The "Corpernican turn" of biology in the 20th Century

Prof D F M Strauss
E-mail: dfms@cknet.co.za

Abstract
One is reminded of the turn towards the "subject" in early modern philosophy by looking at the ermergence of the term "Umwelt" within 20th century biological thought. The term "Umwelt" originally has a spatial connotation, explaining why an analysis of it unveils an interdisciplinary terminological connectedness transcending the confines of any specific scientific discipline. This interdisciplinary consideration opens the way for systematic perspectives developed against the relevant historical background, with particular reference to the "Umweltlehre" of Jakob von Uexküll. The contribution of Jakob von Uexküll, who indeed explicitly introduced the notion of a "subject" into biological research, is assessed in terms of multivocal *spatial* terms such as (bio-)mass, (bio-)milieu and (bio)-sphere. It turns out that this can only be done in terms of those subject-object relations found in nature (within the realms of plants and animals). At the same time pursuing this path highlights the inherent limitations of the concept of an "Umwelt," explaining also why in its purely biological sense it cannot be applied to the domain of human experience as well.

Opsomming
Deur te let op die wyse waarop die term "Umwelt" beslag gekry het binne die biologiese denke van die 20ste eeu word 'n mens herinner aan die Koperknikaanse omwenteling ten gunste van die "subjek" wat in die moderne filosofie ingetree het. Oorspronklik besit die term "Umwelt" 'n ruimtelike konnotasie, wat verduidelik waarom 'n analise daarvan 'n interdissiplinêre verweefdheid blootlê wat die grense van enige spesifieke dissipline te bowe gaan. Hierdie interdissiplinêre oorweging open die weg vir sistematiese perspektiewe teen die relevante historiese agtergrond, met spesifieke verwysing na "Umweltlehre" van Jakob von Uexküll. Hy het inderdaad eksplisiet (in aansluiting by Kant) die nosie van 'n "subjek" in biologiese navorsing aan die orde gestel. Hierdie bydrae word beoordeel in die lig van terme soos bio-massa, bio-milieu and bio-sfeer. Dit blyk dat dit slegs sinval gedoen kan word in terme van die talle subjek-objek relasies wat in die natuur (beide binne die ryke van plante en diere) aangetref word. Tegelyk belig hierdie oorwegings argumente op grond waarvan die ongekwalifseerde toepassing van die begrip "Umwelt" op die menslike bevraagteken moet word.

1. **Orientation**

In their speculation about a world "logos," and a "chain of being" classical Greek and Medieval philosophy adhered to an ordering *outside* the human subject. During the late medieval transitional period a turn away from God and a cosmic world-order took place. Descartes merely drew the radical conclusion of this process when postulated the thinking "I" (*cogito*) as the new source of certainty. The apparent infallibility of mathematics is used to proclaim the sovereignty of human thought. In his "Prolegomena"

to every future metaphysics acting as a science, Immanuel Kant said that it was David Hume who liberated him from his "dogmatic slumber" and helped him to realize that "objective reality" ought to be understood in terms of the subjective categories of thought (cf. Kant, 1783, "Vorrede":260). This is known as the "Copernican turn" in the epistemology of modern philosophy. In a different context I have shown that Kant actually elevated human understanding, through it's *a priori* concepts, to become the formal law-giver of nature (cf. Kant, 1787:163 and Strauss, 1982). It is against this background, having witnessed a return towards the *subject* in modern philosophy, that this article wants to look at a similar occurrence in the 20th century within the field of biology.

1. **Only hierarchical concepts?**

Every scholarly discipline inevitably has to employ key-terms which are constitutive of its theoretical endeavors. Particularly as an effect of misguided attempts to elevate certain basic concepts to be more encompassing than they really are, special sciences tend to coin their own terms and then try to shield them off from those terms employed by other disciplines. According to Thure von Uexküll it was the intention of the German biologist Jokob von Uexküll to design a new method in the development of his "Umweltlehre" ('Umwelt" theory) with its own peculiar conceptual system which cannot be derived from any of the existing sciences. He did this by employing the idea of *purposefulness* ("*Planmäßigkeit*") and *natural plans* ("*Naturplänen*").[1]

Is it really possible to develop a conceptual system which does not have any linkages to other knowledge domains? If the answer is negative, the next issue is whether or not instances of a partial overlapping in the terminology of different disciplines can only be accounted for by means of categories with varying degrees of generality, as it is assumed in the approach of Catton.

Catton attempts to develop a truly *naturalistic* sociology but he does not want to become a victim of *reductionism*. He believes that sociological axioms could be formulated which are parallel to the axioms of Newton. He dismisses the charge that they are metaphorical as irrelevant. The sociological concepts they define and the counterpart physical concepts should simply be viewed as *special cases* of more abstract concepts which are generally applicable to all fields of (naturalistic) inquiry (Catton, 1966:237). In other words, in terms of the classical Aristotelian mode of concept-formation (particularly employed in the classification of plants and animals), he appears to advocate the distinction between a *general concept* (*genus proximum*) and more *specific concepts* (*differentia specifica*). He writes:

> "If a force is that which produces an acceleration, then a physical force is that which accelerates material bodies in physical space, and a social force is whatever accelerates social processes. It makes sense to use the term 'force' in both contexts because both physical forces and social forces are special cases of the general concept" (Catton, 1966:233-234).

Clearly, Catton elevates the concept of *force* to the level of a *genus*-concept, encompassing various *species* of this *general concept* as *special cases*. The crucial

---

[1] "Um den unbekannten Inhalt von Naturplänen zu erforschen, bedarf die Umweltlehre einer Methodik, die aus keiner der bestehenden Wissenschaften entliehen werden kann. Sie muß dafür ihr eigenes Begriffssystem entwickeln." Thure von Uexküll, 1970:XXVII.

question, however, is the following: if *physical forces* and *social forces* are mere specifications of a general (genus-) concept of *force*, what then is the *original experiential domain* of this "general concept" of "force"? As a *genus*-concept this general concept of force must transcend the diversity of properties we can experience, for if it does not find an original "home" or "seat" within the *physical aspect* of reality, where else can we locate it? Perhaps an alternative approach is required.[2]

2. **The formation of analogical concepts**

Something very fundamental regarding scientific concept-formation seems to be at stake. Although *energy-operation* – with the associated notions of *cause* and *effect* – surely pertains in a crucial sense to *physical* phenomena, this does not mean that physics has a *monopoly* on the employment of the terms *energy* and: *force* – or that it is forbidden for other disciplines also to use these terms.

However, if different disciplines employ this term in the *same* sense it would be difficult to maintain that these disciplines are indeed *different*. It seems as if the only other option is that each discipline uses the term "force" in its *own peculiar way*. But there is more to this issue: is there a *primary* or *foundational* use such a term? If so, then other usages simply remind us of its original or primary sense while at the same time they differ from its original meaning.

When one speaks about the "force" or the "validity" of an argument (i.e., employing the terms "force" and "validity" in a *logical* sense) the context is evidently different from references to *physical* forces. Likewise, the sociologist MacIver in 1942 wrote a book which deals with "Social Causation." In that work he discusses all kinds of *social forces*. When economists deal with *economic forces* they are also not using the term "force" in a physical sense. Similar to physical forces both social and economic forces *cause* certain *changes* within social and economic life – an unmistakable *similarity* with physical forces and physical causes and effects (*causation*).

Yet social and economic forces are attributed to *human persons* or to *societal institutions* (*collectivities*) which are considered to be accountable in a normative sense, i.e., in the sense that they can also act in anti-normative ways, violating certain social or economic principles – which clearly indicates that there are also important *differences* between the various *modes* of forces.

It is precisely in the employment of the term "force" – which manifests the element of *similarity* – that the actual *difference* between the two universes of discourse becomes apparent. A different way to formulate this – and in doing that we call upon considerations already surfacing during medieval philosophy – is to say that in these instances the difference is shown within the element of similarity, or that the similarities are shown in the differences. Both formulations are nothing but alternative ways to define an *analogy*. Initially this term was used by mathematics in an arithmetic (10-6 = 6-2) and a geometric (8:4 = 4:2) sense, whereas the combination of both gave birth to a *harmonic* connotation. In the transfer of meaning from a genus domain to that of the species (and vice versa) Aristotle used the notion of an analogy to account for the lingual level of metaphor formation (cf. Kluzen, 1971:214-227).

---

[2] We shall return to the concept "force" in connection with Jakob von Uexküll's vitalistic orientation and the notion of a "vital force" in the theories of Hans Driesch.

The attempt to reflect upon the interdisciplinary conceptual foundations of the term "Umwelt" soon unveils comparable considerations, because it evinces connections particularly to terms with *spatial* connotations. Within the context of a scientific study the term *space* can take on various different forms, more or less synonymous with *extension*. Mathematics struggled with this issue throughout its history, initially within Euclidean geometry and eventually in the context of analytic geometry and the more general discipline of *topology*. Mathematical space – or, as we would prefer to say: the original *aspectual meaning* of space – provides us with the most basic (foundational) sense of *continuous* (dimensional) *extension*. If this claim is sound, then the other analogical usages *presuppose* the original spatial meaning of the term *extension* (and other analogical synonymous equivalents).
Catton approximated this perspective when he remarks that one needs to use the adjective "physical" when physical force is intended "because physics got there first and has a prior claim on the word 'force' " (Catton, 1966:234). Yet, in order to make this remark useful, Catton needs a theory regarding analogical linkages between various aspectual domains. Then it will be possible to explain that the concept of *force* originally refers to the *physical aspect* or reality and can therefore only appear as a *physical analogy* in the *social* (and other non-physical) aspect(s). Any attempt to subsume analogical concepts under a highest genus-concept must inevitably result in the *eradication* of the uniqueness of the different aspects of reality.

3. **The initial "loose" meaning the term "Umwelt"**

An account of the first employment of the term "Umwelt" shows that it surfaces during the 19th century and subsequently developed in close connection to the notion of *milieu*. Schröder refers to a contribution of Spitzer on "Milieu and Ambience" which appeared in his work on "Essays in historical semantics" (1948, 1968[2]) where he points out that up to the first decades of the 19th century the term "Umwelt" emerged as a newly formed (undefined and concept-free) word which was predominantly related to human beings in a topographical sense. The phrases mentioned are: the "surrounding world," "environment," "outer world" and "surrounding neighborhood" (Schröder, 2001:99).
Haeckel introduced the term "ecology" in 1866 (Schröder, 2001:100). During the 19th century it was mainly the term "milieu" that was used by biologists. Related terms apparently intending the same reality are "environment" and "habitat."
Since the rise of modern evolution biology the interaction between living entities and their "Umwelt" gave birth to the distinction between "phenotype" and "genotype." The latter brings to expression the inherent genetically determined structure of a living entity whereas the former captures the way in which a living entity appears on the basis of its adaptation to the environment.
The fact that the further development of the term "Umwelt" was accompanied by a fundamental reassessment of "object" and "subject" is best demonstrated by paying attention to the biological thought of Jakob von Uexküll.

4. **The theory of von Uexküll**

It was in particular Jakob von Uexküll who explored the concept of an "Umwelt" in his biological thought. His general work on "*Theoretical Biologie*" explains his views and

they are also articulated in a very accessible way in his work "*Streifzüge durch die Umwelten von Tieren und Menschen: Bedeutungslehre*."
The traditional scene of academic disciplines dealing with various aspects of living entities encompasses special sciences such as physics, chemistry, physiology, anatomy, the study of the behavior of animals (ethology) and even sociology. Yet, as Thure von Uexküll remarks, no one of these disciplines gave an answer to the question how the individual living being experiences the things of its environment, how it orders these entities in its own world and how this world is connected to the worlds of other living subjects. The greater the distance between human beings and animals, the more problematic the answers provided by psychology become.[3]
Jakob von Uexküll is critical of the predominant mechanistic view of the "organism" as a *machine*. Portmann points out that he respects the mysterious fact that the full-grown organism presents itself to us as a purposeful structured whole.[4] His theoretical biology, supported by extensive biological investigations, aim at substantiating certain basic features of Kant's philosophy (cf. von Uexküll, 1973:12 ff.).

Remark:

> In passing we have to note that the recent project of Lakoff and Johnson, in analyzing "conceptual metaphor," stems from the same Kantian legacy. They claim that the world as we *know* it does not contain any so-called "primary qualities," "because the qualities of things as we can experience and comprehend them depend crucially on our neural makeup, our bodily interactions with them, and our purposes and interests" (Lakoff & Johnson, 1999:26).

Jakob von Uexküll introduces the notion of a "functional circle" ("*Funktionskreis*") by which he intends to capture the given structural coherence between the animal body and its environment – whether or not the latter is non-living, belongs to a fellow species member or even to what may be dangerous. The "features" ("*Merkmale*") of the environment are co-dependent upon the *sensory organs* (and neural structures) of animals – these structures in advance co-determine the quality and intensity of the relationship between the animal and its environment. In order to penetrate to the "inner" side of what animals experience ("erleben"), quantitative methods fall short. Suddenly the world of colors, forms, sound tones, and odors with their joys and pleasures appears as the worthwhile "object" of scientific biological research (cf. Portmann, 1970:XII).

---

[3] "Physik, Chemie, Anatomie, Physiologie, Ethologie und Soziologie, alte und neue Wissenschaften, Disziplinen, die auf den exakten Naturwissenschaften aufbauen, und solche, die andere Begriffssysteme verwenden, haben uns viele Antworten gegeben. Aber die Fragen, wie das einzelne Lebewesen die Dinge und Vorgänge seiner Umgebung erlebt, wie es sie zu einer Welt ordnet, in der es sich zurechtfindet – und wie diese Welt mit den Welten anderer lebender Subjekte zusammenhängt, diese Fragen finden im Kreis all dieser Wissenschaften keine Antworten. Sie werden von ihnen ausgeklammert, und die Antworten, welche die Psychologie zu geben vermag, die einzige Wissenschaft, in der Subjekte auftreten, die etwas erleben können, werden im Bereich der Tierwelt um so problematischer, je weiter wir uns vom Menschen entfernen" (Thure von Uexküll, 1970:XXIV).

[4] "Von Anfang an lenkt Uexküll den Blick des Beschauers auf die übermaschinellen Eigenschaften des Lebensstoffes, auf die geheimnisvolle Tatsache, daß im reifen Organismus ein planmäßig gefügtes Ganzes vor uns ist" (Portmann, 1970:X).

With great care Jakob von Uexküll describes the introduction of the "subject" in biological research. He points out that although we do not *know* the *experiencing tone* ("*Erlebniston*") of things from the environment according to the subjective quality they have for animal subjectivity, we can deduce their *effects* from the actions of animals. By lifting out this "toning" ("*Tönung*") of "objects," biological thought is brought to its limits in the acknowledgement of an *inner mood*. Portmann remarks that the theory of Jakob von Uexküll regarding the peculiar *Umwelt* of every animal species indeed became a chapter of modern biology (1970:XIII). Whereas the science of ethology and physiology treat living organisms as "objects," the "Umweltforschung" (*Umwelt*) of Jakob von Uexküll focuses on animals as *subjects*.

Jakob von Uexküll constantly argues that we as human beings are never able to see, hear, smell or feel what a foreign subject sees, hears, smells or feels (Thure von Uexküll, 1970:XXV).

The relationship to the environment is given in an intricate and intimate connectedness, which causes Jakob von Uexküll to consider this reality in terms of a true *totality* ("*Ganzheit*").

In addition to the "Merkwelt" of animals he introduces the notion of their "Wirkwelt" (action-world). The subject is endowed both with "Merkorgane" (organs open to "features") and with "Wirkorgane" (organs for taking action). The "Merkorgan" receives the features inhering in the bearer ("object") of these "marks" while through the "wirkorgane" and the "Wirkwelt" the "Wirkmal-Träger" (bearer of the effects of the actions of the animal subject) is affected. The "functional circle" ("*Funktionskreis*") encompasses the coherence, adaptation and interaction between subject and object as a purposeful whole ("*planmäßiges Ganzes*"). (Jakob von Uexküll, 1970:11).

His classical example concerns the way in which an Oak tree at once functions as the central reference point for different kinds of animals which respectively disclose specific parts of the tree as constitutive for their life-world ("*Umwelt*"). In Chapter 13 of "*Streifzüge*" he discusses this issue under the heading: "The same subject as object in different Umwelten" (pp.94-103). The fox explores the roots of the oak tree in order to build its hiding place, safely underneath the oak tree which functions as its roof. The tree only acquires a protective tone for the fox, which is similar to that of the owl. For the squirrel the tree has a climb tone, for the singing bird that builds its nest in the tree it has a supporting tone. Jakob von Uexküll writes:

> "Each Umwelt isolates out of the oak tree a particular part whose characteristics are appropriate to be the bearer both of the properties and activities of their functional circle. In the *Umwelt* of the ant the whole of the oak tree diminishes in its crack-rich bark which, with its valleys and hights, becomes the hunting field of the ant. … In all the various Umwelten of its various inhabitants the same oak plays a widely diverging role, sometimes with particular and then again with none of its parts. The same part can be large or small, the same wood hard and soft, it can serve as a means of shelter or attack" (Von Uexküll, 1970: 98, 99, 100).

As we have mentioned, although all these "Umwelten" in an objective sense coincide with the concrete many-sidedness of the tree and in this sense overlap, the "Umwelt"-*experience* of these different kinds of animals do not overlap.

If we invert the perspective and look at the animal subject in order to understand more about the way in which each subject "cuts out" what is required for its own "Umwelt,"

the difference between our human ambient and animal "Umwelten" becomes more striking. The paramecium as a unicellular organism only reacts by fleeing (known as: *phobotaxis*). Yet, in the absence of any specific sense organs, this reaction is sufficient to guide this animal to live in optimal conditions. Von Bertalanffy remarks that the "many things in the environment of the paramecium, algae, other infusoria, little crustaceans, mechanical obstacles and the like, are nonexistent for it. Only one stimulus is received which leads to the flight reaction" (1973:241). He points out that this example demonstrates how the *organizational* and *functional plan* of a living entity is decisive in selecting what can become a 'stimulus' and a 'characteristic' to which the organism will react in a specific way:

> "According to von Uexküll's expression, any organism, so to speak, cuts out from the multiplicity of surrounding objects a small number of characteristics to which it reacts and whose ensemble forms its 'ambient' (*Umwelt).* All the rest is nonexistent for that particular organism. Every animal is surrounded, as by a soap bubble, by its specific ambients, replenished by those characteristics which are amenable to it. If, reconstructing an animal's ambience, we enter this soap bubble, the world is profoundly changed: Many characteristics disappear, others arise, and a completely new world is found" (Von Bertalanffy, 1973:241).

Jakob von Uexküll portrays the world of a tick which reduces its environment in an astonishing way. It hangs motionless at the edge of a branch in the bushes and by virtue of its nature it is capable to explore the possibility to fall onto a passing mammal. No stimulus from the total environment is registered. But then suddenly a mammal approaches and the tick requires its blood for its offspring.[5] And then something quite remarkable happens: of all the effects which proceed from the mammal body only three, and in a determined succession, are turned into stimuli. From the majestic world surrounding the tick three stimuli lights up like light signals from the dark and as guide for the tick serves it to reach its goal with certainty. Its world is reduced to three characteristics and three actions (*Merkmalen* and *Wirkmalen*).[6]

---

[5] Of course it may happen that the tick needs to wait for quite a time before a mammal passes by. But it is equipped to cope with this obstacle, for ticks were reported to subsist for 18 years without food (cf. Jakob von Uexküll, 1970:13-14)! Von Uexküll adds the remark that there is a difference between the "Umwelt" and the "environment ("Umgebung") of an animal. Whereas the conditions in the former is optimal, the picture may be more negative ("pessimal") in the latter. Yet, if this state of affairs did not prevail, the optimality of a specific "Umwelt" may overpower other species (cf. Jakob von Uexküll, 1970:13, note 3).

[6] "Die Zecke hängt regungslos an der Spitze eines Astes in einer Waldlichtung. Ihr ist durch ihre Lage die Möglichkeit geboten, auf ein vorbeilaufendes Säugetier zu fallen. Von der ganzen Umgebung dringt kein Reiz auf sie ein. Da nähert sich ein Säugetier, dessen Blut sie für die Erzeugung ihrer Nachkommen bedarf. Und nun geschieht etwas höchst Wunderbares: von allen Wirkungen, die vom Säugetierkörper ausgehen, werden nur drei, und diese in bestimmter Reihenfolge zu Reizen. Aus der übergroßen Welt, die die [13] Zecke umgibt, leuchten drei Reize wie Lichtsignale aus dem Dunkel hervor und dienen der Zecke als Wegweiser, die sie mit Sicherheit zum Ziele führen. Um das zu ermöglichen, sind der Zecke außer ihrem Körper mit seinen Rezeptoren und Effektoren drei Merkzeichen mitgegeben worden, die sie als Merkmale verwenden kann. Und durch diese Merkmale ist der Zecke der Ablauf ihrer Handlungen so fest vorgeschrieben, daß sie nur ganz bestimmte Wirkmale hervorzubringen vermag. Die ganze reiche, die Zecke umgebende Welt schnurrt zusammen und verwandelt sich in ein ärmliches Gebilde, das zur Hauptsache noch aus 3 Merkmalen und 3 Wirkmalen besteht – ihre Umwelt. Die Ärmlichkeit

Von Bertalanffy captures the thrust of Jakob von Uexküll's tick example in a striking way:

> "Von Uexküll has given innumerable examples delineating the ambients of various animals. Take, for instance, a tick lurking in the bushes for a passing mammal in whose skin it settles and drinks itself full of blood. The signal is the odour of butyric acid, flowing from the dermal glands of all mammals. Following this stimulus, it plunges down; if it fell on a warm body – as monitored by its sensitive thermal sense - it has reached its prey, a warmblooded animal, and only needs to find, aided by tactile sense, a hair-free place to pierce in. Thus the rich environment of the tick shrinks to metamorphize into a scanty configuration out of which only three signals, beaconlike, are gleaming which, however, suffice to lead the animal surely to its goal. Or again, some sea urchins respond to any darkening by striking together their [242] spines. This reaction invariably is applied against a passing cloud or boat, or the real enemy, an approaching fish. Thus, while the environment of the sea urchin contains many different objects, its ambient only contains one characteristic, namely, dimming of light" (Von Bertalanffy, 1973:241-242).[7]

5. **Thermodynamical open systems: transcending the vitalist legacy**

Implicit in Jakob von Uexküll's account of the "Umwelt" of distinct animals we have to recognize a new assessment of the importance of *subjects* in nature. Although the notion of a subject could be understood in the sense of *activities*, one cannot side-step the correlating concept of a *law* to which entities in nature is *subjected*. Physical entities are subject to *physical laws*, living entities to *biotical laws*,[8] while sentient creatures, such as animals, are subject to their *typical structural laws*.

The classical mechanistic point of view in biology believes that living entities (like plants, animals and human beings) are fully explicable in terms of non-biotic ("material") categories. In general the mechanistic standpoint rejects any "immaterial" force. Yet such an extreme materialism has severe difficulties with the ontic status of physical entities, which are supposed to be subject to *physical laws* – like those of thermodynamics – for these physical laws are not themselves *material* in nature.

Traditional vitalistic approaches elevated the biotic aspect of living entities into an *immaterial entity*. 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 (characterized by him as *harmonic equi-potential systems*) 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

---

der Umwelt bedingt aber gerade die Sicherheit des Handelns, und Sicherheit ist wichtiger als Reichtum." Jakob von Uexküll, 1970:12-13.

7 In terms of the idea of objectification discussed below, we can say that the milieu of animals are divided into whatever is objectified into their species specific "Umwelt" and all the other potentially objectifiable entities belonging to their environment. The term "Umwelt" captures what have been objectified, while the term "environment" designates those entitary subjects not objectified.

8 Note that we do not speak of *biological* laws, since biology, as a scholarly discipline, is the product of human endeavors, whereas living (biotical) entities are not!

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 a 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.

The unsolved problems entailed in this vitalistic position was effectively realized when Von Bertalanffy generalized the second main law of thermodynamics to *open systems*. The internal order built up by a living entity is not more than the chaos created at its outside.

Von Bertalanffy generalized 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 thermo-dynamically *open*, since in the first place it accounts for the numerous examples of *physical* systems that are also 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! In his work about the *physical aspect* of the cell Schrödinger speaks about *negentropy* in this connection (cf. Schrödinger, 1955).

That the physical aspect is foundational to the biotical aspect is even clear from the term used by vitalism to account for something immaterial, for it is designated as a "vital force." In terms of our initial remark about original and analogical usages of the concept of force this designation actually begs the question. "Force" first of all belongs to the domain of *physical* phenomena. It is crucial to the physical aspect of energy-operation and it entails physical causes and physical effects.

The concept of a *vital force* simply reflects the unbreakable coherence between the biotical and the physical aspects of reality and cannot be used to support the idea of an entity-like immaterial "substance." Speaking about a *vital force* actually highlights a *physical analogy* within the structure of the biotical aspect, similar to the way in which speaking about *social forces* unveils a physical analogy within the structure of the social aspect.

6. **The original spatial foundation of a theory of an ambient ("Umwelt")**

Our exposition thus far implicitly and intuitively employed the idea of modal, functional aspects of reality pertaining to the *how* (mode of existence) of entities and not to their concrete *what*. The quantitative aspect of *numerosity* enables the human being to ask questions about "how many?"; the spatial aspect of *continuous extension* enables us to ask questions about the dimensions and size of things, and so on (cf. Cassirer, 1910).

Aspects relate to the *modus quo* of reality and are therefore also succinctly designated as *modalities* (see Dooyeweerd, 1997-II). It belongs to the classical heritage of philosophy and logic to distinguish between entities and their properties. Yet, our intention is to argue for universal *ontically given* (functional) modal aspects. In their universality they co-determine the typical way in which concrete entities, processes and societal collectivities *function* within these modalities.[9]

Space in its original mathematical sense is characterized by *continuous extension*. The arithmeticistic claim of modern set theory, namely that it has succeeded in fully arithmetizing continuity, entails an inherent circularity (cf. Strauss, 2002). Although the Greek atomists, Leucippus and Democritus, believed that there indeed are last indivisible units, which they called *atoms*, modern philosophy since Descartes switched to the conviction that physical space is both *continuous* and *infinitely divisible* – a view already found in the thought of Anaxagoras and Aristotle. However, by the end of the 19th and the beginning of the 20th century it turned out to be necessary to distinguish between *mathematical* space and *physical* space. Whereas the former – in a purely abstract and functional perspective – is at once continuous and infinitely divisible, physical space is neither continuous nor infinitely divisible! Being bound to the quantum structure of energy physical space cannot be subdivided *ad infinitum*. Energy quanta indeed represent the limit of the divisibility of energy. In his theory of relativity also Einstein has a clear insight in the way in which the original meaning of space (simultaneity) is relativized. Neither the spatial point at which something occurs nor the temporal moment in which it happens has physical reality. It is only the *event* itself which has physical reality (1982:33).

Although the meaning of space comes to expression in its coherence with other aspects, its core characteristic, *continuous extension*, is indefinable. The same applies to our concept of number, where the intuition of a *distinct multiplicity* could be paraphrased but never "defined" in a non-circular way. This explains why modern axiomatic set theory, for example the system of Zermelo-Fraenkel, had to proceed from the acceptance of the *undefinied* term: "element of" (which is equivalent to the notion of a "set").[10]

Furthermore, the term "totality" ("Ganzheit"/"Totalität") is merely synonymous to continuity. Whatever is continuously extended, such as a straight line, *hangs together* in the sense that all its parts are *connected*. With disconnected parts it would not be continuous. But if *all* the *parts* are present, then the line is given as a *whole*, in its *totality*. The *whole-parts* relation is therefore derived from the core meaning of *continuous extension*. It should not surprise use, therefore, that it is precisely this totality feature of continuity which forms an obstacle in the attempt to arithmetize continuity completely. Paul Bernays, the co-worker of the foremost mathematician of the 20th century, David

---

9 For this reason we do not adhere to the *nominalistic* legacy which believes that number and all other universals are *mere modes of thought* – as it was already asserted by Descartes (cf. his *Principles*, LVIII).

10 Kurt Gödel highlights the circularity entailed in the attempt to "define" a set: "The operation "set of x's" (where the variable "x" ranges over some given kind of objects) cannot be defined satisfactorily (at least not in the present state of knowledge), but can only be paraphrased by other expressions involving again the concept of set, such as: "multitude of x's", "combination of any number of x's", "part of the totality of x's", where a "multitude" ("combination", "part") is conceived of as something which exists in itself no matter whether we can define it in a finite number of words (so that random sets are not excluded)" (1964:262, note 14).

Hilbert, aptly writes: "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."[11]

In a discussion of the foundational issues of mathematics Hermann Weyl also alludes to the irreducibility of continuity. In following the Dutch intuitionist, L.E.J. Brouwer, it is the conviction of Weyl that mathematics should acknowledge the crucial whole-parts relation whenever continuity is treated. He says that the fact that it has parts is a fundamental property of the continuum. The "atomistic" understanding seriously violates this intuition, as it is emphasized by Brouwer.[12] It belongs to the essence of every continuum that it permits an infinite division: that every part allows for an unlimited number of further subdivisions (Weyl, 1921:77). Mathematical analysis which tries to side-step this crucial place of the whole-parts relation when it treats issues of continuity, had to employ the notion of an *environment* (*Umgebung*).

> "In order to account for the continuous coherence of points, contemporary analysis, which indeed broke apart the continuum into isolated points, had to take recourse to the environment concept."[13]

In spite of the fact that mathematics did not explore a third option – as opposed to both arithmeticism and geometricism which dominated the history of mathematics (see Strauss, 2001:17-51) – namely to acknowledge number and space in their uniqueness (irreducibility) and mutual coherence, it proves to be worthwhile to use this insight in an assessment of atomism and holism.

7. **The one-sidedness of opposing "element" and "totality" (*Ganzheit*)**

Jakob von Uexküll constantly argued against the *atomistic* assumption of the prevailing mechanistic trend in biology. Since Democritus atomism acquired two senses, one indicating the attempt to explain the material world in terms of last indivisible *elements* ("atoms") and the other broader conception using the term to designate different forms of *pluralism*.[14]

In opposition both to mechanistic monism and vitalistic dualism as biological theories the term *holism* was introduced by J.C. Smuts in 1926. In this narrow sense it aimed at a dialectical synthesis which can do justice to the supposedly highest concrete totality (in the case of Adolf Meyer: *Ganzheit* – cf. Meyer, 1964). An expanded connotation is given to holism when it is used in the sense of a *universalism* which, in opposition to (sociological) individualism, wants to account for the meaningful coherence and mutuality within societal institutions, i.e. for wholeness / totality as an essential trait of

---

11 "Und es ist auch dieser Charakter, der einer vollkommenen Arithmetisierung des Kontinuums entgegensteht" – Bernays, 1976:74; cf. also Strauss, 2002.

12 "*Daß es Teile* hat, ist aber die Grundeigenschaft des Kontinuums; und so macht die Brouwersche Theorie (im Einklang mit der Anschanung, gegen welche der heutige "Atomismus" so arg verstößt) dieses Verhältnis zur Grundlage für die mathematisehe Behandlung des Kontinuums" (Weyl, 1921:77).

13 "Um den stetigen Zusammenhang der Punkte wiederzugeben, nahm die bisherige Analysis, da sie ja das Kontinuum in eine Menge isolierter Punkte zerschlagen hatte, ihre Zuflucht zu dem Umgebungsbegriff" (Weyl, 1921:77).

14 In the case of human society the last units were seen as the *individuals*. Since 1825 Saint-Simon and his followers (amongst them Comte) employed the term *individualism* in order to capture the social philosophy of the 18th century as a whole – the view in which society was broken apart in isolated individuals (cf. Strauss, 1999).

societal collectivities (as introduced by the German philosopher, sociologist, and economist, Othmar Spann, in the twenties of this century and also applied in his nature philosophy – cf. Spann, 1937). The German biologist, Richard Woltereck, a contemporary of Jakob von Uexküll and Othmar Spann – in his "Ontologie des Lebendigen" – also develops a position which emphasizes wholeness and "Ganzheit" (see Woltereck, 1940 and his reference to Spann on page 476, note 13).

From a theoretical point of view one can say that atomistic (individualistic) stances in philosophy over-emphasize the explanatory potential of the quantitative mode of reality (or analogies of it in other modalities),[15] whereas holistic (universalistic) orientations do the same with the spatial mode and its inherent whole-parts relation or analogies of it in other aspects of reality.

Living entities integrate the multiplicity of their vital functions in order to persist. They function in a *unified* way, thus exhibiting a function within the *quantitative aspect* of our experiential horizon. Note the subtle difference at stake in the distinction between the concrete function of a living entity within the numerical mode of reality and the inter-functional connections between the biotical and the arithmetical modes as expressed in the numerical analogies within the biotical aspect. A living entity is a *biotical unity in the multiplicity* of its vital functions. This state of affairs is well reflected in the uniqueness of biotical *growth* phenomena, for if a living entity does not continuously succeed in *integrating* its vital functions, it *disintegrates* and *dies*.

Within the discipline of physics we encounter the concept *mass*. It represents a numerical analogy within the physical aspect since it relates to a "quantity of matter." Similarly, a biologist may speak about *biomass*. Jones, for example, refers to the fact that plants constitute 99% of the world's biomass, while fungi are estimated to have *twice* the total biomass of animals (Jones, 1998:54).

But living entities certainly also function within the *spatial mode* of reality – they are spatial subjects and they are related to other (surrounding) spatial subjects (i.e., those in their environment sharing in the mode of being spatially extended). Even the smallest independent "unit of life" – the living cell – exhibits a remarkable constant proportionality in respect of the ratio between the nucleus and the cytoplasm.[16] The size and shape of living entities (a manifestation of their concrete function within the spatial mode) provide a foundation for the inner coherence between the spatial aspect and the biotic aspect, captured in the well-known expression: *bio-milieu* and the equally familiar concept: the *bio-sphere*.

---

[15] *Organicism* as a theoretical position does not necessarily need to be *holistic* because one can just as well explore the *numerical analogy* in the biotic aspect in stead of the spatial whole-parts relation. Herbert Spencer, for example, advocates an organicistic view but he clings to an individualistic perspective. Spencer repeatedly speaks about an *organic aggregate* which is basically the same as a *social aggregate*. But he loads his conception of a biotic organism with an atomistic (individualistic or aggregate) perspective in order to be consistent with his individualistic liberal political convictions. Compare in this regard Spencer's statement concerning a decrease of authoritative control in society: "A more pronounced individualism, instead of a more pronounced nationalism, is its ideal" (Spencer, 1968:22).

[16] Hertwig speaks about the "nucleoplasmic index" which is equal to the volume of the nucleus divided by the volume obtained when the volume of the nucleus is subtracted from the volume of the cell (cf. West & Todd, 1962:208).

The way in which living entities are adapted to their environments received a peculiar designation in the *holistic* biology of Adolf Meyer. With the aid of extensive empirical information he formulates a "basic typological law":

> "There is no group of existing organisms belonging to any taxonomical category of the Natural System, whose members possess all group characters in their most primitive or in their most progressive phases only. Rather are primitive, intermediate and progressive character phases thus combined with each other in each real member of a group that an organismic holism suited for living in any real existing ecological biotope results from it. Forms which possess all their morphological characters in their primitive or in their progressive phases only are neither living holisms nor suited for existence in ecological biotopes and are, therefore, but purely ideal constructions" (1964:59-60).

Yet one should question the mode of speech advocated by Jakob von Uexküll when he attributes the feature of being a true *totality* (*Ganzheit*) to the subject and object encompassing nature of an "Umwelt." The various entities involved in these interrelations are indeed, in their own right, genuine totalities (wholes) which escape any atomistic attempt to reduce them to last constitutive elements ("atoms"). But in their interrelations these entities do not terminate their wholeness, however intimate their interwovenness with other entities may be. The Dutch philosopher, Herman Dooyeweerd, employed the term "enkapsis" (borrowed by Theodor Haering from the German anatomist Heidenhain) in order to explain the interlacement intended in these instances. This term intends to account for the maintenance of the *internal structural properties* of an entity even when it is intertwined with other entities – like the atoms bound through a chemical bonding into the enkaptical whole of a molecule. A similar interlacement is present when the relationship between physico-chemical constituents are explained as *foundational* to the typical *vital* functions of living entities. A living entity necessarily functions on the basis of material configurations (largely macromolecular in nature), but the phrase *living organism* of a living entity should actually be reserved for the biotically characterized dimension of a living entity which is alive through and through – just think about the *organelle* present within the organism of a living cell: lysosomes, mitochondria, ribosomes, and so on are all *alive*. The same could not be said in respect of the living entity as a whole, because the atoms, molecules and macromolecules as such (in which the functioning of these *organelles* are founded) are not alive although they are also present within the total existential form of the living entity.[17]

7. **Objectification in living and sentient creatures**

Hans Jonas aptly describes the underlying assumption of a pan-mechanistic approach where he treats pan-mechanism and the problem of life (1973:22ff):

> "Life as problem here indicates recognition of its strangeness in the mechanical world, which is the real world; to explain it means – on this level of the universal ontology of death – to deny it, reducing it to a variant of the possibility of the lifeless" (1973:23).

Compared to the mass of "unbelebte" matter (as Von Weizsäcker prefers to refer to physical entities – cf. 1993:32) in the universe, living entities indeed appear to be a negligible layer at most. Yet living entities ensure that the earth is kept in a dynamic state

[17] Cf. Dooyeweerd, 1997-III:634 ff.

which is not in a chemical equilibrium (just recall Von Bertalanffy's concept of a "Fliessgliechgewicht" = "steady state"). It is worthwhile to pause for a moment at some of the most remarkable facts regarding the "life-controlled" condition of our earth:

> "Through the key processes of respiration and photosynthesis (the world's most important redox reactions!), organisms entirely renew the carbon dioxide in the air every few years, and even the much larger volume of oxygen is renewed in about 2000 years. Most incredibly of all, even the 1.5 billion, billion metric tonnes of water on the Earth are eventually split and reconstituted by the activities of living things. It would seem incredible, because the biosphere is such a very thin film on the Earth's surface (it is spread throughout the oceans of course, but incredibly thinly). Compared with the depth and volume of the atmosphere, hydrosphere or crust, the biosphere is insignificant. For every atom in the biosphere, there are about 700 in the atmosphere, 400 000 in the hydrosphere and 2 000 000 in the crust! Yet this insignificant 'scum' maintains most of the rest of the world in a steady state adjusted optimally to its own needs. So accurate is the biosphere's system of balances and adjustments that, for example, the oxygen concentration in the air has not measurably varied during the 80 years for which accurate measurements have been available" (Jones, 1998:42).

Biologists tend to explain this reality by using the term "adaptation." This practice may easily lead to a disregard for the guiding and qualifying *biotic activities* which are involved – as if the environment fully determines what happens to biotical subjects. Such an understanding loses sight of the fact that the organic function of living entities surely is dependent upon environmental conditions – the legitimate side of the meaning of "adaptation" – but that this is not sufficient to explain their guiding and stamping role in respect of the inorganic surroundings. The splitting up and reconstituting of the water on earth, mentioned above, can only occur when living entities absorb water into their life cycle. Through their enkaptic bonding within living entities, water molecules are *structurally objectified* within the biotic aspect of reality, i.e. they function in service of the *biotic needs* of living entities.

Similarly, in the life of animals, the surrounding physical environment becomes partially objectified into the "Umwelt" of animals through and under the guidance of *subjective animal functioning*. Objectification as such is always the activity of a *subject*.[18]

What should be kept in mind is that Jakob von Uexküll's "Umweltlehre" finds a solid basis in the fact that each different species does have its own (different) "Umwelt." However, his attempt to expand its scope in order to incorporate human beings does not withstand the scrutiny of a critical assessment. Analogous to the way in which he expanded his "Umwelt" theory to human experience we may consider the way in which the oak tree is opened up through human acts of objectification (cf. von Uexküll, 1970:94 ff.). The human experience of the oak tree transcends the natural aspects of reality to which animal experience is restricted. Animals experience reality exclusively out of their natural inclination, directed at that which is *physically*, *biotically* and *sensitively* important to them. They experience reality in terms of that which is accessible and not

[18] An interaction with the ideas of Lakoff and Johnson briefly referred to above, which naturally falls outside the scope of this article, would have to introduce this view of objectification and its implied subject-object relations.

accessible, edible and inedible, in terms of same sex and opposite sex, and in terms of what is comforting and alarming (or: endangering).

The human experience of a tree opens up vistas beyond the grasp of animal capabilities. The natural scientist sees the tree as an object of analytical study, the hiker as something with a particular aesthetic attraction, the criminal as a hiding place from the law, the woodworker as material from which to make furniture, and so forth. This human experiential perspective with its rich variety is linked to a person's cultural calling which enables a person to be variably settled in any environment by means of cultural formation. But in the case of humans none of these domains of objectifiability is *exclusive*. Human beings share all of them and precisely in doing that they differ fundamentally from animals with their non-overlapping "Umwelten." Portmann understands this shortcoming by mentioning that Jakob von Uexküll neglects the fact that all these different "Weltansichten" (world perspectives) share a communal species world which enables a mutual understanding as well as interaction on the basis of opposing views. The communal world in which humans live constitutes a shared domain which is not even broken apart by the most severe differences in potential or cultural traditions. Poetry thrives on differences in world perspectives but depends on a last horizon of mutual understanding. The term "Umwelt" should be reserved for the separation of the different worlds of animal species, but it should not be applied to different ways in which human beings view the world. [19]

Gostonyi attempts to account for the difference between animal "Umwelten" and the domain of human experience in terms of the opposition between *constancy* and *dynamics* (*change*). He holds that the "Umwelt" of animals is largely stabilized through processes that are directed by instincts which cause them by and large to be *unchanging*. By contrast, as an effect of the "Instinkt-Ungebundenheit" of human beings (the fact that humans are not determined by their instincts), the "world" of humans is subject to continuous change, i.e., it is constantly broadened and transformed. The animal is borne as a part of its "Umwelt," while the human being "conquers" its "world."[20]

---

19 "Diese Gemeinschafts-Sphäre der Menschenwelt, in der die Eigenwelten – deren Kontraste wir ebenso groß sehen wie Uexküll – eingebettet sind, dieses Umfassende der grundsätzlichen Verstehensmöglichkeit schafft die besondere humane Situation. Wie groß wir auch die durch Anlagen-Unterschiede oder durch Tradition entstehenden Gegensätze menschlicher Welten ansetzen, sie liegen alle in einer Sphäre. Alle Dichtung lebt von der Darstellung solcher verschiedenen Weltauffassungen und ihrer Begegnungen – aber gerade die Dichtung beruht auch auf dem Grunde letzter Möglichkeit des Verstehens der Andern. Die Trennung tierischer Artwelten als gesonderte Sphären soll im Worte 'Umwelt' festgehalten und betont werden – gerade darum müssen wir aber diesen Begriff für die Kennzeichnung menschlicher Gegensätze des Weltbildes ausschalten" (Portmann, 1970:XIV).

20 "Der entscheidende Unterschied zwischen der menschlichen "Welt" und der Umwelt der Tiere ist – vereinfacht formuliert – der, daß letztere durch weitgehend gleichbleibende, weil von Instinkten gesteuerte Verhaltensabläufe stabilisiert und somit im großen und ganzen *unveränderlich* ist, während die "Welt" des Menschen – dank seiner Entwicklungsfähigkeit und seiner "Instinkt-Ungebundenheit" – ständiger Veränderung, Wandlung, d. h. Erweiterung und Umstrukturierung unterworfen ist. Das Tier wird in seine Umwelt hineingeboren, der Mensch "erobert" sich seine "Welt" " (Gostonyi, 1976:902).

8. **Concluding remark**

The term "Umwelt" emerged and eventually found an application mainly within the domain of biology and the discipline of animal behavior. But given its original spatial connotation, it turned out that an account of its meaning had to consider the inter-connectedness of terminology transcending the confines of a single discipline. This interdisciplinary insight opens the way for the systematic considerations which we have developed in confrontation with the relevant historical perspectives.

Although we have argued that animal subjectivity is presupposed in every animal process of *objectification*, our subsequent argument had relativize the "Copernican turn" by reverting to the acceptance of ontically given modal aspects of reality which ultimately *condition* every kind of animal (and human) subjectivity.

The merit of Jakob von Uexküll's "Umweltlehre" is primarily given in its aim to give animal subjectivity its due place. His understanding of the "Funktionskreis," which highlights the interdependence between animal subjectivity and whatever is objectified by animals into their respective "Umwelten," indeed unveils the constitutive domain of *objectification* underlying the very existence of living entities (in a biotic sense) and animals (as sentient creatures).[21] Although this subjective capacity to *objectify* also inherently belongs to human beings, we had to point out that applying the "Umwelt" concept in Jakob von Uexküll's sense to this domain as well neglects the mutuality of human understanding.

In order to come to a more systematic account of the original and analogical meaning of spatial (and numerical) terms we had to address related issues, such as the uniqueness and mutual coherence between number and space and the analogical concepts found in other disciplines, as being based upon the inter-modal connections between various modal aspects of reality.

These ontic modalities turn out not to be merely *functional conditions* for concretely existing entities, since they also serve as *modes of explanation* within different but mutually cohering scientific universes of discourse. Through the inter-modal coherence between the spatial aspect and other aspects we are fully within our epistemic rights to employ (analogical) concepts of space in diverse disciplines. Although we have highlighted some of these analogical phrases – such as *physical* space, *biotical space* (*bio-sphere*, *bio-milieu* and so on), and *sensitive space* (the content given by Jakob von Uexküll's to his notion of an "Umwelt") – there are still many others not paid attention to in this study. To mentioned just a few unexplored contexts: *logical space* (Rudolph Carnap wrote a work in which he reduced space to so-called *formal space* – see Carnap 1922), *lingual space* (also encompassing theories regarding the *semantic domains* of words), *social space* (think about notions of *social stratification* and *social distance*), and *jural space* (intricate legal questions regarding the location of a legal fact).

9. **Consulted Literature**

Benacerraf, P. & Putnam, H. 1964. *The Philosophy of Mathematics*, *Selected Readings*, Oxford: Blackwell.

Bernays, P. 1976. Ueber den Platonismus in der Mathematik, in: *Abhandlungen zur Philosophie der Mathematik*, Darmstadt: Wissenschaftliche Buchgesellschaft.

[21] Portmann characterizes animals as *milieu-bound* and *instinctively secured* ("Umweltegebunden und Instinktgesichert" – 1969:86).

Carnap, R. 1922. *Der Raum*. Berlin.
Cassirer, E. (1910): *Substanzbegriff und Funktionsbegriff*, Berlin (1910), Darmstadt 1969.
Catton, W.R. 1966. *From Anamistic to Naturalistic Sociology*, New York: McGraw-Hill.
Descartes, R. 1965. The Principles of Philosophy, translated by John Veitch, London: Dent.
Dooyeweerd, H. 1997.*A New Critique of Theoretical Thought*, 4 Vols. The Collected Works of Herman Dooyeweerd, A Series, Volumes 1-4, General Editor D.F.M. Strauss. Lewiston NY, The Edwin Mellen Press.
Driesch, H. 1920: *Philosophie des Organischen*, Leipzig.
Driesch, H. 1931: *Wirklichkeitslehre*, Leipzig.
Einstein, A. 1982. *Grundzüge der Relativitätstheorie*. Reprint of the 1969 Braunschweig edition (original edition 1922). Wiesbaden: Friedrich Fieweg & Sohn.
Gödel, K. 1964. What is Cantor's Continuum Problem? in: Benacerraf & Putnam 1964.
Gosztonyi, A. *Der Raum, Geschichte seiner Probleme in Philosophie und Wissenschaften*. München: Verlag Karl Alber (2 Volumes).
Jones, A. 1998. Science in faith. Essex: Reprographics Ltd. Meyerside.
Jonas, H. 1973. *Organismus und Freiheit*, *Ansätze zu einer philosophischen Biologie*, München 1973.
Kant, I. 1783. *Prolegomena einer jeden künftigen Metphysik die als Wissenshcaft wird auftreten kõnnen*, Hamburg: Felix Meiner edition.
Kant, I. 1781. *Kritik der reinen Vernunft* (1787[2]), (references to A or B). Hamburg: Felix Meiner edition.
Kluxen, W. 1971. Analogie, in: *Historisches Wörterbuch der Philosophie*, eds. J. Ritter, K. Gründer & G. Gabriel, Volume 1, pp. 214-227, Wissenschaftliche Buchgesellshcaft, Darmstadt.
Lakoff, G. and Johnson, M. 1999: *Philosophy in the Flesh*. New York: Basic Books.
MacIver, R.M. 1942. *Social Causation*, Boston 1942.
Meyer, A. 1964. *The Historico-philosophical background of modern evolution-biology*, Leiden 1964.
Müller, G.H. 2001: Umwelt, article in: *Historisches Wörterbuch der Philosophie*, eds. J. Ritter, K. Gründer & G. Gabriel, Volume 11, pp.99-107, Wissenschaftliche Buchgesellshcaft, Darmstadt.
Portmann, A. 1969. *Biologische Fragmente zu einer Lehre vom Menschen*, 3rd expanded edition, Basel 1969.
Portmann, A. 1970: Ein Wegbereiter der neuen Biologie, Vorwort, in: Jakob von Uexküll 1970 (pp.IXXXI).
Schrödinger, E. 1955: *What is Life? The Physical Aspect of the Living Cell*, Cambridge.
Spann, O. 1937. *Naturphilosophie*, Jena: Verlag Gustav Fischer.
Spencer, H. 1968. Reasons for Dissenting from the Philosophy of Comte and ohter Essays, Berkely 1968.
Strauss, D.F.M. 1982. The place and meaning of *Kant's Critique of pure reason* (1781) in the legacy of Western philosophy. In: *Journal of Philosophy*, 1982, (pp.131-147).
Strauss, D.F.M. 1999. Atomism and Holism with special reference to a key issue in social-political philosophy, in: *South African Journal of Philosophy*, 1999, 18(1) (pp.74-89).
Strauss, D.F.M. 2001. *Paradigms in Mathematics, Physics,and Biology*: *their Philosophical Roots*, Bloemfontein:TEKSKOR.
Strauss, D.F.M. 2002. Philosophical reflections on continuity, in: *Acta Academica*, 2002(3), pp.1-32.
Uexküll, Jakob von, 1970. *Streifzüge durch die Umwelten von Tieren und Menschen: Bedeutungslehre* Stuttgart. S. Fischer Verlag.
Uexküll, Thure von, 1970. Die Umweltforschung als subjekt- und objektumgreifende Naturforschung, in: Uexküll, Jakob von, 1970.

Von Weizsäcker, C.F. 1993. *Der Mensch in seiner Geschichte*, München : DTV 1993.
West, E.S. and Todd, W.R. 1966 (third edition). *Textbook of Biochemistry*, New York: MacMillan.
Weyl, H. 1921. Ueber die neue Grundlagenkrise der Mathematik, in: *Mathematische Zeitschrift*, Volume 10, (pp.39-79).
Woltereck, R. 1940. *Ontologie des Lebendigen*. Stuttgart: Ferdinand Enke Verlag.