisible whole, unified, coherent" (B Fragment 8, 3-6).

Modern intuitionistic mathematics made an appeal to these insights of Greek thinking in developing their alternative to the atomism entailed in the thought of Cantor and the formalism of Hilbert. Hermann Weyl, for example, points out that it "... has parts, is a basic property of the continuum", and adds: "... it belongs to the very essence of the continuum that every one of its parts admits a limitless divisibility" (1921:77).

According to Weyl, the general aim of Weierstrass, Dedekind and Cantor, namely to advance an *atomistic* perspective on space (i.e., to arithmetise spatial continuity completely), had to take recourse to the *neighbourhood* concept: "To account for the continuous coherence of the points, contemporary analysis, which has separated the continuum into a set of isolated points, takes refuge to the neighbourhood concept" (1921:77).

However, it is not at all imperative to adhere to the intuitionistic approach in modern mathematics in order to realise that the *totality-character* of continuity (its "wholeness") is irreducible to numerical notions. Paul Bernays, the collaborator of David Hilbert, states this outcome emphatically:

> The property of being a totality undeniably belongs to the geometric idea of the continuum. And it is this characteristic which resists a complete arithmetization of the continuum (1976:74).

In another context he writes:

> We have to concede that the classical foundation of the theory of real numbers by Cantor and Dedekind does not constitute a complete arithmetization of mathematics. It is anyway very doubtful whether a complete arithmetization of the idea of the continuum could be fully justified. The idea of the continuum is after all originally a geometric idea (Bernays, 1976:187-188).

From the fact that a (continuous) whole is infinitely divisible it must be clear that *spatial continuity* presupposes the meaning of number (a discrete multiplicity). Another way to phrase this state of affairs is to say that within the structure of space the meaning of number is *analogically reflected*. The meaning of space therefore comes to expression in its coherence with other aspects of reality.

Whereas the history of mathematics completed the circle by starting with an initial arithmetization of mathematics, then moved on to an attempt to explore the meaning of space as basic denominator and finally once again returned to an arithmeticistic conception in modern set theory, we may suggest a *third alternative* not yet explored: accept both the uniqueness and mutual irreducibility of space and number.

This brief argument about the uniqueness and irreducibility of number and space explains why systems theory is justified in employing both numerical and spatial terms in its definition of systems.

A similar position ought to be developed with regard to the perennial problem of *constancy* (stability) and *change* (dynamics).

Constancy and Dynamics

The modern concern to over-emphasise the *changefulness* of reality does not realise that any form of *change* only has meaning on the basis of something *enduring*. The ease with which we speak about *change* invites us to ask:

a) Do we need, for example to be able to speak about a *changing* society, something that is not itself *changing*, i.e. persistent and enduring?
b) Is there anything *constant* lying at the basis of whatever *changes*?

Early Greek philosophy already wrestled with the dialectical opposition of *constancy* and *change*. It inspired Heraclitus' famous statement: one cannot step into the same river twice, for fresh and ever fresh waters are constantly pouring into it. Cratylus, a pupil of Heraclitus, challenged Plato with this problem of constancy and change, as can clearly be seen from Plato's dialogue with that name. In this dialogue, Plato had to account for the nature of *knowledge* in terms of something more fundamental than *change*. He found it in what he termed to be the essential form (*αὐτὸ τὸ εἶδος*) of what is known. Although this argumentation gave birth to his speculative theory of ideas, located in a supertemporal domain of ideal being, it must be honoured as the first argued acknowledgement of the unbreakable foundational coherence between *constancy* and *change*.

This insight enabled Galileo to explore its natural scientific meaning. He realised that *uniform motion* (constant motion) is a *primitive notion*. Therefore it is not in need of a *physical cause*. The physical meaning of a *cause* always implies certain *effects*, i.e., *dynamic changes*. What needs a cause is not *motion*, but a *change* of motion (cf. Stafleu, 1980:80) – for instance *acceleration* or *deceleration*. This implies that the *phoronomic* (or: kinematic) facet of reality is indeed a (foundational) condition for *energy-operation* (with its implied *causes* and *effects*). Just as continuity presupposes a foundational arithmetical multiplicity, physical changes presuppose some form of continuation (persistence, constancy), for only on the basis of something *persistent* is it meaningful to identify *changes*. The basic intuition of *constancy* will not be canceled if the velocity of light in a vacuum varies, because establishing that it changes will then continue to presuppose the idea of constancy – it is only on the basis of the latter that it will be possible to detect changes. Widening our perspective of course will show that motion itself presupposes space (its path) and number (through which its speed is expressed). Similarly, the physical meaning of energy-operation does not only rest on the (kinematic) basis of constancy, since it also (analogically) reflects the foundation of the spatial and numerical aspects (respectively in the physical concepts of *volume* and *mass*).

If this line or argumentation is sound, then it must also be the case that the biotic mode of organic life presupposes the aspects of energy-operation, kinematic motion, spatial extension and numerical multiplicity. Without realising that the connection between biotic functioning and energy is an expression of the irreducible coherence between the physical and biotical aspects of reality, the age-old legacy of vitalism in the discipline of biology stumbled upon this coherence in its notion of an "entelechie" (Aristotle), a "vital force."

"Vital force" and "open systems"

The neo-vitalistic biology of Hans Driesch extensively experimented with phenomena of *regeneration*. Driesch accounts for the internal order and harmony displayed in the functioning of living entities by introducing his notion of an *immaterial vital force*, an *entelechie* (Driesch, 1920:139 ff.). This vital force is even capable of "suspending" physical laws, such as the second main law of thermodynamics (the law of non-decreasing entropy) (Driesch, 1920:434 ff.). He envisaged that this *entelechie* can account for the fact that living entities are apparently indeed capable of increasingly building up internal order (that is, apparently a decrease of entropy) in spite of the existence of the physical law of non-decreasing entropy. Driesch comes to these conclusions after having shown convincingly that certain parts of living entities, after division, can function as immature wholes capable of developing integral maturity. In the case of an *hydra*, for example, a part as small as 1/200th can regenerate a whole new snake! Yet, when *no* part is separated from an organism, the original living entity will mature normally without, by itself, developing into *more than one* individual.

Thus, according to Driesch, living entities display an internal *order* and *harmony* which keep the "equal potential" of each part in its proper place when the organism is not disturbed, but when it is divided at an early stage, each part will explore its full regenerative potential. Consequently, Driesch calls a living entity a "harmonic equipotential system" (Driesch, 1920:135 ff.). No machine possesses parts that have this capability (1920:132-133, 410, 512).

The fundamental question is simply whether or not one needs to subscribe to the vitalistic notion of an "entelechie" in order to acknowledge the mentioned regenerative phenomena which lead Driesch to his construction? Von Bertalanffy is a case in point, for although he rejects *vitalism* as a point of orientation for biological thought, he does agree with the arguments raised by vitalism against the machine model of living entities. He acknowledges that self-repairing machines are conceivable in terms of the modern theory of automata, but he points out that the "problem comes in with regulation and repair after arbitrary disturbances" (Von Bertalanffy, 1973:148).

However, in his historically significant contribution to modern physics and biology, Von Bertalanffy abandoned this notion of the "suspension" of physical laws by an immaterial entelechie, simply by providing a *generalisation* of the second law of thermodynamics. The original formulation of this law of non-decreasing entropy is only valid for *closed physical systems*.

Already in 1824 Carnot discovered irreversible processes – a discovery that would eventually challenge the mechanistic main tendency of classical physics which believed that all physical phenomena may be reduced to *reversible* processes of motion, i.e., to the kinematic aspect of reality. By 1850 Clausius and Thompson, independently of each other, formulated the second main law of thermodynamics. Clausius introduced the term *entropy* only in 1865. Thomson's formulation of 1852 reads as follows: "All the available energy strive at dissipation, it aims therefore at a uniform dispersion" (cf. Apolin, 1964:440). [In passing we may note that this eventually eliminated the basis of the mechanistic trend in modern physics (cf. Planck, 1910:53). Physical processes are *irreversible*.]

Von Bertalanffy generalised this law to include cases of a constant interchange of systems with their environments:

> Chemical equilibria in closed systems are based on reversible reactions; they are a consequence of the second principle of thermodynamics and are defined by minimum free energy. In open systems, in contrast, the steady state is not reversible as a whole nor in many individual reactions. Furthermore, the second principle applies, by definition, to closed systems only and does not define the steady state (Von Bertalanffy, 1973:132).

Von Bertalanffy's generalisation not only shows that living entities are thermodynamically open, since in the first place it accounts for the numerous examples of *physical* systems that are thermodynamically open, such as a glacier or a fire. This dynamic equilibrium, designated with the term "Fliessgleichgewicht" by Von Bertalanffy (1973:165), therefore concerns a *physical* feature of living entities, not a *distinctive biotical* one![2] The physicist Schrödinger wrote a book about the *physical aspect* of the cell (cf. Schrödinger, 1955).

The apparent "equilibrium" present in a living entity is completely different from any true equilibrium in a physical sense. The latter state is incapable of *performing any work*. Von Bertalanffy points out that the dynamic pseudo-equilibrium of living entities is kept constant at a certain distance from true equilibrium enabling it to perform work while requiring continuous import of energy for maintaining the distance from true equilibrium (Von Bertalanffy, 1973:133). Schrödinger describes this state of affairs by saying that living things feed on *negative entropy* (Schrödinger, 1955:71 ff.).

As a matter of historical interest it is worth noting that the neo-vitalists who continued the legacy of Driesch in the 20th century indeed made use of Von Bertalanffy's theory of open systems. While fully acknowledging the nature of thermodynamic open systems Schubert-Soldern, for example, continues the neo-vitalism of Hans Driesch in the following remarkable way. To explain the (thermodynamic) "state of highest improbability", i.e. *instability*, present in a self-maintaining system, he introduces an "instability factor" (Schubert-Soldern, 1962:62, cf. 68). Concerning the steady flow of building material in a living entity we are fully justified in saying that it is, physically seen, in an *unstable* condition. At the same time, however – and without any contradiction – we may also say that the same entity is, seen from a biotical perspective, in a *stable* condition! Whenever *physical* stability is approached (true equilibrium), *biotical instability* is on its way as an inevitable symptom of forthcoming *biotical death*.

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2 Note that one has to distinguish between the biotic mode in an ontic sense and theoretical reflection upon this given mode undertaken by the discipline of biology. A living cell, for example, is therefore not a biological but rather a biotic phenomenon. Theories concerning the nature of the cell as living entity belongs to the discipline of biology.

This non-contradictory fashion of grasping both the (physical) instability and the (biotical) stability of living entities, once more points at the *irreducible* nature of the biotical aspect of reality. Evidently, in a purely physical sense it is contradictory to claim that the same entity can exist both in a stable and in an unstable condition!

From the perspective of his organismic biology Von Bertalanffy strikingly indicates the *cul-de-sacs* of the mechanistic point of view which eliminates the *biotical function* of life processes:

> These [biochemical – DFMS] processes, it is true, are different in a living, sick or dead dog; but the laws of physics do not tell a difference, they are not interested in whether dogs are alive or dead. This remains the same even if we take into account the latest results of molecular biology. One DNA molecule, protein, enzyme or hormonal process is as good as another; each is determined by physical and chemical laws, none is better, healthier or more normal than the other (Von Bertalanffy, 1973:146).

Conceptual clusters and ontic domains

We have identified five *conceptual clusters* involved in the definition of a "system." *Implicitly* we have related them to the following ontic domains: (i) the arithmetical sphere, (ii) the spatial sphere, (iii) the kinematical sphere, (iv) the physical sphere and (v) the biotical sphere. On the *epistemic* side each one of these spheres finds its focuse in an indefinable *core intuition*, and on the *ontic* level we follow Dooyeweerd in his designation of this core meaning as the *meaning-nucleus* of each aspect (guaranteeing its indefinability, irreducibility and therefore its *uniqueness*). In addition to guaranteeing the irreducibility of every sphere the meaning-nucleus of each aspect at the same time qualifies the links (connections) between the different aspectual domains. An intuition of unity and multiplicity, wholeness, constancy amidst change, and that of a dynamically organised and living entity thus co-determines the understanding of a *system*. Traditionally only concretely existing entities were considered to be *real*. However, in the present context we want to argue that not only the concrete *what* but also the functional (aspectual) *how* participates in what is *ontic*.

The ontic basis of conceptual clusters[3]

At this point, however, it must be clear that we conjecture that the said conceptual clusters reflect *ontically given spheres*, *aspects* or *modes* (functions) of reality itself. Although the theoretical acknowledgement of these spheres/aspects/modes/functions is the outcome of *human reflection*, I want to argue that these aspects in an ontical sense *precede* human cognition and understanding. This position distances itself foremost from the *nominalistic* conviction that "that number and all universals are only modes of thought" (cf. Descartes, *Principles*, Part I, LVIII).

Contemporary debates about universals still distinguish between entity (substance) and properties. Nominalistic and realistic options contemplate about phenomena such as predication, exact similarity and abstract reference. Although authors like Wolterstorff, Butchvarov and Loux prefer to give prominence to one of these three phenom-

3 have treated this issue within the context of a broadened understanding of the nature of abstraction primarily focused on the thought of Frege. It was presented to the Annual Conference of the Philosophical Society of Southern Africa in January 2002 at Stellenbosch and afterwards sent to an accredited Journal for publication.

ena, Moreland may be correct in his assessment when he states that he sees "no reason to choose any as most important" (2001:159 note 15, see page 4).

The fist conceptual clusters we have in mind relate to the domains of multiplicity and extension (roughly referred to as "number" and "space"). The statement quoted from Descartes suggests that his nominalism implicitly assumes that there is a contribution by the human subject when universals are at stake. As "modes of thought" their existence is dependent upon thinking. Yet the question remains whether or not a given multiplicity (for example of entities) precedes the human capacity to form a concept (such as the concept of number)? Prominent mathematicians of the 20th century indeed wrestled with this issue. The co-worker of David Hilbert (known as the leading mathematician of the 20^{th} century), namely Paul Bernays, explicitly questions the dominant conception that only *one kind of factuality* ought to be recognised, namely that of the "concrete" (Bernays, 1976:122). Because what is called "mathematical objects" are not plainly open to *sense perception*, the challenge is to account for the subject matter of mathematics in terms of non-entitary ontic features. The extreme platonist ought to clarify this issue, because the assumed "objective existence" of "mathematical objects" is in need of some or other foundation if it is not merely (nominalistically) postulated as *constructions* of the human mind.

Perhaps the most striking mathematician to refer to in this context is Kurt Gödel, who acquired interdisciplinary repute at the age of 25 when (in 1931) he demonstrated the inherent incompleteness of (formal) axiomatic systems. He introduces the idea of "semiperceptions" in order to account for the nature of "mathematical objects". Distinct from a physical causal context (within which something can be "given"), Gödel is convinced that the data of this second kind "cannot be associated with actions of certain things upon our sense organs" (quoted by Wang, 1988:304). The mathematician Wang is "inclined to agree with Gödel," but he does "not know how to elaborate his assertions" (Wang, 1988:304). Wang says that he feels "that 'an aspect of objective reality' can exist (and be 'perceived by semiperceptions') without its occupying a location in spacetime in the way physical objects do" (Wang, 1988:304).

Surely these considerations call for the acknowledgement of a *function* or an *aspect* of reality which is *given* in an ontic sense but nonetheless differs from physical (or other kinds of) *entities*. Understanding the meaning of these ontically given aspects or functions indeed requires a formative (constructive) human activity, in its scholarly sense performed by mathematicians (and scientists from other disciplines) who are capable, through their articulation of mathematical theories, to make these given aspectual phenomena conceptually understandable. In particular this approach will enable us to take a position different from both platonism and constructivism. In opposition to platonism it acknowledges that thinking about the meaning of number and space does not simply rest on the acceptance of an already existing transcendent (ideal) world of "mathematical objects" independent of the thinking human mind, since without the interference of human thinking the ontically given meaning of quantity and continuity cannot be disclosed and articulated in mathematical structures. By contrast, it also opposes constructivism in acknowledging that the subject matter of mathematics is not merely the product of the thought-activities of mathematicians, because such activities, in the words of Gödel and Wang, presuppose "an aspect of objective reality."

But it is neither only the numerical and spatial aspects nor merely the kinematical and physical ones that participate in the ontic status of modal aspects. All other identifiable aspects also participate in this dimension of reality, including the *biotic* aspect.

Living systems

Living systems – such as plants, animals and human beings – in addition to their concrete functions within the modes of number, space, motion and the physical, also function actively in the biotical mode of reality. In other words, the fact that such entities are *alive* does not mean that their existence is exhausted by their biotic functioning – manifested in phenomena such as growth, adaptation, differentiation and integration, maturation, ageing and dying. Let us briefly explain the function of living entities in each of the aspects that constitute the ontic foundation of the biotic mode.

Von Bertalanffy did realise, as we have seen, that living things, in a thermodynamic sense, are to be considered as *open systems*. Moreover, this indicates that every living entity, in distinction from its characteristic biotical aspect, also displays a *physical aspect* (cf. once again Schrödinger, 1955). Laszlo continues this perspective in his statement: "The relevant kinds of systems are those that exist in a state of dynamic nonequilibrium within an enduring energy flow. The condition of nonequilibrium signifies the presence of energy concentrations and chemical ingredients. This is the precondition for the availability of free, usable energy in a dynamic state characterised by negative entropy" (Laszlo, 1993:xix).

Any living entity also has active (subject) functions in the three aspects of reality which are *foundational* to the physical aspect – namely the aspects of number, space and movement. For example, linked to the question whether or not living things can move by themselves we find another important distinction in biological systematics, namely that between plants and animals. The continuity (endurance) of the life of a plant cannot be determined apart from the kinematic function of living entities. In addition to the proportions or spatial form of living things, their spatial function is also prominently exhibited in expressions like *bio-milieu* or *Umwelt*. The term *Umwelt* gained prominence especially owing to the biological thought of Jacob von Uexküll (cf. e.g. Von Uexküll & Kriszat, 1970). Finally, a living entity is a *unity* in the *diversity* (multiplicity) of its organic life processes – if these various processes are not bound together as a unity, as we have argued, the inner diversity of living entities *disintegrate* and they *die*.

What we have established with this brief characterisation is that *systems* are indeed co-conditioned (co-determined) by the five fundamental modes (functions) identified in our analysis. Though these modes primarily *condition* systems (and whatever else exist in an entitary way), as *points of entry to reality* they also serve as *modes* of (scientific) *explanation*. Of course the cosmic system of the world order comprises many more *functional modes* than the five identified. Without providing an argument for identifying and naming the others, we simply enumerate them: only think about the sensitive mode of *feeling*, the analytical mode of *logical thinking*, the historical mode of *cultural formation* (formative control/power), the sign mode of *symbolical signification*, the social mode of *human interaction*, the economic mode of *avoiding excesses*, the aesthetic mode of *beautiful harmony*, the jural mode of *retribution*, the ethical mode of *love* and the fiduciary mode of *certainty*.

Some implications of the multi-aspectual nature of reality for systems theory

The original modal spatial "seat" of the whole-parts relation entails that whatever functions within this aspect will exhibit features true to the nature of this aspect. Systems theory is therefore justified in its emphasis on the wholeness or totality character of systems. Nonetheless we have to point out that the legitimate application of the whole-parts relation does have definite boundaries. If it is true that all variants of atomism expanded the discrete meaning of number beyond the limits of a justifiable application of the meaning of discreteness, then the same applies to an unjustified expansion of the meaning of the spatial whole-parts relation in various forms of holism. These limits may caution us to avoid the practice of characterising systems with the aid of the qualification *holistic*. Nowadays it is fairly commonplace that a person who wants to explain that all aspects of a situation ought to be taken into account will call such an approach holistic. Rather, the term *holism* should be reserved for an overestimation of the whole-parts relation, applying it beyond its legitimate confines. In this sense *holism* is just as one-sided and mis-directed as *atomism*.

What are the limitations to the whole-parts relation? In order to find an answer to this question we may consider a few examples. First of all we will look at the interlacement of physical entities such as *atoms* and *molecules*. Then we will highlight the function of the latter within the smallest biotical unit of life, the *cell*. Finally, as an example of an illegitimate application of the whole-parts relation we will briefly pay attention to the systems concept as it is developed in the sociological theory of Parsons. In all these cases, as an expansion of the justified intentions of systems theory, an alternative application of the idea of the interconnections and intertwinement between differently natured systems will be proposed.

Limitations of the whole-parts relation

Although we have argued that within the context of the original spatial mode of reality we are confronted with the infinite divisibility of a spatial whole, there are important limitations to the *unqualified* use of this spatial whole-parts relation. The interweaving which exists, for example, between the *sodium* and *chlorine atoms* which are found in table salt, cannot be accounted for exclusively with the help of the whole-parts perspective. Every division of table salt must – that is if we still want to be working with real parts of salt – still possess the *same* chemical structure (NaCl). The critical question is whether, considered in separation, *sodium* and *chlorine* each individually has a salt structure? Are sodium and chlorine true *parts* of salt? The answer is obvious: No, because neither Na nor Cl as such has a NaCl-structure on its own!

What is needed is a theoretical account of the continued existence of the internal structure of the Na and Cl atoms in spite of their molecular connection in table salt. The Dutch philosopher Herman Dooyeweerd proposed to employ the term *enkapsis* to account for all kinds of interlacement where this is the case (cf. Dooyeweerd, 1997-III:627 ff., 694-780). Although a thorough explanation of this alternative theory will be treated in a separate article, an outline of its basic intentions will be given.

Take a water molecule as an example. Without atoms there is no molecule. Does this mean that the bound atoms become integral parts of the molecule? But what about the atomic nucleus which is not affected by the chemical bond? Does this mean that the nucleus – which is not merely an accidental characteristic of the atom but precisely that central part which determines the place of the atom within the periodic table – is a threat to the wholeness of the water molecule? The theory of enkaptic interlacements is designed to account for these difficult and complicated states of affairs in a theoretically satisfactory way.

Von Bertalanffy's challenge to neo-Darwinism

Modern biology struggled in diverging ways with the relation between living entities and their constitutive material building blocks (cf. Von Bertalanffy, 1952). Is it possible to describe and characterise living entities exclusively and completely in terms of their constitutive physical-chemical components? If the latter point of view is correct, then one has to ask whether the distinction between "life" and "death" still makes any sense. If everything is determined by the interaction among lifeless material constituents, then the difference between being alive and being lifeless fades to an illusory peripheral phenomenon of the physical mass of reality.

In neo-Darwinist thought natural selection receives much prominence, for example in the story told about the supposed origin of the first living entities. The assumption is that by means of selection organic combinations accidentally emerged – amino acids, nucleic acid, enzymes, etc. This process, in turn, supposedly gave rise to the formation of reproductive units, virus-like forms, proto-organisms and eventually true living cells. However, in view of physical laws, Von Bertalanffy, amongst others, is justified in his questioning of this construction:

> In contrast to this it should be pointed out that selection, competition and 'survival of the fittest' already presuppose the existence of self-maintaining systems; they therefore cannot be the result of selection. At present we know no physical law which would prescribe that, in a 'soup' of organic compounds, open systems, self-maintaining in a state of highest improbability, are formed. And even if such systems are accepted as being 'given', there is no law in physics stating that their evolution, on the whole, would proceed in the direction of increasing organization, i.e. improbability. Selection of genotypes with maximum offspring helps little in this respect. It is hard to understand why, owing to differential reproduction, evolution should have gone beyond rabbits, herring or even bacteria, which are unrivalled in their reproduction rate (Von Bertalanffy, 1973:160-161).

Those who have respect for scientific modesty may do well to reflect upon a remark once made by Haldane in a discussion with Silver:

> I had a long conversation with J.B.S. Haldane, which started off with politics and ended with science. When I questioned him about evolution, one of his remarks sparked my interest, and sent me to the library that evening: 'Evolution's not the problem. Life is.' Then he said, 'Oparin and I once had an idea about that, but we'll never know the real answer' (Silver, 1998:353).

The physical uniqueness of the living cell forms the counterpart of its irreducible biotically characterised structure. With regard to the unique manner in which the living cell functions in the physical aspect of reality, Karl Trincher mentions four macroscopic characteristics (Trincher, 1985:336). Von Bertalanffy realised that apart from such physical characteristics of living entities – such as being "open" in a thermodynamic sense – living entities are also to be viewed as organised wholes or totalities.

Before him Driesch already made an effort to come to terms with this totality character of living entities. However, he failed to describe the influence of a supposedly immaterial *entelechie* (immaterial vital force) on the material components of living things otherwise than in terms appealing to the physical aspect. He could not see that scientific conceptualisation necessarily utilises *functional modes of explanation* (points of entry). He even preferred to see *entelechie* as a system of *negations* which could not be determined positively: it is *non-spatial*, *non-mechanical*, *indivisible* [cf. Sinnott, 1963 and Haas, 1968] and *non-energetic* (Driesch, 1931: 297).

Within the context of the ordered (centred) systemic structure of the cell, we do however (from a biotical perspective) come across the various organs (organelles) which are true *parts* of the living cell-organism. Since the cell is built up of non-living material components we cannot simply say that these organelles are parts of the cell in its totality. In order to indicate the *biotical activity* of the cell it is appropriate just to employ the mentioned phrase: *cell-organism*. The various organs of the cell are all parts of the *cell organism*. Yet the different *organelles* only exist on the basis of physical-chemical constitutive substances – which once again highlights the need for a theory of structural interlacements which can do justice to the interweaving of different spheres of operation (to be treated in a separate article). Instead we terminate our discussion with a brief indication of the limitations of applying the whole-parts relation to human societal realtionships.

Is it possible to understand human society in terms of a whole and its parts?

Theoretical reflection on the nature of human society is practically as old as philosophy itself. Traditionally it was placed within the context of an encompassing theory of the state and, particularly during the Middle ages, it was accompanied by a particular view of the church. Plato, Aristotle and Thomas of Aquinas started from the *social nature* of being human and thought in terms of a largest societal whole (the state or the church) encompassing all of society. The late scholastic nominalistic movement, starting with John the Scott and elaborated by William of Ockham, and in particular by Marsilius of Padua and Jean of Jandun in their writing in defense of peace (*Defensor Pacis*), transformed the holistic mode of thought dominant during the medieval period into its opposite, an atomistic view.

This dilemma between atomism (individualism) and holism (universalism) was fundamentally challenged for the first time by the German legal scholar, Johannes Althusius. In a work from the year 1603 he addresses the question of what can be considered to be a part of the state (a *regnum*). Whereas traditionally it was unproblematic to include in this list societal collectivities such as the church, the family, the business enterprise, and so on, Althusius realised that it is only provinces which are truly *parts* of a state. Everyone of these non-state forms of social life is ruled according to its own laws which are fitting to the peculiar nature of each one of them. Althusius declares:

> It can be said that individual citizens, families, and collegia are not members of a realm (i.e. the state – DFMS), ... On the other hand, cities, urban communities, and provinces are members of a realm (Althusius, 1603:16).

With respect to social forms of life distinct from the state Althusius holds:

> Proper laws (leges propriae) are those enactments by which particular associations are ruled. They differ in each species of association ... as the nature of each requires (Althusius, 1965:16).

Unfortunately Woldring does not highlight this difference in principle between the whole-parts relation and the "own laws" peculiar to the various non-political realms of life in the thought of Althusius (cf. Woldring 1998:125 ff.). Although Althusius formulated his ideas within the context of his "symbiotic" view of society, his insights indeed form one of the most important points of connection for an understanding of human society transcending the dilemma of *individualism* and *universalism*.

In conclusion we will briefly investigate the question whether the systems theory of Parsons succeeds in giving an account of these "proper laws."

The reduction present in Parsons' LAIG scheme

The primary categories used by Parsons in the functional classification of his sociological systems theory are that of *pattern-maintenance* (also designated as *latency*), together with *integration*, *goal-attainment* and *adaptation* (Parsons, 1961:30). He declares that the "function of pattern-maintenance refers to the imperative of maintaining the stability of the patterns of institutionalised culture defining the structure of the system" (Parsons, 1961:38) and then adds the following remark:

> Pattern-maintenance in this sense plays a part in the theory of social systems, as of other systems of action, comparable to that of the concept of inertia in mechanics. It serves as the most fundamental reference point to which the analysis of other, more viable factors can be related (Parsons, 1961:39).

When Parsons and Bales formulate a law imitating Newton's first law of motion (basically Galileo's law of *inertia*), they characterise it as being merely "another way of stating one aspect of the fundamental postulate that we are dealing with equilibrating systems" (Parsons and Bales, 1953:100 – note the influence of Schumpeter). Parsons and Bales do not understand the *difference* between the kinematical and the physical aspects. They also do not adequately distinguish between *closed* and *open systems* within the physical aspect. Consequently, they wrongly identify *homeostasis* with the analogy of *inertia* (which has an original *kinematical* meaning) in their characterisation of "equilibrating systems." The same comment is relevant with respect to Parsons' use of the concept of *pattern-maintenance*, seen by him as something comparable with the concept of *inertia* in mechanics. *Maintenance* always requires new *energy-input* (into an *open system*) – something different from the inertial notion of mere *continuation*.

His *animistic* (Aristotelian) conception of inertia alerts Catton and causes him to mention "the subtly animistic connotations of his vocabulary as well as the 'animistic overtones' in Parsons' use of the phrase 'pattern-maintenance' " (Catton, 1966:82).

Partly due to the asymmetry between the concepts of *structure* and *function* Parsons eventually preferred to speak about *functionalism* instead of *structural-functionalism* (cf. Parsons, 1977a:49; 100; 116).

> Our view is that the economy and the polity should be treated as functional subsystems within a society (Parsons, 1961:34).

The *terminological context* of Parsons' concept formation is clear. First of all he explores the *spatial* whole-parts relation by employing the terms *system* and *subsystem* as well as the distinction between *internal* (inside) and *external* (outside). Integration and pattern-maintenance are directed to the inside whereas adaptation and goal-attainment relates to the outside. Pattern-maintenance, mistaken by Parsons with an analogy of inertia, actually (analogically) reflects the meaning of thermodynamic open systems, while the other three categories are all derived from the original meaning of the biotical aspect of reality – adaptation, integration and goal-attainment.

However, the identification and distinguishing of different societal collectivities transcend the scope of the LAIG scheme. If the "polity" is characterised by (collective) goal-attainment and the "economy" by adaptation, nothing *distinctive* is asserted. Any average firm has to attain certain goals and any "polity" has to adapt to its environment.

The classical school in economic theory saw in the *market* the prime manifestation of the operation of the 'law' of *supply and demand* and used the functioning of the market to explain everything within economic life. Both R.H. Coase (1937) and O.E. Williamson (1975, 1985) start from the assumption that markets are basic and historically original. The *firm* is a secondary phenomenon, emerging through the attempt to economise and internalise the cost of market transactions between individuals. Fourie correctly asks whether it is legitimate "to attempt to explain the typical and distinguishing inner nature of the firm exclusively in terms of another, typically different relation, i.e. the market (transactions, contracts) (Fourie, 1993:41). Only when we look at the *economic aspect* of reality as it guides the totality structure of the firm do we discern its qualifying function. Carefully distinguishing it from the *jural aspect* opens room for an insight into the equally unique structural principle of state. Since the economic and the jural aspects are modal functions of reality in their own right, it is mistaken to try to side-step them in the characterisation of the "economy" and "polity." The biotic "descent" of the terms *adaptation* and goal-*attainment* disqualify them to elucidate what is distinctive between the "economy" and the "polity."

Every unique societal whole or system has its typical qualifying function, without allowing any one of them to embrace all the others within a differentiated society. The inner sphere-sovereignty of each differentiated sphere ought to be acknowledged without stretching the whole-parts relation beyond the confines of any one of them.

According to Münch the starting-point of the theoretical debate of the 1980s within sociological theorising is "Weber's theory of rationalisation of modern society into spheres that are guided to an increasing extent by *their own inner laws* (I am italicising – DFMS). This theory of rationalisation has been combined – by Schluchter and Habermas – with the theory of functional differentiation as it was formulated by Luhmann" (1990:442).

Conclusion

The acknowledgement of the functional dimension of modal aspects co-conditioning the reality of whatever exists in a concrete way enables the identification of those conceptual clusters that are constitutive in the definition of systems. The complexity of a system is given in the fact that it is impossible to provide an exhaustive description merely employing *one* modal point of entry. The attempt to overextend the explanatory power of any single mode invariably results in a reductionism, such as that of atomism or holism. Understanding systems therefore in terms of the simultaneous usage of a complex of explanatory modal functions highlights a constructive and positive feature of modern systems theory. Yet, systems theory did not sufficiently succeed in liberating itself from an over-extension of the spatial whole-parts relation – a shortcoming that may be rectified by exploring the enriching alternative guideline of sphere-sovereignty and the theory of enkaptic interlacements entailed by it.

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