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# The conceptual framework of the system theory

In this article reality is viewed through 'system spectacles'. The system theory offers a generally appropriate instrument for describing the structures and processes that make up reality. The modern technical scientific view of controlling all manner of processes, systems and organisations receives ample treatment. A game metaphor is used to explain the highly complex system that the world is. Special attention is devoted to the concept of objectives, using which the essence of the behaviour of complex systems can be succinctly described and the gap between the exact sciences and the social sciences bridged. The problem of objectives, values and giving meaning to life is undoubtedly a central issue in the construction of world views. We establish a link between the objectives of survival and humanisation and the growing complexity of the world. The problem of objectives is also at the heart of the crisis that faces Western society, lacking as it does a meaningful perspective. In an attempt to break the deadlock and tackle the pressing problems, we argue in favour of integrating objectives, seeking balanced solutions, joining forces and restoring unity. Finally, we opt to strive for a decent world that cares about life and heeds a transcendental existence.

## *1 A survey*

We cannot avoid the question of whether there is a scientific theory that at the very least forms a prelude to a world view. A general theory that offers an answer to the fragmentation of science and succeeds in spanning the various specialisations. A workable theory that can also provide a sufficiently broad yet reliable picture of reality. The applied sciences offer a conceptual framework, a way of looking at and describing reality, which in our view offers a suitable springboard for constructing a scientific world view. We are talking about the system theory, a generalising theory that forms a bridge between mathematics and the applied sciences. Although the system theory is often described in very abstract and mathematical terms, a qualitative discussion of this theory is easily accessible for the layman. The system theory can be formulated very generally and aspires to be a unifying theory that will re-unite science into a coherent whole. In the system theory, reality is regarded as a collection of elements that influence one another, a unity of interacting entities or a network of relationships. These abstract and general definitions indicate that the system theory is not restricted to a particular field but is broadly applicable. It can be successfully applied not only in the various engineering science disciplines, but also in demography, biology, ecology, economy, management science, etc. Concepts derived from the system theory are also found in psychology and sociology. The system theory is particularly useful for solving complex and multidisciplinary problems.

Blackbox, system and model are important concepts used in the system theory. A blackbox is a part of the universe that interacts with its environment. The internal workings of the blackbox are not known or are deliberately left out of consideration. The blackbox is affected by 'stimuli' from its environment and reacts with 'signals' to the outside world. The interaction actually occurs by means of incoming and outgoing matter, energy and/or information flows, which are characterised by so-called input and output variables, respectively. The diagram in *Figure 1* illustrates this. There is a certain correlation, a more or less clear relationship, between the inputs and outputs, which is characteristic of the blackbox. The behaviour of a blackbox without memory functions can be characterised by the input-output relationships. For a blackbox with memory or storage properties, however, it is not enough to know the inputs at any particular moment to be able to determine the outputs at that same instant. What the blackbox has remembered or retained from the past should also be taken into account. This is done by considering the internal states. The state space approach provides a very elegant mathematical description of this. We shall examine later on in more detail the concept of state, which is very important if we are to understand the dynamic (time-dependent) behaviour of systems.

The modern electrical and electronic appliances used in the home are excellent examples of blackboxes. Most people know how to operate appliances such as radio and TV but do not know their internal structure or workings. Blackboxes are also found in physics. No further explanation has been found for elementary particles and their interactions. Nevertheless it proves to be possible to make some meaningful statements



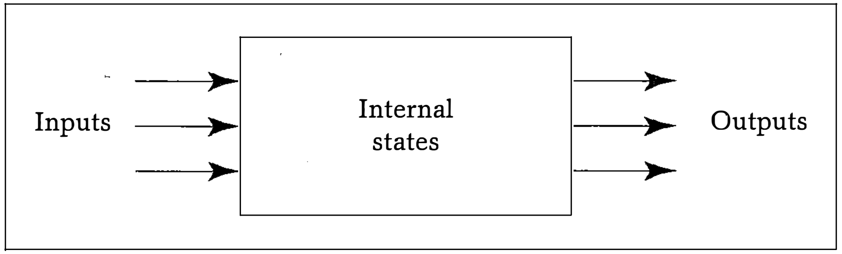


*Figure 1 – Diagram of a blackbox.*

about reality without considering each of the underlying levels with their building components and their structure. The theory of strength of materials, for example, had been fully developed and applied on a large scale before metallurgists could provide an adequate explanation for the elasticity, plasticity and rupture behaviour of materials. The concept blackbox is therefore constantly used in science and in everyday life. People usually manage quite well without needing to consider every 'detail'. The blackbox approach also makes it possible to remove the subject to be studied from its environment, concentrate on certain aspects and greatly limit the field of research. This analytical and reductionist approach has led to enforced specialisation and an explosive development of science and technology. Various scientific disciplines were developed, such as mechanics, thermodynamics, the theory of electricity, chemistry, biology, psychology, sociology and economics, which then broke up into various highly specialised fields. The result of this is that science has become fragmented and we can no longer take an overall view. The negative effects of reductionist analytical methods can be absorbed to a large extent by the system approach.

A system is made up of a number of interconnected blackboxes, which interact with one another and possibly with the outside world. Since both the building components and the connections are characterised by relationships, a system can also be defined as a set of relationships. These relationships establish the connections in space and time between the attributes of the interacting entities. Examples of systems include all kinds of structures, networks, organisms, organisations, etc. As a result, a system can also be described as a physical, technical or organisational structure in which material, energy and/or information processing processes take place. An open system interacts with its environment, whereas a closed system is isolated from the outside world. If a blackbox is forced open, a system is usually found. This open system is

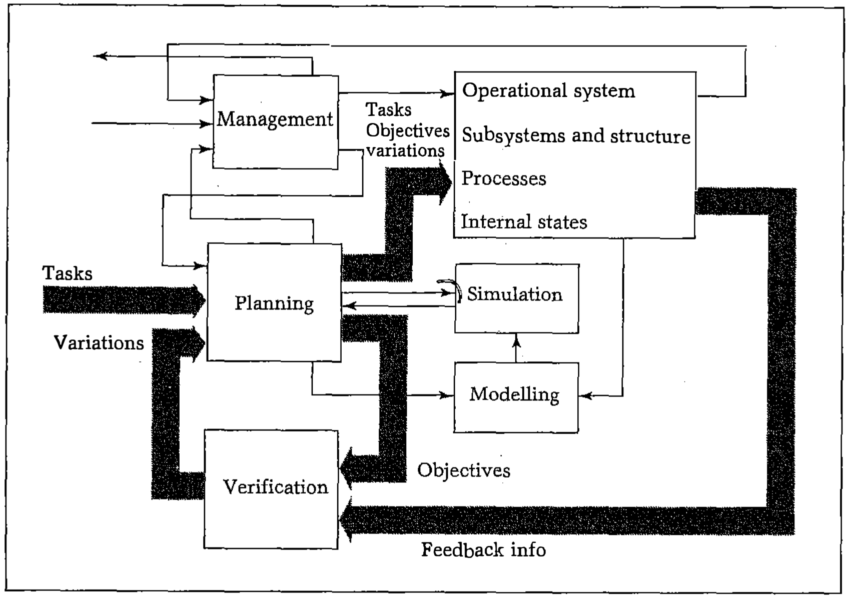


*Figure 2 – Structure of a business information system.*

made up of a number of interconnected aspect or sub-systems, which can also be treated as blackboxes. If a blackbox is further analysed and if known physical laws of the basic elements and their connections are finally identified, then it is sometimes called a 'white box'. The interactions between the elements in a system can be illustrated by means of a block diagram. *Figure 2*, for example, is a diagram of the operating system of a company with the functions that are essential for efficiently managing a business. These functions, which are also vital for controlling all kinds of complex processes and systems, will be explained in the following two points.

In the analytical approach, an attempt is made to solve complex problems by splitting them up into subproblems, which are easier to manage and to solve, and which are tackled one by one. When complex systems are being studied, this process is preferably done in several stages and in a hierarchically structured way. In breaking down problems, various levels of detail can be distinguished and there is a shift from macro to micro-scale. If, for example, we are analysing the operation of a company, we concentrate on the functions of the various departments, services and employees successively. With the system approach, attention is not



only given to the behaviour of the isolated elements, as is the case with the reductionist analytical methods, but also to the interconnection laws. Using the structured approach, the large number of relationships that characterise large-scale and complex systems can be studied without losing the overall picture. In addition, the analysis phase is followed by a so-called synthesis phase in which the interactions are taken into consideration again along with the interconnections. This laborious but efficient method is applied very rigorously in the development of complex computer programs to automate complicated processes and companies. Reality as a whole can also be viewed in a structured way. When elementary particles rise to become social organisations, a number of successive layers, each with their own characteristics, are identified. Besides the material layers, emotional, cultural and knowledge layers can be distinguished. Analogue layer models are used in the computer world. A clear distinction is made, for example, between hardware, system software and application software.

In the course of this article a technical organisational view of the system theory will be presented as a unifying approach. Moreover, a good deal of attention will be given to the role of models, the problem of control and the concept of objectives. Starting from a technical scientific basis, we shall move up to the social and organisational level. In so doing, we have to bridge the gap between the exact sciences and the social sciences. With some diffidence we shall also forsake the purely technical and scientific field and make a number of statements of a rather more intuitive nature. After all, the exact sciences do not offer any sound and satisfactory answer to the fundamental questions. We have no wish to conceal the fact that this is an action-oriented engineer's view. Man is able to consciously intervene, to make the most of the opportunities offered by nature, to considerably improve his living conditions and to determine his fate to some extent. The successes of science and technology do not blind us, however, to the limitations, disadvantages and dangers of the current technological and economic developments. We have limited knowledge about large-scale and complex economic, social and ecological systems, the means of influencing their behaviour and the consequences of human intervention. We have already created more problems than future generations will be able to solve. Moreover, we seem to be losing control over events and many problems are becoming uncontrollable. In modern technical scientific thinking, people are aware of this and are looking for models and methods to describe and control complex systems and to systematically solve the problems that these create.

## 2 Modelling and simulation

The model is a key concept in the applied sciences. Models represent the physical structure, the functional relationships and/or the state transitions of systems. Models can therefore be used to predict the behaviour of systems, to gain an understanding of how they work, to optimise their operation and ultimately to help control these systems better. Various types of models are used to describe systems and their behaviour. Examples include scale models, laboratory animals, flowcharts, graphs, diagrams, algebraic formulae. In terms of the aspects studied, these models have similar properties to the systems examined but are easier, cheaper, safer, etc. to handle. The pharmaceutical and cosmetics industries, for example, make large-scale use of laboratory animals to test the effects and side-effects of new substances without endangering humans in the process. Mathematical and graphical models are preferred in the applied sciences. Mathematics provides a wealth of potential models on which the system theory can draw. The system theory can therefore be regarded as a link between mathematics and the applied sciences. *Figure 3* shows a classification of systems according to their mathematical models. In most models reality is represented in simplified form by concentrating characteristics, ignoring coincidence, determining behaviour only at certain points in time, disregarding non-linearity and/or regarding the system properties as constant. In many instances these abstractions permit an acceptable approach using fairly simple mathematical techniques.

In particular, an extensive and effective range of mathematical tools is available to describe and study the behaviour of linear systems. Under certain circumstances the outputs of a linear system are directly proportional to the inputs and the outputs may be added up if the corresponding inputs are combined. With the help of the state space approach and orthogonal transformation and decomposition techniques, mathematical models have been reduced to a simple form that is also easy to solve by computer. The set of linear differential equations that characterises a linear system can be converted into a set of linear algebraic equations by carrying out Fourier or Laplace transforms. It is possible to further simplify a model to a set of uncoupled equations after applying an eigenvalue or singular-value decomposition. The rapid development of modern computer technology and numerical calculation techniques have also ensured that so-called discrete methods have broken through and are widely used. In addition the behaviour of the system is examined not only with regard to particular aspects of this behaviour but also only at



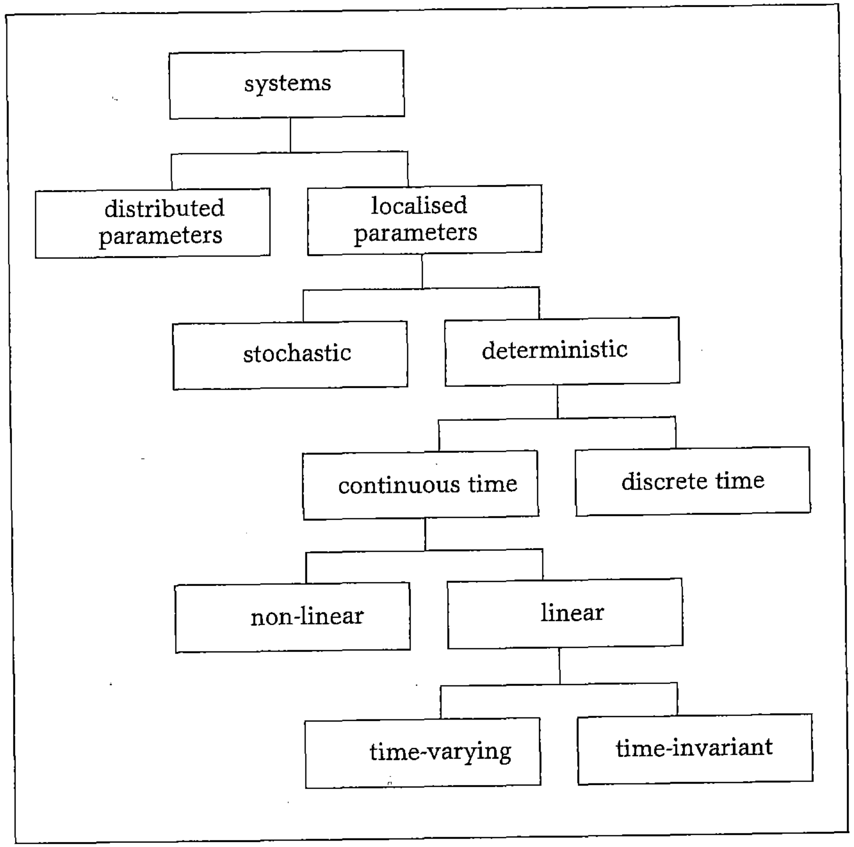


*Figure 3 – Classification of systems according to the type of mathematical model used to describe them.*

certain times. Reality is approached as a discontinuous entity both in space and time. The time-dependent behaviour of a system is represented in these methods by a series of discrete state transitions. These kinds of mathematical models have become indispensable when designing new products, installations, structures, etc.

The equations that describe the behaviour of non-linear systems are much more difficult to solve analytically than linear systems. This explains why non-linear behaviour is often neglected or ignored. Nevertheless non-linear systems can produce some very remarkable phenomena that are characterised by bifurcations, catastrophes and/or chaos. Modification of system parameters, inputs and/or states then results in indeterminacies when bifurcations occur, in unexpected sudden leaps and in more or less unpredictable fickle changes. Non- linear systems that are far from being at equilibrium could hold the key to life. These dissipative systems have received a good deal of attention thanks to the work of I. Prigogine. Modern computer techniques also offer unprecedented possibilities for calculating the behaviour of non-linear systems and presenting the results in graphical form.

Although the exact sciences usually concentrate mainly on the possibilities of mathematical models, structural graphical models such as graphs, flowcharts, block diagrams and organisation charts are also very important. This is especially so where complex and large-scale systems are being studied. Graphic techniques and hierarchically structured approaches play a large part in the analysis, description and design of complex organisations, information systems, computer programs, etc. Geometric models such as figures and graphs are also vital for gaining insight into the complex behaviour of non-linear systems.

Two methods are available for modelling systems, which actually complement one another. The first method is based on the available physical laws or models for the elements and the interconnections. One example of this that is very interesting from a theoretical and didactic viewpoint is the multidisciplinary bond graphs method. In the second method a general mathematical model is the starting point for determining unknown parameters using identification techniques. In order to study the behaviour of a real system, stimuli are applied, the reaction to them is measured and the relationship between inputs and outputs is recorded. By optimising the parameters, an attempt is made to build a model that represents the measured behaviour of the system as closely as possible. The identification of the parameters of a linear function using the least squares method is a well-known example of this black-box approach. This method can be used, among other things, to determine the coefficient of linear expansion, which establishes the relationship between the temperature and length of a metal bar. In the case of systems with memory properties, not only do the input-output relationships need to be identified. The internal states also have to be reconstructed from the observation of the development of the input and output variables. In order to be able to make a sufficiently accurate model of an existing system, the model cycle usually needs to be completed several times in succession. A mathematical model is postulated, the parameters identified and the model validated by comparing it to reality.



If the model does not meet the requirements, it is adjusted and a new identification and validation phase begins. This process is repeated until the model represents the actual behaviour of the system accurately enough. When choosing the mathematical model, all the information available about the structural and functional characteristics of the system is used to achieve a good result quickly. The two methods are in fact combined with one another. In every case the model should stand up to the test of reality.

Once a valid model has been found, the behaviour of a system can be imitated or 'simulated' and the results used to control or improve the system. Systematic use of modelling methods and simulation programs could save companies and society in general a great many technical and other problems, a lot of money and sometimes a great deal of suffering. Simulation techniques are therefore already frequently used in a variety of fields. Examples include the calculation of the strength of buildings, vibration of vehicles, currents in the North Sea, depletion of raw materials and sources of energy (Rome Club), economic development, weather forecasts, etc. There are currently some very powerful numerical 'tools' available for 'predicting' the dynamic behaviour of both linear and non-linear multidisciplinary systems. Modern computer systems can quickly solve large sets of equations numerically and present the results in all possible graphical forms. One notable aspect is the development of software packages for computer algebra or automatic formula manipulation that correspond to traditional mathematical analysis methods. In these computer programs the sets of equations are symbolically solved before the numerical values are input. As a result problems associated with rounding off and approximation, which occur in numerical calculation, can largely be avoided and more accurate results obtained.

Models may consequently be used to anticipate potential problems. Very intensive use is therefore made of them to design technical systems. Using modelling and simulation techniques, engineers can check whether the proposed system will meet the requirements before the system is actually built. With the iterative methods, the design is repeatedly analysed and improved in successive stages until an optimum solution is found that best satisfies the criteria. It is evident that, except in simple cases, no model can completely represent reality. Surprises during the production of systems cannot therefore be ruled out. Every model should be validated and adjusted if necessary. If reliable models are available, expensive prototypes do not need to be built. There is also a growing trend towards deliberately using models to control systems.

## 3 Control of complex systems

In the applied sciences, engineers study the methods, techniques, processes and systems used to manipulate nature for the benefit of mankind. They try to influence phenomena and events in a rational way and control them as much as possible. The problem of control is therefore important in engineering practice and is at the heart of control engineering and cybernetics. The feedback mechanism is constantly used to control a system. When a difference is found between actual and desired behaviour, an adjustment is made. This is the case, for example, if a car or bike deviates from its respective lane due to a disruptive influence. This method is also used to monitor planning within a company. Checks are made to see whether the planned tasks have been carried out and the objectives achieved. Any variations with respect to the standards fixed are determined in order to deduce the necessary corrective measures. Conveying information from the output back to the input of a system is characteristic of a control system and is called feedback. Feedback only happens if deviations occur and problems have already cropped up. Social feedback, for example, is a reaction to injustice and wrongdoing. Prevention is always better than cure, however. To avoid problems we need to anticipate and build models. This introduces the term 'feed forward' and model-based regulation. Companies talk about planning. As *Figure 2* illustrates, a model is used during the planning process to develop optimum plans for the management of a company with the help of simulation techniques. The best possible model has to be made not only of the system itself, but also of its environment in order to minimise the effect of unexpected external problems. With adaptive systems, the model is constantly adjusted on the basis of the results of the regulating measures taken, so that the process can still be controlled reasonably well despite the uncertainties. Models have therefore become an indispensable tool in modern control engineering. They are also essential for engineers and managers.

Although mathematical models are used successfully, and especially so in the technical world, their limitations become apparent when complex systems and uncertain situations are involved. This is the case, for example, with combinatorial problems where an enormous number of possibilities has to be evaluated. Problems of this type arise, for example, when planning activities in the workshop. Even the most advanced computers cannot find a complete solution to these problems within a reasonable period of time. With certain models the outputs appear to be highly sensitive to changes in state variables. Small errors then lead to



completely unreliable results. In recent years the dream of a completely controllable world has consequently lost a great deal of its credibility. This is also the result of the study of non-linear systems whose behaviour is uncertain owing to, among other things, bifurcations. Chaotic behaviour also proves to be difficult to predict because of its extreme sensitivity to changes in state variables. Moreover the limits of systematic planning have become apparent. The collapse of the Eastern European planned economies implies, among other things, the failure of certain scientific management theories. Autonomous, self-organising, competitive and flexible organisations appear to be more successful than centrally managed, monopolistic, bureaucratic, rigid (state-owned) organisations.

If quantitative methods fail, then we have to resort to the qualitative approach. We have to make do with graphical and linguistic models. As a result of developments in the field of artificial intelligence and expert systems, there is growing interest in knowledge formulated into rules, and fuzzy logic. The highly exact world of engineering is rediscovering the importance of intuition and feeling. The rules which experts employ to make decisions in complex and uncertain situations, and which are being incorporated into expert systems, often prove not to be based on scientific or conceptual arguments. In many instances the use of vague rules is the only practicable way that the overall behaviour of complex systems can be described. These kinds of general, not sharply defined, intuitive statements are also of great importance in the construction of world views. With very large- scale and complex systems it will often prove to be impossible to formulate an overall model. In this case several models, possibly partly overlapping, need to be used, each of which is valid in one field and/or for specific aspects. The construction of world views is therefore at times regarded as the compilation of an atlas of models of the world.[1] One fully integrated world view will probably remain an unattainable dream.

The problems currently facing engineers are characterised by increasing dynamism, complexity and uncertainty. Technical projects are growing in scale and becoming increasingly more complex but at the same time more vulnerable and risky. Examples include large nuclear power plants, huge chemical plants, jumbo airliners, etc. As a result the systems not only need to be satisfactory on the technical and economic front; they also have to meet stringent safety and environmental requirements. Controlling the enormous complexity they encounter is the main challenge facing modern engineers. The traditional specialist approach no longer seems adequate to tackle the increasing and multidisciplinary problems posed. There is a great need for integral views that take all relevant aspects and interactions into consideration. The search for a general approach to problems of a technical organisational nature leads the engineer to the system theory. This is the case, for example, when developing an 'architecture' for computer-integrated manufacturing (CIM). Broadening his field of vision eventually brings the engineer to the world views problem. This problem follows naturally from modern technical scientific thinking, which strives for integration.[1]

## 4 *Integration and unification*

As an integrating, generalising, overlying and even unifying approach, the system theory is particularly well suited to tackling multidisciplinary problems. An important precursor of the system theory is the less abstract discipline of thermodynamics. This discipline is indeed situated further from modern mathematics and more closely associated with physical reality. Thermodynamics studies the transformation of energy and, in particular, the conversion of heat to mechanical work. The first law of thermodynamics states the equivalence of heat and work and the conservation of energy. The second law of thermodynamics, also called the law of entropy, states that the entropy of a real thermally isolated system, left to its own devices, increases. Expressed in simpler terms, the law stipulates that heat can only be transferred from a body at a higher temperature to one at a lower temperature. The network and structural theories can also be regarded as historical predecessors of the system theory. Nowadays they may also be looked upon as branches of the system theory. Examples of networks and structures include electrical installations, electronic and hydraulic circuits, mechanical structures such as bridges and buildings, etc. In general we talk about n-ports or multiports where the ports refer to the external outputs or possible influences. In this class of system the variables occur in pairs, for example, voltage and current, pressure and flow, force and velocity (or displacement). This enables the concept of energy to be introduced with the product of both types of variable as the definition of power (or work). The concept of energy forms the link between the various scientific disciplines and allows an interdisciplinary approach to be adopted. With the help of the concept of energy, very general statements can also be made about the overall behaviour of systems. This concept brings us back to thermodynamics. It allows thermodynamics to be integrated into the system theory and a network and structural thermodynamics to be formulated. In these theories abstract concepts of energy and entropy can be defined that also have some very remarkable properties.

We can ask ourselves to what extent it is possible to fit the various scientific disciplines into a system framework and whether this generic conceptual framework does not become completely hollow when abstraction and generalisation are taken to extremes. In the system theory an attempt is made to combine the essential and common characteristics of the various scientific disciplines while renouncing all that is incidental and specialist. As in every analytical science, elements and interactions are identified that are characterised by variables and relationships. These relationships may be of a functional, organisational and/or structural nature. They represent the typical interactions between the characteristic variables and determine the behaviour of the system in space and time. The concepts of space and time enable the phenomena that occur to be distinguished (or discriminated between) and the stream of successive events to be ordered. Abstract multidimensional vector spaces are used to describe aspect variables that vary in space and time. The system theory is not therefore concerned with a collection of physical laws but rather with a pattern to view reality. This conceptual framework must be 'fleshed out' on an individual basis by making an appropriate choice of model. Technical system theory was developed from control engineering. The work of N. Wiener and others has clearly shown that some very useful work can be done to solve control and management problems without the need for specialisation. Within the system framework outlined, it is possible to demonstrate some general energy theorems of practical use using limited hypotheses concerning the properties of the building components and their connections. This is the case, for example, in Tellegen's theorem and the analogous theorem of virtual work. We shall examine this point in more detail later.

The question arises as to how it is that the system theory can span different disciplines. Is it simply a result of the analogy between the various aspect views of reality or do the fundamentals of the system theory represent the essence of reality? There is clearly a similarity between the concepts and laws in the various areas of science. Mechanical systems and electric circuits, for example, can be handled in a similar way. The analogies can partly be explained by the important influence that the development of mechanics has had on other scientific disciplines. Another factor is the interaction between the exact sciences and mathematics. An explanation can also be found in the way the human mind works. The view of reality we form is undoubtedly partly determined by the way in which the brain processes and stores information. This process is associated with a huge reduction in the volume of data. We are able to recognise patterns, distinguish similarities, distance ourselves from concrete reality and reason using abstract concepts. We try to fit new facts into known patterns, possibly after a process of abstraction. We usually rely on images from everyday experience to understand complex phenomena. In the theory of electricity and the system theory, for example, we fall back on the hydraulic analogy. The idea of flowing liquids is used to make electric currents, energy 'flows' etc. understandable. This does not rule out the possibility that we can gain 'physical insight' into new concepts in science. Mathematicians also try to make new concepts and methods understandable by generalising existing concepts. The 'orthogonal' decomposition of signals using Fourier analysis techniques, which is intensively used in the study of linear systems, can, for example, be regarded as a generalisation of the orthogonal expansion of vectors in analytical geometry. In its abstract form orthogonality proves to be a very powerful and broadly applicable concept that plays a major part in identifying systems. The main identification techniques can be reduced to a generalised orthogonal projection.[2]

The problem remains why the system theory and the mathematics it uses are a suitable instrument for describing reality and how it is that we are able to capture and understand reality in the form of a model. Geometry and arithmetic were developed through solving practical problems and are still closely linked with physical reality. The higher and modern forms of mathematics, which developed by abstraction, generalisation and even an element of fantasy, are moving further away from their starting point; nevertheless they can often be applied in other fields. An outstanding example is non-Euclidean geometry. The system theory was also developed through solving real problems and has acquired a broader field of application as a result of generalisation. The system theory and the mathematics it uses actually study the properties of one or more sets of entities, between which there are a number of relationships. Furthermore, the system theory borrows many of its models from mathematics and tries to represent reality as accurately as possible by using well-chosen functions. The similarity between the structures of the system theory and mathematics is no coincidence. The ability to classify elements and find relations is characteristic of the human mind. From this point of view, man also sees reality as an entity composed of interconnected elements. This view explains the usefulness of the system theory and mathematics that have been built up in a similar way. It is not clear to what extent the model that man forms of the world really corresponds with reality. Some go so far as to regard reality as a pure mathematical construction. The image that we have of the world, however, is not only determined by the workings of the brain but should also be a fairly adequate representation of reality. It would be difficult for us to live with a 'virtual reality' and we would certainly not be able to survive. The human mind therefore must reflect the world of which it is a part in a reliable and understandable way. There are many indications that the sets of entities and relationships, which characterise the existing structures and the processes that occur, come very close to the essence of reality. The system theory does not explore the question of the essence of reality. The usefulness of the models is a key factor. If the models are not found to be effective in practice, they should be replaced by better ones. It is therefore more a question of validity than truth.



Scientists not only explore the unknown but are also interested in making models of their discoveries. Moreover, their aim is to produce a description that is as succinct as possible and preferably also aesthetic. They seek out elementary particles and fundamental laws. According to a rather debasing definition, science is therefore regarded as a systematic and rational form of data compression. This view is currently very important in view of the explosive growth in scientific knowledge and the flood of publications, which it is humanly impossible to absorb. There is a great need to re-organise the scientific and technical landscape and to 'reduce the entropy' of science. We should not only be interested in discovering the unknown and disseminating new facts, but also in organising, structuring and integrating available information. The dream is to develop an all-encompassing and unifying theory, yet one which is still clear and reliable. Can the whole of reality be captured in a few quite simple principles, however? Gödel's theorem would suggest that this is not possible. According to this sensational theorem, it is impossible to fully substantiate all of the valid propositions of arithmetic with a limited number of consistent axioms. As the 'construction' grows, the 'foundations' need to be broadened. Physicists, however, still regard the Grand Unified Theory (GUT) as the key to reality. This theory tries to unite the different types of forces and interactions between elementary particles into one law. In the world of object-oriented programming, an attempt is made to develop a very general program module, called the primal object or the 'Object'. Although the dream of an overall, coherent and unifying vision of the world will be found to be unattainable, the system theory is currently the most practicable candidate. The system theory recognises a constantly recurring pattern in reality and offers a universal grid to capture events.

## 5 Fundamentals of the system theory

Following this rather intuitive introduction to the system theory, we can ask ourselves what the fundamentals of the theory are. We shall try to give a physically oriented overview of the principles and shall endeavour to achieve a synthesis between the basic concepts of system theory, the state space approach, the network theory and thermodynamics. The discussion also includes elements from the multiport theory and the bond graphs method. A hydraulic analogy is also introduced, in which interactions are seen as flows of matter, energy and information.

In the system theory it is assumed that it is possible to define the limits of blackboxes and to distinguish what is part of the blackbox and what is part of the environment. Blackboxes are delimited by a sealed boundary that separates the interior from the exterior. Blackboxes can be influenced by the outside world and in turn they can influence the outside world. The relevant part of the outside world that interacts with the blackbox is called the environment. The interaction between the blackbox and its environment can only take place via 'ports' in the boundary line. The ports are the only known and observed input and output possibilities for matter, energy and information flows. The physical phenomena that affect the blackbox are called inputs and can be characterised by input variables while the response of the blackbox or outputs can be characterised by output variables. Hence the inputs and outputs are phenomena that link events happening inside and outside the blackbox.

The behaviour of a blackbox can be established by studying the effect of input changes on the outputs and making a model of the relationship between the input and output variables. Generally speaking, however, it is impossible to represent the behaviour of a blackbox fully and accurately without considering its internal states with the help of state variables. The stopping distance of a car, for instance, depends not only on its brake force, but also on its initial speed and corresponding kinetic energy. The state variables characterise the internal entities that can play a part in an event. This is the 'free' part of the matter, energy and information that is present inside and available for the process. The state variables should unequivocally represent the physical state (possibly as a whole or excepting one constant). The internal energy is an example of a function that may be used as a state variable for a thermodynamic system. It can be demonstrated that this is not the case for stored heat. The heat absorbed or released is determined not only by the initial and final states, but also by the route taken during the change in state. On the other hand, the entropy, which takes both the heat energy and the absolute temperature into consideration, can be regarded as a state variable. The outputs of a blackbox are dependent on the inputs and the internal states. The internal states are themselves influenced by the inputs but are also partly determined by the previous states. Past events can influence the present via the internal states. In this state space model, inputs are regarded as the cause and outputs as the effect. Input variables are independent variables and output variables are dependent variables. The states and state variables also take delay effects as a result of internal 'inertia' into consideration.

The behaviour of a blackbox is therefore described in terms of relationships between input, state and output variables. A change in the input and/or state variables causes a change in the output variables. In abstract mathematical approaches, the internal states are regarded as the minimum information which, together with the inputs, fully determines the outputs. If the blackbox can be fully controlled, all of the internal states are accessible and the state variables can be influenced from outside by the inputs. If the blackbox can be observed, the internal states are reflected in the outputs in such a way that they can be reconstructed for an outsider. A comet or a ballistic missile, for example, can be observed but not controlled. If a blackbox is taken out of its environment and possibly moved, but is still subject to the same inputs, and if it is assumed that the states are identical, then the outputs do not change. This also applies if a shift in time occurs in a time invariant system.

In the process that determines the general behaviour of a blackbox, three functions occurring in combination can be distinguished. These are the transformation, conservation and dissipation functions. The first function is responsible for directly converting inputs into outputs. This function leads to an amplification or attenuation effect of the output variables in relation to the input variables. This kind of effect occurs, for example, in a mechanical lever action and the electrical transformation of voltage and current. The conservation function resists change, tries to preserve the existing states and shifts the situation from the past via the present to the future. This function therefore implies retention, memory and storage properties. The matter, energy and information stored determine the internal state of the blackbox. The third function represents the dissipative effect as a result of physical phenomena that can be associated with losses. In practice, matter, energy and information always seem to disappear from the process itself, become disseminated and no longer take part in the process. This happens in the case of wear, erosion, leaks, friction, heat dissipation, information loss, etc. The transformation and conservation functions can be associated with invariance and perpetuation. The dissipation function indicates time asymmetry and irreversibility. This is explained below.

If the process that takes place in a blackbox is observed from outside for a certain period of time, in general there appears to be a difference between the output quantities of matter, energy and information emitted and the input quantities absorbed. This difference cannot be explained by a transformation function that complies with the conservation laws. The change in the internal states as a result of absorbing or emitting the available matter, energy and information must also be taken into account. The losses that always occur in the process balance the books as it were. Indeed it is assumed that the conservation laws are also respected by the blackbox as a whole. Matter and energy do not appear out of nothingness and cannot disappear into nothingness either. This can also be postulated in the case of information. When data is processed or copied, for example, no new information is created. The deletion or loss of data can be regarded as a dissipation phenomenon. The conservation function therefore ensures that the blackbox behaves like a reservoir and initially absorbs and subsequently possibly emits matter, energy and information during the process. The dissipation function, which is usually not considered to be desirable but which always occurs in practice, leads to an effect that can be regarded as a leak. These two functions explain why the changes in input are not directly and fully passed on to the outputs, even in the case of linear transformation functions. In general the 'signal' is deformed and delayed. In physical systems the effect never precedes the cause. The past cannot be influenced. This asymmetry is a notable property of the time dimension.

If we look at the ideal case where no dissipation of matter, energy and information occurs, the blackbox seems to be able to exhibit reversible behaviour. It is possible as it were to reverse the course of events, to achieve the original states once again and to emit entirely everything that was absorbed from the environment. With a fully controllable blackbox this happens if the input variables and the state variables reach the start value again after completion of a cycle. In the ideal case, if the input variables are allowed to change slowly from an initial value to a final value via various 'routes', the 'route' followed and the period of time involved do not appear to have any influence whatsoever on the internal states reached. In this ideal and controllable case, the amounts of matter, energy and information stored only depend on the input variables. In mathematical terms, the increases in the state variables can be expressed as the line integral of an exact differential that is determined entirely by the limiting values. Consequently the state variables are



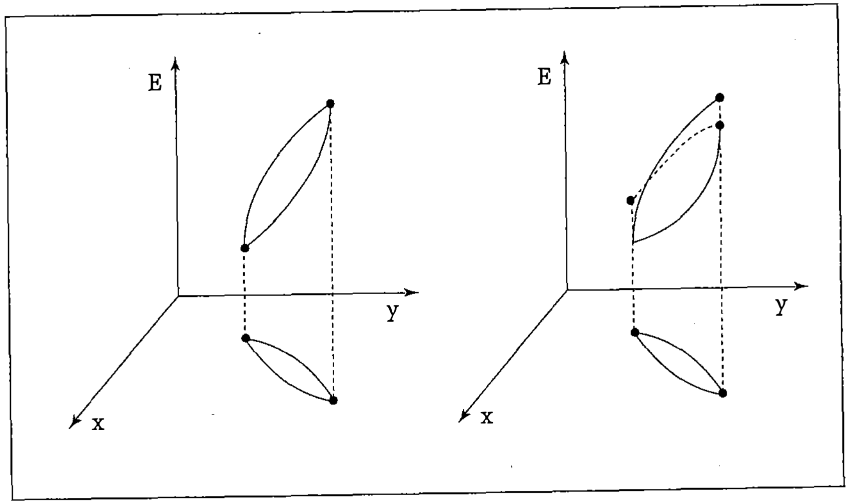


*Figure 4 – Change in the state variables in a reversible and irreversible process.*

unequivocal functions of the input variables in which time does not occur. If, for example, one climbs a mountain, the difference in height between the summit and the base camp and the associated increase in potential energy are not dependent on the route followed and the duration of the journey. If dissipation phenomena occur and non-exact differentials appear, the route taken does in fact play a part and the reversibility of the process is lost. After completing a cycle, there is no return to the original state. The two alternatives are illustrated in *Figure 4*. If no losses were to occur, perpetual cyclic processes could take place as a result of the delay phenomenon and the exchange of the stored matter, energy and information between the blackbox and the environment. These processes ultimately do not use up anything. The losses that always occur in practice must, however, be compensated for in order to maintain the process and rule out perpetual motion.

The phenomenon responsible for the influence exerted on the blackbox by its environment and on the environment by the blackbox has not yet been explained. The interactions and the associated flows can be characterised by two types of variables, which occur in pairs. The first type of input and output variables can be associated with a flow rate, i.e. a quantity per unit of time. The second group corresponds as it were to a level. A difference in level leads to a flow from the environment to the blackbox and from the blackbox to the environment. Heat energy, for example, flows from a body at a higher temperature to one at a lower temperature. The differences in level also explain the absorption and emission of matter, energy and information by the reservoirs. These are also responsible for the leaks that cause matter, energy and information to disappear from the process. The flows only cease if the differences in level disappear. In fact the flows try to neutralise the differences in level between the blackbox and its environment and inside the blackbox and to equalise the levels. The natural tendency of matter, energy and information to spread is in line with the law of entropy. This law rejects the existence of perpetual motion, explains irreversible processes, postulates the increase in disorder and predicts the 'heat death' of the universe. The dissipation of heat appears to be a crucial condition for processes that convert heat into other and higher forms of energy. The cooling towers in electric power stations, for example, are necessary to remove the heat released when thermal energy is converted into mechanical energy. Without a 'cold sink' and heat losses this process would be impossible. Paradoxically, the dissipation of energy also turns out to be a condition for the creation of complex structures and of life itself. Dissipative structures evidently go against the law of entropy and can reduce entropy locally and create 'order out of chaos'.

A system is made up of a number of blackboxes that interact with each other and possibly also with the environment of the whole system. It is sometimes argued that a system is more than the sum of its parts. In the technical system theory it is assumed that this 'surplus value' is simply the result of the connections between the elements. The interactions explain the creation (or emergence) of new properties. The connections give the system its structure, allow interaction between the subsystems and make division of tasks, a tuning process, collaboration and/or synergy possible. The interactions between blackboxes are characterised by continuity and compatibility conditions. The sum of the flow rates that converge in a node equals the total of the flow rates that emerge from the node. A interconnection brings the ports to the same level. Starting from these simple linear laws, it can be demonstrated that the quantity of matter, energy and information that a system absorbs is completely distributed and is all found in the blackboxes. The nodes and connections therefore do not store any matter, energy or information. This at first sight evident theorem was formulated by B.D.H. Tellegen, a Dutch engineer, for electric circuits and forms the cornerstone of very general energetic approaches.[3] It is closely related to the virtual work theorem, which is widely known though little understood in the world of mechanics and the theory of strength of materials.



## 6 Invariants and maxima and minima principles

It has already been stated that one of the main problems facing the modern engineer is to control complexity. In order to make useful statements about very complex systems, he has to distance himself from details and look instead at broad laws. This is not a new problem. In thermodynamics, for instance, some fairly simple macroscopic laws were discovered for phenomena that are microscopically very complicated. It appears to be possible to broadly characterise the behaviour of systems with the help of invariants. Despite the changes in state that a system goes through, characteristic quantities do exist that do not change. Functions that remain constant can be defined. One example is the total amount of energy that a closed system contains. These kinds of functions are found in conservation laws such as the first law of thermodynamics. A direction can also be discerned in the evolution of certain classes of system. Examples are the maxima and minima principles. According to the second law of thermodynamics, or law of entropy, the total entropy of a thermally isolated thermodynamic system tends towards a maximum. This maximum corresponds to the most probable state. Mechanical systems settle down and find a stable equilibrium if the potential energy reaches a minimum. Under these conditions there is no longer any 'potential' to change and the system becomes a fixed structure. This kind of law, in particular, is very interesting within the context of the world view problem. It allows us to characterise complex reality succinctly and to give some indication of its evolution.

Starting from Tellegen's theorem, we can deduce a highly remarkable property of systems with network elements that exhibit 'positive' behaviour. These elements are characterised by the appearance of an increasing (or constant) 'level' if the 'flow rate' supplied rises. To formulate the law in question, a fairly simple energetic function, the energy content, is introduced and defined for each of the elements individually and for the system as a whole. This function appears to be minimal if the internal distribution of the flow rates and levels through and over the elements satisfies the continuity and compatibility conditions and consequently corresponds with reality. The interconnection laws, together with the condition imposed on the elements, lead to a simple rule with which the behaviour of the system, viewed from outside, should comply. Since there is no linearity requirement, this theorem is very general and also applies to a broad class of non-linear systems. Moreover, the conclusion appears to be remarkably simple bearing in mind that it is applicable to complex and large-scale systems. With the help of energy functions and maxima and minima principles the overall behaviour of complex systems can be characterised very concisely. They form the basis of the variational methods used, for example, to calculate mechanical structures.

Many philosophical observations are associated with the maxima and minima principles. In many instances nature seems to lend itself to a simple description and often proceeds in the most economical way. This principle was formulated by de Maupertuis as the law of least action. It was given a scientific basis by Euler, Lagrange and Hamilton. According to Hamilton's principle, a conservative mechanical system moves so that the integral of the Lagrange function, also called action integral, reaches an extreme value (usually a minimum). The Lagrange function of the system is equal to the difference between the kinetic and the potential energy. The criterion that the states a system passes through have to satisfy is unexpectedly elegant. Full of admiration, Euler wrote: because the form of the entire universe is uncommonly perfect and is in fact devised by the wisest Creator, nothing takes place anywhere in the world that does not have something to do with the maximum and minimum rule.[4] Many physical systems display dynamic behaviour that can be called purposive. The interaction between the elements of a system results in a certain coherence in their behaviour and a trend in the evolution of the whole system. This is most evident in systems with feedback, which try to achieve the standard imposed on them. If a purpose can be linked with the course followed, a 'rule of economical thinking' can be found to describe the overall behaviour of the system. With organisational systems, common interests, values and objectives ensure a coherence in structure and behavioural pattern. The coherence created by shared objectives is comparable to but 'vaguer' than the bond created by 'simple' physical laws. This brings us to the concept of objectives, which can be defined at various system levels and in both the exact sciences and the social sciences. Like the concept of energy, the objectives concept offers the opportunity of linking together different disciplines. The dream is to bridge the gap between the 'two worlds'. In our view, the objectives concept is central to the world view problem. Using this concept, the essence of a complex event can be concisely represented.

## 7 *Purposiveness and finality*

Purposive or normative systems exist in the organisational branch of the system theory. The behaviour of the elements of these systems has a certain coherence and direction so that the system as a whole pursues an objective. This can occur by moving towards an ultimate goal and/or by optimising a performance criterion during developments. In most cases and broadly speaking, living beings, organisms and organisations seem to manifest themselves as purposive systems. If this is not the case in reality, nevertheless it is often possible to deduce from their behaviour an imaginary objective, which they apparently have in view. This extrapolation allows us to describe their evolution very economically and succinctly. Usually a hierarchy of objectives can be discerned, whereby the objectives of the elements, the subsystems and the whole system are geared to one another. By coordinating functions and tasks, a cohesive behaviour for the whole system can be determined. In many cases the objectives of the system need to be geared to its environment. In modern companies one of the main tasks of management is to gear the internal objectives to the external objectives.

The process of gearing the objectives of the various subsystems to the assumed objectives of the whole system requires optimisation. The pursuit of an overall optimum state by optimising each of the subsystems is usually not the right solution and can even have a destructive effect on both the whole system and its components. A company's profits cannot be maximised by minimising the costs in each of the departments concerned without thought. If the costs of a particular department are irresponsibly kept down, this will often result in an explosive rise in costs in other departments, which counteracts the desired effect. Traditional accounting methods often lose sight of these interactions. The subsystems will only be prepared to contribute towards achieving the objectives of the whole system if they can fulfil their own objectives to a sufficient extent. This calls for a constant search for a balance between individual and common objectives. The process of tuning objectives and coordinating activities can be centrally managed and hierarchically organised or can develop spontaneously by mutual agreement between the parties involved. The first approach is adopted in a planned economy while in a free market economy the process is left to an 'invisible hand'. The deduction of overall objectives from sub-objectives is not an obvious process. The result of individual actions, the prevailing intent, the dominant trend or the overall direction need to be determined. Moreover, we should not confine ourselves to superficial aspects. The underlying motives and mainsprings and the deepest reasons and expectations must be tracked down. The primary objectives are about perpetuation, continued existence, survival, growth and about acquiring the means to achieve these aims. This applies both to individuals and to complete organisations.

The evolution of the cosmos and the development of life can be regarded as the result of a constructive process that has led to the development of very complex structures. As well as binding, constructive, structuring, organising, integrating 'forces', there are also divergent, decomposing, eroding, destructive, disintegrating phenomena at work in nature. We have already mentioned on the one hand the aim of minimum potential energy, which has a structuring effect, and on the other hand the evolution towards maximum entropy, which — broadly speaking — leads to disorder. Living beings make skilful use of the law of entropy and constantly interact with their environment. They succeed in building and maintaining complex structures by taking in matter and energy from the outside world and giving it back again as waste. These flows ensure that complex dissipative structures, which are far from equilibrium, can develop and, despite decomposition phenomena, can continue to exist. In a competitive and/or hostile environment, purposive behaviour aimed at survival and the acquisition of the at times limited means to do so is vital. Species whose 'instinct' in this respect is insufficiently developed or has deteriorated are destined to become extinct. This also applies to living beings who cannot adequately adjust to changes in their environment. The nervous system and communication channels play a major part in the survival of organisms and organisations. The information flows ensure that we can react in an alert manner and take advantage of changes flexibly.

In biological systems a central nervous system has developed as a result of diversification, specialisation and organisation of cells. This enables these kinds of system to react to minimal matter and energy stimuli and store information and learn. Humans and animals have a model of their environment, which they constantly adapt to reality on the basis of their experience. An adaptive model is essential in order to proceed successfully and hold one's own in a changing world. Man also has a perception of himself and of his position in the world. This gives rise to consciousness and self- awareness. He is also able to form an image of his fellow-men and their feelings. This leads to understanding, compassion and altruistic behaviour and acts as a springboard to higher objectives. The fulfilment of individual material objectives alone does not seem to satisfy people, or at least does not satisfy a significant group of them. They also expect recognition and appreciation, among other things. In addition they try to distance themselves from personal interests and rise above material things. Another important factor is the ability of humans to fantasise, to make up imaginary worlds, to long for a better world and to develop utopian models. Man is able to make plans, present dreams as objectives and pursue goals. He does not accept reality as a fact to be experienced passively and sees the difference between what is real and what is desirable as a problem that has to be solved. This view, which in fact is the control engineer's viewpoint, drives him to exert a systematic influence on the world, bend it to his will, bring it under control and 'improve' it. In so doing, however, he comes up against the limitations, rules, laws and boundaries set by the physical world and which curb his imagination. By a vast majority of people shared views, images and models can also develop in organisations and companies and in society as a whole as a result of internal information exchange. These world views are just as important for the continued existence of a group as models are for the survival of an individual. We can even talk about a collective consciousness and self-awareness. Generally accepted and common objectives are highly mobilising and binding and give meaning to actions.

Objectives have to do with appreciation and giving meaning to actions. Anything that is in keeping with the objectives is deemed to be good and valuable. Everything that runs counter to them is considered to be bad. Conversely, it can also be argued that experiences of good and bad can lead to a purposive direction being chosen. Objectives can create a meaningful perspective. A lack of clear, shared objectives results in a feeling of confusion and pointlessness. A society that has no common objectives will lack coherence in its conduct and will react to challenges in a chaotic manner. The real objectives indicate what it is ultimately all about. They express the essence and the why and wherefore of things. The body of rules, traditions and behavioural patterns that embody values and support objectives can be called culture. If common objectives and values are undermined, called into question and no longer considered important, we are plunged into crisis.

In the exact sciences it is assumed that reality can be laid down in causal laws and that uncertainty plays an essential part. Stating a final intention as motive is fundamentally rejected and purposiveness is labelled as nothing more than a pretence. At best purposiveness can be a broad manifestation of fundamental laws. Similarly, for example, the deterministic laws of thermodynamics are regarded as the macroscopic results of stochastic microscopic phenomena, which may be characterised statistically. If everything is determined by causality and probability, there is no room left for genuinely purposive behaviour. Nor is there room for independent, free decisions. There are strong indications that highly complex systems such as living beings and their organisations display behaviour that can not only be considered to be purposive but actually is so. Moreover, purposiveness can not only be regarded as the consequence of an attractive 'pole' but also as the result of a driving 'force' or as the result of a directing 'field'. Various possibilities present themselves, which are not necessarily mutually exclusive:

- purposiveness as a broad manifestation of fundamental causal laws and/or in-built programmes;
- purposiveness that results from exploring the alternatives by means of chance mutations and natural selection as a filter for viability;
- purposiveness as a fundamental principle;
- purposiveness as the result of an 'appeal' that is in operation within the scope of free decisions.

Moreover, one important question that arises is the extent to which the pursuit of objectives and, in particular, higher values, can be reduced to fundamental laws of nature. Is there a level of complexity above which a system displays a fundamentally different behaviour that is not reducible and cannot be explained by analytical methods? Do systems like this achieve a certain autonomy and do they become susceptible to a higher source of inspiration? Can a trend in the overall developments be detected and can the absolute goal be deduced from the models? If purposiveness is accepted as a motive, we should also ask ourselves whether an underlying and explanatory principle is involved. Or is purposiveness complementary to causality and probability? Do these three principles cover reality as a whole or is there still room for complete unpredictability and free decisions? Is it so that not everything has been pre-programmed so that there is still room for unforeseen events, real creativity and new creations?

The system theory provides no answer to these questions. In each case it uses the types of models that best represent reality. If, for example, a purposive pattern is established in human behaviour, the system theory tries to utilise this. In cases where purposiveness is dominant, an attempt could be made to find out the direction in which developments are heading or their ultimate aim by formulating the models appropriately or by simulating the events. In view of the uncertainties and indeterminacies characteristic of complex non-linear systems, in general we should not expect too much of these approaches. Physics cannot provide a complete and definitive answer to these types of questions either. Science can only explain clearly the unbelievably complex, improbable and mysterious aspects of events. Forecasts are often highly speculative and unreliable. The scientific researcher is like a traveller in the fog. Only in his immediate proximity does he have a clear picture of his environment. Man is caught between the microworld and the macroworld, between the past and the future. Moreover, his intellectual grasp and his ability to get an overall picture are limited. This forces scientists to make crude generalisations and extrapolations. There is no certainty at all that even reliable models are a truthful representation of reality. They cannot answer questions about essential matters, the actual purpose and the why and wherefore. This is more a matter of intuition and religious faith.



## 8 *The world as a game*

This brings us back to the world views problem. The system theory sees the world as a system of interacting elements that can be characterised by a network of relationships. This view is more open than the models that regard the world as a clock, a mechanism or even an organism. The game metaphor seems to us to be closer to reality and the system view. It is no coincidence that games captivate both children and adults. A game is a reflection of real life with its laws, chances and options. A game, with its development and situations, can be associated with a reality characterised by a succession of events that link a series of states. The development of a game is determined by rules, coincidences and goal-oriented decisions. Mathematics and the system theory offer specific models to describe each of these elements. Using a limited number of elements and rules, a wide variety of game situations and developments can be devised. There is a real possibility that a generic game can be developed, which closely approximates reality, by gradually adding new elements and rules. A game is not a pointless exercise but rather a highly goal-oriented activity. Winning or losing, success or failure, are linked with achieving pre-set goals. There are limited resources, which forces the players to make choices, and there are different sides with opposing objectives, which creates competition and leads to tension. The players who form a team can only perform efficiently and purposively if tasks are divided, their performance is coordinated and everyone makes a contribution. In almost every game situation, there is a range of possible moves and the future looks like a branching tree. The situation is so complex and uncertain that the players can no longer get an overall view and can only partly predict what will happen. Playing strategy needs to be constantly adapted to the changing situation. The players learn by trial and error the rules of conduct that often prove to be successful and the moves that bring the goal within reach. Anyone who wants to understand the game not only needs to know what the possible moves are; in particular he needs to know what the objective is. Real life is ultimately about mainsprings, motives and objectives, which are consequently the key to the world view problem.

Incontestable structuring forces are at work in the world, which have lead to the development of living beings and create social structures. In addition, disintegrating phenomena also exist, which are responsible for deterioration, death and decomposition. These forces give rise to the life cycle of organisms and organisations. In a simple world view, the opposing forces can be associated with good and evil. Anything that affects the life or survival of an individual or group is regarded as evil, against which people have to arm and defend themselves. World events can therefore be seen as a game between integration and fragmentation, structuring and disorganisation, construction and destruction, life and death. Man, who is caught up in this game, is a part of it and plays an active role in it, must opt for life. Just as life feels its way by exploring all the possibilities, so too does man unremittingly seek new structures to achieve his objectives. The destructive forces ensure that there is room for renewal within the limited scope available. Failure and success are therefore characteristic of this game and life continues building on the ruins of the disasters. The belief is growing that the game of life and death is not a pointless process and that an overall trend can be detected. Despite temporary recessions, an increase in complexity and interrelationships can be detected. The rapid development of international trade, the tremendous increase in mobility and the expansion in global communication play a major part in this.

The recognition of a changing trend still does not provide man with an adequate answer to his need to give things meaning. Is he just a link in a chain, a cog in the machine or a pawn in a game? Is there a purpose behind it all and what is it in aid of? Believers are convinced that the painful conflict between life and death is not futile or hopeless and that there is an aim and purpose. Man is not just destined to resignedly go through the struggle for life. He should make the world a more 'human' place and alleviate the suffering that is an inseparable part of life. In this he is directed by his experiences of good and evil and his hopes of a better world. Believers know they are inspired by a higher authority on their path through life and feel themselves borne through the difficult times. The pursuit of a better world does not, however, bring man complete fulfilment. It does not fully satisfy his deepest desires. He is regularly brought face to face with the relativity of life and the ultimate questions. The essence of life seems to lie on a different level and eludes an observer who simply follows the rules of the game. This leads him to the



fundamental question of the giving of sense. He is forced to ignore this question, to leave it unanswered or to open his mind, believingly or otherwise, to the great mystery.

## 9 *Complexity and balance*

In the previous paragraphs a world view has been put forward that looks upon reality as a ga me between structuring forces and disintegrating phenomena, resulting in a growing complexity of life forms and organisational forms. This game leads to the rise and fall of movements, cultures and nations. The life cycle of companies is also determined by this game. The business world, which is currently in a state of rapid mutation, serves, as it were, as a laboratory where the viability of all possible forms of organisation and cooperation is tested. Two opposing trends are evident in the changes occurring in business organisations. There is a constant search for an optimum between centralisation and decentralisation, large-scale and small-scale business, diversification and specialisation, dependence and autonomy, systematic planning and free enterprise, etc. In modern organisations, for example, the subsidiarity principle is adopted. Only those functions that are strictly necessary are centralised, a great deal of autonomy is granted locally and there is sufficient room for people to use their own initiative. Depending on the external situation and the internal possibilities, a suitable compromise between extremes is sought. In many companies this leads to a constant change of views, which causes a periodic oscillating movement in the organisational form. As a consequence of the ever increasing external and internal requirements, repeated restructuring results in a spiral movement that increases the complexity of the organisation.

Complexity indicates a complex form of relationships and closely knit relational patterns. Complexity is not equivalent to large-scale systems and rigid centralisation. Complex systems have highly developed feedback channels, construct models, learn from experience and are able to prepare for the future. This means that these kinds of adaptive systems are very flexible in changing circumstances. They are also primarily geared towards survival as an individual and as a group. They therefore have, among other things, distributed and redundant (duplicate) functions that lessen their vulnerability. In addition, stratified and hierarchical structures exist that are more or less extensively developed. This organisational form can be extremely efficient if purposive and coordinated action has to be taken and all resources have to be deployed to combat threatening situations. Strong leadership is called for in a crisis. New organisational pyramids often arise in times of uncertainty and as a reaction to dominant and repressive structures. Hierarchical organisations that are not sufficiently modernised fossilise and are not flexible enough to adapt quickly to change. Moreover, they are very susceptible to dictatorial, incompetent and parasitical elements that occupy key positions. People in management positions are often remote from reality, lack vision, take more than they give and create no new prospects. A crisis of objectives and values arises. This accounts for the decline of many systems and regimes. The collapse of the communist dictatorships and the crisis in Western democracies are part of the same trend. It is impossible to maintain organisational structures without having shared objectives and strong feedback channels and adapting to changing circumstances. Structures that are not sufficiently coherent and are not adapted to the times will be superseded by others. In addition to a minimum degree of coherence and adaptability, which are essential for survival, a certain diversity and continuity are also needed to keep life bearable. If the aim is to avoid major stresses, shocks and revolutions, a balance needs to be found between uniformity and pluriformity, between preservation and modernisation.

All this brings us to a strategic view of developments. Individuals, various organisations and human society as a whole are situated in a framework that has possibilities and limitations. In plotting a course through life, strengths and weaknesses need to be considered as well as the opportunities and threats presented by developments in the outside world. Inevitable choices also have to be made from a wide range of possible solutions. Extremes should be avoided. The optimum solution is often a compromise. Only exceptionally does consideration of every aspect advantageously result in an extreme case. A balanced compromise should be sought between opposing purposes and interests. Balance is dynamic and changes according to developments. A framework that has limited resources and great mutual influence has competition and stress built in. Unbridled competition must be rejected, though. If we are to avoid destructive conflicts and major catastrophes as population density and environmental pollution increase, we should strive to gain a good understanding and make sensible use of resources. Man cannot constantly live under uncertain, unstable and chaotic conditions and instead seeks certainty, stability and order. All this demands harmony, coordination and rules, calls for a large measure of consensus and leads irrefutably to a more complex organisation. Increasing complexity is a condition for survival and for making life more bearable. The humanisation of interpersonal relationships also leads to more complex systems. A society becomes more human if motives such as power and possession, coercion and reward, and even exchange or trade make way for a voluntary and unselfish commitment to common objectives perceived as being meaningful. It is evident that relationships between equal partners that are based on integration of their deepest desires and hopes make heavy demands and are vulnerable, but can also remain very strong. The trend towards more complex structures is therefore closely associated with the survival objectives and the pursuit of a more humane world.



The growth in complexity does not just manifest itself on a material level. The physical layers form the substrate for the development of the emotional, cultural and knowledge layers. In these layers we find the emotions, feelings, intuitions, ideas, concepts, stories, rules, models, values and world views. Like biological creatures, shared conceptual structures that have been exchanged also lead a life, they are in competition, they struggle to survive and try to spread. This analogy is quite remarkable and indicates a great similarity between the structures and organisational forms that are found on the various levels. In modern society the higher layers are greatly expanding owing to intense communication, cultural confrontation and intellectual activities. The project that science undertakes to seek all-encompassing knowledge through systematic research takes place in these layers. This is also the case for the integrative *Worldviews* project. Broadening and integrating scientific knowledge is associated with growing abstraction. We become increasingly divorced from physical reality and move up to a higher and more general level of a highly symbolic nature. This development can also be regarded as an attempt to discover the grand 'principle' of creation or the intentions of the Creator by acquiring and structuring knowledge and ascertaining the fundamental laws of nature. We can ask ourselves, however, whether it is not possible to achieve the same outcome by distancing ourselves from all that is material and from all knowledge, and turning in on ourselves to plumb the depths of the human soul in search of the Absolute.

Thanks to science, people in Western society have succeeded in eliminating basic material worries to a large extent, creating space for all kinds of social and cultural activities as well as achieving a hitherto unknown level of comfort. Modern technology, economic development and an affluent society result, however, in large-scale intervention in nature and create huge amounts of waste. It is possible that human activities will exceed the capacity of our planet, cause irreparable damage to the biosphere and jeopardise the survival of life on earth. Like every human action, even the most biological form of agriculture interferes with nature. To what extent can, may and must man plan, influence and control the development of very large and complex biological and ecological systems? These systems comprise a large number of elements that are in tune with one another and between which a fairly stable equilibrium has been established. Man has more and more opportunities to intervene and bend nature to his will but often lacks the necessary knowledge to do so properly. Instead he behaves like 'an apprentice sorcerer'. By proceeding impetuously he loses control over events and inflicts serious damage. Natural systems are not robust enough to absorb every interference. It is now unthinkable that every 'artificial' technical intervention be eliminated and nature left to its own devices. Even freezing economic development is difficult to justify on a worldwide scale. After all, we cannot be indifferent to the famine and misery in the Third World or to the marginalisation of a growing group of people in the prosperous West. We need to observe a few rules of the game, however, otherwise our interventions will be counter-productive. Anyone who breaks rules, such as failing to treat life carefully, is punished as an individual or a group sooner or later. Steps should also be taken to avoid overestimating technical possibilities in very complex situations. Something that is technically possible may not yet be economically feasible, socially acceptable or ecologically permissible. We need to be aware of the limits of systematic planning and growth. Large-scale interventions, in particular, have to be carried out with great caution. We have to prevent quasi irreversible problems from being created. This is the case, for example, with nuclear and chemical pollution and the destruction of biological diversity. Like a good manager, man should recognise that he is responsible for his fellow-men and for nature, for passing on the gift of life and preserving his natural heritage in all its perfection and abundance for future generations. This calls for well-considered decisions based on ethical principles and an understanding of how complex biological and ecological systems function. The search for balanced solutions and the control of complexity are therefore themes of vital importance. The system theory provides a conceptual framework that can be of great assistance in this area.

Man has always tried to limit his dependence on nature, to exclude uncertainties and to take his fate into his own hands. He has no wish to experience life passively, but instead tries to dominate events and gain control of the situation. Helped by science and technology, he has been largely successful in this. However, man also needs a framework to



explain his experiences as well as a meaningful future. This he gets from myths, stories, philosophies of life and world views. Western society is in a profound crisis, destructive in nature, exhibiting at times self-destructive tendencies. Its vitality has been affected, coherence has been lost and there is no credible and hopeful outlook. The grand welfare project is stuck in a profound economic crisis. Society no longer offers any clear answer to the fundamental questions. Traditional values have been called into question and have declined. Society cannot react effectively to important contemporary issues either. There does not even seem to be any solution to the harrowing problems of unemployment and poverty. It is doubtful whether social feedback, spontaneous initiatives and natural developments alone will be able to avert disaster. The problems are so large and so interwoven that fragmentary solutions and short-term policies are no longer of any use; instead overall views, strategic plans, systematic approaches and effective measures are becoming essential. All too often well-intentioned attempts to tackle problems thoroughly founder on a chaotic tangle of conflicting ideas. There is a lack of consensus concerning the important themes that trouble society and the joint actions needed to break the deadlock. A community under threat needs to work together, join forces, close ranks and react against excessive pluriformity and over-extreme individualism. Generally accepted and largely similar opinions, perceptions and world views are vital for its survival. The construction of new world views that give society direction, indicate possible solutions, offer a meaningful perspective and ensure unity is badly needed at the moment. First and foremost, these world views should confirm the will to survive, describe ways to bring about a more humane world and refer to an inaccessible, transcendental existence.

## Notes

1 Weiler & Holemans, 1993.
2 Eykhoff & van den Boom, 1984.
3 Penfield *et al*, 1970.
4 Hildebrandt & Tromba, 1989.

*Jan Van der Veken*

# No man without a cosmos. No cosmos without man ?

In this contribution I shall be arguing for a thoroughly relational view, and more particularly for a solidarity between man and the cosmos, in both the cognitive and the ethical fields. Understanding something always means locating it against a background. Well then, the cosmos is undoubtedly the broader background in relation to which we are able to understand at least certain aspects of man. Our views of the broader cohesion of everything fundamentally determine our self-understanding, and even the fact of whether, all-in-all, we consider our existence worthwhile, as well as what meaningful things we can do in this world.

Progress in the sciences confronts us with questions other than the scientific. Wittgenstein had already seen this: 'It is our experience that even when every scientific problem has been solved, the problems of our life have not yet even been touched upon'.[1] And yet the way we assess man's place in the cosmos helps determine the question of the sense of our existence.

When the scientists, in the full enthusiasm of the beginning, first drew aside the veil surrounding matter, life and the cosmos, it seemed for a moment that in a certain sense the progress of the sciences would piece by piece explain away the mystery of human existence. It was Max Weber's opinion that the progress of the sciences brought with it a loss of the world's magic. Anyone occupied in contemporary cosmology experiences one surprise after another. The universe turns out to be more amazing than we ever thought, in proportion to our better acquaintance with it. The more we learn about the cosmos, the clearer it becomes that it is a unique object that encompasses us and without which we would not exist. A new insight is that man would not be able to come into being in just any universe. Cosmogenesis and anthropogenesis cannot, de facto, be comprehended independently of each other.

## 1 From anthropogenesis to cosmogenesis

Until recently, in the search for wider links between man and the nature surrounding him, man's problem was more or less limited to a question of the connection between living nature (the animal kingdom) and man. A new dimension has now been added to this. The preconditions for man's existence are not only to be found in his biological ancestors; the whole cosmos has 'conspired' together in the most amazing fashion *so that* (not *in order that*) one day there would be someone in one place at least who would ask himself the sort of questions we are concerned with in this article. Technically speaking, someone like this is called 'an observer', or a subject, someone who is aware of his existence. That anyone should be aware of his or her existence in this cosmos, which probably started from a single point in an enormous release of energy, is far from self-evident. All the life we know is based on carbon. And the first sources of carbon in this cosmos are physical processes taking place in the heart of stars. The molecules which now form the earth already have the lifetime of a star behind them. The earth very probably tore itself away from the sun 4.6 billion years ago. Our sun is a star of at least the second generation; that means that it has the lifetime of at least one star behind it. If carbon only occurs as a result of this type of star formation, which takes about 10 billion years, it follows that a smaller universe (meaning a younger universe) would not be able to include us. The formation of heavy molecules appears to precede life and is one of its preconditions.

Here we are faced with an enormous paradox: cosmically speaking man is a latecomer. Even so, the *preconditions for man's existence* were inscribed in an evolutionary event counted in billions of years. Seen purely chronologically, man is a newcomer in this universe which apparently could just as well have existed without man. On the other hand we are increasingly discovering the universe to be a *layered* universe: this means that the 'higher' is already lying in preparation in the 'lower', but that on the other hand the 'lower', in its own contribution to the whole, can only fully be understood on the basis of the entire development.

The following question arises here: how can we make a distinction between 'lower' and 'higher'? From a quantitative point of view, complexity seems a good criterion. No one denies that structures occur in this universe in varying degrees of complexity. The brain is undoubtedly the most complex structure known to us. In this sense one may say of the brain that it is the most complex structure known to us in this universe. If we were to link all the computers in the world together, their complexity would still be outdone by that of a mouse's brain. The precondition for deliberative consciousness seems to be a highly complex nervous system (we are not aware of any forms of deliberative consciousness without brains). It is equally plainly clear that the most complex structures are also the most recent. Their preconditions lie scattered through time, long before there was any notion of deliberative consciousness. We are not only talking about structures that are complex because they consist of multiple components. A purely quantitative criterion is not sufficient. There are more grains of sand in the desert than nerve cells in our brain. And yet our brain is unimaginably more complex than the desert. It also, mainly, has to do with more complex links and multilateral forms of interaction, which themselves make possible a different and higher form of behaviour. A qualitative criterion linked to this might be: the wealth of experience. This wealth of experience can only be expressed with the aid of aesthetic and moral categories. Behaviour, certainly on the human level, has something to do with the grasping of meanings and patterns in the world around us, with the evaluation of what fulfils one's own desires and what does not, and with a way of one's own of dealing with congeners. Nothing prevents all these forms of dealing with the world from being prepared in one way or another in the animal kingdom. According to Buytendijk's happy expression, animals are 'shadows of mankind'. This looks like an anthropomorphism, but that is not the case. After all, we know nothing about animals except by analogy with what we know about ourselves. The surprise is not that we know so little about them, but that we know so much. We can at least 'sympathise with them' to a certain extent.

An important question here is: what is the connection between these various layers of reality? Is there any connection, or does it only appear so? Is this connection a retrospective illusion?

## 2 The copernican revolution: man torn away from the centre

Many things have contributed to the suppression of man's conceit regarding his privileged position in the cosmos. Since the classical science of Copernicus and Galileo dragged man away from the centre, it seems that man's place in this universe is extremely incidental. Also according to Darwin's view of evolution, life in its many forms is the result of a long series of chance occurrences. In short, as a consequence of scientific findings in the areas of both cosmology and biology, man became rather an outsider in nature, an 'accident', though certainly a 'magnificent accident'.[2]

## 3 So is man really in a privileged position?

In a paradoxical way Immanuel Kant returned man to the centre. Kant has reality revolve round the knowing subject, and not the reverse. According to Kant, it is the same in gnosiology as it was in astronomy at the time of Copernicus: a radical reversal is essential. He uses the same expression — Copernican reverse — to indicate something completely different to what Copernicus had established. Copernicus tore the Earth away from the centre; Kant returned man to the centre, not as a cosmological being but as (transcendental) knowing subject. The situation of gnosiology is 'like Copernicus who, when the explanation of the course of the heavenly bodies would not go smoothly, as long as he assumed that the whole starry host revolved around the viewer, wondered whether it would not go better if he were to have the viewer himself turn and let the stars as they were'. This was how Kant put it in the foreword to the second edition of the *Kritik der Reinen Vernunft* (1787). So man comes back to the centre of the world he knows after all. We know things because they adapt themselves to the *a priori* structures of our sensory perception and our intellect. This seems like an extreme turn towards subjectivity. Kant defended himself against this objection. In fact it is his purpose to save the objectivity and necessity of Newton's laws of nature. We shall never be able to demonstrate that the world *must* be so by seeing how it is really put together (the scientific approach). We shall never find *necessity* by simply looking at the facts. Kant saw that clearly. But did Kant succeed in his purpose? Kant attempted to ground the necessity of the laws of nature on 'the' structure of 'the' human intellect, and in fact on the structure of the intellect plain and simple. Kant is in fact a thorough 'Aufklärungs' philosopher, a thorough rationalist. Kant assumes that we are able to speak of 'the' reasonableness, which in theory links up every intellect, be it the intellect of a man, an angel or God. Kant's subject is a transcendental subject, which is partly given with every appresentation, with every representation of anything whatsoever. It seems to me that in this way *we* cannot give any explanation at all of the objectivity of the world, because the transcendental subject itself is fragmented. The subject of which Kant is speaking is not simply subjectivity as such, but the historically situated subject of 18th-century rationalism. After all, we cannot speak of 'the' structure of 'the' human intellect. It follows that, the solution offered by Kant for the necessity of the laws of nature is no longer possible either. And the question again arises in its full clarity: why are the laws of nature as they are? It is an illusion to state that the laws of nature are like that because that's the way *we think*. Some theoretical scientists



conclude from this that the laws of nature are purely incidental. Is that really the case? If the laws of nature were only slightly different from the way they are now, we would very probably not be here. So the fact that the laws of nature cannot be explained as the *a priori* forms of the human mind does not necessarily mean that they do not have anything to do with our existing self.

Most cosmologists and scientists are of the opinion that, given the fact that the laws of nature are what they are, sooner or later man was to be expected — or at least a creature having extremely complex nerve-like structures that enable deliberative consciousness. If we look at the whole thing it seems increasingly to indicate that the universe is 'calibrated for life's existence'. The Nobel Prizewinner Christian de Duve also thinks that life is inscribed into the universe. Stephen Hawking would also find it highly surprising if it were all to be chance. So there appears to exist a clear link among scientists between the initial conditions, the cosmic constants and the actual principles that the laws of nature adopt. 'Man was cooked up in the stars', according to Professor J. De Vreese. Heinz Pagels goes so far as to say: 'Life was written in the cosmic code'. To A.N. Whitehead man is 'the child of the universe'.

There would not be much point, according to Heinz Pagels, in accepting that the laws of nature would be other than they actually are. And given that the laws of nature are as they are, he considers life not in the least unexpected. Pagels assumes that the laws of nature have always been geared to each other. In fact most academics assume that, given that the initial conditions and the laws of nature are the way they are, the development of life is in accordance with one reasonably should expect.

## 4 The contentious 'anthropic principle'

It would not be meaningful for anyone to dispute that the conditions enabling man to exist have actually been fulfilled. In fact the so-called 'anthropic principle' in its weaker form states no more than this. The 'weak anthropic principle' simply states that, given the fact that man (carbon-based life) exists, the conditions necessary to his existence have also in effect been fulfilled. These conditions are: the actual values of the cosmological constants and sufficient time for life to evolve. This does not however in any way say that man also had to appear.

A whole discussion has grown up around the so-called 'anthropic principle'. It seems as if supporters and opponents do not really wish to understand each other. There is already so much confusion on the subject that this topic, interesting in itself, leads to fruitless arguments. If the anthropic principle only says what the 'weak anthropic principle'[3] (or WAP) says, then it is as obvious as it can be: if man exists, and he does, then all conditions for man's possible appearance must have been fulfilled, and the universe must have existed long enough for that development actually to have taken place. If something *is*, then it is also possible. Who would have anything to say against such an elementary principle? It does *not* say that man *had to* appear (which leads some to call it the weak anthropic principle); given the fact that man *does* exist it is only said that the preconditions for his existence must actually have been fulfilled.

The problem with the (weak) 'anthropic principle' (or WAP) is not its logical validity but its status. It is not a scientific principle because it has no explanatory value. From the fact that man exists it is deduced that the preconditions for his existence have actually been fulfilled, but not that man had to appear. The WAP reasons from the consequence back to the antecedent causes, whereas a scientific explanation begins with the antecedent causes in order to explain the consequences (if...then). This is why some scientists find the anthropic principle of little importance. You might equally speak of a 'flea principle'. All conditions have of course been fulfilled whereby fleas, mice or computers might actually be able to come into being in this universe. Should this surprise us? We can and should in any case be surprised that the universe has the characteristics which are the preconditions for our existence. A universe with fleas, mice and computers is no less complex than one with people. There is an enormous accumulation of evidence[4] that allows us to state that if the initial conditions and the laws of nature (the measure of gravity, for example) were only a little different, no galaxies would ever have been formed, nor carbon, nor life. From the point of view of the beginning, looking towards the future evolution, it is completely impossible to say that man (or a similar being) *had* to appear[5]. From the point of view of the completed evolution, however, it *is* possible to say that, in any case, the circumstances (and the necessary time span) were so that man *could* appear. The global isotropy of the universe, the local inhomogeneities (such as star systems), the weakness of gravity, the close correspondence between the original speed of recession and the so-called escape velocity are witness to a highly exact but unexplained precision in the bringing about of the prerequisites for intelligent life. Now, given the fact that the conditions for the existence of man are exceedingly strict, the question arises: why are the initial conditions the way they are? But there is



no possible scientific answer to this question. That the laws of nature are the way they are is something scientists take for granted.

I would like to summarise this argument as follows:

The prerequisites for that highly complex being that man is, are exceedingly strict and have in any case been fulfilled. The most plausible account of what actually happened seems to be that there is a direction in the whole cosmic evolution, moving towards the most complex structures possible in the given circumstances. That man would inevitably arise, and that he was therefore intended to come about, cannot from a purely scientific point of view be proven. In short, a distinction has to be made between direction and purpose or, as Teilhard de Chardin put it, a distinction between 'finalité de fait' and 'finalité d'intention'. 'Finalité de fait' we understand to mean: actual direction (from the more simple to the less simple). 'Finalité d'intention' we take to mean purposiveness. Since scientists are often very much opposed to 'purposiveness', in the sense of 'finalité d'intention', they are sometimes tempted to ignore the actual direction of the whole of the cosmic process.

## 5 *Is our cosmos 'a cosmos to live in'?*

A similar set of problems arises in connection with the emergence of life. There was a time when people did not find this particularly astonishing. D. Diderot assumed that if one left flour untouched for long enough, little creatures(bugs) would spontaneously develop in it. Everyone has seen how worms emerge 'spontaneously' in a piece of rotting meat, he says. The phenomenon of the 'pourriture' fascinated the first materialists, since they were of the opinion that it gave them experimental proof of the fact that life could form spontaneously. Pasteur proved that in a sterile environment no life at all would form. His tests led to the 'generatio spontanea' being left permanently behind. The next question is: where does life come from? Jacques Monod made another attempt to explain the development of life by chance, and by chance alone. A huge mass of literature has accumulated on this problem. The problem does not lie in the fact that chance plays a large role in the mutations, but in the fact that it would take something completely different from chance to explain anything at all. In any case, even Monod has to admit that the universe exists, as well as its laws. In addition to this he does have to admit that minimal structures must be present for the whole process of the doubling of molecules to even get started.

In a recent article in *Time* it was stated that it is highly improbable that even a slightly complicated living molecule could be formed by chance alone[6]. A new interdisciplinary science has developed whose key words are 'complexity' and 'self-organisation'. Complexity and self-organisation are 'buzz words': they have a ring, without anyone knowing precisely what they mean. Here too there is a problem of the status of the terms. Are they descriptive? Complexity means, as already said, that in living beings not only can more building blocks be detected (molecules, neurones), as one goes up the evolutionary ladder, but that those building blocks are also more profoundly connected to each other. So I think that we can retain the term 'complexity 'as a descriptive one.

It is more difficult with the term 'self-organisation'. This term appears to be both descriptive and explanatory, and according to me that should be avoided. The names most associated with this new science are Ilya Prigogine and Stuart Kauffman. Complex structures might develop 'spontaneously' under the right circumstances. But what does this mean? In Prigogine's work it can only mean that the path from simpler structures to more complex structures is not arbitrary. What is not arbitrary is not random. These researchers' great dream is to demonstrate better that in this universe there is indeed not only a path to the greatest possible disorder (in accordance with the second law of thermodynamics), but that there is also the reverse: an equivalent law which leads to more complex structures. If that is so, then the development of complex structures (such as life) is in theory predictable. And that is a plain indication that a systematic rather than a random process is at work. An unobservant reading of Prigogine's book, particularly when based on the English title, *Order out of Chaos*, leads some to decide that there is not the least problem with the development of order out of chaos (or less order): 'It happens spontaneously'. The implication then is that in fact no explanation for it is necessary. Here the point is being missed completely: what is meant by the development of 'order out of chaos' is precisely that this is *not* a random phenomenon, but that it is as much subject to laws as the increase in entropy. That's why the increase in order is sometimes called 'negentropy' or negative entropy. If such laws were to exist in the direction of order, and many things seem to point to this being so, then the origin of life would be much less of an exception and so be more in line with expectations. It seems then to me to be obvious to see intelligent life in the same line as that continued increase in complexity. We might then say, by way of extrapolation: the universe is not only geared to life, but also to the sort of life that sooner or later enables deliberative consciousness to arise[7]. The



*Time* article quoted, which so remarkably represents the state of the art, also concludes that many, and probably the most evolutionary, biologists today take the view that life and even the most complex forms of it are inscribed in the cosmic code (to use Pagels' expression once more)[8]. Given that the laws of nature are the way they are (*why* they are the way they are is according to me not a scientific but a philosophical problem),[9] and so given sufficient time (the Hubble time of the universe being the time when conscious life was able to develop), the development of intelligent life appears to me probable. To say such a thing was for a long time taboo. Now it appears almost inevitable to say that the universe (in the broadest sense) is capable, and even more, designed, to generate platforms which can serve as prerequisites for other platforms, so that in the end conscious life becomes possible. It seems *as if* everything has contributed, in the most fantastic way, to the creation of a being capable of asking itself why it exists. Paul Davies says: 'The impression of design is overwhelming'. Not everything that Davies says appeals to everyone. But as far as this aspect is concerned, what grounds would one have for contradicting him?

## 6 *There are many more questions, but a few answers too*

A lot is still unknown. A strong dose of agnosticism suits the scientist and the philosopher. The ultimate questions have not been answered. Why are the laws of nature the way they are? Newton wrote to his friend Bentley that he couldn't imagine that the laws of nature would be as they were unless someone had decided they would. To us this seems too much like a *'deus ex machina'*, a god that intervenes from outside. There are rightly not many defenders of this kind of intervening god to be found today. Nowadays there's hardly anyone that argues for a restoration of deism. Newton's remark is, nevertheless, interesting. He understood that knowing the laws of nature (the *how*) still provides no explanation of why (*why* they are the way they are). As far as the initial conditions are concerned, the only thing we can say *with certainty* is that they are of an order that, given the necessary time, a thinking being has been able to develop in this cosmos. And as far as the postulates of quantum mechanics are concerned: 'Nobody knows how it can be like that', says Richard Feynmann, who is after all not an inconsiderable figure. Many important questions remain unanswered. The sciences can help us state them as correctly as possible.

Even so, I think that certain conclusions can already be drawn.

1. Determinism (in its strict form, meaning as formulated by Pierre Simon de Laplace)[10] is in fact not capable of giving an account of the actual evolution which led to man. It is not the case that at the moment of the 'big bang' the development of man, as later actually took place, could have been predicted, even if a Spirit, greater than ours, or one or other Demon, had had an exhaustive knowledge of the initial state and of the laws of nature.
2. Expressed positively, this can be formulated as follows: the universe appears to have an inconceivable creativity. That conscious life was able to develop out of an initial state (a fluctuation in a quantum field, for example) is extremely remarkable, and hardly self-evident.
3. 'Self-organisation' is a term which can be taken to mean various things. If its meaning is that the development of life was a thoroughly creative event, whereby the organism appears itself to design the instruments to maintain itself in its environment and to develop, then perhaps self-organisation is the definition of life. But is it a descriptive or an explanatory term? Sometimes I have the impression that by speaking of self-organisation one renames the problem as a solution. In order to understand the processes of organisation clearly present on all levels in the living being, a great deal more empirical work has to be done. The impression is certainly overwhelming that life's processes are not preprogrammed, but can only be maintained by constant adaptation.
4. The universe clearly displays a layered structure. Higher levels (in terms of complexity and the possibility of more complicated experiences) presuppose the existence of the lower. We are unaware of any case where these higher conscious actions are performed without the support of the most complicated structures (the brain) that this universe has produced. Whether extra sensory perception exists is primarily a question of facts. If it exists, it is possible. But whether ESP actually occurs is as yet not scientifically verifiable.
5. In my view it has been sufficiently demonstrated by the whole area of psychosomatics that psychological processes have an influence on somatic and physical events. There is an urgent need for new conceptual frameworks on which to base thinking on the relationship between 'mind' and 'body'. The metaphor of 'the ghost in the machine' (the expression used by G. Ryle) is surely finished. It is probably preferable to consider the physical and mental poles as aspects of highly complex events, which are to a greater or lesser degree physical and psychological. Leibnitz' monad model, or the 'existing entities', with their physical and mental poles (according to Whitehead), are in my view better conceptual frameworks than the more traditional expressions 'soul' and 'body', since those expressions make one think too much of elements existing alongside each other. As an all-embracing theory of reality, Aristotle's hylomorphism may be an inspiration, since it states that the principles of matter and form are correlated, not as entities with a separate existence, but as the principle of actuality or definiteness (the soul) and the principle of potency (the organic physicality, which can recieve or 'incarnate' the form).
6. The *why* of the laws of nature, and of the determination (choice?) of the initial conditions up to now have come up against enormous conceptual problems. We are here clearly clashing with more than scientific questions, though in principle the notion should not be excluded that a better understanding of the cohesion of the laws of nature and of the initial conditions might show that the laws of nature ruling our universe are in fact the simplest that could make an extremely creative and unpredictable universe possible.
7. Advancing a little further philosophically, it does not seem rash to state that there is a great deal of converging evidence to suggest that the whole universe is permeated by a certain intelligibility, of which the laws of nature are the most easily ascertainable and of course abstract expression. Anaxagoras spoke of a cosmic intellect, a cosmic Nous. It is no coincidence that in their book on the anthropic principle, Barrow and Tippler devote much attention to Anaxagoras. There have been many variations on this theme throughout history. The Stoa spoke of a world soul, or '*anima mundi*'[11].
8. In his conclusion to *A Brief History of Time*, Stephen Hawking says that if we had a general theory that allowed us to unite the theory of relativity with quantum mechanics, we would also have an insight into what might have happened before $10^{-43}$ seconds after the big bang[12]. Current cosmological theories here come up against a boundary. If we were able to advance further by means of a unified theory linking quantum mechanics and relativity, then, he says, we would have access to 'the mind of God'. Paul Davies devoted a fine book to 'The Mind of God'[13]. That is not just any old tacked-on statement. It also appears as the conclusion of the film devoted to Hawking. Is it really responsible to speak of 'God' already, at this level of deliberation? It occurs to me that the word 'God' is used here with much too broad a meaning. 'God 'is primarily a religious word, which the believer uses when he knows he has a bond with something more, beyond himself, but especially when he conceives this More as loving and merciful[14].

## 7 *Philosophical and theological implications of contemporary cosmology*

In conclusion I would like to say something more about the philosophical and theological implications of the view put forward here regarding man's place in the cosmos. The greatest change that has taken place since the development of our species is that man does not only undergo evolution, but is also an 'actor' (or a factor) in cosmic events (on the scale of this planet, at least). Man is not only geared to nature, but can also manipulate and convert that nature into a culture. There is no 'balance' between man and nature, as it is sometimes so inaccurately expressed. On the contrary. Like all life, man is a creative *im*balance with regard to his environment. He is constantly taking order away from the environment in order to bring about higher levels of order himself, without which he cannot live. Arguing for 'ecocentrism' is fundamentally ambiguous. There is no point in preferring the ecological niche which supports man to man himself. Respect for nature is according to me inseparable from respect for man. There is no reason for finding carnivorous tigers more important than people. Even so, there is something to be said for this point of view: a world in which tigers and elephants can flourish is probably also a better world for man.

The agitation of those who lay complaints against man for the unbridled overuse of nature is easily understood. The greatest threats, linked closely to what the Earth offers us and to what we ask of it, are stated by the Universal Commission for the Environment and Development: population growth and the increasing need for resources; the maintenance of the variety of species and of the ecosystems; our use of energy and its consequences for the environment; the need for raw materials for industrial production; urbanisation and the problems of the urban environment[15]. Man is also capable of seriously upsetting his environment. The primary concerns here are of course the ecological prerequisites for man's survival. But these are not independent of the cosmological prerequisites. The problem lies in the fact that we are faced with a conflict of timescales. Biological evolution can of course put up with heavy blows, and it is possible there will arise unimagined forms of adaptation to new situations. But the time scale on which biological evolution works is completely different from the time scale on which man is able to interfere in his environment. The delicate balance of a rain forest only develops once in a particular place during the lifetime of the planet. Man, however, is capable of clearing a rain forest in just a few generations. Complex life forms such as tigers and elephants come about only once. Man can wipe them out forever.

Our economic thinking and actions should take these facts into account. Well now, thought and deed are impossible without direction and perspective, meaning without values, and these cannot be given by the positive sciences and technology. World views are needed as an inescapable frame within which man determines his objectives. Economy, politics and social interaction need orientation. A world view is a requirement for the whole of society in all its dimensions. If one does not try to develop this view of reality as a whole as rationally as possible, various forms of 'wild reason' (*pensée sauvage*) are given a chance. If our philosophy of life becomes clouded, the possibility of acting becomes limited and arbitrary. This situation is experienced as a loss of freedom, as a crisis. Philosophies of life are always interpretations of reality. They put emphasis on what someone considers to be of value in a certain situation. Philosophies of life are essential to resolute action. In order that our actions should appear coherent, we must link up the various areas concerned politics, economy and the dimension of knowledge. If, on the basis of our cosmological views, we can gain any understanding of the whole of man's exceptional position in the evolution of the cosmos, it would be unforgivably reckless to spoil, out of sheer egotism and short-sightedness, the 'result' of 15 billion years of cosmic growth in just a few centuries.

Does the way we look at man's place in the cosmos also have consequences for the question of the purpose of life and for the confirmation, or lack of it, of what religious man understands as 'God'? If we came to the conclusion that we were lost in an infinite universe that in no way expected or wanted us, this would also undermine what we think about the ultimate sense of our humanity. A religious or humanist interpretation of this existence is in that case little more than a heroic attempt to make the best of an absurd situation. If, on the contrary, it should turn out that the history of man is linked to the universe as a whole, by its very roots and in an organic way, then this seems rather to tempt us to allot to humanity a meaningful, though vulnerable, place in the Whole of reality, which, it's true, is awesomely greater than man, but which still in one way or another sustains us. The positive sciences give no answer to such questions as: 'Why is there something rather than nothing?', 'why is the universe like it is?' and 'why are the laws of nature the way they are?' Wittgenstein said: 'It is not the way the world is that's mystical, but that it exists'[16]. It is however premature to say that we should call on God to explain what the positive sciences cannot. One can also look at the ultimate reality in non-religious ways (as materialism does, for example). The word 'God' is an 'integrator word' in which several different levels of meaning are bundled together. Another very well-known integrator word is 'I' (ego). The 'ego' is pre-eminently a layered reality. The 'ego' is a material reality, but at the same time also the centre of interpretation and of free decisions. is also, in its depths, an irreplaceable person, a 'you'. Under the 'God' we understand more than the Encompassing Reality or the Absolute. The word God is only suitable if we look in a particular way at the ultimate reality: if we see *'more'* in it: more than an anonymous Structure or a Cosmic Intellect, more than an explanation for the existence of everything there is, but also an orientation towards value, beauty and harmony. We only talk of God in the Christian sense of the word when we accept that the supporting Fundament of our existence also has loving intentions, and is on our side in the fight against suffering. This is obviously more than one can deduce from any cosmological theory, even if God is to us no less than the cosmic Logos 'in which everything is created'. It is part of the essence of the doctrine of creation that the world is contingent, and yet in essence good, though not yet complete. That man has an organic place in the cosmos as a whole is more in unison with the Christian doctrine of creation, which sees in man, of all beings, not in the cosmos itself or in the animals, the 'icon' or image of God, 'the Beginning and End of all things'[17].

'When I listen to music, when I walk in an art gallery, when I treat my eyes to the lines of a Gothic cathedral, when I read a poem or an academic article, when I watch my grandchildren at play or when I simply think about the fact that I can do all these things, including the fact that I am able to reflect on them, it is not possible for me to imagine that the universe of which I am part, by its own nature, somewhere, sometime, perhaps in several places and at various times, would not be bound to give rise to the development of beings capable of justifying the beauty of the universe, of experiencing its love, seeking after truth, and divining its mystery. By saying this I probably rightly end up in the category of the romantics. So be it.'[18]

## Notes

1 'Wir fühlen, dass, selbst wenn alle möglichen wissenschaftlichen Fragen beantwortet sind, unsere Lebensprobleme noch gar nicht buührt sind', L. Wittgenstein, *Tractatus Logico-Philosophicus*, 6.25.

2 From the title of the book by Wim Kayser, *Een Schitterend Ongeluk*, Amsterdam/Antwerp, Contact, 1993. 'Steve Gould wrote: 'Through no fault of our own, and without any cosmic plan or a conscious creator being involved, but by means



of a marvellous evolutionary accident, called intelligence, we have become the stewards of the continuity of life on earth. We did not ask for this role, but we cannot renounce it. We may not be suited to the role, but now there's no turning back', *op cit.* p.233- 234.

3 'The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so', John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle*, Oxford/New York, Oxford University Press, 1988, p.16.

4 For the interpretation of the 'anthropic principle', see Joseph M. Zycinski, 'The Anthropic Principle and Teleological Intèrpretations of Nature', in *The Review of Metaphysics*, vol.XLI, no.162, Dec.1987, p.317-333. On the impressive list of essential preconditions for the development of an intelligent observer, see John Leslie, 'The Prerequisites for Life in Our Universe', in *Newton and the new Direction in Science. Proceedings of the Cracow Conference*, published by G.V. Coyne, S.J.M. Heller and J. Zycinski, Città del Vaticano, Specola Vaticana, 1988, p.229-258. A collection of critical articles on the relationship between cosmology and philosophy is provided by *Physical Cosmology and Philosophy*. Edited, with an Introduction, Notes and a Bibliography, by John Leslie, New York/London, Macmillan/Collier Macmillan, 1990.

5 This is what the Strong Anthropic Principle (SAP) says: 'The Universe must have those properties which allow life to develop within it at some stage in its history'. I would not subscribe to this in its present form.

6 'But more recent, more careful analysis suggests that even a mildly impressive living molecule is quite unlikely to form randomly', *Time*, 4th January 1993, 'The universe more explainable as well as more amazing'.

7 A question often asked is whether there is the possibility of a different sort of life from the human life we know. The answer is clearly yes. But not just any sort of life. It seems highly contingent that *homo sapiens* should have developed out of the smaller mammals left after the extinction of the dinosaurs. If this had not happened, I don't see why other branches of living creatures (dolphins, for example) should not be able gradually to develop a more complex nervous system. It seems to me to be an extremely risky claim, however, that life other than that based on carbon is possible. Theoretically, complex structures such as the brain can have another material base (silicones, for example). However, since we have no single case of complex life forms which are not based on carbon, this is a gratuitous affirmation, and as yet nothing indicates that such theoretically possible life forms actually exist.

'Many, perhaps most, evolutionary biologists now hold this belief'. *Time*, art. cit.

9 There are, essentially, not many explanations. For additional elaboration, see Van der Veken, 1992.

10 P.S. de Laplace, at the start of his *Essai philosophique sur les probabilités*, 'Nous devons donc envisager l'état present de l'univers comme l'effet de son état antérieur, et comme la cause de celui qui va suivre. Une intelligence qui, pour un instant donné, connaîtrait toutes les forces dont la nature est animée et la situation respective des êtres qui la composent, si d'ailleurs elle était assez vaste pour soumettre ces données à l'analyse, embrasserait dans la même formule les mouvements des plus grands corps de l'univers et ceux du plus léger atome: rien

ne serait incertain pour elle, et l'avenir, comme le passé, serait présent à ces yeux'. Summarized: 'Imagine an omniscient mind, which knows, at a certain moment, the mass, the position and the state of movement of every particle occurring in the universe. On the basis of this information, this mind would be capable of calculating entirely the new situation for any moment in the past or future'. P. van der Hoeven in *Filosofische oriëntering in de natuurwetenschappen*, Aula Books, 1967, p.40.

11 On this subject see Bonifazi, 1978, et al.

12 The current physical theories (the theory of relativity and quantum mechanics) do not allow us to 'see' further back in time than $1/10^{43}$ or $10^{-43}$ after the theoretical point $t_0$, the moment of the big bang.

13 Davies, 1992. It is worth quoting the book's closing passage: 'How we have become linked into this cosmic dimension is a mystery. Yet the linkage cannot be denied. What does it mean? What is man that we might be party to such privilege? I cannot believe that our existence in this universe is a mere quirk of fate, an accident of history, an incidental blip in the great cosmic drama. Our involvement is too intimate. The physical species *Homo* may count for nothing, but the existence of mind in some organism on some planet in the universe is surely a fact of fundamental significance. Through conscious beings the universe has generated self-awareness. This can be no trivial detail, no minor product of mindless, purposeless forces. We are truly meant to be here', op cit. p.232. Although I have some reservations about Davies' arrogant tone, I still find his position in this book very balanced.

14 On this subject see J. Van der Veken, 'De referent van het woord God', in *Bijdragen. Tijdschrift voor filosofie en theologie*, 53 (1992), p.118-134.

15 *Universele Commissie voor Milieu en Ontwikkeling: Onze aarde morgen. Brundtland rapport*, Tielt, Lannoo, 1989.

16 'Nicht wie die Welt ist, ist das Mystische, sondern dass sie ist', *Tractatus Logico-Philosophicus*, 6.44.

17 'Deus Principium et Finis omnium rerum': God is spoken of in this way in the first Vatican council.

18 'Quand j'écoute de la musique, quand je me promène dans une galerie d'art, quand je régale mes yeux des lignes pures d'une cathédrale gothique, quand je lis un poème ou un article scientifique, quand je regard jouer mes petits-enfants ou simplement quand je réfléchis sur le fait que je peux faire toutes ces choses, y compris réfléchir sur mon pouvoir de les faire, il m'est impossible de concevoir l'univers dont je fait partie comme n'étant pas contraint, par sa nature même, de donner naissance quelque part, à quelque époque, peut-être à de nombreux endroits et à de nombreuses époques, à des êtres capables d'apprécier la beauté, de ressentir l'amour, de chercher la vérité et d'appréhender le mystère. Cela me met, sans doute, dans la catégorie des romantiques. Qu'il en soit ainsi'. Christian de Duve, 'La vie est inscrite dans l'univers. Le savant s'interroge... et prend position', interview in *La Libre Belgique*, 23rd October 1990.

*Leo Apostel*

# Symmetry and symmetry breaking: ontology in science

## (An Outline of a Whole)*

### INTRODUCTION AND SUMMARY

'unzeitgemäsze Betrachtungen'
F. NIETZSCHE

1. Anyone attempting to understand the nature of global reality cannot do otherwise than look for a feature which, on the one hand, characterises the most diverse of regions, while on the other hand still contributing to an understanding of the specificity and individual nature of each region. Our basic assumption in this article is that this *key* feature can be found in the opposites *symmetry* and *symmetry breaking*.
2. This polarity will be shown to be at the same time unifying and specifying. The world view construction we are concerned with here, needs moreover that the 'unifying' characteristic is both clearly philosophical and metaphysically meaningful and demonstrates scientific fruitfulness.
   We show that the *importance* of the polarity can be deduced from an analysis of *'system'* and *'cause.'*
   In addition we see that 'being' implies both 'system' and 'cause'. Reality (in its total pattern) *must* necessarily be the way it is. But not all problems *can* or *may* be solved: we can show *why* some symmetries are necessary, but not *all*. The problem of the relationship between symmetries and symmetry breaking has only partially been cleared up.
3. The fundamental polarity provides a deeply unifying description, and a partial explanation of symmetry and symmetry breaking is deduced from the concept of 'being'. However, philosophical analysis of what value is allows us to say that a universe characterised simultaneously

by symmetry and symmetry breaking is of value by and in itself (just as it is explained by and in itself).

4. From this stress on the universe as a whole follows an 'anti-anthropism' (a universe focused on mankind would by narrowing its scope show anti-ecological, anti-diversifying features). Anyone who understands the universe-as-a-whole as a self-explanatory system must reject an explanation of that whole by the properties and privileges of one of its parts.
5. Our topic — an outline of a whole — is complicated because by its very nature it must bring together a great variety of information in an unusual way. The table of contents at the front of the book actually provides a detailed plan which is important to the understanding of this account. As might have been expected, the *descriptive* section, (making clear the importance of symmetries and symmetry breakings as integrating factors) , is the longest (A,I,II and III and B,I,II and III). It corresponds to point number one in this introduction. Then follows the most uncertain (and yet, in our opinion, the most essential) part: the attempt to *understand* the structure of the whole just 'shown' (C and D). Questions of *meaning, value and action* are the most important for our practice and our inner life (they are dealt with in E and F). In order to situate this attempt in the greater field of world view constructions, they are then typified, slightly simplified, in the series of 'characteristics' in G. We finish with a reference to future work (H). More empirically oriented readers will choose A and B, more speculative ones will prefer C and D, and more active ones will look mainly at E and F. One may, if one wishes, become acquainted with A and B without the rest, or, to the contrary after a very brief encounter with A and B, concentrate on C and D or E and F. Intellectually, E and F presuppose A and B as well as C and D. But, one can accept A and B and reject C and D, just as one can accept A, B, C and D while rejecting E and F.

## A SYMMETRIES

## *I Symmetries and inorganic nature*

### *1 Being and becoming*

We look through a window. Clouds float across the sky. Cars drive along the roads. Houses stand upright. Things are constantly happening, there



is constant change. Even houses age (slowly). But the changes we see are not chaotic: wind with a particular strength and direction always results in the same movement of clouds. The car driver can make his car go as fast as he likes (within limits) by regulating the supply of fuel to the engine. Events are arranged in such a way that the relationships between them remain constant (cloud speed/wind force; car speed/fuel supply).

The laws of nature express which *relationships* remain unchanged while changes are occurring in the position and properties of objects.

Apart from the laws of nature, which express what is unchanging, observation also teaches us that we are surrounded by continual changes. We ourselves are ageing. Buildings are being demolished and built. Ebb follows flow. In the long term the climate does not remain constant. Human society is embedded in a history, life in a development, and the universe in a cosmic evolution (we currently believe in an expanding universe, about 10 to 15 billion years old). *Trends in evolution* describe the direction(s) in which history, evolution and the cosmos are going.

Invariability and change; being and becoming; intensely involved in each other yet fundamentally different from each other they characterise the whole of reality. Their opposition and their alliance *unite* the whole of nature.

Do change and invariability cohere in the same way in all aspects of reality? What in fact are invariants (which things, quantities, relationships and structures remain constant?) and what are changes? In a first approach it is sufficient simply to position the two aspects opposite each other. In a second approach, however, it will be proven that becoming is also partly determined by invariable laws and that — at least as a hypothetical possibility — an evolution of laws cannot be excluded. However, we request the reader to concentrate on the first approach for the time being.

### *2 Variations and symmetries: symmetries of bodies*

In order to understand what invariants are, one may look at the concrete invariants that are linked to symmetries.

Let's take a sphere. We let the sphere turn round an axis or its centre. The rotation of the axis may cover a greater or smaller curve, yet the sphere remains identical with itself and appears to us analogous; it is seen by us in the same way.

The six surfaces of a cube are identical. When we look at the cube from the six different directions which are perpendicular to each surface and intersect each other forming the same angles, we see the identical shape six times. Even if we look at a mirror image of the cube (in which left and right are reversed) we shall see the same image.

Both the sphere and the cube have many 'symmetries' — though the sphere has *more*: in three dimensions it is the most symmetrical form, *after*... the empty space (a limit case). The empty space looks identical from every direction, in every position.

Perfect crystals look the same if one looks at them from various, particular directions (the directions to be chosen depend on the type of crystal).

Stars and galaxies are more or less symmetrical bodies (in the field of very large things); but so too are snowflakes and many atoms and molecules (in the field of the very small).

The examples mentioned show that symmetries and invariants are closely related. The symmetries of a body are the movements of that body that leave it *unchanged* in certain respects. Herman Weyl rightly says: 'Given a spatial configuration F, these automorphisms of the space (meaning these uni-univocal depictions of the space in itself) that leave F unchanged, form a group G and *this group traces exactly the symmetry of F*.'[1] We know that a group is a collection of operations to which apply (if A, B, C... are separate operations) the following laws: 1. for every A and B there exists a C in G, so that A.B = C, where . is the generalised product; 2. A.(B.C) = (A.B).C; 3. for every A there is an $A^{-1}$ so that $A.A^{-1} = e = A^{-1}.A$ (where e is the unit operation and $A^{-1}$ the inverse of A); 4. that A.e = A = e.A .

A single configuration can exhibit many different symmetries. Since symmetries are operations, we shall, for every sort of symmetry (e.g. permutation, dilatation, rotation) call the series of properties affected by the operation (in these cases the position, size and angle to a reference body) the variations which, given the symmetry, leave the configuration unchanged.[2]

## 3 Variations and symmetries: symmetries of laws

The sphere, the cube, the crystal are *special* bodies which do indeed display striking symmetries. They are exceptional. Although tools, plants and animals also possess striking and important symmetries, they are however also highly asymmetrical (the root and the flower of a plant make the organism highly asymmetrical, even though flowers *themselves* are



often highly symmetrical. The same applies to the left and right parts or head and hind parts of an animal, or the grab and the arm of a crane). The invariable relationships which are not altered by or in *all* changes will not be symmetries of *things*, but, on the contrary, symmetries of laws.

We observe nature in a laboratory. The laws we discover

1. do not depend on the orientation of our laboratory;
2. do not depend on our position;
3. do not depend on our calculation of time or on the moment at which we measure;
4. do not depend on the speeds at which our laboratory moves (we assume that no accelerations or decelerations take place).

Eugen P. Wigner was the first, with Herman Weyl, to point to the great importance of these symmetries, which express the most general invariants in nature. But as E.P. Wigner himself remarked, these symmetries were discovered[3] by Henri Poincaré and are now known as the Poincaré group.

'If the first three invariants did not apply then knowledge by inductive generalisation would not be possible, since laws would vary according to place and time.'[4] So the possibility of inductive knowledge depends on a property of reality. The question immediately arises: *why* does reality have this property?

Apart from the *philosophical bond* between the four fundamentals of invariability, they also have a fundamental scientific meaning.[5] From the first symmetry follows the constancy of angular momentum (momentum = amount of movement = mV = mass times speed) of a system, from the second follows the constancy of the linear momentum of a system, from the third the constancy of the energy of a system, and from the four together one can deduce the special theory of relativity.

In the fourth chapter of his book *The Character of Physical Law*, Richard Feynman emphasises that the laws of nature are invariant both under translation in space and time and under rotation or under acceleration (positive or negative). So he is repeating Wigner's statement.

It is easy to understand that time and space as such are not causes and that simple movements within them cannot change anything. But it is less obvious that space is isotropic and has the same structure in all directions, or that an alteration of the state of movement of a body has no impact.

The fourth symmetry is far less obvious. As is known, (4) was only discovered late in the day. But we might observe again that nature's distinguishability is put in danger if (1) and (4) were false. If the laws we ascertain were dependent on the *direction* in which our lab is oriented in the universe, and on the *absolute* speed with regard to the universe, then we would have to understand the whole universe to know how and why our laws change locally. Inductive knowledge would again be impossible.

The philosophical implications of these conclusions are extremely substantial. Classical, pre-quantum mechanics follows from the four fundamentals we have just specified and which are at the same time fundamentals of invariability symmetry and constancy. So one can say that the bodies in our universe move according to laws which themselves express the prerequisites for inductive knowledge.

This at first appears to make a subjective explanation of these laws acceptable. I. Kant's *Metaphysische Anfangsgründe der Naturwissenschaften* point in that direction (although the fundamentals of invariance and symmetry were not yet clarified: group theory was still to be born).

This subjective turn would actually cut us off from knowledge of objective nature. If it were justified, then Arthur Eddington's *a priori* deduction of the laws of nature from the nature of our acts of measurement and observation would be natural.

We shall demonstrate in later paragraphs that an ontological deduction from these same laws would be possible and preferable.

In any case, the *philosophical* significance of the *content* (not of the form or of the method) of classical mechanics has been proven by the relation of its basic laws with the fundamental symmetries.[6]

## 4 Discontinuous and approximate symmetries

The symmetries presented up to now have been continuous: rotations, translations and movements in general are continuous transformations. There are also other symmetry operations however: a mirror-image replaces left with right; the conversion of positive to negative charge is a discontinuous symmetry; a possible reversal of the time axis is a discontinuous operation.

99% of natural processes are symmetrical when mirrored (a so-called transformation of parity P)[7]; every particle has an anti-particle displaying the same properties but the opposite electrical charge and so are invariant under the reversal of charge (under the transformation C); nearly all laws of nature are invariant under reversal of the arrow of time (i.e. the T transformation).



We see that the three discontinuous transformations leave *most* (but not all) phenomena invariant. Such invariants may be called approximate invariants. They cannot be directly deduced philosophically but are rather enigmatically counter-intuitive. Understanding nature demands understanding why it is so nearly (and yet not completely) symmetrical under discontinuous symmetries.

## 5 Internal symmetries

The continuous and discontinuous symmetries just mentioned are external, in the following sense: one alters the relationships between a system (which internally remains the same) and the external environment (by movement in time or space, rotation, acceleration, mirroring, ...). However, one can also change the internal composition of a system and observe that it remains invariant. This applies to a proton/neutron invariance in an atomic nucleus. Atomic nuclei have, broadly speaking, protons and neutrons in various numbers (more correctly: they are made up of a probable superposition of protons and neutrons).[8] One can replace the protons and neutrons with each other (without making essential changes). This applies to a number of sorts of particles. What also applies to *all* sorts of particles is that one may — for example — replace electrons by other random electrons without the slightest consequence. They have no individuality. They are indistinguishable.

## 6 Local and global symmetries

Both the continuous and the discontinuous, both the external and the internal symmetries are global: one finds that operations that affect all systems in a particular area in the same way (the whole lab is shifted, moved, rotated, altered internally, mirrored) do not bring about qualitative changes.

One might, however, change parts of the area in random positions or at random moments, and ask oneself whether invariant relationships would *still* remain. This is possible if the many different changes bring about forces that interact with each other and thereby preserve the unity of the system. Such invariants are called local gauge invariants (and originate from Herman Weyl).

J. Rosen provides an intuitive survey of the various symmetries in physics[9]. He introduces the local transformations as follows. Associate a local system of coordinates with every point in space-time. The x, y and z axes of these local coordinates may have various orientations at different places and at different moments. A local transformation of this infinite number of coordinate systems is (for example) a rotation of the axes at every point in the xy field, but such that the angle of rotation *depends* on the space-time point. 'Gauge transformation' is synonymous with 'transformation of a local frame of reference' (one thinks intuitively of the recalibration of measures of weight and length by changes in standard units). So a local transformation is a recalibration of the gauge. Local symmetries exist if configurations are invariant under local transformations.

Both Maxwell's Laws, which describe electromagnetism, and Einstein's equations for gravity in the general theory of relativity, *ensue* from the demand for local gauge invariance for intensities of electrical and magnetic fields on the one hand, and for gravitational fields on the other. It is evident that we cannot summarise here the proofs of these fundamental results (which one will find explained and proven in Wigner and Mainzer). However, they inspire our entire exposition because they *deduce* the laws of nature from more fundamental, qualitative principles (the reason for whose existence we, as philosophers, are seeking).

## 7 *Changing perspective: invariants and symmetries as search strategies*

By way of example it is fascinating to see how the existence of gravitation can be deduced from a symmetry requirement. The requirement in question is: the laws of nature we ascertain in a normal laboratory must be the same as those we ascertain in a rapidly rotating laboratory. At first sight this cannot be true: we observe centrifugal forces in the rotating room, which do not occur elsewhere. Newton was having problems with this in his day. In about 1880 Mach suggested the solution: an astronomer who looks at the stars from a rotating laboratory sees them turning round the point where he's standing. Naïvely we interpret this as the consequence of the rotation of the laboratory. If, however, we suppose that the astronomer considers his 'system of coordinates' to be 'fixed' then he must, on the contrary, assume that the universe revolves around his position. Mach asks whether one might attribute the centrifugal force observed in the rotating laboratory to the rotation of the universe around it. If this were possible, then one would detect the *same* natural



laws in a *fixed* laboratory as in a rotating one; the different phenomena observed in the second could be attributed simply to the different environment (the starry sky rotates in the second case and is fixed in the first). Einstein's general theory of relativity made Mach's proposal concrete. In his equations, gravity allows the generation of a field which accounts for centrifugal force. We may therefore conclude that the invariance of the laws of nature, in a transfer from a stationary to a rotating laboratory (a symmetry) requires that one of the four main natural forces (gravity) exists.

We shall not demonstrate in detail how the *two other* basic forces (weak and strong electric interaction) can be inferred from symmetries. They can be[10]. In order to understand that, however, one must take local symmetries (which we just described) as a starting point and not the global ones we used to infer gravity.

## 8 *Combined symmetries*

If one requires (1) that the internal gauge symmetries count as much as (2) the Poincaré symmetries and (3) the CPT symmetries *and* (4) that no infinities occur, then the empirically determined laws for these three basic forces (strong interaction, electroweak interaction and gravitation) follow from four extremely general qualitative requirements. It then also becomes understandable that one looks out for (1) analogous symmetry properties in other areas of reality (life and humanity) and for (2) an explanation of the fact that *these* symmetries count and *not others* (e.g. invariance under increases and decreases of scale does *not* hold good, except in chaos theory, by means of self-similarity, about which something will be said later).

## 9 *Symmetry breaks*

Various symmetries would not have been discovered if the notion of 'spontaneously broken symmetry' had not been available. Because in the world of phenomena, perfect symmetries are as rare as platonic ideas (to which they are sometimes compared).

Let's assume that an equation expresses a law. Solving equations means finding quantities that satisfy the relationships expressed in the equation. An equation in which 'masses' occur is completely symmetrical for two variables if it implies an equal role for the two changing components. Anyone interested in the masses of two such 'symmetrical' variables will at first sight come to the naïve conclusion that these masses should be equal, in a concrete model of the equation. This may be the case, but need not be, however. One can have different masses on condition that, in addition to a model with a greater mass for variable 1 and smaller for 2, there exists an entirely equivalent model with a greater mass for variable 2 and a smaller for 1. A theory can be actualised in various models which have highly differing forms but which all behave according to the same laws. The symmetry of the law is preserved by the existence of opposing asymmetrical models of it (the symmetry of the law is proven by the equal frequency of its asymmetrical models). An ordinary magnet also displays an example for an analogous breaking of symmetry. Electromagnetic forces are completely symmetrical with regard to directions in space and make no distinction between North and South or East and West. But if a magnet comes into being by cooling, from a sufficiently low temperature it develops a magnetic field in one clearly defined direction. We understand why. Forces work between neighbouring iron atoms that make them spin in identical directions. It is sufficient that one atom should, by chance, come to face in one particular direction, for all the rest also to end up in this asymmetrical state.

The weak electric symmetry[11] is broken at our temperatures, into electromagnetism and weak interaction. We do not yet know what does this. We suppose also strong nuclear force and gravitation arose, by means of symmetry breaking, from a more symmetrical initial state (in which they cannot be distinguished from each other). The symmetries detected empirically can be ordered by means of a sequential hierarchy of symmetry breaks. Problems remaining open are: what are the symmetry breaks that led to the separation of gravitation and strong interaction. As appears from a book like Heinz Pagels' *Volmaakte Symmetrie*, one can (speculatively, but well-foundedly) see the history of the universe as a succession of symmetry breaks, starting from an entirely symmetrical situation in which all the fundamental forces are equal to each other, and all fundamental particles mutually generate each other.

If one were able to infer the possibility of spontaneous symmetry breaks from the nature of symmetries of laws, then one would be able infer 'time' (= the ordered series of breaks) from 'being' (= symmetry). This inference appears to be possible and desirable but has certainly not yet been achieved.

Now we have briefly made acquaintance with symmetry breaks, it is necessary to define asymmetry, antisymmetry, dissymmetry and symmetry breaking as clearly as symmetry itself was defined.



At first sight it's a simple business: if the symmetry of a configuration F is determined by the group G of those automorphisms of the (physical *or* conceptual) space in which F is embedded, which leave the properties of F unchanged, then the asymmetries of F are determined by the automorphisms of that space that do *not* leave F unchanged. But this is a purely negative definition: in this way we say *nothing* about the structure of the second sort of automorphisms. We do not define the 'asymmetries of F' positively.

This is quite undesirable. Can we say anything more? One would normally start from the group G. G contains several operations as elements. We can form the lattice of the subgroups of G. It always exists and in general is not trivial. We can consider the configurations $F_1F_2...F_n$ which are not invariant under G but are invariant under subgroups of G. These configurations still display symmetries, but they are fewer in number. Some of these subgroups have an equal number of elements and are either disjunctive or partially overlapping. Others, however, are themselves subgroups of other subgroups. This produces a tree structure.

After a finite or infinite number of steps (intermediate layers) one reaches the configurations $F_x$ which now only display trivial symmetries (they are only invariant under empty groups or under groups that consist solely of unit operations). We call such structures $F_x$ dissymmetrical. The relationship between a group $G_m$ and a group $G_n$, where $G_m$ forms a genuine subgroup of $G_n$, is an antisymmetrical relationship (in the purely logical sense of that word: R is an antisymmetrical relationship if, when R(ab) exists, R(ba) *cannot* exist; R is an asymmetrical relationship if, when R(ab) exists, R(ba) does not *have to* exist; if R(ba) follows from R(ab) (and the reverse) then R is symmetrical). The *pregnant* form of symmetry we have used up to now is, however, much richer than the purely logical symmetry we have just introduced. The latter may by no means be identified with the former.

*Symmetry breaks (related to 'time' and 'process') exist in the transition of the universe U, or of S, a system forming part of it, from a state which is invariant in a group G, to a state which is only invariant in a sub-group of G.* Having said this, we have given a positive definition of symmetry breaking. In what follows we shall make the assumption that irreversible processes, causal relationships and time as such are connected to these symmetry breaks.

The importance of this positive interpretation of the notion of 'symmetry breaking' is this: that reality is characterised by certain symmetries, *and* by certain symmetry breaks, is no empty tautological statement. Such confirmation expresses a genuine property of nature. If it were possible to account for the existence of this property, on the basis of more general and qualitative assumptions, then we would have 'understood' something of reality.[12]

## II Symmetries and life

### 1 Waves as symmetries and invariants

The importance of symmetries in physics having now been demonstrated, one would expect us to move on to chemistry. Atoms and molecules display an abundance of symmetries. The space we have available does not, however, allow us to do this. All we would like to do, having demonstrated the pivotal part played by symmetry and asymmetry in mutual interactions in the physical world, is to show that this duality is repeated in the living world in a specific way.

Living systems are systems in a state of constant self-destruction and self-construction ('autopoiesis' and metabolism) and of which both the parts and the whole, adapted to each other and the environment, fulfill particular *functions*. So it is obvious that the symmetries important to living creatures are symmetries in processes (and not in static states or forms) and in functions (less than internal properties). The distance between the symmetries of laws and of bodies in the inorganic world is greater than the distance between the symmetry of biological laws and the symmetry of living organisms, insofar as laws themselves are defined as invariants in processes. Biology has fewer general laws, however; most of the laws it discovers are statistical and probabilistic. The invariance of probabilistic laws under certain group transformations is less well-known than the invariance of strict laws (but is conceptually equally important).

In the morphological thinking of biologists there remains in existence a literal trace of the symmetry invariants we encountered in physics.

Let's compare a wave movement to a straight line. Shifting the straight line from left to right brings about no changes. Lets take a regular sine wave. A shift of half a period to the left or right will map a wave peak in a wave trough and thereby change the whole thing. Then no invariance or symmetry exists. But if the length of the shift is equal to the length of the period of the wave then the wave is not changed at all.

So waves are also characterised by symmetries (though by a smaller number than the straight line). This is certainly simply true for regular waves. Yet it is known (by means of the Fourier analysis) that one can



construct any wave by combining regular waves. Therefore all waves, including the irregular ones, can be connected to symmetries.

We can connect rhythmical movements (meaning wave movements) with all living processes. All organisms considered each as a whole, as well as all living cells and all neurones and sense organs give evidence of rhythmical activation and deactivation *(of activity and inactivity)*. We can even infer this cyclicity, characteristic of living material, from the essence of life itself.

### 2 Metabolism and self-reproduction as symmetries

Living systems are open systems, constantly active and therefore far from equilibrium, which only retain their organisation by the intake of material and energy (a) and which are capable of reproducing themselves (b).

The inevitable consequence of these two fundamental properties of life is that life is a wave movement. 1. Material and energy are absorbed, altered and ejected again. Metabolism is a rhythmical process — and therefore a symmetry. After a certain number of time units, the metabolising cells and tissues are again in the same state. 2. Self-reproduction is a symmetry (across time). Generations reproduce each other. The form of the species is kept invariant by the transfer of genetic information.

These two forms of invariance and symmetry are naturally not eternal: organisms and cells age and species change into other species by mutation, adaptation and selection. Evolution as a *whole* is not a symmetry, but an asymmetry. By contrast, the pauses in evolution itself, and the species, are symmetries (as we just saw).

While we see the invariants and the (strong) asymmetries strictly separated from each other, they prove to be connected with each other in a special way in the living world. In man this will be different again. We suspect that a general structural property of reality is showing itself here.

### 3. The antisymmetries and symmetries of DNA

In 1953 J.D. Watson and F.C. Crick proposed the double helix model of DNA (deoxyribonucleic acid). This double helix model for the chemical bearer of the genome (the genetic material) displays a striking mixture of symmetries and antisymmetries.

The DNA molecule consists of two DNA series which wind in a regular double spiral round a common axis. The two series are parallel but inversely oriented. The succession of bases in the one series determines the succession of bases in the other. A-T and G-C (adenine, thymine, guanine, cytosine) are linked by hydrogen bonds. DNA's antisymmetry is shown by the following two facts.

1. In the selection, occurring in all living creatures, of one of the enantiomers when a polymer occurs in two forms (here we again see the symmetry break). Some chemical substances occur in two forms which are mirror images of each other (and which have *the same* chemical properties). Among polymers (complex molecules) these two forms are called enantiomers. It appears that in *every* organism, without exception, contrary to what one would expect, only *one* of the two enantiomers is present, *if* that substance occurs in living creatures (and it is *the same* enantiomer in *all* organisms).
2. The sequences of bases are also strictly linear (their order is essential for the inherited characteristics and every permutation involves a qualitative change).

But on the other hand the overall morphological structure of DNA is highly symmetrical, based on its axis. We can even see the strong link between symmetry and antisymmetry in the *form* of the genetic carriers.

### 4 Symmetries in overall biological forms

Manfred Eigen points out in *Das Spiel* that we can regard an organism as a 'message'. We know from information theory that messages only come across in 'noisy channels' if one makes them sufficiently redundant (that's to say: if one sends the most important information many times). Redundant parts may replace each other without the meaning being changed. So symmetry is closely linked to redundancy. But redundant parts of an organism are checked by the same parts of the DNA. So if a mutation occurs there, possible changes will be reflected in *more* varied aspects of the organism. Favourable mutations are multiplied in many symmetrical parts. One may therefore understand why radiolarians, for example, and snails show strong symmetries (in the case of snails by means of translation, rotation and dilatation of the radius of rotation of the overall form).

Among moving animals it is primarily bilateral symmetry that occurs (a consequence of gravity); from this follows the frequency of mirror symmetry.



Plants (particularly the higher plants) show translation, rotation and mirror symmetry. The leaf implantation often displays a spiral symmetry (where translation is linked to rotation).

D'Arcy Thompson's *On Growth and Form* can be seen as a study of symmetries. His chapter on Cartesian transformations demonstrates that the overall form of an animal species can be considered to be the transformation of the form of another species of animal, by means of the transition to another system of coordinates. This application of the idea of invariance to the whole set of living structures is certainly too daring; but, like the pre-Darwinian morphologists, perhaps we can consider all living creatures as transformations of a limited number of construction plans. All the forms belonging to one construction plan would then be characterised by both great invariance and symmetry.

Why this should be ought to follow from the relationship between evolution and symmetry (see Eigen) or embryology and symmetry (see D'Arcy Thompson).

The life sciences developed either later or according to a different pattern from that of the physical sciences. We shall encounter less profound and universal laws there than in the physical sciences. Nevertheless the importance of symmetries proves to be so great on fundamental points that the future emergence of laws of symmetry in the life sciences can be looked forward to.

## III Symmetries and man

### 1 Symmetry and anthropology

People become socialised by their upbringing. Upbringing takes place in a family. The elementary structure of a family is always the same: a man (the son-in-law) receives from another man (the father-in-law) a woman to marry. This man and woman, partners, become the father and mother of children. These children, themselves men and women, are each other's relations. So the elementary family relationships are man/woman, parents/children, brother/sister (with, as complementary relationships, those between the children and the brother or sister of the father or mother). This structure is the consequence of a symmetry break (the following scheme: a woman receiving a man to marry from another woman is entirely equivalent in structure, but seldom or never occurs because of the patriarchal system that exists in both matrilineal and patrilineal societies). In the elementary family structure we find both symmetrical and asymmetrical relationships; the typology of the families itself depends on whether the child/father or child/uncle relationship is authoritative-asymmetrical or egalitarian-symmetrical; the two always occur. Symmetrical and asymmetrical relationships both occur and require each other to stabilise the whole.

All primitive societies appear to break up into subgroups, organised with regard to each other in such a way that when subgroup A receives women from B, B receives women from A. This may take place within a dual structure (A↔B) or in a generalised cyclical structure (A↔C↔D↔B). The relationship of 'having a right to a marriage partner' is invariant under a transition from subgroup to subgroup. Moreover, the complex relationship of 'forming an elementary family unit' (which itself consists of various symmetrical and asymmetrical relationships) is also invariant under the transition from generation to generation.[13]

At this point something of the importance of the idea of invariance or symmetry becomes apparent. The driving force behind 'structuralism' (which defends these ideas in the human sciences) lies elsewhere, however: the form or structure of family relationships is encountered anew in the form of myths, in the planning of settlements, in the style of the arts, in ornamentation and in language. These 'forms' (meaning complex collections of symmetries and asymmetries) are therefore invariant under the transition from social relation to myth, art or architectural structure. We do not even have clear terms to characterise these transitione.

These invariances make innovation difficult. They will therefore not be preserved as such in more dynamic societies. There, however, other invariances will turn out to play a pivotal part.

## 2 *Symmetry and norm: reciprocity*

In dynamic societies, in all cultures, the notion of reciprocity plays a central part in ethics and law, as do the notions of buying and selling in economy.

The relationship between A and B is reciprocal if it is symmetrical (if A can make the same claims on B as B on A). Ethical and legal relationships are essentially reciprocal, in the following sense: the reciprocity is the *norm*. In actuality there will be a great deal of oppression and inequality but the group exercises pressure to arrive at a partial or at least a fictional symmetry (some sociologists, such as Foucault, see power and asymmetry everywhere and others, such as Habermas, appear to be fascinated by symmetry).



In another sector of society (the economic), the essential symmetrical actions are buying and selling (which conceal the essential asymmetry of profit). Here there will also be pressure, less prescriptive and more actual, towards symmetry. What Marxism saw in the class struggle can be understood from this angle.

## 3 *Symmetry, gestalt and intellect*

Until now we have remained in the social field. But people are not only marked by their family structure, their ethics and their economy. They also have a capacity to observe and think (specific to our species). The notion of symmetry appears to play a central part in these sectors.

3a. People do not perceive incohesive stimuli (colours or sounds). They arrange them — pre-consciously — into meaningful patterns. Gestalt psychologists (Max Wertheimer, Wolfgang Köhler, Kurt Koffka, Kurt Lewin) have examined *how* they do this. It turns out that people arrange the stimuli presented to them to form a whole that's *as symmetrical as possible* (while yet compatible with the real impact of the stimuli that affect them from outside).[14]

3b. Perception is at the service of action. Action is fundamentally problem-solving. Cognitive psychology has sought the laws in accordance with which this problem-solving occurs. It appears that the given information is classified and ordered (in many different ways, in order to arrive at a multiplicity of views of the given problem) and then the new insights gained are again classified and ordered into theories (and reclassified and ordered). Henri Poincaré had already observed that the structures of thought are connected to mathematical groups (whose realisation in physics he saw as symmetries and invariants). Jean Piaget, inspired by Poincaré and Einstein, then traced mathematical groups in various structures of thought (whose mobility creates a tension with the rigidity of the Gestalts).

These are just a few isolated examples. We find them crucially important because they occur in areas essential to man: family, laws and ethics, economy, perception and thinking.

We may take it as proven that symmetries play a crucial part in nature and life as well as in humanity.

What we have not yet made clear, however, is how this role of the *same* fundamental ideas can nevertheless also be *different* in different areas.[15] This remains an important question which need not be answered in the present paper, but which, as we said in the introduction, conditions the wealth of the topic of symmetry.

## B THE SYMMETRY BREAKS

### *Time, change and irreversibility*

Apart from spheres, cubes and mirror images, which one can map in many different ways on themselves without changing anything qualitatively, we know a great number of irregular shapes, every movement of which shows another aspect, as well as many oriented shapes (houses are not symmetrical as far as their roofs and cellars are concerned, like people and their head and feet, and arrows with their points and tails). But — as we have already observed — the great *relationships*, the laws of nature, are invariant and symmetrical under a large number of transformations.

Irreversible processes are the most fundamentally asymmetrical entities. A kind of process, P, is by law irreversible if its reversal, O(P), is excluded by the laws of nature. The reversal of a process that consists of a series of sub-processes is defined as follows: O(ABCD) = (O(D)O(C)O(B)O(A)).

We know of a number of irreversible processes. They are in essence symmetry breaks. They are the opposites of the symmetries that determine the laws of invariance. When we were talking about symmetries, we were not so much interested in special symmetrical bodies, but rather in relationships that always remain invariant and which held for *all* bodies.

In the same way we are here also fascinated by processes that change a large number of systems (taken to the extreme, even *all* systems). Time is one such universal irreversible process. It forces itself irresistibly on our experience. But even so it is a puzzle. So many attempts have been made to describe the concrete, intrinsic, irreversible process that is time, all of which left us somewhat dissatisfied, that many people (the most competent including A. Grünbaum) reduced time to a subjective form.

And yet a number of irreversible processes can be called candidates for *universality* (even though the essential and universal irreversibility has not been achieved). We shall summarise a few.

## *I Asymmetries in inorganic nature*

1. If hot and cold objects are brought into contact with each other, they will in time reach an average temperature between the two extremes,



whereas it never occurs that two objects with the same temperature suddenly display a great difference in temperature.

A gas that occupies a part of a container will spread itself throughout the container (whereas the reverse never occurs).

These and similar facts are explained by the only law of nature that implies irreversibility: entropy never decreases in a closed space (but remains either constant or increases). Entropy is a measure of the homogeneity of a system, or, put differently, of the degree of difficulty of the operation by which means one can extract usable energy from this system.

Translated into statistical mechanics, we can interpret the gases, liquids or solid bodies as collections of particles. A microsituation of the system tells us the velocities and positions of all the particles. A macrosituation provides the values of several macro-variables: temperature, volume, pressure (for example). A given macrosituation can be realised by many microsituations. If we may assume that all microsituations are equally probable, then the probability of a macrosituation is the number of all the microsituations that are compatible with it, divided by the total number of possible microsituations. This probability is proportional to the entropy. The second law of thermodynamics says that a closed system always moves towards macrosituations with a greater entropy and greater probability.

Systems do not have the tendency to move towards situations that are less probable than the one in which they were. A natural law from which this irreversibility would inevitably be inferred was sometimes proposed, but never generally accepted.

This arrow of time discovers the basis of irreversibility in a relationship between different *layers* of reality (micro and macro layers). The behaviour at the micro-level manifests itself on a macro-level as an arrow of time.

2. The universe in which we find ourselves can best be accounted for by assuming that it is a volume which up to about 10 to 15 billion years ago was little more than a point, and since then it has increased its diameter at a recordable velocity. This expanding universe displays one irreversible process: its expansion. This expansion itself is not, however, the consequence of a known law of nature. It cannot even be explained by any actually known natural force.

Once we accept it, there occurs in the universe a process which is up to now irreversible (it cannot be excluded, however, that the process might reverse itself). In reality symmetrical universes (where the situations at the beginning and end are identical) remain possible. The expanding universe may also be a part of a mega-universe that remains constant, or an episode in a series of forms of universe, a series which, taken as a whole, remains the same. This arrow of time finds the basis of irreversibility in a property of the *totality*.

3. A source of light radiates electromagnetic energy in all directions. It does not occur, however, that a wave of light coming from space gathers itself into a source of light.

Here, a time asymmetry is grounded in the interactions on one *intermediate* level of reality (neither the cosmos nor the elementary particles) and not by interaction between layers (as was the case with the first arrow of time).

4. Up to now we have sought examples of irreversible processes in the universe as a whole (expanding system) in relationships between macro and micro layers (thermodynamic arrow), and in a meso-layer (the spread of electromagnetic waves). We also find them on the micro-level: in the field of the elementary particles: a K-meson (it is not necessary for us to know here what this particle is) usually disintegrates in the following way:

$K_L \nearrow$ $\pi^-$ negative pion
$K_L \rightarrow$ $e^+$ positron
$K_L \searrow$ $V^+_e$ neutrino

However, it may disintegrate as follows:

positive pion $\pi^+$
electron
antineutrino $V_e$

The two forms of disintegration are literally each other's mirror image: mirror images in space (right or left) and mirror images as charges (what was negative becomes positive, and *vice versa*). Everything we know about the laws of invariance would lead us to suspect that the two processes occur with the same frequency. This is *not* the case, however. The second process occurs *slightly* less frequently.

This hardly seems an essential point. It is, however, as important as it is incomprehensible. A law provable in the quantum theory says: CPT = I, which means that if, in succession, one reverses a system's direction of movement (T), then takes the spatial mirror image (P) and then replaces positive by negative charges (C), one obtains an operation that changes nothing, an identity I. This "CPT = I" law, taken together with the small difference in the frequency of the two decompositions just mentioned, entails that the $K_L$-system is not invariant under a T-transformation (reversal of the arrow of time).



This is the only place where the impossibility of the reversal of time follows strictly from a law of nature and an experiment. In addition to this, everything occurs on a *micro-level*. Seeing, however, that we do not understand why this should be (and what possible consequences it might lead to) we have little more than a tantalising riddle.

5. A much more understandable irreversible process is deterministic chaos. We know that we cannot measure with infinite precision. This implies that we cannot determine the exact place and time of a body. In practice this is not such a problem for many movements: 'small' differences in position or speed do not change their course appreciably. *Many* systems, however, (one might say it is the 'generic' case) are extremely sensitive to their initial state. The tiniest differences can force these systems into random and widely separated courses. If these systems do end up in a part of space and remain there (we call such a region an attractor) then this region will in general have a totally a-periodical form (put crudely: is extremely irregular). Such an attractor is an 'strange attractor'. The movement of an initially sensitive system towards a strange attractor and its movement within this attractor are very often irreversible. Here we have a form of irreversibility which in principle may occur at any level, but which cannot be attributed to an interaction between levels. This case is analogous to 3.

6. There remains one more source of irreversibility in physics: the measurement of quantum theory systems. We know that quantum systems (characterised by the fact that their states are weighted probabilities of the states of the parts in interaction) transform deterministically in accordance with a Schrödinger equation (the superpositions remain in existence).[16] If one carries out a measurement the system always appears in one entirely determined state (the superpositions have vanished). This phenomenon, called 'the collapse of the wave function', is interpreted in the most varied ways. Whatever it may be, it is an irreversible process.

If one may interpret the measuring apparatus as an exceptional physical system which, interacting with a quantum system, has these surprising effects, then we have an objective source of irreversibility.

So these are the six irreversible processes in physics which have been found, with a great deal of trouble, in a world dominated by symmetries and invariances. None of them is without problems: their mutual relations are obscure.

## *II Asymmetry and experience*

Even so, we find, in our experience, the following fundamental facts:
1. We cannot change the past; but the future we can, in part.
2. We can at least partly represent the past, but *not* the future (much as we would like to).
3. Consequences do not precede their causes.
4. The future does not explain the past.

If we cannot find systems of irreversible processes that represent time in the objective world, in 'greater' nature, then we must explain time as a projection of man or life. We choose not to do this (although great figures like Einstein, Costa de Beauregard and Adolf Grünbaum did do it). Our choice is explained by the fact that we cannot understand our experience if we have to degrade biological time, historical time, economic time, social time and psychological time to projections of our knowledge system. As a short glance at 'human' times will show us, they are, however different from each other and from the physical arrows of time, yet unthinkable without the latter.

## *III Asymmetries in life and mankind*

I. *Biological time*. Since all organisms age and the average lifespan is a characteristic of a species, irreversible time remains tied to life. In the field of the living we encounter 1. the irreversible process of evolution: the process by which the incidence of genes in gene pools changes is a *statistical* process bound to the interaction between the environment and the organism (inter-system process), 2. the irreversible deterministic *algorithm* of growth and age (in this respect differing from evolution), 3. the internal clocks which regulate the physiological cycles (so a deterministic cyclical time), 4. the memory of the species (DNA), and, in complex animals, the immune system that generates a historical identity for the individual by means of antibodies (the product of an *individual learning process*, partly a random series and partly an algorithm), as well as



the nervous system that introduces the parameter of time itself into the *representational systems* of the organism.

Biological time is multiple, both random process and algorithm, provided with chemical and electromagnetic clocks, with units of time in terms of seconds, hours, days, generations, and centuries superimposed on each other.

2. *Mental time* is based on a memory which is explicitly at the service of anticipation and choice. We do not deny that biological time also contains memory and anticipation. But in mental time the two are more in tune with each other and are thereby more selective and reconstructive. Long and short-term memory interact; affective and intellectual consciousness of duration too. The make-up of adults' intellectual time is brought about by a coordination of the succession of events (discontinuous) and the registering of the duration of time intervals (continuous). This coordination is a reversible intellectual operation which, on the other hand, is coordinated with affective time and the irreversible flood of long-term recollection. Moreover, this mental time interacts with historically evolving clocks.

3. *Social time* is the statistical time of traditions, annual ceremonies, commencement and termination of careers and functions, opening and closing of parliamentary sessions and school years. This is a cyclical time, externally linear (made so by the collective actions of the various traditions, tuned both to each other and to the physical clock systems).

4. *Historical time*, as Gilles-Gaston Granger[17] notes, is a process which cannot be defined solely in terms of an initial state and laws of movement, but which must use the state of the system in the course of an interval as the starting point for prediction.[18] It is, moreover, a statistical time in which strict laws are not valid.

Historical and social time can clearly not be converted into mental time. We must therefore have an objective time basis that includes consciously experienced time (le temps vécu) but into which it cannot be converted.

One then tends to convert social, historical and psychological time into biological time. It was a common claim that life was fundamentally a process, and the basic laws of nature timeless. We would certainly be the last to underestimate the importance of the laws of physical invariance. But there are also invariants and symmetries characteristic of life and humankind, and there are also (C.F. Von Weiszäcker was the first to emphasise this in his *Geschichte der Natur* and I. Prigogine made it the subject of his *From being to becoming*) irreversible fundamental processes in nature.[19] Not only is this so; but it must be so. There is no place for an irreversible life in a totally reversible world. No more than the symmetries and invariants of life and humankind would have a place in a nature that was only flux.

*Note*. There are connections between the thermodynamics of systems far from equilibrium (based fundamentally on the boundaries of systems and the gradients at the various boundaries) and biological irreversibility. There are affinities between time for quantum measurement and psycho-social time. The universe's expansion time has a (very) partial analogue in the expansion of humanity and its social systems. Forms of time can be classified by their continuity or discontinuity, by the openness or enclosure of the systems that carry them, by the superposition of rhythms and cycles that occur in them, by the different internal or external clocks they are measured by the natural units and periods which organise them. Later work will have to involve this multiplicity of irreversibilities with each other, provide a rational classification of them, and, first of all, link them up to the various basic symmetries found in reality.

Little can be done in this direction at the moment, but one basic result is too important to our entire world view not to be mentioned. It is taken from *The fractal geometry of nature* by Benoit B. Mandelbrot. Mandelbrot is the creator of the theory of fractals (figures whose Haussdorf dimension differs from the topological dimension). In the course of his work he came across forms and processes which are self-similar. This means that they contain fragments and fragments of fragments which are divided among various classes in accordance with the same law of probability effectue on all levels. It turns out that turbulent hydrodynamic currents always contain sub-processes which themselves display the same form as the whole process to which they belong. Most of the fractal distributions that Mandelbrot studied (terrestual coastlines and the surface of the moon, the outlines of mountain ranges, the distribution of galaxies throughout space) turn out to be self-similar. Strange attractors (which, as we have seen, characterise one of the irreversibilities of nature) are, in general, self-similar. (in many exceptional cases they can even remain deterministically similar in structure while subject to a reduction in scale). One discovers that even at the centre of the world of irreversible processes there are still core symmetries and invariants present (though different from those mentioned earlier). This result is extremely encouraging, but not yet understood, and solidly confirms our overall world view. Self-similarities are symmetries. The future will continue in this direction.



We said earlier that 'being' is also to be found in 'becoming', and therefore also symmetry in symmetry breaks. The self-symmetry of turbulence (a perfect example of an irreversible process) is a concrete realisation of this general idea.

In what we have said up to now we have been expressing, we think, the opinion of most physicists. David Ruelle writes about 'Cette ideé d'invariance d'échelle qui joue un si grand rôle dans la physique moderne'. But we still have no complete theory of turbulence. 'La turbulence réelle satisfait — elle à l'invariance d'échelle? Nous ne le savons pas. La théorie de Kolmogorov, qui est une bonne théorie approchée de la turbulence, est invariante d'échelle.'[20] But according to Ruelle, this theory cannot be complete.

## C FOUR FUNDAMENTALLY DIFFERENT WORLD VIEWS

As we have just seen, the reality in which we live is characterised as a whole by a fairly large collection of symmetries on the one hand, and by symmetry breaks on the other. For the time being we shall leave it open whether we can reduce the invariants to one invariant and the irreversible processes to one irreversible process. The question which is immediately raised, however, is the following: what is the relationship between the symmetries and the symmetry breaks?

We can provide a *dualist* answer: symmetries and symmetry breaks are mutually independent. A *static* answer is also possible: symmetry breaks are derived from the symmetries which are themselves declared to be independent. The counterpart to the static answer is the *dynamic* answer: the symmetries are grounded in the symmetry breaks that explain themselves.

A fourth possibility is that a more fundamental property of reality (which we have not yet encountered) is the foundation of both the symmetries and the symmetry breaks. For reasons we shall explain later, we call this the *ontological* answer.

So we can consider the four following possibilities diagrammatically:

1. Dualism: Sym/As (As represents symmetry breaking)
2. Staticism: Sym $\rightarrow$ As
3. Dynamism: As $\rightarrow$ Sym
4. Ontologism: x $\rightarrow$ Sym *and* As (what 'x' might be will be discussed later)

None of the four possible answers can be considered certain. All four deserve to be expanded. But we do see a number of strong and weak sides to all four. We shall mention them briefly and then go on to formulate and choose our own option.

Let's just observe that the four hypotheses do not completely exclude each other. 1 is of course incompatible with 2 and 3. But (this is important) 1 and 4 can both be true; 2 and 3 can both be true; 2 and 4 as well as 3 and 4 can both be true; 2+3+4, as well as 2+3+not4, 2 and not 3 and 4 and not 2 and 3 and 4 can be true. This follows from pure logic. It is impossible for us to consider every case, but at least we want to make sure we remember the large number of possibilities.

If symmetries and asymmetries, invariants and variables were independent of each other, then (negative argument) a dualistic gap would separate two global aspects of reality present everywhere. This makes the total reality rationally inexplicable. On top of this, every regular cohesion between variants and invariants becomes incomprehensible. We therefore think we may reject 1.

Dynamism also seems unacceptable. Let's suppose that the universe was one big (finite or infinite) asymmetry (more specifically, a process without fundamental invariants). If the universe is a finite process, it starts from nothing and vanishes into that same nothing. Both the beginning and the end are rationally inexplicable because no basis for a process can be found in what does 'not' exist ('nothing').

If, conversely, the alternate explanation (*even* of the partial invariants) had to be given by an infinite process without global invariants, the unity of the process would be lost (since it is assumed that there are no global invariants) and its continuation become as incomprehensible as the coming into being out of nothing in the previous hypothesis.

As since dualism and dynamism prove to be hard to defend, the only possibilities remaining are staticism and ontologism. A total staticism, however, cannot even be formulated. After all, symmetries, invariants and constants can only be determined by *transformations* (which are, *in essence*, asymmetries) which keep certain relationships invariant. Symmetries cannot be determined or recognised except by asymmetries.[21] But can they not even *exist* without asymmetries?

In order to answer this question we are compelled to go back to the 'essence' of 'being', to the 'nature' of 'existence'. This leads us to give preference to ontologism.

The way we put the question (but not the answer) resembles Roger Caillois' 'La dissymmétrie'.[22] We realise that this part of our paper is purely deductive and speculative. In this, it differs greatly from our cautious empiricism in previous sections.



It is our opinion, however, that metaphysics — even when it is scientific — should have the courage to speculate.

## D OUTLINE OF AN ONTOLOGICAL 'DEDUCTION' OF SYSTEM AND CAUSE, OF SYMMETRY AND SYMMETRY-BREAKING. (ONTOLOGY = THE BRANCH OF METAPHYSICS DEALING WITH THE NATURE OF BEING)

We give preference to the fourth hypothesis and try to deduce both the symmetries and the asymmetries from a common basis. We can arrive at our choice of this basis in more than one way.

The 'x' appearing in the fourth hypothesis can represent several different things.

### *I Our option*

We choose one particular option. Everything that is, exists. If we, contrary to what many people think, ascribe a unique content, a fixed meaning, to being or existing itself, then it is not impossible to deduce the most general properties of the totality (on the one hand the symmetries, on the other the symmetry breaks) from the 'essence' of 'existence' itself. If this were to succeed, the most fundamental properties of the total reality discovered by our sciences (which we encountered — in different incarnations — in the great invariances *and* the great irreversibilities) would cease to be accidental riddles, or projections of our human categories, and become essential prerequisites for being itself. We put all our money on this being the case.

### *II Ontology: what is being?*

How do we go about finding out what being is? We can see three sources for ontological study.

1. A psychological analysis of the experience of being (and of its possible disappearance in certain pathologies).
2. A linguistic analysis of words and phrasing that express 'being' in different language families.
3. A logical analysis of symbols employed to express 'being' in different formal systems.

Where the three sources converge the results may be taken as a provisional basis (*if* such results are available). We cannot here present the (not so numerous) analyses of being (of the three types mentioned). We shall only present the reader with their results (he will have to decide for himself to what extent he considers them empirically legitimate).

## *III Being, system and cause*

Everything that exists has the following two properties.

1. What exists has an internal *autonomy*: it has an internal structure which keeps it relatively invariant in different contexts. In other words: everything that exists is a *system*.
2. What exists is linked *systematically* to other existing things, so that changes in the one leads to changes in the other. Everything that exists is a *cause*.[23]

Systems are determined by symmetries. Causes to the contrary are determined by asymmetrical relations (forces by means of which the causes change what is outside themselves and bring about their consequences).

So, if *anything* exists, we may assume that in this existence there will necessarily occur both invariants and irreversible processes.

However, it is evident that this conclusion only gives us new information, insofar as the analysis of the 'notion of being' was convincing, and insofar as we are able to understand 'being', that abstract instrument of thinking, as more than a human projection, as a basic aspect of the existing reality. Not many share this conviction, but I am not entirely alone.

What René Thom calls the most generally intelligible ontology points in the direction of ours. His ontology consists of three entities (S,F,P). S is the set of entities of the ontology; F is the set of conspicuous forms; P a number of propagation mechanisms. I cannot prevent myself from discovering our systems in F and our causalities in his P. F and P allow what exists — the elements of S — 'to be'.[24]

René Thom links up mathematics and philosophy. Eugene Dupréel links up sociology and biology. In his last work, *La Pragmatologie*, he makes an attempt to write a general ontology of daily experience. He uses hardly any scientific material. He too arrives at a dualistic structure, just as we do. If one looks at the two poles of his dualism, they are on the one hand symmetries (providing consistency and similarity) and on the other asymmetries (providing difference and hierarchy). Perhaps



the present text, written forty years later, will succeed in giving greater precision to certain aspects of Dupréel's thinking.

Put briefly, our text presents an essay that, paradoxically, is intended to prepare a scientific synthesis on the basis of an ontology (to bring Heidegger and structuralism together, as it were) and to defend a pre-Socratic philosophy of science against the post-Kantian critique, by means of 20th century science

*Note*

I. The reader might gather from our basic ontological assumption that we are proposing a 'metaphysics good for all time' (*aere perennius*). This is not the case. It is our opinion that progress can exist in the understanding of what 'being' is in general, and of what 'system' is, as well as of what 'cause' is. This progress will at the same time bring with it metaphysical progress, if our hypotheses hold up. We do not even exclude the possibility that there might be such a radicalisation in the development of reality that even a history of being, system and cause (in their ontological dimension) is possible. We cannot see any clear traces of this, however. If such a radical historicity applied, we would, however, (for the reasons that led us to reject dynamism) still believe that this radical process was itself a system, and would occur in accordance with structural invariants on a higher level.

II. The reader might also think that the success of our way of working in ontological metaphysics depends on the starting point we choose. This is equally not the case. It is possible to arrive at the same conclusions from different starting points. Our reality is a multiplicity that is at the same time a unity. Our starting point might also be: what conditions does every uni-multiplicity (which is, moreover, comprehensively complete) have to satisfy?

If it is rational, our reality is a coherent (consistent) self-explanatory system. We could try deducing our basic symmetries and symmetry breaks as the consequences of this coherent self-explanation.

Put more dynamically, we might understand this self-explanation as a self-organisation. Then our deductive question would be: how can basic symmetries and symmetry breaks be a consequence of the idea of a self-organising entity?

These three different forms of deduction can supplement our own and do not conflict with them. If reality is robust, it must be over-determined. We prefer our ontological approach because it is more radical (being takes precedence over uni-multiplicity, completeness, self-explanation, coherence and self-organisation and, encloses all these aspects).

III. The reader will observe that in our story two families of concepts are set opposite each other. The families concerned are: 'Causality-Symmetry Breaking-Change-Process-Force' and 'System-Symmetry-Structure-Invariant-Constant'. These two families do not form confused aggregates.

A causal process occurs when an event or process produces another event or process. If a is the cause of b, b is not the cause of a (the relationship is antisymmetrical in the logical sense) and moreover, the symmetries of the outcome are a subgroup of the symmetries of the cause (so symmetry breaking occurs). A cause always effects a change. So it exerts a force (the most general meaning of force is: to be the cause of work, or of a change in the state of a system; mechanical forces are special cases). A system is an organised unit which remains relatively invariant through a number of transformations. A system is a concrete object with a structure; its structure is the pattern of the interactions of the parts, whose form remains relatively unchanged. Structure is less fundamental than system (just as process was less fundamental than causation). The consequence of what we said is that system is necessarily connected with symmetry and structure. 'Constants' are *quantities* (1) which in *time* (2) remain unchanged (they are therefore special cases of symmetries under time translations).

The two families are clearly internally connected. But what is their relationship with each other? One can argue just as well for the priority of causality as for that of system (this, in a different form, is a repetition of the discussion concerning being and becoming, symmetry and symmetry breaking).

The components of a system interact with each other. This means that causal relationships exist between the events and processes occurring in those components, and which affect each other so much that they make the system as an organised whole affect its environment. In this perspective causality dominates.

But one might also say that a cause acts when it is out of equilibrium and when, by means of the effect it produces, it resolves this imbalance. This means that the degree of symmetry of the cause before it produces the result is lower than the degree of symmetry of the complex system (cause + effect). In this perspective, the notion of the system dominates.

Since these two ways of thinking seem equally defensible (and neither one of them really provides a foundation) we prefer to look for that 'something' from which *both* 'system' and 'cause' follow. We find that 'something' in the concept of 'being' (in spite of knowing how many schools have rejected 'being' as a predicate (Kant), or have argued the multivoty of 'being' (Aristotle)), since something that 'is' must necessarily be able to be identified (and so must possess a lasting autonomy, however minimal) and moreover has to affect other things (and so has to be a cause).



## IV What is deduced?

Having come so far, we actually have an exciting programme before us: on the basis of our points of departure we have to deduce why, in our world, the invariants we discover in it occur (why these and no others) and why the irreversible processes we discover in it occur (why these and no others). The deduction is fruitful insofar as it can be demonstrated that what we *see* <u>must</u> be present in every existing totality.[25]

When we say this we do not mean of course that all chance events at given places and times are fatalities. We only mean that the greater types of invariants and irreversible processes inevitably ensue from being as such.

We cannot carry this plan out completely. We shall choose just three, not unimportant, parts.

1.a. Galileo-relativity (invariance under a shift in space and time and under rotation) has to be true in every universe that contains subsystems.
1.b. Every universe has to display gauge symmetries (local symmetries).
2. An irreversible arrow of time must be true in a universe that displays causality.

In the first part of this paper we listed a number of results of scientific research which characterise the whole of reality (though in various modulated ways). In the second part we put philosophical questions about precisely those results of scientific research. In the third part, which now follows, we link up the (provisional!) answers that we have given to these questions with a few details of the most important scientific results.

## V Symmetry breaks and symmetries demand each other and, as prerequisites, both are consequent to the nature of being

Before we argue in favor of 1. and 2., we put forward another important principle: staticism, dynamism and ontologism can all be true (under a particular interpretation).

1. The basic symmetry breaks must imply the basic symmetries, and *vice versa*: the basic symmetries the basic symmetry breaks.
2. Both symmetries and symmetry breaks are prerequisites for 'system' and 'causality' (linked to each other, as expressions of 'being').

The link between the two follows from the link between system and causality. The coherence of the components of a system and the retention of its structure should follow from the causal interaction of the components. So the symmetries (systemhood) have to be deduced from the symmetry breaks (i.e. the causal interactions).

On the other hand an object can only work on and affect another object when both belong to a common system (temporarily or enduringly). So the symmetry breaks (causation) have to be deduced from the symmetries (systemhood). This forms the second part of our programme.

We can either deduce a given symmetry break from one or more invariants locally, or *vice versa*, a given symmetry from one or more irreversibilities; this is the most precise but also the most difficult task. We can also formulate a *global* maximalisation hypothesis. We assume then that the symmetry breaks that occur are those that maximalise the degree of symmetry of the whole, and that the symmetries that occur maximalise the degree of asymmetry of the whole. Such an hypothesis of maximalisation will have to prove its fruitfulness, but expresses a *global* relationship between symmetries and asymmetries. A global relationship like this must certainly exist if the universe as a whole is a structured system (and not chaos). The global relationship could, however, also have led to mutual minimalisation instead of mutual maximalisation. It will in any case be connected to an extremal principle . We have decided to work with the hypothesis of maximalisation.

This option is far less directly defensible than our other options. We are only using it exceptionally.

## VI Galileo-relativity, gauge symmetry and system; irreversibility and causality

For the building of bridges between science and philosophy it is preferable to take simple examples.



### 1 Relativity and subsystems

Let's assume that in the macrosystem of the totality, systems occur as subsystems. This means that for a number of interactions that take place *within* the subsystems, it holds that they do not depend on the interactions that happen between the subsystem and the total system. If a relative independence like this never occurred, it would be impossible to differentiate between internal and external interactions and we should not be able to speak of subsystems. But what is Galileo-relativity 'in essence'? It states that in a closed vehicle travelling uniformly in a straight line it is impossible to deduce the external state of motion of the vehicle from the internal movements inside the vehicle. In other words: for the special interactions, which movements in space are, Galileo-relativity expresses the possibility of the existence of subsystems. Although this reasoning remains fairly qualitative and vague, it still expresses a basic intuition of our total approach: it is possible — and here we have a simple example — to infer a scientific law (Galileo-relativity) from a qualitative philosophical requirement (subsystems exist). This is not strict deduction, but it does have an argumentational probability.

### 2 Gauge symmetries and systems

We have already mentioned gauge symmetries. They are local symmetries that allow us to change parts of a system at random while yet retaining the system in its global form (forces do then arise between the altered components so that in this case invariance leads directly to causality).

There are many gauge symmetries. It is impossible to consider them here in detail. We have to realise that without the existence of gauge symmetries, systems as such are not possible, since only gauge symmetries preserve structure when components undergo independent changes. Both the whole of the universe and each system in particular will have to display gauge symmetries.

We must emphasise that we did not use the hypothesis of maximalisation in argument in favor of (1) and (2).

### 3 Subsystems as systems

Points 1 and 2 together imply that subsystems exist which, with regard to certain changes, are Galileo-invariant while displaying gauge symmetries with regard to others. More mathematical means would enable us to show that this *double* necessity again puts new demands on reality. Demands which, however, in their turn follow from the fact that it is 'reality' (something which is both system and cause).

### 4 *Causality and irreversibility*

Causality is an asymmetrical relationship (if A is the cause of B, B is not the cause of A: the interaction has an orientation). Let's assume for a moment that two events A and B which, taken by themselves, in relation to the external circumstances, are not probable, nor causal of each other, still occur together. In this case they will have a common cause, C, which has occurred earlier. It is not so, however, that two such events necessarily also have to have a common result, D (it's possible, but not inevitable, whereas the occurrence of C is necessary). So from causality there follows an asymmetry with regard to the transformation of cause into effect (called 'fork causality', by Paul Horwich).

Let's again use the hypothesis of the existence of subsystems (which we have just mentioned in connection with Galileo-relativity). With Hans Reichenbach, we shall then have to assume that the universe as a whole evolved in such a way that many 'branching' subsystems exist that display a high degree of organisation (if they did not display this, then they would not be subsystems, since they would not be enduringly differentiated from the rest of the universe). Forces at work in the environment of the subsystems do not, however, have any causes in common with these subsystems (subsystems and environment are like A and B in the example in the previous paragraph). So they are not correlated with each other (if an external cause, C, is necessary for a correlation between such an A and B). But since a subsystem will not be completely and lastingly isolated (it is a *sub*system), the external and internal forces — uncorrelated as they may be — will still have an effect on each other in the long run. In this way the degree of organisation of the subsystem will decrease by its interaction with non-correlated forces. So, the fork-causality (inferred from causality itself), leads to a form of thermodynamic irreversibility (the non-decrease of entropy in the great majority of branching systems).



## E MEANING AND VALUE

It is almost universal scientific practice and philosophical doctrine not to link up problems of science and value, descriptive or theoretical questions and questions of meaning. The first area is entrusted to research; the second to poetry, politics and prophecy. 'And never the twain shall meet'. We do not agree with this attitude. Our practice has shown us that we may not take part in the schizophrenic division of man into scientist and metaphysician. Confronted with the gap between questions of meaning and of truth, we again reject splendid isolation.

Does our personal life and our collective life have any meaning in this universe, or not? In order to answer this question we must first determine what meaning is. *Meaning is that which gives a global positive value to our global personal existence and/or our global collective existence.*

What is value? Many believe that value judgements cannot be true or false, and cannot be verified or falsified. This conviction is highly counter-intuitive because it gives value judgements the same status as arbitrary preferences. It is my opinion that value judgements should be understood in such a way that they can be true or false. Now, in one form or another, only a theory of correspondence yields a correct theory off truth.[26] The question of meaning (which is also a question of fact) forces us to accept an objective, realistic theory of values. How can we develop it? We suggest starting from our central definition of being.

We found that being is both system-being and cause-being. We saw systems as determined by symmetries and causality by symmetry breaking. Now, a *value* is (this appears, as in the case of being, from linguistic analysis and the logic of values) both something that displays a reference and an orientation, implies a call to action (and so has an asymmetrical structure) and yet also perpetuates itself and 'deserves' to be by means of what it is (and so has a symmetrical structure).

But many values display properties of both symmetries and symmetry breaks. What is characteristic of values is the unity of the two (their symmetry and asymmetry mutually imply each other). In our account we are trying to show precisely that such mutual implication has also been achieved for the totality of existence

If this holds the whole of 'being' has a *positive* value. And our human existence also has a positive value, a part of the totaly of being, capable of reflecting this totality.[27]

However, we must be careful not to let tragedy and evil out of our sight: even if the whole of evolution (for example) had a positive value, there is still so much life destroyed in pain within it that at the same time it exhibits a very large negative value. This can be said with even more justification about the history of a species such as mankind (remarkably aggressive towards itself and others). It may be so that the totality has a positive value, but that few of its parts have a positive value (just as the totality is necessarily the way it is, but few of its parts are necessarily the way they are).[28] Our experience of values revolts against existing reality. However, it is on the basis of what the totality is, what it could become, what the fragments of it are and what they could become, that we revolt against the existing chance structures, starting from an understanding of fundamental and essential structure.

The two attitudes (global being is positively valuable and being is partially negatively valueless) do not rule each other out.

How this can be developed further is work for the future. We shall now be concluding with an outline that begins with an interdisciplinary and integrating descriptive section, then rises to a theoretical explanatory viewpoint and ends with a fundamental assessment and interpretation. Nothing is complete. But a great deal has been started.

## F PRACTICAL CONSEQUENCES

a. The decisions that mankind, or parts of it, have to take on the active stage that is the earth in the twentieth century (a much smaller context than the cosmos about which we have been speculating), are influenced by the way in which this humanity thinks of its universe.

b. Among the decisions that have to be taken, some of the most important are: 1. decisions about auto-regulation of systems (forms of government, oligarchy or democracy); 2. decisions regarding relationships between systems (international politics; intercultural interpenetration and cooperation); 3. decisions regarding the auto-reproduction of systems (bio-ethics in general and educational systems in particular); 4. decisions regarding relationships between human systems and their environment (economy and ecology).

   It is not our immediate intention here to show how these decisions are influenced by the various aspects of the world view just outlined. We are convinced that this influence exists, and must exist (the clearly systematic character of the problems argue for this).

c. The convictions summarised influence:

   1. Our affective attitude towards the total reality: it is of value in itself; it is, however, unfinished and incomplete and also displays tragedy in its essential brokenness. Appreciation and revolt do not rule each other out.
   2. Our affective attitudes towards our own thinking: it appears to us as a familiar (it is inter-system adaptation without imperialism) and expected fragment of the total reality. It appears to us as a never-ending adventure, in a reality to which we are so related that the application of general processes of system selection to our own search guarantees our understanding — both *a priori* and *a posteriori*.
   3. Our affective attitudes towards our own future. The development of the theory of automata provides us with partially superior successors; space travel is preparing our future mobility; the interpenetration of cultures, *and* that of the sciences, sets us up as an increasingly unified humanity against a unified reality. Diverse nationalisms and different forms of poverty oppression and fanaticism cut us off from the bliss surrounding us. The courage not simply to accept the mutilation, when the whole universe indicates totality in diversity and stability in change, is surely a consequence of the picture outlined. But — and one also encounters the fundamental bifurcation here — the value of diversity is not less than that of interaction and communication.



## G CHARACTERISTICS OF TOTALITY

In the previous paragraphs we ascribed a number of properties to the global reality. In order to position our description alongside others and to give it a certain 'countenance', it is useful to link it to a number of short, slogan-like names. But we must be careful that these names or 'isms' do not disguise the complexity of our views.

1. There exists a reality independent of the subjects who conceive it. 1. *Realism. Even* if it is true that the word 'reality' and the concept of 'reality' are constructed by subjects in their interaction with that external, independent world, the independ universe exists.
2. The independent reality is partially knowable (this means that we can partially describe, explain, predict and manage it). II. *Cognitivism. Even* if complete knowledge is excluded, and even if one can never bring together all the knowledge at one's disposal into one theory, reality can be known and understood.
3. Every part of reality belongs to the total reality which, as such, has a structure. III. *Cosmism.* We prefer this word to holism because of the associations the latter summons up.

4. Every part of reality (and the total reality) exists. This most general property 'existence' turns out, after analysis, to be equivalent to being a cause, exerting force. IV. We call this *ontological causalism* or *dynamism* or *nomologism*. Being means being a cause: an object is real if at least one other object exists whose state depends systematically on the state of the first object.
5. Every real object is a system or belongs to a system as an integrating part. V. *Systemism*. A system is a set of components which, by means of real, relatively constant relationships, are linked to each other so that the system affects its environment as a whole and so that structure is relatively well retained during this action.
6. Since the whole is both a system and a force, it must be a qualitatively changeable whole, certain internal relationships of which remain constant. The subsystems have the same properties. VI. *Universal evolutionism*. The totality is both a system and a process.
7. Reality has a *layered* structure. There is the layer of the elements (1), that of the systems composed only of elements (2), that of the systems composed of systems of type (2) (= 3) and so on. The highest layer is the total system. VII. We call this *hierarchism*. Every system arises from the disintegration of supersystems or by the fusion of subsystems.
8. Every layer has properties characteristic of that layer which cannot be predicted on the basis of the properties of other levels. VIII. We call this *emergentism* or *antireductionism*. This does not keep us from being able to know the properties of a given layer only by analysing its elements into parts and linking them into wholes (i.e. by connecting them to other layers). Emergentism rules out neither analysis nor synthesis, but gives primacy to neither of them and never neglects the specific laws of every level of the system.
9. Every kind of system is characterised by a number of invariants (symmetries); and every process is characterised by a number of symmetry breaks. Every 'being' is a system and a process. IX. *Symmetrism and fractalism*.
10. (a) Symmetry breaks maximise the global invariance. (b) Symmetries maximise the global innovation of processes (or emergence, or creativity). X. *Maximalism*.
11. Mental processes are emergent (1) complex activities (2) of self-organizing systems (3) of interacting special cells with maximum connectivity and variability (neurones). So the psyche is an emergent system of transformations of complex energetic-material systems. This is neither spiritualism (the psyche is a structure or form of transformation of systems of 'material' entities) nor materialism (the psyche is not a physical activity nor can it be reduced to such; the material — itself a system of systems — is actually neither inert nor strictly localised). XI. *Energetic mentalism*. (which does not rule out *energetic materialism*).
12. Societies are structured systems of organisms capable of mental processes, purposive action, building models of the environment and purposive learning. They arrive at the form of system characteristic of them by means of self-regulatory global and local subsystems, oriented towards interaction with subgroups, with the physical environment and the interacting societies. This leads to conflict and cooperation which, on a social level, embody typical general system properties. XII. *Social systemism*.
13. In every part of the universe, all characteristic variables have finite values. This does not mean that the universe itself should be finite, but that every fragment is. XIII. *Fragmentary finitism*.
14. The universe is an independent self-explanatory system. XIV. *Autonomous immanentism*. a. This is why the universe is also necessarily *eternal*: Nothingness explains nothing. A universe that grew out of nothing would be completely inexplicable. b. This is why the invariant laws, on the one hand, and the historical succession of situations, on the other, mutually imply each other.

    *Note*

    a. These propositions are compatible with big bang cosmology if one considers the observable universe to be a part of an eternal mega-universe, or as an episode in an infinite series of fluctuating universe periods.
    b. S. Hawking set the mutual implication of law and history (simply another version of the mutual implication of symmetry and symmetry breaking) as a goal (as most certainly did A. Einstein and A. Weinberg), but this goal has not yet been achieved. Apart from the essential synthesis of general relativity and quanta, of genetics and ecology, embryology and evolution theory, mechanics and thermodynamics and history and ethnology in various subareas, this is one of the tasks which is essential, both scientifically *and* philosophically.
15. Since the universe is built upon maximum unity (1) of maximised invariance *and* variability (2), it cannot be purposive. Or, to put it better, it has to develop in a fan-shaped multiplicity of directions. XV. *Ontological pluralism*. This rules out both an anthropic explanation of the universe and the reduction of life or humanity to a peripheral coincidence.

16. An evaluation is an aspiration which is itself a psychological system (a Gestalt) aimed at realising a system with — in that context — maximum symmetry *and* asymmetry. The evaluation — as a dynamic Gestalt or aimed at the realisation of a Gestalt — may be understood on the basis of the subject, of the relationship of subject to object *and* of the object. The universe — as a dynamic system — is, *in its impact on a self-conscious model-building subsystem* (man) — *a value in itself* (in balance) and *aspiring to value* (out of balance). XVI. *Objective axiologism.*
17. a. Mankind, which now already has a planetary role (leading it to more selective self-restriction), *may* have the *chance* of a cosmic role in which it might, cautiously, project its own purposiveness onto that of its broadest environment. b. This chance, which also exists for the other conscious civilisations probably existing parallel to us in other galaxies (until now too far distant to interact), does not prevent conscious civilisations from being only necessary (not coincidental!) by-products of an evolution which necessarily follows from the prerequisites of being. XVII. *Potential cosmic role.*
    P.S. Information and redundancy, complexity and integration, unstable equilibrium and stable equilibrium are related to symmetry breaking and symmetry.
18. Totality is the only possible *existing* system that's consistent with itself. It is therefore not logically essential, but it is ontologically essential. XVIII. *Ontological necessitarianism and rationalism.*

We have not dealt with all eighteen of these convictions, let alone proved them. Most of the eighteen convictions have played a part somewhere, but the complete list serves only as background and frame of reference.[29]

## H WORK FOR THE FUTURE?

Of course we know that this 'Outline of a whole' is unfinished. How could it possibly be otherwise? We would like to put forward a few of the many unsolved problems.

1. The 'deduction' of more symmetries and asymmetries has to be tackled.
2. The notion of symmetry and asymmetry should be applied more consistently to life and history.
3. The ontology should be based on more detailed foundations.
4. A system theory and a theory of causality have to be developed.



5. The maximisation hypothesis in the relationship between symmetries and asymmetries must be developed and legitimised.
6. The theory of values has to be underpinned and developed.
7. The philosophical significance of the various attempts to synthesise relativity and quanta must be analysed (with particular reference to supersymmetries).
8. Other 'bases for deduction' should be tried (deduction from the 'maximally consistent system' or the 'self-explaining system').
9. The 'practical' consequences of the world view must be written out.
10. The mathematical aspects of symmetry and asymmetry in theories of groups, semi-groups, lattices and categories must be developed.
11. Ontology must be used to answer the question, 'Why not nothing?'.

## Notes

* The writer would like to offer special thanks to Hubert Van Belle who took the time to read and criticize this article thoruoughly. He saved the writer from a great deal of darknes and confusion. There undoubtedly remains much to be improved. But it is the author alone who is responsible for that.

1 Weyl, 1952: 45.

2 In *The Science of Pleasure - Cosmos and Psyche in the Bourgeois World View* (Routledge, 1990), Harvie Ferguson says (p.327): 'Symmetry - has largely replaced 'force' as the most fundamental of physical concepts. See Gal-Or (1981:30-31), Davies and Brown (1988:33-47) and Shubnikov and Koptsik (1974)'.

3 *Compt. Rend. Ac. Sc. de Paris*, 140, 1504, 1905.

4 E.P. Wigner, 1979: 43.

From the four 'symmetries' we have just listed one can deduce the basis of classical mechanics (which still forms the core of our physics, though partially supplemented and adjusted).

6 René Thom (in his *Stabilité structurelle et morphogenèse*) has, under another name, put symmetries and invariants in a central position: 'Une G-forme (= class of equivalence for closed areas from a space E, the elements of which are mapped on each other by a group G) A sera dite structurellement stable si toute forme B assez voisine de A dans E est G-équivalente à A'. Systems are in this sense structurally stable if they are invariant under a sufficient number of transformations. Thom (p.31) states correctly that one can only observe and name such systems. We would like to add that they can only exist fully because other, structurally unstable systems are eliminated by infinitesimal fluctuations at the very moment they come into being.

7 We have known since 1956 that some of the changes brought about by the reversal of left and right in weak interaction have other properties.

8 Paul Dirac (*Principles of Quantum Mechanics*, 4th edition, Clarendon Oxford) says (p.13): When a state is formed by a superposition of two other states, it will have properties that are in some vague way intermediate between those of the two ori-

ginal states and that approach more or less closely to those of either of them according to the greater or less 'weight' attached to this state in the superposition process.... The intermediate character of the state formed by superposition thus expresses itself through the probability of a particular result for an observation being intermediate between the corresponding probabilities for the original states, not through the result itself being intermediate between the corresponding results for the original states.

9 'Fundamental Manifestations of Symmetry in Physics', in *Foundations of Physics*, vol.20, no.3, 1990.

10 Weinberg, 1992: 144-147.

11 A state in which electromagnetism and weak interaction, according to the so-called 'standard theory' of Glashow, Weinberg and Salam, cannot be distinguished from each other. Since 1983, the unity of these two forces can also been demonstrated empirically.

12 The transition from a state which is invariant under groups to a state invariant under semi-groups might be a *generalized* symmetry break. We are only stating its possibility. Semi-groups are structures with a part of the properties of the group: a) A(BC) = (AB)C; b) for every A and B, there is a C so that AB; c) $A^{-1}$ does *not* exist for all A; d) e exists. One can weaken even further by abandoning requirement (a) or (b) or the unicity of (e). Weak symmetries may be invariances under semi-groups.

13 In Claude Lévi-Strauss' *Structures élementaires de la Parenté* an appendix written by the mathematician André Weil, expresses which rules of marriage for primitive societies in algebraic groups. So the correspondence between human symmetries and physical symmetries is sometimes *exact*.

14 That this is so appears from the shapes favoured (circle, sphere, square, rectangle, cube), all of which display a large number of symmetries.

15 Because we, in the area of organism and man, have fewer laws and a different sort of laws.

16 David Ruelle, *Hasard et chaos*, p.98.

17 The reader is requested to glance back at Dirac's definition of superposition, quoted previously.

18 'Méthodologie Economique' by G.G. Granger (Chapter II : Equilibre économique et temps).

19 The behavior of economic agents does not only defend on momentary prices and preferences, but also on their memories and anticipations.

20 Prigogine's theory of time belongs for our type 5. It is highly suggestive but departs from formal axions that need deeper justification.

21 This may seem like a contradiction, but isn't. It is sufficient just to analyze the definition of symmetry once more. A symmetry is a transformation (an automorphism) that leaves a configuration unchanged. But: in order to carry out a transformation, its domain and co-domain have to be ascertained to be different. This implies that we cannot speak of a symmetry without assuming a change *in a different respect*.

22 From his *Cohérences aventureuses*, Idées - Gallimard, 1973, p.193-281.

23 A whole series of terms (structure and substance on the one hand and cause, causality, process and force on the other) are connected to the two basic concepts we are using here. They are related but not identical.

24 Thom, 1992: 459.



25 There occur few such attempts in our times. But Ross Harrison put it to the test in his *On what there must be* (Clarendon Press, Oxford, 1974). The basis of his deduction is epistemological rather than ontological.

26 A judgement is true when it 'corresponds' to reality.

27 This is a very daring conclusion. We may be able to reduce the reader's astonishment a little by drawing his attention to one special type of value: 'beauty'. In his *Le Problème esthétique de Thomas d'Aquin* (translated by M. Javion, PUF), Umberto Eco shows that according to Thomas beauty exists if proportion, integritas and claritas are present. 'Proportio' is the adaptation of the parts to each other and of the whole to the parts. 'Integritas' is completeness: achievement in reality of that towards which the object tends (stability). 'Claritas' is an ordered multiplicity in which the total plan is 'visible' (meaning in non-anthropomorphic terms, in which the total plan acts as a cause and ground). It is our opinion that our picture of the universe displays proportio, integritas and claritas, as objectively real in reality. We do not wish to claim that Thomas' aesthetics is necessarily correct, but only to give an example of an objectivist and structurally determined value, whose presence in nature can be checked by a scientific metaphysics. Thomas is not alone. G.W. Leibniz characterizes reality as a system that maximizes complexity *and* integration at the same time. Modern information aestheticians have defined beauty as the maximization of a function of information quantity (= complexity) *and* redundancy (= integration). So in this sense of beauty, G.W. Leibniz' universe is beautiful (as beautiful as in Thomas' definition, as we stated above). Our own duality of 'symmetry' (= integration and redundancy) and symmetry breaking (= complexity, information quantity) is related to Leibniz, information aesthetics and Thomas. It is not so much the literal exactness of these theories of beauty we are defending here as the possibility, in *principle*, of defining values in such a way that it proves possible to check, on the basis of objective facts, whether (and to what extent) they are realized in the global reality. Even the entirely non-'ontological' aesthetics of I. Kant's *Kritiek der Oordeelskracht* provides us with support. To him, beauty is 'aimless purposiveness'. 'Purposiveness' is a clear symmetry break, aimlessness is clearly a symmetry.

28 Those who know modalities know that one must clearly distinguish 'logical necessity', physical necessity' and technical necessity' from each other. We are not asserting that the most general laws and characteristics of our universe are *logical* necessities: we only speak of 'ontological necessity' (following as prerequisites for being or existence).

29 Here this outline ends. This provides the occasion to draw the readers attention to a possible application of the 'symmetry-symmetry breaking' polarity to the act of writing itself. The writer, faced with the fascinating empty sheet of white paper knows himself to be in a position of extreme imbalance, symmetries breaking and asymmetry. He will venture to make his mark in the only world he can call his own - that of text. Every act of writing is a symmetry breaking. But what he will produce is something that he himself has to understand, and that only genuinely exists in his dialectic relationship with the silence that precedes, accompanies and follows, by means of the clear boundaries, the enclosure and the references to himself which produce symmetries in what is written. Group theory has already been applied to prosody; it must and can be applied to general text theory.

*Leo Apostel*

# The Unfinished Symphony: Positions, Agreements, Disagreements and Gaps

## *1 Positions*

First we give a summary of the aims and points of view, formulated by the authors themselves. Then we analyse the agreements and differences. Starting with individual declarations, it is our intention to work toward the broad options which each contributor confronted, in mutual interaction and through personal reflexion.

### *1A Diederik Aerts*

The process producing our universe permuates the whole. It creates 'in sequence' various structured layers. With regard to understanding this creative process, the social and cultural history of mankind gives us a better insight into what happened earlier (in more elementary transformations from prematerial particles to atoms, from atoms to molecules and polymers, from polymers to organisms). The creative process is not a simple movement but a qualitative transformation. Time is more fundamental than space and on different levels different kinds of spaces are created as procedures organising the coexistence and interaction of available entities. The meaning of the whole process is best comprehended on the basis of an inverted reductionism (taking the higher layers as starting point).

### *1B Edel Maex*

Things that are usually thought of separately can be thought of together in a coherent whole without being reduced to each other. This is the case, for example, with human behaviour, the biological structure of body and brain, and the social groups to which we belong. A cognitive space in which all these data have a place can be found. Starting with unicellular organisms, one sees that multicellular organisms come into being through relationships between unicellular organisms (relationships that become relatively stable), just as groups come into being through relationships between multicellular organisms (relationships that again become relatively stable). Through these multilateral networks of relationships, integration and differentiation, processes come into being in unicellular organisms, in multicellular organisms and in groups that finally lead to language, consciousness and self-awareness (all of them created by relationships, all relative stabilisers and at no point reducible to structures of higher or lower layers).

### *1C Staf Hellemans*

Staf Hellemans has a double aim: to give a sketch of the history of mankind — the evolution of the social world — and, to understand how world views function in this real life, in the past and present. The 'worlds' and the 'world views' of ordinary people are the most important objects of study. World-view construction, as an attempt at systematisation and integration of a person's total experience, has always existed and will always exist. This contribution aims to show why this construction has encountered serious problems in our period (due to the immense information explosion, the disappearance of coordinating mechanisms, the disintegration of culture areas and the emphasis on independence and individualisation) and it offers a few suggestions to overcome these difficulties.

### *1D Bart De Moor*

Bart De Moor's contribution is mainly concerned with action. If we build models for parts of the outside world we select the facts we want to portray on the basis of their relevance to our action. World views are special kinds of models that are intended to depict large and heterogeneous regions, used by individual or collective actors for special kinds of action. At the present time we have developed a total technology that leaves nothing undisturbed. This irreversible evolution demands the global models that are world views. An efficient model presents everything in as wide a context as possible in a universal network. There are no fundamental layers and no irreducible layers. In past, metaphysics the prototype of completeness was a self-sufficient substance; in present thought the prototype of completeness is a maximally connected network, the components of which have a maximum impact on each other.



### *1E Hubert Van Belle*

System theory offers a framework capable of integrating virtually all parts of the applied engineering sciences. The author sees the universe as a purposive system of which the complexity increases (locally) and in which organisms and organisations oriented to living and surviving were able to come into being. The optimal conditions under which complex systems such as companies can survive are determined by seeking an equilibrium between extreme possibilities. In the language of system theory, thermodynamics can be expressed, maximum and minimum principles of classical mechanics can be stated and a cybernetic organisation theory for the management of complex organisations can be worked out. The concept of purposiveness, can bring the exact sciences and the humanities in a significant relationship with each other.

### *1F Jan Van der Veken*

When one examines the relationship of man to cosmos and that of the cosmos to man, one finds that a deep solidarity — in both directions — exists between the two. Although man is a late-comer in his universe, he can only come into being and continue to exist in a universe very similar to the present one. The solidarity of man and the planet earth is threatened by our technology and the solidarity of the cosmos with man is forgotten because of our lack of consideration of the relevance of the universe to the 'presence' of man. We should correct these two mistakes, both in action and thought. The meaning that we can give to our existence depends on the position we see our species occupying in its world.

### *1G Leo Apostel*

When one examines the principal laws of nature in physics they prove to expres symmetry characteristics (invariances under transformations). Symmetry and invariance also play an important role in biology and in the humanities. As a consequence, invariance theory and symmetry theory can play an integrating role. However, time and irreversible development also characterise our universe. They are breaks in symmetry, but the symmetry breaking also has an integrative function. Primary Attention should be given (1) to the relationship between symmetry and breaks in symmetry and (2) to an explanation of the types of symmetries and symmetry break observed. From an ontological point of view, the two problems are studied; the relevance of the relationship between symmetry and breaks in symmetry for the experience of value is pointed out.

## 2. *Agreement*

Each contributor to this volume assumes responsibility for his own contribution, as an expression of his own world view. The chapters are not the result of the development of a global plan. Nevertheless it is remarkable that the separate writings meet important common themes. It is important to emphasise this.

### *2A The functions of world views and world-view construction*

2A.1. Each individual and each group continually forms a picture of nature, society and mankind in order to position himself and his action therein. In modern society, fragmented and dynamic, this construction and reconstruction has unavoidably become independent improvisation. Different groups (scientific and philosophical societies, churches, political parties ideological clubs) are called on to provide a multiplicity of suggestions (no ready-made solutions) to individuals *and* collectivities who are searching. This helping function is especially emphasised by Staf Hellemans.

2A.2. A successful dialogue among the different world views is important. To adapt our actions in a meaningful way to those of others, we have to bring our respective world views into contact. It is required to find a commonly acceptable and sufficiently efficient language to picture man and his world. The dialogical function of world-view development is paramount for Edel Maex.

2A.3. Mankind, in a 'technotope', intending to transform itself and its environment by technology and action, must have access to a model of this environment that depicts the variables relevant to action. The applied scientist, Bart De Moor, defends this view. Hubert Van Belle, another applied scientist, looks upon a world view as a concept in control engineering. Complex systems need a *model* of themselves and their environment *to respond adequately to internal and external complexity*.

2A.4. For Diederik Aerts, world views have actual pioneering significance in the development of our universe. Knowing is also creating. Correct unifying world views also create new layers of reality. Just as the larger units of each layer are precursors of new, 'higher' layers of reality, so in the cultural layer of our world, world views are an early attempt by mankind on its way to *a new phase of integration in the development of future reality*.

2A.5. World views are — according to Jan Van der Veken — mainly attempts to *give meaning* . We seek a picture of reality, as correct as possible, in order to better judge what that reality means for us and what we can do that is meaningful in that reality.

2A.6. Why these laws of nature and no others? Why this history of the universe and no other? Why this global architecture of reality and no other? What worlds are possible? Why has this particular reality been realised among the multiplicity of possibilities? Leo Apostel is interested in making intelligible the reality in which we find ourselves immersed. He hopes that an answer to his questions will also provide us with a positive answer to the question of the value of the universe (and to the subsidiary question of the value of man as participant in the universe).

In these seven chapters, different functions of world views are advanced for consideration. They are aids to orientation both for the individual and for groups (Hellemans), they are means of communication for dialogue (Maex), they are 'regulators' in the dynamic equilibrium of complex systems (Van Belle and De Moor), they are stages in a cosmic process (Aerts), they are structures bestowing meaning (Van der Veken) and they guarantee intellectual harmony and intelligibility (Apostel). Regardless of the differences, these accounts remain all compatible and supplement each other.

### *2B The layered and hierarchical structure of reality*

2B.1. Reality rests on a layer of basic entities: the elementary particles. According to Diederik Aerts they are not originally situated in space but become localised in space by a pre-spatial interaction with systems that belong to a higher layer (for example in our laboratories, with test equipment or in primaeval times with macromolecules). The new layer of atoms is in turn the basis for the layer of molecules and macromolecules. This series of layers leads, on the one hand, to the megastructures of gas masses, stars, galaxies and, on the other hand, to organisms, groups and cultures. Analogous layered structures are also found in the article by Edel Maex who goes from cells, via multicellular plants and animals, to groups and groups of groups, and builds the interaction patterns of all these entities on top of one other. Also for Jan Van der Veken, Hubert Van Belle and Leo Apostel, the layered structure of reality is an important postulate.

2B.2. In addition, all maintain that each layer of entities is subject to specific laws that cannot be deduced from the laws of 'lower' structures. This anti-reductionism is found in all seven authors. It is most clearly worked out by Maex and Aerts, but is also present as a conviction explicitly stated in the work of the others.

2B.3. In addition, since sooner or later all speak of 'higher' and 'lower' layers, they all assume that the system of layers has an 'hierarchical' structure.

2B.4. When the series of layers is viewed as produced by a process, one could understand this process in three ways:

- as being determined by its later stages (finality or purposiveness);
- as being determined by its earlier stages (mechanism; in special cases: neo-Darwinism);
- or with no stage of the process being given prominence, but with each stage being explained on the basis of the whole.

With regard to these points the opinions are divergent. Hubert Van Belle and Jan Van der Veken (each in a different way) recognise purposiveness. Jan Van der Veken, however, pleads for a distinction between 'direction' and 'purpose' (or between 'finalité de fait' and 'finalité d'intention'). Diederik Aerts, Edel Maex and Leo Apostel, each in his own way, reject purposiveness. All articles, whether they do so expressly or implicitly, reject a mechanistic causal determination of later stages by earlier stages (this is just the dynamic expression of the anti-reductionism that is expressed by all authors).

2B.5. Various authors examine either explicitly or implicitly a principle of hierarchical arrangement of the layers. Diederik Aerts and Edel Maex do not see a progression in the layered structure. Cells have (Maex says) a more complex structure than sponges; individual humans a more complex structure than many groups. Diederik Aerts sees the transition from a 'lower' to a 'higher' (possibly stated better as from an 'earlier' to a 'later') layer simply as a conservation of creativity which, after having been active in the construction of one layer, expresses itself again in the construction of other layers on the basis of the first. For him, processes in the quantum layer (the separation of matter and antimatter, for example) could be just as complex as cultural evolution.

For a second group of authors (Van der Veken and Van Belle), the hierarchy of the layers is determined by a vector of increasing complexity.

The central concept of the one group is 'creativity' and that of the other 'complexity'.

Apostel's contribution concentrates less on the discovery of a development law than on the understanding of laws of nature and on finding a universal unifying pattern. Implicitly, however, (on the basis of Apostel's proposition) one could deduce degrees of systematisation, degrees of causality and degrees of interrelationship of systematisation with causality. One could seek a vector of increasing systematisation, increasing force of causality or increasing interrelationship between systematisation and causality in the development of the universe (one could then ask to what extent such vectors are related to complexity (stressed by Van der Veken and Van Belle) and creativity (stressed by Aerts and Maex). This was not done in Apostel's text, however. He only offers a fairly modest attempt to distinguish a more intimate interrelationship of symmetry *with* breaks in symmetry (or a different interrelationship of symmetry with breaks in symmetry) in living matter than in the inorganic realm.

2B.6. Both in the texts themselves and in the discussions of the group, a large number of problems arose with reference to this a layered hierarchical, anti-reductionist world view based on either progressive complexity or creativity conservation.

A) The concept 'complex' is itself very complex. A quantitative definition can be sought. 1. A system with more elements is more complex than a system with less elements. 2. When two systems have an equal number of elements, the system with the most interrelationships (and/or interactions) among the elements is the most complex. 3. The complexity of a system increases as the diversity of the interrelationships increases. 4. Interrelationships among n elements are more complex than interrelationships among m elements where m<n. 5. Interrelationships among relationships are more complex than interrelationships among objects. (This assertion can be generalised by introducing relationships of the 1st, 2nd, 3rd ... nth order and asserting that R(Rm1Rm2) is less complex than R(Rn1Rn2) where m<n.

This enumeration shows that different dimensions of complexity can be distinguished. We do not possess a natural 'aggregation procedure' that enables us to use one single universal measure of complexity by which all entities (stars, galaxies, brains, cultures, cells, works of art) can be compared. It is worthwhile to seek such a procedure. But a quantitative definition of complexity must be connected with, and enriched by, a qualitative definition.

B) The concept 'creative' is just as complex. We could refer to a system as creative to the extent that it produces a number of systems that differ from the first system. Here everything depends on the standard for designating something as 'different', on the number of products, on their divergency and on the degree of transformation their production demands of the first system. In other words, as with complexity, we are confronted once again with the problems presented by any multidimensional standard (applied here to 'creativity').

C) These are not the only 'problems' which a layered world view encounters. Both Diederik Aerts and Edel Maex draw attention to the fact that the transitions from one layer to another can differ greatly. Furthermore, the layers are not discontinuously separated from each other but in places merge into each other seamlessly. And finally, a strict hierarchy is sometimes also interrupted. (The cultural and social layers can alternately precede each other. Psychosomatic interaction introduces a cyclic definition of one layer by the other. Pre-material entities are components of larger entities which in turn first materialise the pre-material entities.)

D) In the *Worldviews* group, consensus could not be reached on the definition of reductionism. For a subgroup, a 'characteristic' of a system **S** is irreducible if it cannot be explained by T(S), (the accepted theory about S) solely on the basis of characteristics of parts of S. This can be called Irreducible - 1 (Irr - 1).

A second subgroup requires more. For its members a characteristic is only irreducible if in T(S) it cannot be deduced from the characteristics of the components of S, together with the existing relationships among them (Irr - 2).



A third group was even stricter. Here a characteristic is only irreducible if in T(S) it cannot even be deduced from properties of S's components, taken together with the internal relationships of those components, and with the external relationships between S and its environment (Irr - 3).

Since a different definition of 'emergent' is associated with each definition of 'irreducible', there are obviously very different views about what is irreducible or emergent.

Even so, these difficulties did not detract from the global orientation of the seven authors towards a universe that demonstrates a great and ordered qualitative diversity of systems and 'layers', diversity that cannot be made redundant by reducing it to a smaller number of (or even to one single) classes of entities. Precisely because of the desire to take 'non-compressibility' seriously, further debate about its exact nature was needed.

## 2C *Metatheory of world views and system theory.*

One of the seven authors (Staf Hellemans) is working on a theory of world views. (In traditional jargon, he is occupying himself with meta-world-view theory.) Another author (Hubert Van Belle) discusses the difference between the control of simple and complex organisations. The characteristics which Hellemans assigns to our present-day culture (and which are decisive for the constitution of a 'world view' in this context) coincide remarkably with the characteristics of complex organisations that Van Belle enumerates. They are capable of being expressed in system-theoretical terms (although Hellemans does not wish to do so here). An agrarian civilisation is characterised by segmentation, hierarchism, scarcity and stability. In system theory this corresponds to:

a. A system that is permanently split up into subdivisions with little mutual interaction (segmentation).
b. The subsystems are arranged in a pyramid, with control from the top down, in a tree structure with few feedback cycles (a hierarchy).
c. Both the structure and the function of the system remain constant, as do also the models the system has of its environment and of itself (stability).
d. The system receives a relatively small input of material, energy and information (scarcity).

An industrial society, on the other hand, is characterised by globalisation, individualisation, historicising and specialisation.

a. The frequency of interactions among subsystems increases and various non-inclusive interaction patterns appear (globalisation).
b. The hierarchies allow greater mobility. They are less linear and the distance between the ranks decreases (individualisation).
c. The structure and functions of the system change constantly and are especially dependent on the recent past. The models of the system and of the environment are subject to the same development (historicising).
d. The system receives an excess of energy, material and information (abundance).

Hubert van Belle applies the same duality to organisations that Staf Hellemans applies to our developing culture. The fertility of system theory as an analogising mechanism is demonstrated by the fact that the development of world views themselves can be expressed in the language of system theory.

The problem arises whether the equilibrium prerequisites which Van Belle notes for complex organisations (an optimal combination of centralisation and decentralisation, of large-scale and small-scale attributes, of specialisation and diversification, of autonomy and independence, of planification and free initiative) do not also apply 1. to all world-view construction (viewed as a problem-solving activity) and 2. to all living and non-living, physical and organic systems in every real world!

## 2D A consensus on 'being'?

Several contributors (not all) ask the most abstract of all subjects: 'What does reality mean? What does being mean?' Bart de Moor deals with ontology, Leo Apostel is seeking an ontological basis for his symmetry-asymmetry dialectic, Jan Van der Veken sees 'occurrences' (Whitehead's 'current entities') as the basic component of being, and Diederik Aerts is outlining a 'discovery-creation theory' of existence. That four authors deal with this question in this context is itself noteworthy. Furthermore, the answers seem to converge (although some interpretation is required to realise this fact).

For Diederik Aerts 'interaction with' is the primal event. All experience is interaction too. In every interaction each participant undergoes the impact of the other, but also exercises influence on the other (each interaction makes each participant both active and passive). When active, a component retains its structure (a form of perpetuation of which



stability is the most extreme form), and interferes irreversible and asymmetrically — another name for such interaction is causality) with the other participants in the interaction. If 'being' is inter-action, then 'being' is perpetuation, linked with efficiency and impact. This duality is also found with Apostel where 'being' coincides with invariance on the one hand and causality on the other hand. Diederik Aerts writes somewhere in *De Muze van het Leven*: 'The essence of the biomousa (his central 'élan créateur') is perpetuation through creativity.' If one replaces 'biomousa' with 'being', 'perpetuation' with 'invariance' and 'creativity' with 'causality' the definitions of being given by Aerts and Apostel coincide.

It is remarkable that for Jan Van der Veken also, the most elementary occurrence is a form of creativity: the preservation of the past by its inclusion in a new entity belonging to present and future. We meet the duality of permanence and becoming once again. At first sight, the ontology of Bart de Moor seems to be radically different (the invariance of the classic substance is opposed to the maximum causal impact that joins the elements of a technotope together). Duality seems to be replaced by monism. If, however, the technotope is not self-destructive, but maintains itself, then we again have the 'duality' we have already noticed (the connection of causality and invariance)! Maex does not develop an ontology. He is a proponent of a strictly constructivistic epistemology in which subject and object are only actualised by their mutual interaction. In this context, he cannot conceive an ontology to be possible. 'Being' (for those who are 'ontologically' oriented), is for Maex the 'elementary object of attention', the simplest object that can be 'referred to'. However deeper analyses of this view yields a result, once again familiar. It must be possible to distinguish the elementary object of attention from its environment, differing from it in a way relevant for the subject. This is only possible, if the object has a certain duration, a certain permanency and also involves a certain becoming, a certain transformation. We can only observe *relatively constant contrasts*. The 'difference' for Edel Maex is an epistemic equivalent of the ontological minimum spoken of by those who think more ontologically.

When one considers this beginning consensus on 'being' one starts to think about the relationship between the being of the beings and their essence. Here there will no doubt also be divergent paths. For some (Apostel) something of the essence of beings will follow from their being. For others the difference between being and beings will be precisely what is important.

### 2E System thinking as an integrating pattern?

To think of reality as an entity, one obviously does not start with a incoherent dust cloud of elements or with an unorganised conglomerate, but neither does one start with a monolithic closed unit. Between conglomerate and rigid monolith there is the system! Both Hubert Van Belle and Leo Apostel give prominence to the system concept, the first on the basis of its unifying force in the engineering sciences, the other on the basis of ontology and as a preparation for the symmetry concept. Hubert Van Belle defines a system as a number of interconnected 'blackboxes' that interact among themselves and with the outside world.

The 'blackboxes' are circumscribed by a closed boundary that separates their interior from their environment. Through a finite number of gates or entrances, the 'black boxes' can be influenced by each other and by this environment, and can also influence each other and the environment. Internal conditions contribute to determining how the present relationship between input and output is influenced by the past. It is immediately obvious that if the classes of 'inputs', 'outputs' and 'internal states' were to completely change at every moment, we would not identy a system. So, every system involves a number of invariants: the class of internal states remains the same (although the states change), the input and output classes remain the same (although inputs and outputs change), the network that connects the 'blackboxes' with each other and with the environment remains the same (although that network, a system itself, also has input spaces, output spaces and spaces of internal states). From all of this it follows that each system remains itself during permutations of input, output and conditions (within limits of course). Furthermore, the system only preserves its identity if the functions remain the same which express how output depends on input and how previous conditions determine following conditions. So there are always invariants and symmetries connected with systems.

A real correlation exists between Van Belle and Apostel on this point. But systems *grow* (both organisms and organisations), *evolve* (both species and economies) and *learn* (animals, persons and certain machines). Now, whether these transformations are defined internally in a strictly deterministic way (growth) or half deterministically and half probabilistically externally (evolution), or are mediated by the growth *and* evolution of the models systems construct for their environment (learning), these transformations are irreversible and therefore asymmetrical. Yet it remains true that as transformations they are themselves dynamic systems (systems of processes) that modify the static character of a system



but do not destroy; these transformations retain a certain process pattern. A connection can be seen between the conservation and dissipation of energy discussed by Hubert Van Belle and the invariants and breaks in symmetry discussed by Apostel.

The asymmetries (which modify the input space and the output space and the space for conditions or — less drastically — the output function and the condition function) are characterised, as systems of process, by symmetries of a higher order.

The fertility of system theory and of symmetry theory are linked, and stand or fall together.

Both Van Belle and Apostel are confronted with, an unsolved problem. System theory is a quasi-mathematical language that does not appear to have any axioms of its own, and no propositions of its own.

Symmetry theory is a part of group theory which also contains no physico-ontological tenets. Both Van Belle and Apostel must prove that their proposal helps them to understand reality. In other words, in their two different but related languages they must express ontological or physical intuitions that make reality intelligible. Neither general systems languages nor group theory are sufficient.

The concepts of mass, energy and information (assumed by Van Belle's system theory and not deduced by it) and Apostel's causality (also assumed and not inferred) present related problems. Whether Van Belle will actually succeed in deducing thermodynamics on the basis of system theory and whether Apostel will actually succeed, on the basis of amplified symmetry, in deducing the necessity of relativistic and gauge invariances, are decisive questions for both. One may also state that Edel Maex' thought is related to that of Van Belle and Apostel (although the system concept does not appear formally) because his sources of inspiration (Bateson, Maturana and Varela) make use of simular distinctions.

The same remark applies — as we saw in 2C — to Staf Hellemans (with Niklas Luhmann in the background).

### 2F Taking science beyond the limits of science

All contributions are characterised by references to values expressed but not developed.

The central value of creativity — and of man as a creator — characterises the contribution based on quantum mechanics (Aerts).

The central value of communication and of the development of coherent accounts of reality (dynamic patterns), which make suffering meaningful and make it possible for action to be coordinated, are the sources of inspiration for the contribution from the field of psychiatry (Maex).

The central value of the maintenance of both autonomy and mutual solidarity is the motivating force of the contribution from the field of sociology (Hellemans).

The central value of the preservation of the human species and of the stability of highly complex systems and of objective value insight — based on the purposiveness of certain phenomena in the universe in the work of one applied scientist (Van Belle) and on the orientation of human history in the work of another (De Moor) — motivates the contributions from the applied sciences.

The central value of the advancement of the highest human potential, of the maximisation of complexity and of action in agreement with the evolutionary tendency of the cosmos inspires the contribution of the philosopher, Van der Veken.

The central value of reality in its entirety, and of our participation in this reality in particular, is the concern of the philosopher, Apostel.

As important as the sciences are for the *Worldviews* group, all of its members believe that a dynamic interaction between description, explanation and valuation is possible and necessary.

This association has not yet been developed as a detailed theme, however (as a consequence of a deliberate self-limitation).

## 3 DISAGREEMENT

The significance of the convergencies increases by placing them against the backdrop of the divergencies. In the dialectic of convergency and divergency, the real vitality of thinking is revealed. For this reason we thought it useful and necessary to ask each author about his objections to the contributions of his co-authors, fellow members of *Worldviews*. What follows is mainly a condensation of the responses of the writers to this question.

### *3A Diederik Aerts*

Diederik Aerts comments about the points of view of Staf Hellemans Hubert Van Belle, Leo Apostel and Jan Van der Veken.

3A.1. Staf Hellemans gives too little attention to the possibility of world-view construction as an episode in the construction of the cognitive-cultural layer of reality. Aerts believes that man will either succeed at creating a greater cognitive and valuating unity through generalised world-view construction (as Hubert Van Belle also wants), or that he will have great difficulties to survive as a species in the world. He does not view a plurality of world views as the unavoidable highest good.



3A.2. Compared with Hubert Van Belle, Diederik Aerts has less faith a priori in the total integrating power of system theory. System theory came into being through abstraction on the basis of macro-objects present in every-day experience (concepts such as boundaries, input, output and state bear witness to this). A discipline such as quantum mechanics cannot clearly define and distinguish the boundary, the input, the output and the state. It appears difficult (if not impossible) to incorporate a concept such as creativity into system theory. Quantum theory was developed on the basis of more specific experiences than system theory and is therefore — as strange as it may seem — more concrete. From that viewpoint, quantum theory may be better suited than system theory to the social sciences (which are also confronted with creativity and have difficulty with concepts such as boundaries).

Diederik Aerts does believe in the possibility (as the so-called 'quantum structures' school espouses) of constructing a new globalising system theory in which 'state' is defined through an interaction with external systems (testing equipment). He refers to work by Randall and Foulis, by Primas, Mittelstaedt and Ludwig.

3A.3. Leo Apostel's symmetry-asymmetry approach is not incorrect. Diederik Aerts is of the opinion, however, that Apostel may be defining the ontological area too narrowly. Knowledge interaction is also part of existence and characterises one of its layers. The relationships between symmetry and asymmetry vary from layer to layer. This changing relationship should be described in greater detail. Once it has been worked out sufficiently, the question arises as to what extent the symmetry-asymmetry polarity is fundamental. One argument pleads in favour of its fundamental character: the dynamics of an underlying layer (an asymmetry) become a symmetry in a higher layer.

3A.4. Diederik Aerts agrees with Jan Van der Veken that man occupies a special and unique place in the universe. He believes that humankind is so specific because of the processes in which it is engaged in the present stage of universe construction. In the region with which we are familiar, mankind is engaged in the creation of new reality layers (the cognitive-cultural layer). Other entities were the most productive in earlier times or might become so somewhere else or at a later time.

### 3B Edel Maex

Maex sees no purposiveness in reality and no orientation in the universe as a whole. He therefore distances himself from Hubert Van Belle and Jan Van der Veken and, to a certain degree, from Diederik Aerts.

He rejects the ontologism of Apostel because he experiences the formation of knowledge more constructively, as the composition of a story that has 'meaning' for the narrator.

System theory cannot be applied to society. The relationship between a cell and a body is not comparable to the relationship between an individual and a society. Too much emphasis is placed on the equality of structure between the transitions of the layers into each other. One may not ignore the differences between them. This distances him from Hubert Van Belle and Bart de Moor.

He feels most in agreement with Diederik Aerts but is afraid that in his scheme the individual person, embedded in complex social and cultural entities, loses too much of his autonomy.

### 3C Staf Hellemans

In contrast with Hubert Van Belle and Jan Van der Veken, he sees neither general orientation nor purposiveness in the universe.

In contrast with Leo Apostel he does not see any chance of deducing as inevitable the laws and history of nature. He also views his search for an ontology as impossible. Apostel's whole approach reminds one too much of Spinoza. Staf Hellemans finds system theory attractive but still keeps himself at a distance. He recognises the creative forces about which Diederik Aerts and Jan Van der Veken speak, but for now (agnostically) sees no reason for bringing them together monistically into one great creative force (whether one wishes to call it 'biomousa' like Diederik Aerts or 'creativity qualified by God' like Jan Van der Veken). In agreement with Edel Maex, he has questions about the application of system theory to the social sciences. In order to apply them one must, among other things, be able to define the boundary and identity of a system. Anyone who wishes to describe politics and/or economics as systems cannot clearly see how their boundaries and identities can be characterised. And what are the components of a social system? People as organisms and as psychic systems certainly do not qualify. Niklas Luhmann proposes the act of communication as the social-system unit. But that is just as difficult to circumscribe.

All in all, Staf Hellemans feels most closely affiliated with Edel Maex.



### 3D Hubert Van Belle

According to him, to make collective action possible a society must have at least a minimally common world view. At present this is almost completely lacking and he is participating in *Worldviews* in the hope of finding one. In contrast with this motive, Staf Hellemans (for example) wants groups such as ours to limit themselves to helping individuals in their efforts toward world-view construction, by our example and by providing factual information. Van Belle finds this in and of itself important, but not sufficient. Hubert Van Belle finds Apostel's concept of 'breaks in symmetry' insufficiently defined.

### 3E Jan Van der Veken

He believes that Leo Apostel wants to explain too much. The *why* of physical laws and the *why* of the global evolution of the universe (in their mutual solidarity) is a problem that cannot and does not need to be solved. It is certainly not possible to deduce the essence of beings from the nature of being.

Furthermore, 'being as such' or 'being in itself' is only a 'being for the subject' from which the subject is abstracted.

When one reflects on purposiveness one must make a distinction between orientation (direction) and intentional orientation (purpose). That the universe demonstrates orientation in its development can hardly be questioned. That a 'purpose' is also involved is more difficult to conclude. In that sense Van Belle is half right and half wrong.

With regard to the rest of the contributions, Jan Van der Veken sees much more unity than they themselves emphasise and he is of the opinion that from a global viewpoint he can agree with them.

### *3F Leo Apostel*

3F.1. He would like to ask the two engineers (Bart De Moor and Hubert Van Belle) about their concept of truth. Hubert Van Belle says specifically that for models truth is purely a matter of their serviceability. In system theory, the question of the essence of reality is not asked. Bart De Moor gives even more emphasis to the degree to which each model is connected to action. Leo Apostel thinks that serviceability must certainly be sought after but wants to make a clear distinction between truth and serviceability. As difficult as it may be to construct a correct theory of truth, it seems to him that success and efficiency cannot be the final and only purpose of world-view construction. He certainly does not identify with this himself and believes that — certainly in the case of Hubert Van Belle — an ambiguous attitude exists with regard to the relationship between truth and serviceability.
This same problem also arises with Edel Maex who is searching for an efficient collective story about reality. Efficiency is fine. But is it not necessary for efficiency and usefullness to have a basis in the nature of reality?

3F.2. Positioning himself opposite Hubert Van Belle, he sees no purposiveness in the total of reality. For him purposiveness is always connected with regulatory cycles (feedback and feedforward), as Van Belle also states, and Apostel sees in the universe as a whole no normalising regulatory cycles and feedback. The ultimate principles (minimum and maximum) of classical mechanics are for Apostel no proof of purposiveness. 1. They are logically equivalent to differential equations. 2. They are not related to regulatory cycles. In general, Apostel has questions about the unity of Van Belle's system theory (a system theory that is to include or serve as a basis for thermodynamics or the theorem of Tellegen seems different from a system theory built to incorporate cybernetics).

3F.3. Apostel is half in agreement and half in disagreement with Jan Van der Veken's relationship between man and the cosmos. He believes — with him — that the anthropic issue is a fertile question for discussion. He distances himself, as does Van der Veken, from Monod and others who view life and mankind as two improbable and extraordinary chance occurrences.
But he does not believe — in contrast with Jan Van der Veken — that conscious humanity is unique in the universe, and even less that the universe is teleonomically or teleologically oriented to allow mankind. He would try to deduce the probability of life from the probability of autocatalytic cycles (Stuart Kaufman) and the probability of consciousness and self-consciousness from the existence of life. Apostel — in contrast with Jan Van der Veken and also partially with Diederik Aerts — observes no clear evolutionary vector in the development of the universe. Apostel is in agreement with Jan Van der Veken when he says about God that 'God is an integrator word in which various meanings are bundled together'. From such a view it follows, according to Apostel, that a language which allows an adequate discussion of religious matters has its own criteria of meaning, coherence and truth which are still to a great extent unclarified. Research in that direction is urgently needed. We already know, however, that the criteria for religious language very definitely differ from the criteria of meaning for scientific and philosophical language. Apostel therefore would not speak about God in the framework of his world view. He is of the opinion that the essence of religion must be sought in mysticism. With regard to that mysticism, however, he finds, as is specifically stated by Edel Maex, that this spirituality is necessary, but that it should not be used in world-view construction (out of respect both for the special nature of spirituality and for the special nature of a world view).

3F.4. In comparison with Diederik Aerts, Apostel has sought more for timeless laws and structures (and for their explanation) than for a line of development (as Diederik Aerts and Edel Maex have done). He would prefer to and understand the line of development later, on the basis of these invariants and symmetries. He is therefore not yet able to decide for or against the specific tendencies of Maex and Aerts. He already believes, though, that he can see that the birth of multicellular organisms, of social groups, of concepts and of languages described by Edel Maex could be understood as the birth by symmetry break of new forms of constants, invariants and symmetries, and that the same applies to the transition of the layers in Diederik Aerts (the transition from the prematerial to the material layer — and more generally — every creation of a new kind of space is always coincidental with the introduction of specific invariants — see F. Klein's 'Erlangen Programm'). But these are just preliminary comments.
In particular, the role of neo-Darwinian mechanisms (although *not* sufficient to explain all genesis) seem to Apostel underemphasised, by Aerts and Maex. The role of socio-economic history in the birth of humanity is emphasised too little.

This is the end of our list of disagreements. We repeat that the interaction of the divergencies with the convergencies shows the strength of the convergencies and gives direction to the future work of the group.

## 4 GAPS

The work of the group is certainly not complete. These seven sketches are a first attempt to give context to some of the seven aspects of world-view construction discussed in *World Views* (published in 1991 by Leo Apostel and Jan Van der Veken, as spokesmen of the *Worldviews* group). By way of reminder, those seven aspects were: 1. The description of the universe; 2. The explanation of the whole; 3. The valuation of the whole; 4. Anticipations of the future of mankind in general; 5. An integrating view of various forms of human activity; 6. An integrating view of knowledge acquisition processes; 7. The classification and history of fragmentary world views.

Which part of the project has been carried out? We shall first indicate what very definitely has not been done. Futurology escaped attention. Point 4 remains blank. A specific model of the various knowledge acquisition processes was not submitted. Point 6 is thus work for the future.

As far as a general praxeology is concerned, Bart De Moor emphasises the importance of a general methodology, but has not yet developed one. Thus, point 5 remains open.

Value problems (point 3), as has already been mentioned, were raised by all (and inspired each contribution) but specific ethical, aesthetic, religious or political propositions were not defended.

The study and history of fragmentary world views was begun by Staf Hellemans (point 7). Other aspects are mentioned by Bart De Moor.

After examining all these limitations it is clear that the centre of gravity of this book lies in the beginning of work on points 1 and 2 (description and explanation).

Edel Maex partially *describes* the development of life, society and the psyche. Staf Hellemans describes a few main lines of force of agrarian civilisations and societies. Diederik Aerts describes the sequence of layers of reality from elementary particles to culture. Jan Van der Veken describes certain relationships between the universe and humanity. Leo Apostel describes symmetries in physics, biology and the humanities, along with breaks in symmetry in the same fields. Hubert Van Belle describes certain characteristics of simple and complex systems. This all — still very partially — contributes to point 1. In addition, Jan Van der Veken, Leo Apostel and Hubert Van Belle also try to explain certain aspects of reality. Implicitly, there are also explanatory elements in the rest of the contributions, but explicitly they are more prominent in the writings of the three contributions just mentioned.

With this we conclude. We have consciously concentrated on the first two of the seven points of our programme (without losing sight of the rest). In the future we shall have to:

- treat points 1 and 2 more fully;
- argue and defend our premises more vigorously;
- discuss convergencies and divergencies in greater detail;
- begin exploratory work on points 5 to 7.

We hope that many will join us, will criticise our first drafts, will, hopefully, redo, cooperate and continue.

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