# Ultimate Questions of Science

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**Ultimate Questions of Science and the Theory of System Relations**

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SUMMARY. Whenever an adequate theory is found in science, we will still be left with two questions: why this theory rather than some other theory, and how should this theory be interpreted? I argue that these questions can be answered by a theory of system relations. The basic idea is that fundamental characteristics of systems, viz. those arising from the general systemic nature of those systems, cannot be comprehended with the aid of discipline-specific methods. The systems theory required should commence with an analysis of the qualitatively different relations possible between systems, because it is precisely the nature of those relations that determines the basic structures of systems. That the theory of the fundamental system relations and their ontological and epistemological implications is indeed able to provide the answers sought is demonstrated in theoretical physics and Plessner's analysis of the basic structures of plant, animal and human being.



*Key words*: systems theory, system relations, fundamental physical theories, Plessner and the structures of plant, animal and human being

## 1. **Introduction**

Although the sciences offer us much knowledge and insight, in the end they still leave us with basic questions. Even if a theory has been found that allows us to understand a particular domain of reality properly, the question remains why this reality should be as it is according to this theory. The physicist Steven Weinberg has phrased this as follows:

“We will still be left with the question 'why?' Why this theory, rather than some other theory? For example, why is the world described by quantum mechanics? Quantum mechanics is the one part of our present physics that is likely to survive intact in any future theory, but there is nothing logically inevitable about quantum mechanics; I can imagine a universe governed by Newtonian mechanics instead. So there seems to be an irreducible mystery that science will not eliminate".[1]

This holds true for all sciences. In the final instance, all of them show this limitation of their power to explain things. But there is yet another restriction inherent to any science: scientific results always raise the question of how to interpret them. Any theory reached leads to the question: what does it actually *mean*, "what is really going on (according to this theory)?"[2] The disciplines concerned cannot conclusively answer this question themselves, which gives rise to all kinds of interpretations and continuous foundational debates.

Hence, in two different ways the sciences leave us saddled with unanswered questions. But should this bring us to conclude that this is a matter of having reached the limits of what we can know, something to which we have resign ourselves? Must we always be confronted with different interpretations or world views and with endless philosophical discussions? The central aim of this paper is to show that this is not the case, that both types of ultimate questions of the sciences can be answered indeed, and in an exact manner, viz. by means of a framework transcending the individual sciences, that of the systems approach.

That a systems approach might bring us further with regard to those questions arises from the fact that in virtually all domains of reality we are dealing with systems. Whatever we investigate - non-living objects, organisms, people, societies or whatever - in some way or another they are integrated wholes consisting of  a set of interrelated elements; systems, in short. It is the task of the individual sciences to bring to light all properties and regular relationships of the systems specific to each of these sciences. However, the general systemic nature of those systems makes it inevitable that there are things that cannot be comprehended within the framework of the disciplines involved: the *general systemic features* of those systems. Precisely because these features derive from the systemic nature as such, they cannot be comprehended with the aid of the specific methods of the discipline concerned.

Of course, in any domain of reality those *general* and therefore fundamental system features will appear in a *special* way, depending on the nature of the systems. A theory developed by the discipline concerned will bring those fundamental features to light - in the special shape belonging to that particular discipline - and will show their structure and implications. But it cannot do more. The systemic background of these features cannot be comprehended with the aid of the methods specific to that discipline, since this background derives from the general systemic nature. Because insight into this background is lacking, the true meaning of the theory reached remains enveloped in darkness. Hence, within the framework of the discipline we cannot understand "what is really going on (according to this theory)", nor why those fundamental features as described by the theory should exist at all, i.e. why this reality should be as it is.

Thus we see that it is a necessary consequence of the general systemic nature of what is studied in the sciences that any science is limited in two ways. But this also implies that in principle a systems theory bringing to light and analysing the general system features might provide further insight.

It has been approximately half a century since the importance of systems thinking was realized and work commenced on developing a general systems theory as a supra-disciplinary science. In his voluminous *Treatise on basic philosophy*, for instance, the philosopher of science Mario Bunge considers it his task to design "a unifying systems-theoretic framework" by means of which systems of whatever nature "are tractable insofar as they are systems". His aim is "an exact and systematic ontology consistent with contemporary science".[3]

The work of the systems theoreticians has provided important insights into general features of systems, but it has not yielded a systems theory answering the ultimate questions of the sciences. Now, it is a striking characteristic of the prevalent approaches, including Bunge's, that attention is primarily focused on the structure of the systems. It is only in the second instance that attention is paid to the *relations* of systems with other systems. In itself, this approach to focus on the structure of systems is understandable, for the aim is to reach a general systems theory.Yet this is not the right way to get to grips with the essence of systems, because the presence of relations is not a secondary matter, but a central feature of systems. Not only does any system have relations with other systems - for otherwise it could not even be known - but it turns out (as I shall show in detail further on) that it is precisely the nature of these relations which determines the fundamental structure of the systems concerned. Therefore, it is not possible to develop a general theory of the structures of systems successfully without centring the investigation on these relations from the very beginning.

Hence what is needed first and foremost is an analysis of the fundamental relations that systems can have with other systems. The next step is investigating the consequences for the structure of the systems. In short: investigate the *relations* first, and after that the consequent ontological and also epistemological implications. So, the investigation of the general system features that may play a role in all sciences should commence with the relations. I shall show that a general theory of the fundamental system relations, with their ontological and epistemological implications, cannot only shed light on foundational problems of the sciences, but is also able to answer the general why-questions as formulated by Weinberg.

In order to do so, I shall first outline the theory of the system relations in section 2. A detailed application in the domain of physics will follow in section 3. In section 4 I shall briefly discuss a number of other applications, in particular in disciplines dealing with systems capable of undergoing development. In section 5 I shall end with some concluding remarks on the systems theory developed and its relation to scientific research and philosophical analysis.

## 2. The theory of the fundamental system relations

### 1. *The four system relations*

The systems theory to be developed is intended to be of importance for all possible systems, and is therefore necessarily of an abstract nature. In the following analysis I concentrate on the relation between *two* systems, because this is not only the most prevalent situation, but also forms the basis of the relations between several systems. The central question therefore is: what are the *fundamental relations* that can exist between *two distinct systems* (within one and the same domain of reality, of course). Because this analysis concerns all possible systems, no matter what their specific nature may be, at this point we know no more of such a system than that it is an integrated whole consisting of a set of interrelated elements. In the first instance, therefore, the investigation boils down to the question of what different relations are possible between two *sets.*

The nature of the relation between two sets is determined by the degree in which they have elements in common. Elementary set theory teaches us that between two arbitrary sets, labelled K and L, only the following qualitatively different relations can exist: either K and L are disjunct, or K and L intersect (i.e. they have at least one element in common, and each contains elements not belonging to the other one), or K is a true subset of L, or else K comprises L as a true subset, or K = L. Of these relations, no two can exist simultaneously. These are the so-called *fundamental relations between sets.*[4]

The fact that the present investigation is not concerned with totally arbitrary sets, but with *systems*, has important consequences for the *number* of different relations possible in principle. With systems, one of the set-theoretical possibilities mentioned, viz. that the sets intersect each other (i.e. have a subset in common), leads to *two* qualitatively different possible relations, for systems (particularly natural systems) may possess a well-defined boundary. Because they are integrated wholes, it makes an essential difference to the systems' structure whether the subset they have in common should concern their boundary only, or more than only their boundary.[5] In the latter case, the two systems partially overlap. Two other set-theoretical relations, viz. L comprises K or K comprises L, do not make a difference to the *nature* of the relation between two systems. In both cases, one of the systems completely comprises the other. The relation K = L lies outside our discussion, because the present investigation is only concerned with the relations between distinct systems.

For systems, the basic principles of set theory therefore yield *four* possibilities, *four qualitatively different relations* between two systems:

*either the two systems are independent systems (they have no elements in common) -- R0*

*or they are linked by a mutual boundary contact -- R1*

*or the two systems partially overlap (they have a subsystem in common) -- R2*

*or one of the two systems completely encompasses the other -- R3*

I have numbered these **four fundamental system relations** R0, R1, R2 and R3 - and not R1, 2, 3 and 4, for instance - because the first one, R0, is a relation in a formal respect, but not as regards content, for there is no genuine link between the two systems.

It is important to realize that system relation R3 is not simply the relation of a subsystem within an encompassing system, such as a certain organ inside a body, because this investigation concerns itself with the possible relations between two *distinct* systems. This is not true in the case of an organ inside a body, since it is typical for the organization of an organ that it should form part of another system and should function as such.

However, this raises the question: is relation R3 really possible in the case of two *distinct* systems? In fact, there is a concrete and important example of that relation, viz. the relation lying at the origin of every human being: that of the embryo in the mother's body.[6] The one system, whose essence is precisely that it will finally become an entirely independent system, participates totally in the other, encompassing system. This example already shows that this relation R3 brings with it a highly specific structure of the systems concerned and a special occurrence. We shall see below that this system relation R3 plays a crucial role in other fields as well.

At first sight the group of four fundamental relations R0, R1, R2 and R3 looks quite simple, of course, and in a certain sense it is simple. I have to remind however that we are not just dealing with relations between mere sets having elements in common in various ways, but with relations between two *systems*. These are *integrated wholes*, and therefore the *entire* structure of such a system must be inextricably bound up with the manner in which and the degree to which such a system participates in another system. Hence, to each relation must correspond a specific ontological structure of the systems concerned. And if one of the two systems should be a cognitive system, the nature of the relation also determines the nature of the knowledge of the other system, and the manner in which this knowledge is obtained. I shall now analyse these far-reaching implications.

## *2. The ontological and epistemological implications*

The point of the analyses now following is the general ontological and epistemological implications of the four system relations. I shall first analyse the consequences of the relations for the structure of the systems concerned. Immediately afterwards I shall also investigate the acquisition of knowledge within that relation, meaning that I shall analyse the implications if one of the systems in the relation should be a cognitive system, i.e. a system possessing the capability of recording an effect resulting from a contact with an other system. What now follows are abstract analyses, pure deductions from the four system relations - for in principle they should hold true for all possible systems.

R0. We are dealing with the relation R0 when two systems may be considered to exist entirely by themselves and independently of one another. Of course such systems may be in contact for a shorter or longer period, which may change them, but in principle such a contact can be broken again. As regards the structure of these systems, this implies that such a system has well-defined properties independent of the other one.

Should one of the two systems, A, be a cognitive system, then the acquisition of knowledge about the other system, B, of course presupposes that contact should be established first. But it is typical of relation R0 that there is no genuine link between the two systems, hence the cognitive contact can in principle be broken again. Because the systems in this relation may be considered essentially discrete, B will have properties that are not only independent of A, but can also be known as such (and in that sense objectively) by A.

R1. In this relation the systems have part of their boundary in common. So the one system is indissolubly linked with the other by way of part of its 'outside', meaning that there is a relation of interdependence - for the mutual boundary contact is part of system A's integrated whole as well as of that of B. Hence the *entire* structure of each of the systems is genuinely tied up with, and in that sense stamped by, the other one.

In this relation, if system A is capable of acquiring knowledge about system B, this acquisition of knowledge must necessarily take place by way of their mutual boundary contact, for both systems are indissolubly linked through that contact, meaning that there is no other way to bring about a cognitive contact. So this boundary contact, participating in both systems, is the means by which knowledge is acquired. Hence all knowledge about B is stamped by that crucial mutual contact, meaning that knowledge about B is essentially relative to system A, with which B is tied up.

R2. Two systems having this relation to each other have a subsystem in common. Therefore, these systems as integrated wholes, partially participate in each other, implying that the properties of the one system are co-determined by the *internal* contact with the other system. So one cannot say that such a system itself possesses well-defined properties: it is characteristic of the structure of such a system in this relation that its properties come about in a complex process with another system.

If one of the two systems in this relation is a cognitive system, the acquisition of knowledge can now only take place by way of the mutual subsystem, meaning that we are now dealing with a fundamentally different kind of knowledge, obtained in a cognitive process in which the cognizing system A and the system cognized B partially participate in each other *internally.* Hence the cognitive result (knowledge about B) is essentially co-determined by the entire system A.

R3. This is the relation between two systems that we are confronted with if there is complete overlap. On the one hand the two systems are different systems, on the other hand one of them is completely and inextricably a subsystem of the other. The entire system encompassed therefore participates in the other one in a complex occurrence, meaning that for the existence and nature of the system encompassed the relation to the other system is all-determining.

In this relation, if one of the two systems is a cognitive system, the acquisition of knowledge can only take place by way of the internal contact consisting in complete participation of the system encompassed in the other system, meaning that knowledge must now come about through this complete participation of the two systems. Hence, in this relation the *entire* system encompassed participates in the cognitive event and in the cognitive result.

Now, there are two possibilities. If the system cognized, B, is a subsystem of the cognizing system A, this means that the *entire* system B participates in the cognitive event with A, as well as in the coming about of the result of that occurrence. Hence this cognitive result recorded by A does not concern a specific property or aspect of B (as in the other relations), but the entire cognized system B as such. *Everything* that can be known about B, both *that* it is and *what* it is, solely comes into being through this cognitive event, and therefore through its effect, the cognitive result produced by A.

The other possibility is that the cognizing system A is completely encompassed by and therefore a subsystem of B, implying that in this case A is *entirely* involved in the cognitive occurrence. The cognizing system A is then completely interwoven with the cognitive result. In that case, knowledge about B can only be represented by the cognitive system A in its entirety.

### *3. Four ontological structures*

So far these deductions, resulting from the nature of the relations and from the fact that we are dealing with systems, i.e. with integrated wholes. The analyses show that the nature of the relation determines the manner and degree in which the properties of the one system are dependent on the other system. Hence for each relation there is a corresponding, very specific structure of the systems concerned. There are four fundamental relations, and therefore there are also four such qualitatively different structures, *four basic structures.*

The analyses also imply that in each relation, and therefore also in the corresponding basic structure, *time* plays a specific role. Systems in an R0 relation can exist entirely by themselves; they may undergo changes, but these take place in a time which is essentially *distinct* from these systems. An R1 system is indissolubly linked to another system, so it is essentially involved with the other system in an common *event*, and therefore permanently stamped by the contact with the other system. For an R2 system time plays an even greater role, since the system participates in another system in a complex *process*. In the relation R3 the system encompassed is determined not merely partially but completely by its participation in the other system; therefore, it is itself of a completely *temporal* nature, so it is a system in a process of *becoming.*

If we are facing one of the four relations in a given domain of reality, the corresponding basic structure of the systems concerned as well as a specific role of time are also given. The nature of the relation, the basic structure of the systems and time are central ontological structural aspects proving to be closely interdependent. Hence we can conclude that the four relations imply **four ontological structures fundamentally different from each other**.[7]

These are the four ontological *possibilities*, meaning that in concrete situations we shall always be dealing with one of these four. Of course the four ontological structures are still very empty as regards content. The *basic* structures are determined, but nothing else has been filled in yet. It is entirely dependent on the kind of systems in what concrete form it will all appear.

### *4. Four epistemological relations*

Furthermore, the analyses show that the four system relations also possess far-reaching epistemological implications. Should one of the two systems in the relations be a cognitive system, it can be regarded as the epistemic subject system and the other system as the object system. Such a relation then has the character of a subject-object relation.

In all four relations, subject and object can be *distinguished conceptually*, but only in relation R0 can they be regarded as genuinely separate systems. From the analyses it follows that this is no longer so in the other three relations. In R1, the mutual boundary contact plays a central role in all knowledge, so that subject and object are indissolubly linked. In R2, all knowledge is stamped by the internal interaction via a common subsystem: in the cognitive process, subject and object partially overlap. Finally, in the case of relation R3 we are dealing with complete overlap, a complete participation in each other of subject and object.

Apparently, in each of the relations the acquisition of knowledge has a different character. In relation R0 the cognitive event is only needed to obtain knowledge; it has *no* further *relevance* for the content. In the other three relations, on the contrary, the cognitive event increasingly determines the content of the cognitive result. In R1 the *cognitive contact* plays a crucial role, in R2 an *internal interaction* and in R3 the *recording of or by the entire system itself.*

In summary, it follows from the single basic fact of the four fundamental system relations that in principle we are dealing with **four qualitatively different epistemological relations.** From R0 to R3, subject and object are increasingly involved in each other and in the cognitive occurrence, and this occurrence itself becomes ever more important for the cognitive result. Further on, I shall show with the aid of examples that all these are not merely abstract deductions, but of crucial importance for insight into real situations.

## *5. Concluding general reflections*

From the foregoing, it is evident that the four ontologies and epistemologies are closely interdependent, for a basic ontological structure of a system can only be cognized by means of a cognitive system that is able to enter into the system relation belonging to that structure. It is of course also true that the knowledge acquired by a given subject-object relation can only reveal the corresponding ontological structure, since *all* knowledge about the system is acquired by means of that relation, and hence bears the nature of that relation. So, if we know the nature of the subject-object relation in a particular situation, the fundamental ontological structure of the systems concerned is known as well.

The analyses in section 2.2 demonstrated that not only in the R0 epistemology, but also in the case of the subject-object relations R1, R2 and R3 we are dealing with genuine knowledge, albeit that in those relations the cognitive result is (increasingly) co-determined by the relation with the cognizing subject. But this does not take anything away from the *reality* of the structures in question. Each relation provides knowledge with a specific nature, and this also holds true for the structures cognized in this way. Therefore it is not correct to take "real" and "reality" solely in the sense of a (dualistic) R0 epistemology, as is often done. In short, the structures belonging to the subject-object relations R1, R2 and R3 are indeed *different* from, but *no less real* than the structure belonging to the R0 epistemology.

So far nothing special has been assumed about the nature of the systems, which means that the results should possess general validity. We may therefore encounter the four relations and ontological structures in the case of different systems, but we may also find them with *one and the same* system in *different situations,* which is the case, for instance, with systems capable of undergoing *development.* In that case, the different relations and structures manifest themselves with the same system *in succession*. But a system may also be involved in different relations *simultaneously*, if it should function in *different contexts* at the same time. This is particularly the case with complex systems (such as human beings) with many different aspects, allowing such systems to have different relations with various other systems *at the same time*: e.g. R0 with one system and R2 with another, with all the concomitant implications for such a system's substructures.

The abstract theory of the four system relations with all their ontological and epistemological implications that I have outlined here, shows the basic *possibilities.* The theory gives, as it were, the systems-theoretical boundary conditions which any system has to fulfill.  Whatever systems we are facing (material things, organisms, individual people or societies), in all their different situations and possible developments we can only encounter these four possible relations and corresponding qualitatively different ontological (and epistemological) basic structures, always in specific manifestations determined by the nature of those systems, of course. In conclusion, the basic structures of what we find in concrete shape in the fields of the sciences must be understandable by means of this systems-theoretical meta-theory.

In order to show that this theory may indeed offer further insight into very different domains of reality, I shall now discuss a number of highly divergent possibilities. Within the framework of this article this can only be done concisely. I start by focusing on the systems studied in physics. With the aid of these systems, in a certain sense the simplest, in any case least complex, the fruitfulness of this meta-theoretical research programme can easily be shown.

## 3. Application of the systems theory to physics

### *1. The discovered basic structures.*

For all applications of the abstract systems theory we are of course dependent on the results obtained by scientific research into the systems concerned. It is only thanks to that research that we can know *that* in a given domain the systems possess a given basic structure. But not *why* that is so. So we have to start with the question of what physics has brought to light about its systems as regards basic ontological and corresponding epistemological structures.

"Relativity theory and quantum theory have made visible certain basic structures of nature that were unknown before". Thus Heisenberg summarizes the most important developments in physics in the previous century.[8] It is characteristic of these theories (RT and QT), revolutionary in relation to classical physics (CP), that they are "principle theories", because these theories are based on a number of (new) fundamental principles.[9] In RT, one of those principles is the principle of the constancy of the velocity of light, whilst QT is based on the quantum postulate. It is a consequence of the fact that these principles are crucial that in each of these theories a certain aspect of the measuring process is of cardinal importance. In RT the central aspect is the *signal* *transmission*, in which it is essential that its maximum velocity is finite (1/c does not equal zero). In QT it is the *measuring interaction*, in which it is essential that "the basic unit of interaction", the quantum of action h, does not equal zero.

In the measuring event we are always concerned with the relation between the measuring system (the instrument) and the observed object, for in physics all knowledge is basically obtained through instruments. Because in RT and QT, contrary to CP, the measuring event itself plays such a central role, this has consequences for the relation between instrument and object. The way in which instrument and object are related in CP, RT and QT can be described as follows.

In CP, instrument and object are essentially independent of each other. Of course, a measurement always requires a contact with the instrument, but in essence the process of measurement plays no part in the theories of CP. This is different in RT and QT. In RT, signal is a key concept; the signal intrinsically links instrument and object, giving rise to an irremovable relativity of the measuring results. In QT instrument and object are indissolubly and unanalysably linked during the interaction; i.e. they are partially overlapping systems, and Heisenberg's indeterminacy relations express the extent to which they overlap.[10] This is a new instrument-object relation, fundamentally different from the previous ones.[11]

These characterizations show that these instrument-object relations tallies precisely with the general epistemological system relations R0, R1 and R2, analysed in sections 2.2 and 2.4. The physical epistemological relations are evidently special manifestations of the general ones.

In section 2.5 I argued that with each epistemological relation necessarily goes a corresponding complete ontological structure of the systems concerned, since whatever we can know about these systems (i.e. every ontological structural element) is stamped by the nature of the instrument-object relation by means of which that knowledge is acquired.

Therefore both RT and QT do not merely signify a small alteration, but a modification of the entire conceptual framework of physics. Because the epistemological relations are a special case of the general relations R0, R1 and R2, the ontological basic structures of CP, RT and QT must be special manifestations of the fundamental ontological structures (analysed in sections 2.2 and 2.3), implying that it must be possible to fully understand the essential characteristics of the basic structures of CP, RT and QT with the aid of the general system relations R0, R1 and R2 and their ontological implications. In particular we see that in the succesion of CP, RT and QT, time is increasingly connected with the systems themselves - as I analysed in general in section 2.3. I confine myself to a few brief characterizations.

R0. The world of classical physics is one of objects and their properties. As we have seen in section 2.2, this is typical of the ontology belonging to relation R0.

R1. The world of RT is a world of events and relations.[12] Here we are dealing with spatiotemporal systems, linked by the finite signal velocity, in which light bridges a (spatiotemporal) interval with the value zero.[13] This is precisely the ontological basic structure corresponding with R1: they are spatiotemporal systems with a (spatiotemporal) boundary element in common, viz. the signal.

R2. The world of QT is a world not of particles possessing their well-defined properties, but of interactions and processes.[14] From the relation R2, i.e. from the partial overlapping of the systems, all known characteristics of these systems follow. For example, in this domain the systems are not discrete particles; hence we are facing a specific "wholeness" of the phenomena,[15] which also implies a certain degree of irrepresentability.

I conclude that the theories of CP, RT and QT have made visible the ontological and epistemological structures belonging to the relations R0, R1 and R2. In this way, the general theory of the system relations makes it clear that, due to the systemic background of these physical systems, these theories cannot be interpreted in any other way. This also provides us with an answer to the question why we should have these theories at all, i.e. to Weinberg's question why nature should obey the principles of RT and QT. The systemic nature of the physical systems entails that there we necessarily find the basic ontological and epistemological structures, in a special (viz. physical) shape.

Moreover, we have now been furnished with an explanation of the course the development of physics has taken, viz. of the most important stages and their order of occurrence. It is clear that this development should be seen as the successive coming to light of the fundamental ontological structures. The order of the relations R0, R1 and R2 and the corresponding structures determines the order in which they have been discovered: first classical physics, then RT, and next, from classical physics again, QT.[16]

## *2. Implications for the philosophy of physics*

The discovery that in certain domains classical R0 epistemology is impossible, in fact meant the discovery of new, unexpected intrinsic structures of reality. Till now, physics has brought to light three basic structures as special manifestations of three general ontological structures. As I have argued in general in section 2.5, we are dealing with *real* structures with concomitant epistemologies, each valid in a limited domain. This also holds true in particular for the basic structure we have got to know through QT. Hence the systems in the quantum domain are *real* systems, no less real than the systems in the classical context. We have to note, however, that their ontological and epistemological structure is an essentially different one, for these R2 systems do not exist completely all by themselves; their properties are essentially co-determined by their participation in other systems (especially in a cognitive system, a measuring instrument).

With the insight that this quantum ontology is a special case of a normal ontological possibility (normal, for arising from the general system relation R2), the *strangeness* of QT completely disappears. Many have felt the world of QT to be exceedingly strange, but it is strange only from the familiar classical (R0) perspective. And it is a matter of course that, if one hangs on to the ontology of CP or that of RT, and thinks this is the *only* possibility (as did Einstein), one will have trouble with the quantum world.

Many physicists and philosophers, sometimes consciously but more often tacitly, take it for granted that the notion of the unity of nature implies that there must be one single ontology and one single epistemology.[17] Hence numerous interpretations and clever constructions have been concocted to unify CP, RT and QT in some way or other, or at least to harmonize them. However, the analyses given heretofore have not only made clear that there are fundamentally different structures, but that this must be so, due to the systemic background. The unified view is therefore essentially incorrect, which means that this presupposition must be one of the most important causes of much confusion and of endless interpretative debates.

This presupposition is not only disastrous for the philosophy of physics, but also for many physical research programmes, for in these too such a philosophical notion of unity often plays an important role, to wit in the views on the further development of physics. It is then thought that ever more encompassing theories should be created. A clear case of this is formed by the attempts to formulate one all-inclusive "final theory", or Theory Of Everything. We can now understand that programmes aiming to unify RT and QT in a grand, encompassing theory cannot possibly be successful. As an example I mention Einstein's fruitless search, for dozens of years, for a Unified Theory. The same reasons make it doubtful that string theory, which also aims to encompass RT and QT, will be successful in the end. As far as I know, twenty or thirty years of research endeavours by numerous researchers have not yet yielded a clear, empirically verifiable result.

I summarize: in physics, we are not dealing with a single ontology and a single epistemology. This is what the development of physics has brought to light, and the general theory of system relations allows us to understand why this should be so. This systems theory provides insight into the background of the various basic structures that physics has made visible, and especially makes clear that these structures differ essentially as regards ontology and epistemology, and how they differ. These differences are necessary consequences of the general systems-theoretical principles. From this it follows that those structures cannot be forged into a single unified structure and that such is not necessary either. So, not a unification but *combinations* of the different theories (especially of RT and QT) are required, to understand those physical systems that are simultaneously involved in different relations.

The insight, that in physics a unified theory (in the sense of a single ontology and a single epistemology) is neither possible nor necessary, does not imply a denial of a unifying view as such. In fact, the systems approach provides a unifying view with another, wider content - for it is precisely the *single* theory of the four system relations that not only shows that there are different structures, but in particular how these are connected in a single conceptual framework.

### *3. A new physical theory, a conjecture*

So the theory of the four fundamental system relations is important for concrete physical research, because of the philosophical presuppositions often playing a hidden role. But not only that. The theory also immediately gives rise to a specific surmise about the further development of physics. We have seen that in its development until now, physics has brought to light three of the four basic structures (R0, R1 and R2, in that order). So in principle there is a fourth one still, the ontological and epistemological structure belonging to relation R3. It is therefore natural to surmise that this one too will be of crucial importance with physical systems. This (most fundamental) basic structure too will then have to be experimentally as well as theoretically brought to light by physical research.

If this conjecture is correct, a new theory is required which should reveal this new, *distinct* basic structure, implying that this theory will be *independent* of RT and QT (like QT, as it was finally developed, in the first instance was non-relativistic too). In its mathematical-physical structure this theory will have to express the exceptional epistemological relation R3. It is a matter of course that, once that theory exists, later on *combinations* with other theories (especially those based on QT) will be created.

As it has been formulated here, this is a conjecture purely based on the development till now of theoretical physics as well as on the general theory of system relations. But in fact it is more than a pure speculation. In present-day experimental and theoretical physics there are already many matters pointing to the need of such a new theory. For many years now, it has been clear to everybody that in spite of its success the standard model of elementary particles is essentially inadequate. Though the standard model is eminently productive in describing and explaining all kinds of properties and interactions of particles, essential data (e.g. particle masses) cannot be explained. More important than such indications of a 'negative' kind (the fact that existing theories fall short), are the positive indications suggesting that a new *distinct* theory is indeed demanded.

I shall mention only the most important here.[18] Besides the two principles of RT and QT and the corresponding aspects of measurement, physics knows another important principle connected with a third aspect of measurement. It is a fundamental property of all measurement that it should result in a *record*. Therefore any measurement involves an irreversible process and is always accompanied by an increase in entropy. This increase is very small, but cannot be zero, because there is a lower limit; the smallest possible amount is of the order of k, the Boltzmann constant.[19]

Hitherto, in the domains of physics this increase of entropy, and therefore this third aspect of measurement, could be neglected.[20] However, there is a fundamental domain in which this recording process, and therefore also the increase in entropy, must be all-important: the domain of the elementary particle tracks as formed, for example, in a bubble chamber. The special characteristic of these records is that the track can only be comprehended in one way, viz. that in the single track the object system does not reveal one of its possible properties, but the complete system: that it is and what it is. Because one cannot measure this object system a second time, in an essential sense this record is non-repeatable.[21] Consequently, for the knowledge of the object system at this fundamental level the single record, and therefore the recording process, is all-important.

The fact that this third aspect of measurement is crucial is again (just like with the aspects of RT and QT) closely connected with a specific instrument-object relation, the nature of which follows from the analysis of the characteristics of the particle records and of the whole experimental situation. As said before, it is an essential feature of particle measurement in a Wilson camera or bubble chamber, for instance, that in the single cognitive event, with the single track as the cognitive result, the *entire* object system manifests itself, implying that here we are dealing with an instrument-object relation exactly tallying with the general epistemological system relation R3 as described in section 2.2. The relation we are here dealing with is a special case of the first of the two possibilities analysed there. Knowledge comes about through a *complete* participation of the systems, in which in this case the cognized system B (the object) is entirely encompassed by the cognizing system A (the instrument).

It is obvious that with these tracks, which reveal the masses and charges of the particles, we are in fact confronted with a new instrument-object relation R3. As argued in section 2.5, with this relation a new ontological basic structure must correspond. In a theory of this most fundamental level of matter the third principle, the essential irreversibility, will necessarily play a central role, meaning that then (the very existence of) matter and (the direction of) time can be understood in direct relation to each other.

If these analyses are correct, they corroborate the surmise that a new, distinct theory is needed. In any case it is clear that the theory of system relations, and indeed the whole systems-theoretical research programme, not only explains and clarifies known facts in physics, but also does what ought to be expected from a proper programme, viz. it makes a risky prediction.

## 4. Other possibilities of application

### *1. The importance for the philosophy of development*

In virtually all domains of reality we are dealing with systems, so in principle there are just as many possibilities for applying the systems theory developed here.[22] In order to show that the theory can clarify matters and answer ultimate questions in totally different fields as well, it seems useful to review a number of highly divergent possibilities of application.

One category of other possibilities for applying this research programme concerns all systems capable of undergoing development. Study of those systems by various scientific disciplines has yielded all kinds of developmental theories; e.g. theories about cognitive, social and scientific development. Yet in the end these developmental theories too leave us saddled with ultimate questions. Even if they are able to describe properly the developments concerned and their stages, and to explain many of their aspects, questions remain: why should the development run precisely that course, why do we find these developmental stages and no more or other ones? In principle, these questions too can be answered by the theory of the system relations.

The four fundamental system relations not only possess ontological implications, but far-reaching *development-theoretical* ones as well. The analyses in section 2 have shown that each of the four relations brings with it a basic structure of the systems, an important implication of this being that if a *transition* from one relation to another should take place, this must necessarily be accompanied by a *structural change* in the systems concerned. This fact has far-reaching consequences for the *development* that systems can undergo, and in particular for the *stages* that we may find in this development.

In general, we speak of a development if the structure of a system changes qualitatively.[23] And we speak of a qualitative change of structure in particular if the relation to other systems changes essentially at the same time. So in such a development the transition from one stage to another is accompanied by a change of the system's structure as well as of its relation. Because only four qualitatively different relations and corresponding structures exist, systems undergoing such a development with relation changes can have no more than **four (possible) basic stages of development.**

This conclusion must have general validity, because no special assumptions have been made as regards the nature of the systems. Human development constitutes a simple example. In each stage in the development of a human being the special nature of the child's relation with its mother is all-determining. The four stages are: embryo, suckling child, still dependent child, the adult human being having reached independence. The development therefore runs from R3 by way of R2 and R1 to R0. That each relation has its own nature is especially witnessed by the essentially different manner in which feeding by the mother takes place in each of the stages. Of an important category of systems, viz. mammals, systems theory thus explains the developmental stages together with their basic features.

In this way, the general development-theoretical implications of the four system relations enable us to grasp the nature and number of the developmental stages in many fields.[24] Hence it appears that this systems theory can contribute in an essential manner to the philosophy of development as a foundational analysis of developmental theories.[25]

A developmental theory that might be studied from this perspective is the one by *Piaget*, of course. In view of the general framework of the present article and the connection with the epistemological relations in physics discussed before, it is important to pay attention to Piaget's main research programme, genetic epistemology. Piaget has extensively argued that as regards structure the notions of the young child with reference to space, time, causality and object permanence show strong similarities to what modern physics (especially RT and QT) has brought to light about these matters.[26] Following Piaget, the physicist David Bohm too has often pointed this out.[27] From the perspective of systems theory this structural correspondence is easy to understand. The fundamental system relations and their epistemological implications apply to the child's cognitive relations to the objects of its world (relations R1 and R2, in fact) as well as to the instrument-object relations in the sciences, especially in physics. From the theory of system relations it follows that in those two widely different domains the same relations must necessarily show basic epistemological and ontological structural similarities.

## 2. *The four stages of Kierkegaard*

The insight central to the present study, that it is precisely the basic structures of the systems concerned which are completely determined by the relations, is not new in itself. It was already brought forward by some important philosophers in the past, albeit not in general, but only with reference to the specific fields they were concerning themselves with. I am referring to Kierkegaard (in 1846) with regard to the various modes of existence of the adult human being, and Plessner (in 1928) with regard to the basic structures of living beings.

They not only saw that the matters they were investigating could only be grasped from the perspective of the relations, on the basis of their research they also argued that in their domain there are *four* relations and corresponding 'stages', which should be fundamentally distinguished. Kierkegaard in particular indicated the four relations precisely.[28] I shall be brief about Kierkegaard,[29] and pay more attention to Plessner's work.

On the basis of his study of man's concrete existence in relation to his world, *Kierkegaard* comes to the conclusion that there are only a few, viz. four, fundamentally different possibilities of existence. He labels these four stages (or spheres, for they are possibilities rather than stages necessarily to be passed through) as follows: the aesthetic sphere, the ethical one, the generally religious one and the paradoxically religious one.[30] In the aesthetic sphere man has no true relation to the world around him (nor with himself). In the ethical sphere there is a genuine relationship with the other, the human being knows himself responsible. In the other two spheres, man feels that he is internally dependent on the (dialectical) other. This is maximally so in the last sphere.

In his many writings, Kierkegaard described these stages in detail, often in a literary form. In his most philosophical work, *Concluding Unscientific Postscript*, dating from 1846, he shows that the structure of each possibility of existence is completely determined by the nature of the relation, i.e. the degree in which the human being is involved with the dialectical other. This is most clearly seen in the summary he gives at the end of that work of the four relations and man's corresponding possibilities of existence. The phrasing found there (in the terminology peculiar to him) demonstrates that the nature of those relations tallies precisely with the general system relations R0, R1, R2 and R3.[31]

Kierkegaard believes that with the four stages he has presented a *complete* description of the stages of existence to be fundamentally distinguished.[32] However, he does not make clear why this should be so, i.e. why there should be precisely these stages or spheres. Because the possibilities of existence described by Kierkegaard always involve the relation of man with another human being, the theory of the system relations applies. By means of the general relations and their epistemological and ontological implications, in principle we can understand all details in his descriptions, for example that in Kierkegaard man possesses a specific cognitive possibility in each stage, and also a specific attitude to time.[33]

### 3. *Plessner and the structures of plant, animal and human being*

In his chief work, dating from 1928, Plessner aims at uncovering the basic structures of plant, animal and human being.[34] What he is looking for, is the fundamental structures that make the empirically observable phenomena possible. The empirical sciences can investigate all conceivable aspects of organisms, like their anatomy, or the functioning of their metabolism and nervous system, but according to Plessner the preconditions, the fundamental structures on which the phenomena are based, cannot be brought to light by those sciences. Using a "regressive method", Plessner attempts to uncover those preconditions, i.e. the basic structures of plant, animal and human being respectively.[35] He emphasizes that the central feature from which all essential characteristics of the organism can be comprehended is the organism's specific "positionality", i.e. the special *relation* to its environment that the organism itself brings about.

What makes an object a living being? Plessner's answer: the creation of its own boundary. Living beings maintain themselves as independent entities distinct from their environment, which is precisely how they secure a place for themselves in that environment. Typical of *plants* is the creation of a simple, single boundary, allowing a direct relation with the environment. This boundary, created and maintained by the plant itself, is not a simple interface, as with the non-living object. The boundary is entirely part of the organism itself, but at the same time takes care of all contact and interchange with the surrounding world. This relation determines the organism's entire structure.

Through its sensory equipment and its central nervous system, the *animal* possesses a centre, which gives it more possibilities than a plant. According to Plessner, a centric positionality is therefore typical of animals and determines the animal's entire structure. Typical of the *human being* is his eccentric positionality: man can enter into a relationship with his body. One of the many consequences of this is that man is artificial by nature.

His analysis of the human structure forms the basis on which his further philosophical-anthropological and culture-philosophical studies rest. The question is, of course: if his analyses are correct, why should reality be thus and not otherwise? Why, besides the world of non-living objects, do we have these three large domains in living nature? Plessner does not provide answers to these questions, but, as I shall argue in the following, the theory of the system relations can provide further insight here as well. To do so, I have to show how the specific relations and corresponding essential characteristics of plant, animal and human being can be explained, i.e. deduced from the general systems-theoretical principles.

Before we can apply the general theory of the system relations to this situation of systems in relation with their environment we have to ask: is this application possible? After all, the environment of a system is itself *not* a system.[36] So we do not have two *systems*. In order to be able to speak of a relation between *two systems* in the specific situation of system and environment, something special is needed. Because the environment is passive, a system relation (i.e. one or more of the real relations R1, R2 and R3) must now be completely created by the system concerned itself, implying that *by* the system itself and *in* the system itself a structure of such a nature must be created and maintained as gives rise to a certain organization of part of the environment, so that in this way *a second system comes into being*, viz. the surroundings connected with the first system.

Because the system has to create and maintain its own structure and the corresponding system relation itself (which is in turn only possible thanks to feeding through the relation it has created with the surroundings), it may be labelled a *living being*. Contrariwise, a system in an R0 relation with its environment is "non-living", because in that relation there is no genuine contact with objects from the environment, so that the system does not create a real relation; in that sense, the system does nothing.

What now, in particular, is the structure of a living system realizing only relation R1?[37] The general feature of relation R1 implies that there is a mutual boundary contact between the two systems. This must now be realized by the living system itself, meaning that the system itself has to create a *boundary* entirely belonging to the system, but at the same time forming the mutual contact with the ambient system it determines. Therefore, this boundary is totally different from the edge or interface of a non-living object. By way of this boundary, a permanent exchange of input takes place. It has to be capable of continually receiving and passing on *signals* from the surroundings. This *boundary* which has to be maintained determines the system's *entire structure.* The nature of this boundary contact brings with it that the system is essentially tied up with its ambient system. These structural characteristics of systems creating relation R1 with the environment correspond with what Plessner has found as regards the positionality of the simple boundary realization and the concomitant basic structure of *plants.*

The next question is, what is the basic structure of a system realizing not only relation R1, but relation R2 as well. This relation implies that two systems participate in each other by way of a subsystem they have in common. Now the system has to create this relation itself, requiring that *in* the system a special subsystem is created and maintained, by way of which the system and the surroundings belonging to it participate in each other. Because the system has to realize all this itself, the subsystem must have a cognitive character. Of course this cognition is of an essentially different nature from the one by means of a boundary contact. The presence and maintenance of such a cognitive subsystem necessarily determines the entire internal (ontological) structure. Because all cognition takes place through the subsystem, this will also function as a centre of the integrated system, implying a certain duplication of the system.[38] This makes the system capable of modifying itself, gives it freedom of movement and the ability to influence its surroundings. Because in relation R2 we are dealing with a *partial* overlap (i.e. a partial participation of both systems), cognition by the system of its surroundings as well as of the system itself is of a limited nature. If we compare the results of this analysis with those of Plessner, we can conclude that this is the *animal* world.

Finally, what are the essential structural characteristics of a system realizing not only relations R1 and R2, but the final fundamental relation R3 as well? Again our point of departure is the general characteristics of the relation concerned, which implies the existence of complete overlap: the one system is completely encompassed by the other and entirely participates in the latter. Again, this now has to be realized wholly by the living system itself, implying that the system must be capable of *completely incorporating* part of the environment as an organized whole and allowing it to participate in the system. This requires a cognitive ability (different from that in the other relations) to represent such an environmental system *fully in* and *by* itself. As a *result* of the cognition, the entire system cognized must be *present in the system* and be *representable* by the system, implying that the system must possess a kind of language capability. This ability of the system to represent a system *completely* in itself also affects the integrated system itself, so that this system can have a relation with its *own entire* system, giving it self-consciousness and greater freedom and more impact on its environment as compared to animals. These structural characteristics tally in essence with what Plessner decribes as resulting from the eccentric positionality of the *human being*.

These brief deductions of the basic structures of macroscopic living systems from the fundamental system relations reveal that in the context of living systems these relations manifest themselves in a special way. They are not so easy to recognize in this context, because in this case they are realized by and in the living systems themselves. I conclude, that the theory of the four system relations explains why there should be precisely Plessner's three "Stufen des Organischen", three categories of living beings, and hence a total of four worlds, that of non-living objects, of plants, of animals and of human beings.

## 5. Concluding remarks

With the aid of a number of examples that might easily be augmented by many more, I have shown that the systems-theoretical principles of the four fundamental system relations, very simple in themselves, have extremely far-reaching ontological and epistemological as well as development-theoretical implications. That in all those fields, so different from each other, we should always find precisely four relations, structures or stages is therefore not a matter of coincidence. From the theory of system relations it follows that this must be so, that - because in all those fields we are dealing with systems - reality cannot be otherwise.

Systems theory enables us to see that in highly divergent domains we are faced with similar structures. For example, we have seen that the three cognitive relations playing a crucial role in plant, animal and human being are special manifestations of the general cognitive relations R1, R2 and R3. The general nature of these cognitive relations we uncovered through the abstract analyses in sections 2.2 and 2.4. Characteristic of R1 is the cognitive contact, of R2 the (internal) interaction and of R3 the recording of the cognized system itself. In physics, we found the same cognitive relations appearing in a shape corresponding with those systems (signal, interaction and recording process).

Because in this way systems theory can provide insight into the basic structures in very many domains, in a certain sense a remark once made by Einstein holds true for it: "A theory is the more impressive the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability".[39]

Yet it is clear that this systems theory can only function if much preliminary work has been done by other disciplines. First, experimental and theoretical scientific research is required to make the basic structures of the systems concerned *visible*. In addition, these basic structures have to be analysed by foundational investigations and be *made explicit* in general philosophical terms. However, even when this philosophical research is not disturbed by ontological and epistemological presuppositions, philosophical analysis is not capable of yielding more than such a making explicit of what the sciences have brought to light. In order to comprehend the true meaning of the basic structures, and to obtain an answer to the question why reality should be like this at all, insight is required in the systemic background of the systems concerned. Therefore, as argued in the present paper, these ultimate questions demand the theory of the system relations. This theory itself rests on a few set-theoretical principles "that cannot be explained in terms of deeper principles". They are "a few simple principles of compelling beauty".[40]

## NOTES

[1] S.Weinberg, 'A Designer Universe?', *The New York Review of Books*, October 21, 1999, p. 46. Also cf. his book *Dreams of a final theory*, London 1993, p.19: “Why does nature obey the principles of relativity and quantum mechanics? Sorry – these questions  are still unanswered".

[2] See B.C. van Fraassen, *Quantum mechanics: an empiricist view*, Oxford Univ. Press, New York 1991; pp. 8-12 "Interpretation: science as an open text"; p.10: "Interpretations of the phenomena as science actually gives us are radically incomplete in themselves, and therefore call for interpretations too". Also cf. M. Jammer, *The Philosophy of Quantum Mechanics, The Interpretations of Quantum Mechanics in Historical Perspective*, John Wiley & Sons, New York 1974, esp. Ch.1.2 Interpretations.

[3] M. Bunge, *Treatise on basic philosophy*, vol. 4: *A world of systems*, Reidel, Dordrecht, 1979, p. xiii. Following in his footsteps, others too are attempting to create a so-called "systems-theoretical Theory Of Everything", thus far without definitive result. See e.g. Martin Zwick's paper entitled 'Complexity Theory and Systems Theory', presented at the International Institute for General Systems Studies, Southwest Texas State University, San Marcos, Texas, 9th Jan. 1997. At the end of

his paper, Zwick remarks: "Of course, a systems theoretic TOE is not currently available, but ample materials for constructing one are already at hand".

[4] The first to analyse these relations explicitly were the mathematicians Euler and Gergonne. In 1816, in his logical studies, Gergonne analysed the basic relations between two classes. He found that there are five and only five ways in which they may be related. See e.g. W. Kneale and M. Kneale, *The development of logic,* Clarendon Press, Oxford 1968, pp. 349-351.

[5] Further on, in elaborating the ontological implications, the difference will become abundantly clear.

[6] That these are two genuinely distinct systems is also seen from the fact that special enzymes are needed to prevent the rejection of the embryo as alien by the maternal body.

[7] This result from the analyses confirms the criticism of the prevalent systems approaches broached in the introduction. From the very start, the aim of designing a single general systems ontology blocks the possibility of realizing that there are other ontological structures as well, belonging to special relations.

[8] "Die Relativitätstheorie und die Quantentheorie haben gewisse Grundstrukturen sichtbar gemacht, die früher unbekannt waren". W. Heisenberg, *Schritte über Grenzen*, Piper Verlag, Munich 1971, p.31.

[9] In 1919, Einstein explained that the theory of relativity should be understood as a principle theory in order properly to grasp its nature. Most theories in physics are constructive theories (they construct models of complex phenomena using more elementary building blocks). The starting point of a principle theory however is a (new) set of empirical laws or principles. See Jeffrey Bub, 'Quantum Mechanics as a Principle Theory', *Studies in History and Philosophy of Modern Physics*, Vol.31, No. 1, 2000, pp.75-94. Bub argues that QT also should be considered a principle theory.

[10] Cf. Max Jammer, *The conceptual development of Quantum Mechanics*, New York 1966, p. 348: "In Heisenberg's uncertainty relations he [Bohr] saw a mathematical expression which defines the extent to which complementary notions may overlap".

[11] Cf. Niels Bohr, who has often said that QT has taught us an epistemological lesson, in other words a new subject-object relation. *Atomic physics and human knowledge*, John Wiley and Sons, New York 1958, pp. 76, 91.

[12] Cf. D. Bohm, *The special theory of relativity*, Benjamin, New York 1965, pp. VIII-X: "Einstein's basically new step was in the adoption of a *relational* approach in physics" and "We stress the role of the *event* and *process* as basic in relativistic physics, instead of that of the *object* and its *motion*, which are basic in Newtonian theory".

[13] The Dutch physicist A.D. Fokker (Einstein's assistant in 1914) emphasized - e.g. in his inaugural speech in 1928 - that in a four-dimensional perspective there is no action at a distance, since the influence of two systems (such as charged particles) on each other takes place through a signal contact with the velocity of light. Hence this signal contact has a (spatiotemporal) interval ds = 0. See G.C. de Jong, *Fokker en de Formanthese*, M. Sc. thesis, University of Utrecht 2001, pp. 75-85.

[14] Cf. M. Jammer, op. cit. (1966), p. 381: "The language of quantum mechanics is a language of *interactions* and not of *attributes*: *processes*, and not *properties*, are the elements of its syntax".

[15] About the difference of this wholeness from that in RT see D. Bohm, *Wholeness and the implicate order*, Routledge, London 1980, p. 134: "This [in relativity] is a different sort of wholeness from that implied by the quantum theory, but it is similar in that there can be no ultimate division between the observing instrument and the observed object. Nevertheless, in spite of this deep similarity, it has not proved possible to unite relativity and quantum theory in a coherent way".

[16] Please note that in the first instance QT, developed in 1925/26 (by Schrödinger among others), was a non-relativistic theory (after relativistic attempts in early quantum theory). It was only afterwards that relativistic quantum theories came into being, i.e. *combinations* of QT and RT.

[17] For the discussions about the pursuit of unity in physics and about the unity of physics as such, see e.g. T. Maudlin, "On the unification of physics", in: *The Journal of Philosophy*, vol. XCIII no.3, 1996, pp. 129-144; and E. Klein, M. Lachièze-Rey, *The Quest for Unity, The Adventure of Physics*, Oxford University Press, New York 1999.

[18] For far more detailed analyses, see my paper"The fourth structure of physical reality", in *Journal for General Philosophy of Science / Zeitschrift für allgemeine Wissenschaftstheorie* , XIV/2 1983, pp. 354-367; and Chapter IV: "Records of elementary particles and the development of physics" in my book *Science and Liberation*, Thesis Publishers, Amsterdam 1991, pp. 47-68.

[19] Leon Brillouin called this "the negentropy principle of information". He remarks that it has become clear that minute quantities can become very important (as in RT and QT). Therefore he hoped that despite its tiny value, this increase in entropy would "sooner or later, come into the foreground, and that we will discover where to use it to its full value". His conclusion is that the principle of negentropy of information "imposes a new limitation on physical experiments and is independent of the well-known uncertainty relations of quantum mechanics". L. Brillouin, *Science and information theory*, 2$^{nd}$ ed. Academic Press, New York 1962, pp. VII, 229f., 293f.

[20] Irreversibility as a consequence of measurement does not play any role in the theories of CP, RT and QT, hence it is typical of these theories that they are time-symmetrical.

[21] Of course these experiments can be repeated, but the repetition then concerns *similar* particles.

[22] Just as in physics, wherever we are dealing with several relations and structures a belief in unity (i.e. the idea that in that particular field only a single research method and in the end only a single theory can be the correct one) may be the cause of confusion and unnecessary controversy. In psychology, for instance, several research methods are required in order to make the different structures of the human being visible. These methods are not mutually exclusive, but each one of them has its limited value. Therefore the philosopher Charles Taylor is right when he pleads for "a peaceful coexistence in psychology". See C. Taylor, "Peaceful Coexistence in Psychology", in *Human Agency and Language, Philosophical Papers I*, Cambridge University Press, Cambridge 1985, Ch. 5, pp. 117-138.

[23] If such is not the case, we are simply dealing with growth or normal life. Cf. M. Mahner & M. Bunge, *Foundations of Biophilosophy*, Springer-Verlag, Berlin 1997, p. 272: "Any change in a biosystem's life history that is not accompanied by qualitative change is not a stage of development but of (mere) living".

[24] In this way also the theories concerning the developmental stages of society can be analysed and clarified with the aid of the systems theory, such as the stages of Karl Marx's historical

materialism and the structures of consciousness in Jean Gebser's phenomenology of culture. With reference to the latter, see J. Gebser, *The everpresent origin*, Ohio University Press, Athens (Ohio) 1991 (translation of *Ursprung und Gegenwart*, Stuttgart 1949/1953).

[25] Cf. W. van Haaften, M. Korthals, T. Wren, *Philosophy of Development*, Kluwer, Dordrecht 1997. These philosophers of development introduce a number of distinctions, e.g. between "the logic" and "the dynamic" of a developmental theory. In themselves these distinctions are useful, but the foundational investigations performed with their aid do not yield much. It does not become clear, for example, why in those domains reality should be as it is, i.e. why we should be faced with those specific stages there.

[26] See esp. Jean Piaget, *Introduction à l'épistémologie génétique*, tome II: *La pensée physique*, Presses Universitaires de France, Paris 1950. For a detailed discussion of Piaget's genetic epistemology, see e.g. M. Chapman, *Constructive Evolution, Origins and development of Piaget's thought*, Cambridge University Press, Cambridge 1988, pp. 196-261.

[27] See e.g. D. Bohm, *The special theory of relativity*, New York 1965, Appendix: Physics and perception, pp. 187-196.

[28] Kierkegaard was certainly not the first who did not think in terms of substances (as did many philosophers in previous centuries), but emphasized relations. In his *Critique of Pure Reason*, Kant had already made "substance and accident" a subcategory of the category "relation", and in his *Phenomenology of Spirit*, Hegel even more strongly emphasized relationality and process for the understanding of phenomena. However, Kierkegaard was the first to see that it is not a matter of relations as such and of a single kind of dialectic (as in Hegel), but that one should distinguish *four* fundamentally different kinds of relations and therefore - as regards human beings - four 'stages', i.e. different possible spheres of existence.

[29] Elsewhere I have analysed his doctrine of four stages in detail. See my book *Science and Liberation*, Thesis Publishers, Amsterdam 1991, pp. 132-143.

[30] The latter two stages he also calls religiosity A and B.

[31] See S. Kierkegaard, *Concluding Unscientific Postscript to Philosophical Fragments*, translation H.V. and E.H. Hong, Princeton University Press, Princeton 1968, pp.572f. As an example I quote Kierkegaard's phrasing as regards the *aesthetic* sphere: "the individual is in himself undialectical and has his dialectic outside himself".

[32] Cf. G. Malantschuk, *Kierkegaard's thought*. Princeton University Press, Princeton 1974, p.359: "Although the idea that Kierkegaard has created a 'system' must be rejected, one should be continually aware that he does give us a coherent survey of existence".

[33] For an elaboration on this, see my publication mentioned in footnote 29. In particular, systems theory makes clear why Kierkegaard can emphasize that each sphere possesses its own dialectic, since it holds true for each of the four system relations that it determines the entire ontological structure, and hence all ontological relations and categories.

[34] Helmut Plessner, *Die Stufen des Organischen und der Mensch*, Walter de Gruyter, 3d ed. Berlin 1975. In this study he consciously restricts himself to macroscopic multicellular living beings. And because he wants to concentrate on the essential structures, he also leaves transitional forms out of consideration.

[35] See Plessner, op. cit., pp. XX, 107, 116f.

[36] By definition, the environment is the set of objects external to a given system. As Mahner and Bunge correctly remark, it is "a collection of things", "it cannot act as a whole on a given system". See M. Mahner, M. Bunge, op. cit. (1997), pp. 25f.

[37] Of course, this study concerns itself with general structural analyses. Therefore the question of how the structures are realized in a biological-material sense (or how they might possibly be created artificially in another way) is not a point of discussion, as it was not for Plessner either.

[38] Cf. Plessner, op. cit. p. 231: "Physisch betrachtet verdoppelt sich mit der Entstehung eines Zentrums der Körper".

[39] Einstein made this remark (with reference to classical thermodynamics) in his "Autobiographical Notes" in P.A.Schilpp, *Albert Einstein, Philosopher-Scientist*, Vol.1, Harper & Brothers Publishers, New York 1959, p. 33.

[40] See Steven Weinberg, *Dreams of a final theory*, p. 13: "A final theory will be final in only one sense - that it will bring to an end a certain sort of science, the ancient search for those principles that cannot be explained in terms of deeper principles". And p. 131: "It is when we study truly fundamental problems that we expect to find beautiful answers. We believe that, if we ask why the world is the way it is and then ask why that answer is the way it is, at the end of this chain of explanations we shall find a few simple principles of compelling beauty".

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