3. Emergence

3.1. Introduction

3.1.1. About the term "emergence"

Any phenomenon, any movement in the universe belongs to all 6 types of systems or processes simultaneously. We will now attempt to put the results into context, i.e. we wish to create a connection between the various levels of complexity. In this way, we arrive at the process of emergence.

The term "Emergence" has been used with widely varying meanings since the 1920s (STEPHAN 1999). In more recent years, it has been used to characterise patterns of system behaviour which are unpredictable and/or which cannot be traced back to the characteristics of sub-systems or elements. In his discussion of the "emergent behavior" of systems (micro to macro), BAR-YAM (2004) distinguishes four types (pp. 2):

Type 0: Parts in isolation, no positions to whole;
Type 1: Parts with positions to whole (weak emergence);
Type 2: Ensemble with collective constraint (strong emergence);
Type 3: System to environment relational property (strong emergence).

If I understand him rightly, these are the first four system types on the six-part scale of complexity levels with reference to the theory of processes.

In our discussion, we will not characterise the behaviour of systems themselves as emergent, mainly because these events can be described more accurately using the terms of self-ordering, self-regulation and self-organisation. Instead, we would describe as emergence the transition of the processes and systems of lower levels of complexity to those of the next higher level of complexity.

In order to understand the relationships between the various levels of complexity, it is necessary to take a closer look. We showed (see section 2), that the more simply structured processes are involved in the more complex ones. We can progress further here if we treat the levels of complexity (characterised by the systems and processes forming them) as the divisions of a scale. A code leads from one level of complexity to the next (see section 2.2.3, pp.62). Here, a new process takes effect which we will term the "emergence process", because it describes the way in which the structure of the systems receives new characteristics with each succeeding step - characteristics which are not only explained by the components of the system itself.

In the following, we will present the six levels of complexity as a consequence of the emergence process, divided up according to the important indicators:
- emergence and system dimensions,
- course of the processes,
- hierarchy of the processes and systems, and
- folding of the processes and systems.

Previously we take the opportunity of summarising the results of sections 2.1 – 2.6.

3.1.2. Summary of the sections 2.1 - 2.6:

We approach the problem of complexity theoretically by directing our attention at the processes and discussing their course. We take the flows of energy and information as a basis for comparison. The systems are created by the processes, and these in turn are created by the systems. To permit the transfer of energy and stabilisation of the processes, the processes and systems must be concretised by means of a substance. For instance, the social populations stabilise the non-equilibrium systems of the mankind as society. They are the "carriers" which permit the execution of actions and processes.

Tab. 7:
Complexity levels, processes and systems:

Complexity level	Process	System	Control
1	Movement	Solidum	From environment
2	Equilibrium process	Equilibrium system	Self ordering
3	Flow process	Flow-equilibrium system	Self regulating
4	Conversion process	Non-equilibrium system	Self organising
5	Hierarchical process	Hierarchical system	Hierarchically self organising
6	Universal (autopoietic) process	Universal system	Spatially and materially self creating

The processes and systems discussed represent, as mentioned above, archetypes. In the discussion, the broadly inductive results are described inasmuch as they can be described by rules and wherever possible, defined mathematically.

Six levels of complexity can be distinguished due to the internal structure of the processes resp. the systems and their control (see tab. 7).

1st level of complexity (see section 2.1, pp.15):

Reality is constituted materially and is experienced in a multitude of forms. The forms are compact solida definable as units. They are altered by movements. It can be deduced that the energy stimulus in the type of basic process, is conducted through the solidum, i.e. in the co-ordinate system it is oriented to the right (U variant).

The movement of a solidum is occasioned and controlled by its environment (actio/reactio). At the stimulus, it receives energy and returns it to the environment. At this level of complexity, the differentiation of the temporal sequence of events is not yet a matter of discussion. Movement is the simplest form of energy transfer and can be described by corresponding equations in mechanics.

2nd level of complexity (see section 2.2, pp.35):

The movement projects are composed of many movements. They are occasioned and controlled by their environment. During the course of the project, energy is absorbed and again released. This takes place in a certain sequence in time. The process is horizontally structured (C variant). During the course of the process, the elements (and movements projects) adapt to the environmental conditions. In this way, they try to maintain themselves in an energetic equilibrium.

Individually, movement projects behave autonomously and are then identical with the equilibrium process. But frequently they form part of a superior equilibrium process, fit into it according to their possibilities and become involved in it. The sum of all the movement projects is therefore the equilibrium process, and the sum of all the elements the equilibrium system.

The agglomeration depends on the structure of systems of higher levels of complexity. In this way, the elements can be classified by objective factors and are arranged according to their functional context. They are definable as elements of an equilibrium system and strive to achieve an energetic equilibrium for themselves and for the system so that the processes can take place as smoothly as possible.

3rd level of complexity (see section 2.3, pp.69):

The flow processes are composed of many movement projects and equilibrium processes. They receive energy from outside. We distinguish between the energy demanding superior environment and the energy supplying inferior environment, between the flow of information and the flow of energy. The energy supplying inferior environment is involved in the (also energy demanding) system, but both are not connected directly with the other (Lotka-Volterra relations). In this way delays occur between demand and supply. Through feedback, both quantities can be controlled within certain limits. This process of coordination makes the transfer process non-linear.

The processes are vertically oriented (U variant). Supply and demand are guided by the system and the elements. The system and element horizon develop a dynamism of their own within the flow equilibrium system. Both are divided structurally into two parts, thereby producing four bonding levels. This division ensures that the system and all the elements are involved in the process. The process can be formalised.

System and elements strive to achieve a flow equilibrium. The diffusion of the stimulus in the system generally takes place from an initial place and follows a number of different patterns.

4th level of complexity (see section 2.4, pp.119):

The conversion process and the non-equilibrium system are horizontally oriented (C variant). They are composed of many flow processes and flow-equilibrium systems which differ in quality and relate to one another through division of labour. So they are spatially arranged and interlinked with one another as well as with the systems supplying the information and energy in the spatial environment. Energy in the form of products is demanded (flow of information) and supplied (flow of energy).

Tab. 8:
Conversion process and non-equilibrium system. Process stages.

Process level	Process type	Stages
1	Main process	Adoption .... Reproduction
2	Task process	Perception... Stabilisation
3	Control process	1st .... 4th Control stage
4	Elementary process	1st .... 4th Elementary stage

At the same time, the temporal sequence is expanded and ordered so that the internal flow of information and energy can be controlled in time. Processes consisting of several parts are created in a specifically defined hierarchical arrangement, whereby the flow processes and flow-equilibrium systems are coupled and can control certain tasks for the whole.

Four internal process levels can be distinguished (see table 8). The inferior processes work for the superior ones. Each of these processes consists of four stages. In this way, the transfer becomes more controllable than in the flow processes. In this way, it becomes possible to manufacture products which are assembled precisely in accordance with demand (induction process) and supply them to the demanding environment.

Besides, with a certain delay, their own system is shaped by the reaction process in accordance with the requirements identified in the induction process. Both part processes take place in two different process trains which cooperate with one another ("twin processes"). In this way, the conversion process and the non-equilibrium system control and organise themselves.

Outside the controlled non-equilibrium systems, the demanding and supplying energetic environment becomes the horizontally definable sphere of influence (environment). Less time required for transport reduces the energy expended, with the result that short distances are preferred.

5^{th} *level of complexity* (see section 2.5, pp.202):

The hierarchic process and the hierarchic system (here the mankind as society) are vertically oriented (U variant) and hierarchically arranged. They are composed of many conversion processes and non-equilibrium systems. These are bundled at hierarchical levels (flow equilibrium systems) and have certain tasks to fulfil for the whole, i.e. to manufacture well defined immaterial and material products. The hierarchically inferior environment (here the mankind as species) is incorporated in the system. A vertical division of labour has developed. The cohesion of the hierarchical system is guaranteed by a sequence of demand-supply connections (induction and reaction of flow equilibrium systems, specification hierarchy) and by an order-obedience relationship (scalar hierarchy). The non-equilibrium systems occupying lower positions in the hierarchy must produce for the superior non-equilibrium systems. Accordingly, the processes of the inferior systems have a shorter duration (on average by a factor of 10). By means of selection, unsuitable systems are discarded, or new systems are created if these are required. Thus, the hierarchical process and the hierarchical system not only control themselves, but also create themselves structurally.

6^{th} level of complexity (see section 2.6, pp.245):

In the hierarchic systems, it may be possible to create non-equilibrium systems structurally, but not materially. For this, an overriding unit is required, in the final resort, the universe. The universal process and the universal system (examined here in the mesocosmos only), are horizontally oriented (C variant). They are composed of many hierarchical processes and hierarchical systems. These are arranged hierarchically and ordered spatially in spheres. In this way, the systems of the superior spheres encompass those of the inferior spheres. This results in 7 spheres each in the macro and microcosmos (as the involved spatial environment). In the spheres, different forms of matter are generated (autopoiesis). The spheres of the macrocosmos and microcosmos are joined together in the biosphere. The systems of the inter-related spheres in the macro and microcosmos (e.g. the chemical and molecular spheres) are joined together by a system-element relationship. The universe and the systems constructing it control each-other completely.

The creation of matter for its part, is indissolubly bound up with the creation of space. Spaces are defined by their content and this is always linked with matter. The space creating process is originated in the macrocosmos, the matter creating process in the microcosmos. Autopoietic systems create themselves spatially and materially.

3.2. Emergence process

3.2.1. Emergence and systemic dimensions

Why are there 6 levels of complexity and not more or fewer? In determining the course of the processes, our attention was directed mainly at the internal structure of the various processes and systems within the levels of complexity. To find an answer to the above question, it is necessary to look more closely at the relationship between process (or system) and environment.

Increasing complexity is associated with an increasing involvement of the environment in its various forms ("environments"). As the analysis of various process sequences of the conversion processes and the non-equilibrium systems has already shown, we are dealing with two different process trains (see section 2.4.1.2, pp.123). Each of it is divided into 4 stages in the same way as the basic processes, which on their part are dedicated to one system dimension each – quantity (of flow of qualitatively defined information or energy), time (in the sense of the course of the process), hierarchy (in the sense of vertical structural links) and space (understood as geometrical space). We also assume that 4 process or system types are assigned to each process train, and two of these types belong to both trains (see fig. 138).

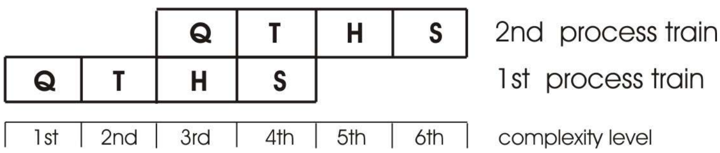

Fig. 138:
Assignment of process types to the process trains and the system dimensions.

In detail:
- 1st level of complexity: The simple movement and the solidum are represented only in the first process train. The stimulus is determined from outside. The path of the stimulus is followed internally. The quantity of the stimulus is the dominant system dimension.

- 2nd level of complexity: the equilibrium process and system too are represented only in the first process train. The stimulus again comes from the environment, the process differentiates the transmission of energy internally. The equilibrium process differentiates the course of time. The flow of energy is divided into 4 steps, i.e. the sequence in the equilibrium process (or movement project) is controlled according to the basic process. In this case, time is the dominant system dimension.
- 3rd level of complexity: The flow equilibrium processes and systems are represented in both trains. In the first process

train the process differentiates the internal hierarchy. 4 bonding levels are created. Energy from the environment is stimulated in the second process train so that the system is fitted into the superior flow of energy. The flow of information and energy can be portioned at the four bonding levels. The hierarchy represents the dominant system dimension in the first process train, the quantity of the energy flow in the second.

- 4th level of complexity: In the same way, the conversion process and the non-equilibrium system are present in both process trains. In the first process train the system as a whole shapes its spatial construction and limits. In this process train, the process is dedicated to ordering space, space is the dominant dimension. At the same time, the chronological environment is involved in the second process train. The chronological sequence is ordered by adopting the rhythm from outside. In this way, it is possible to control the passage of information and energy precisely. Time is the predominant dimension here.

- 5th level of complexity: The hierarchic system is represented only in the second process train. The hierarchic levels consist of flow equilibrium systems (specification hierarchy) and non-equilibrium systems (scalar hierarchy). The hierarchy is shaped, it is the dominant system dimension.

- 6th level of complexity: The universal process and system are also represented in the second process train only. Space and matter are shaped. The hierarchical system and non-equilibrium systems etc. are joined spatially in spheres which shape the macro and microcosmos. Space is the dominant dimension.

Apparently, a clear division of the 4 system dimensions only becomes possible through the co-operation of the two process trains. The first process train is effective throughout four levels of complexity and leads to internal self-organisation, to the process of conversion and non-equilibrium system. The second process train is also effective throughout four levels of complexity, but it leads to spatial and material self-creation, to autopoiesis. It can therefore be seen that we are dealing with six levels of complexity.

With the increasing complexity of the systems, certain characteristics or resources of the environment (according to the systemic dimensions) become involved (see fig. 139). In this way, control over the processes increases. The systems gain independence, i.e. they increasingly dictate the effect on the environment. By contrast, the effect of the environment on the structure and the events in the system declines. The higher up the scale of complexity levels, the more completely this takes place, the more the unregulated environment declines in importance, and the control along the system dimensions of quantity, time, hierarchy and space shifts into the systems. With the aid of space, control is complete at the 6th complexity level. System and elements are enclosed and integrated materially in the cycle of nature.

Movement	Equilibrium process	Flow process	Conversion process		Hierarchical process	Universal process	
Environment		S	S		S	**S**	2nd process train
		H	H		**H**	H	
		T	**T**		T	T	
		Q	Q		Q	Q	
S	S	S	**S**	Q	Q	Q	1st process train
H	H	**H**	H	T	T	T	
T	**T**	T	T	H	H	H	
Q	Q	Q	Q	S	S	S	

Fig. 139:
The predominant system dimensions (bold script) at the six levels of complexity, divided according to the two process trains.

3.2.2. Course of the processes

Now we direct our attention at the differences between the complexity levels. With each step on the scale of the complexity levels, new characteristics of the environment are added. Each extension takes place in the flow of information and/or energy. This leads to the creation of new basic processes with its four stages (input, acceptance, redirection and output). The new parts are connected with one another in a network. Within the network, the basic processes are combined differently vertically and horizontally. Blocks of 4, 4x4=16 and 4x4x4=64 basic-process stages come into being, which for their part, are combined with one another in different ways.

In this way it becomes possible to distinguish the processes of the individual levels of complexity. These internal process structures are linked with one another through the process of emergence. The way in which this is done can be seen by means of the emergence code presented in section 2.2.3 (pp.62). The basis is formed by the sequences of numbers as explained above (see sections 2.1.3 .. 2.6.3). For their composition, see fig. 30.

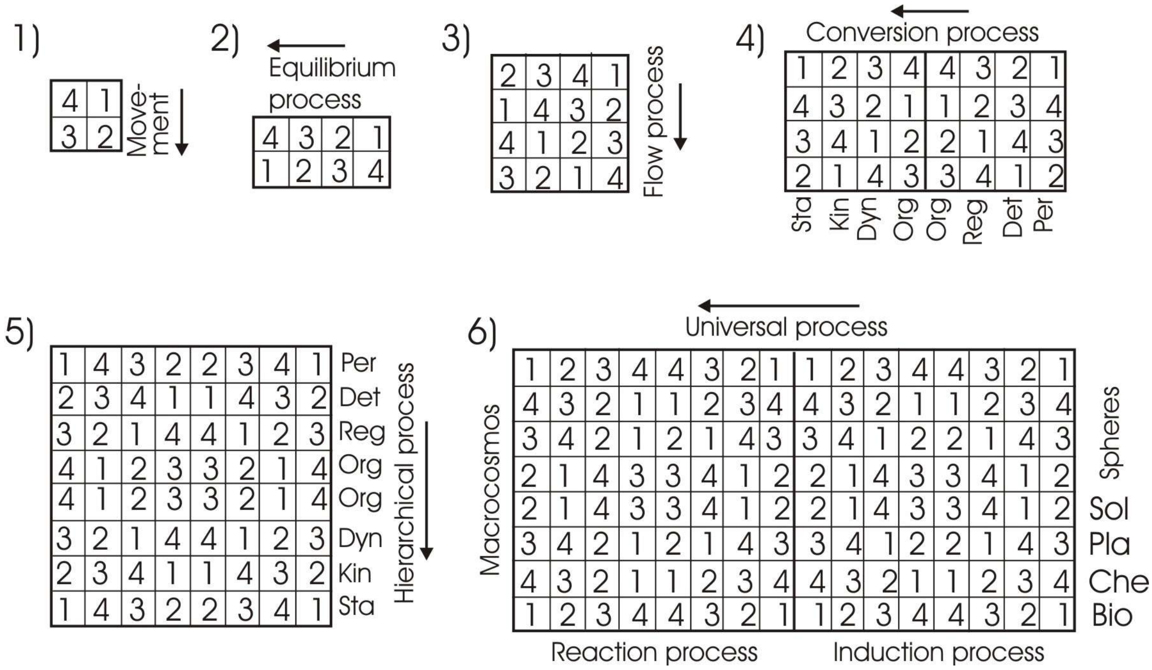

Fig. 140:
The sequence of processes (after the folding stage) at the various levels of complexity (1-6).
Per = Perception; Det = Determination; Reg = Regulation; Org = Organisation; Dyn = Dynamisation; Kin = Kinetisation; Sta = Stabilisation;
Sol = Sphere of solar systems; Pla = Sphere of planetary systems; Che = Chemical sphere; Bio = Biosphere.

The emergence code comprises four operations (bundling - alignment - interlacement - folding). With the aid of this code, it can be understood how, in the course of the process, the process structures of one level of complexity can be transferred to those of the next higher level.

At each transfer, the course of the process changes from the right to the left-hand direction. At the first, third and fifth levels of complexity the processes are oriented to the right (U variant), and at the second, fourth and sixth levels to the left (C variant).

Since the lower half of the process is always folded behind the upper half (see section 3.2.4, p.299) the process sequences assigned to the higher levels of complexity may come into contact with one another. However, they do not mix because they pursue different tasks. Thus, the processes increase in complexity from level to level. Figs. 140 and 141 show how the processes fit into one another.

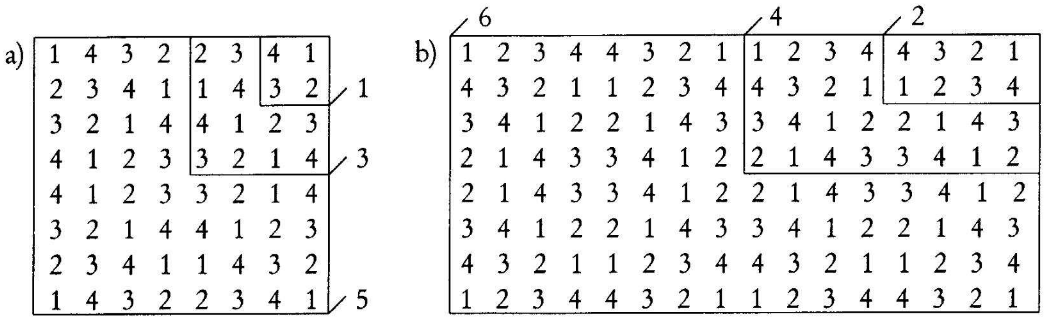

Fig. 141:
The processes of the complexity levels summarised (folding stages):
a) The processes tending to the right of the first, third and fifth levels of complexity (U variant);
b) The processes tending to the left of the second, fourth and sixth levels of complexity (C variant).

3.2.3. Hierarchy of the processes and systems

If the sequences of numbers characterising the different levels of complexity are unfolded (fig. 142), a very simple pattern appears.

A hierarchy becomes apparent, i.e. the processes and systems located further down the complexity scale are subordinate to those further up. With increasing complexity, the transition from one of the six levels to the next can be described typologically as follows:

The basic process with its four stages (see sections 2.1.1.2, p.21) is reproduced exponentially. The types of process preceding on the scale of complexity are included in the processes in each case. Thus the number of stages from the first to the sixth level of complexity increases according to the power series

$$F(x) = \sum_{n=1}^{n=z} x^n = x + x^2 + \ldots x^z ,$$

where x = 4 and n = z representing the number of the complexity level in question.

The processes are circular in structure (see section 2.4.1.2, p.134). In this way, iterative correction of the system structure and shape (in the 3rd - 6th complexity levels) becomes possible depending on the requirements.

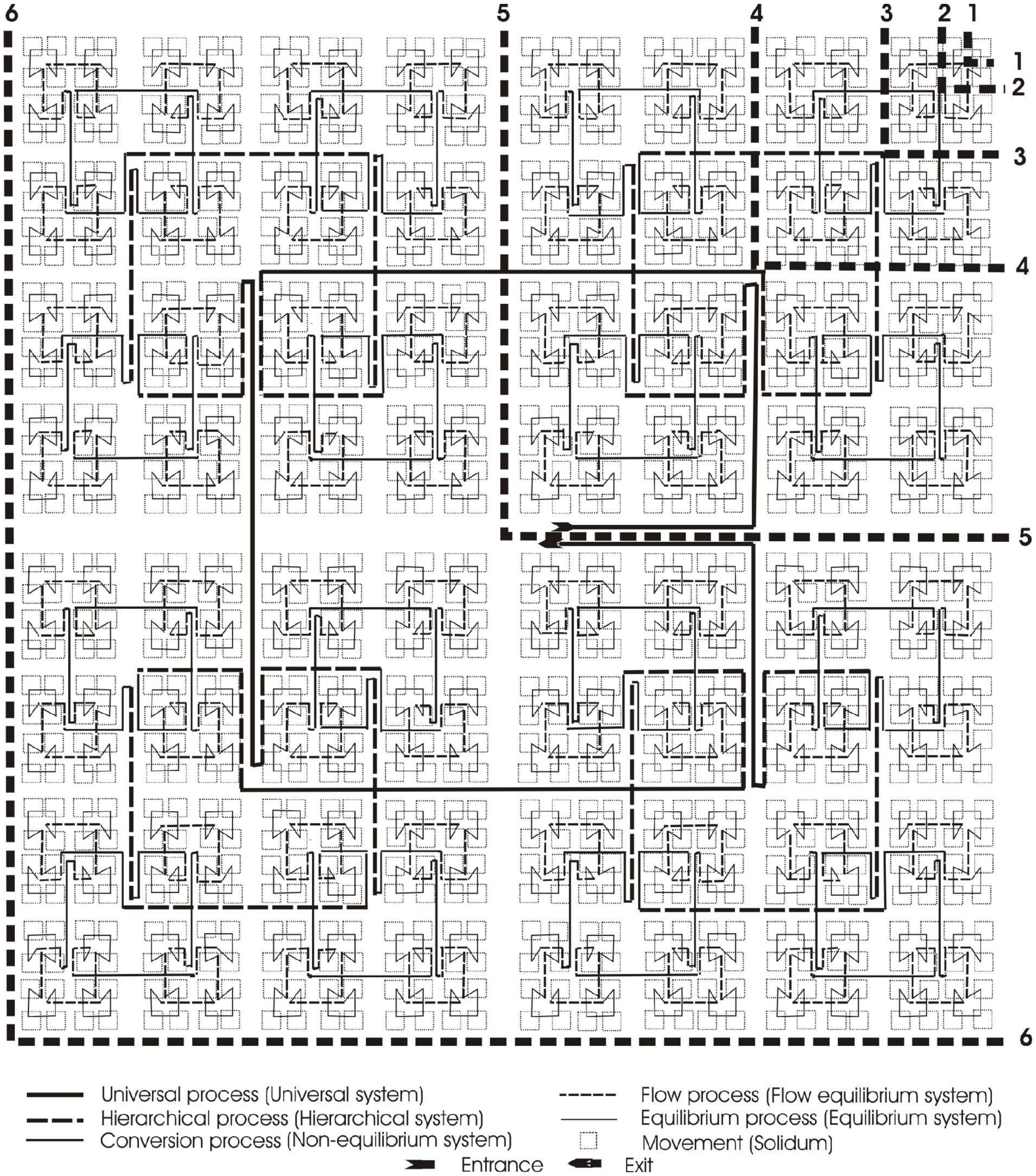

Fig. 142:
The process and system types at the 6 levels of complexity unfolded.
1) Movement and Solidum (U variant),
2) Equilibrium process (Movement project) and equilibrium system (C variant),
3) Flow process and flow equilibrium system (U variant),
4) Conversion process and non-equilibrium system (C variant),
5) Hierarchical process and hierarchic system (U variant),
6) Universal (autopoietic) process and universal process (C variant).
The numbers are omitted as this would overload the diagram.

3.2.4. Folding of the processes and systems

From the above, we have seen that there are different forms of control at different levels of complexity. They are appropriate to the course of the movements and processes, i.e. they are "designed" according to the varying degree of complexity. Every movement, every process has to be kept under control and this is made possible by a counter movement or counter process. In our treatment of the numerical sequences (see sections 2.1.3, 2.2.3 ...2.6.3) we became familiar with the stages of the emergence process. Through folding, i.e. the last of the four operations of the emergence code (see section 2.2.3, pp.62), the process is linked with a counterpart structured as a mirror image (see fig. 143):

There are the system and the involved environment which are connected by the stimulating process and a damping counter process. The folding allows the structured control, either by feedback (vertically structured processes, U variant) or by overlapping of the corner stages (horizontally structured processes, C variant). These operations allow a control and stabilisation of the systems which are appropriate to the respective complexity level.

1st level of complexity: Solida are not systems, and simple movements are not processes. The solidum reacts as an entity, its behaviour is determined according to causality. The stimulus is opposed to a counter stimulus which is originated from the environment ("actio and reactio"; see section 2.1.1.2, p.21, and 2.1.3, p.32). To this extent it is not yet possible to speak of folding. However, in order to develop an approach applicable to all levels of causality, a kind of fictitious folding is used in fig. 143.

At the higher levels of complexity, this is different. Here, control mechanisms are necessary to secure the sequence and preserve the systems.

2nd level of complexity: There are two levels to be distinguished, the stimulating system and the elements as the counterpart. The elements are previously influenced by the environment. They take up their positions and give the system its stability through their movement projects. Thus, the transition of the system as a whole from one state to the next, is subject to deterministic laws. Folding causes the system and the elements to form a unit.

3rd level of complexity: The system stimulates the process, the energetic inferior environment serves as the counter part. Thus, information flow (demand) is opposed by the energy flow (supply). System and inferior environment are coupled with

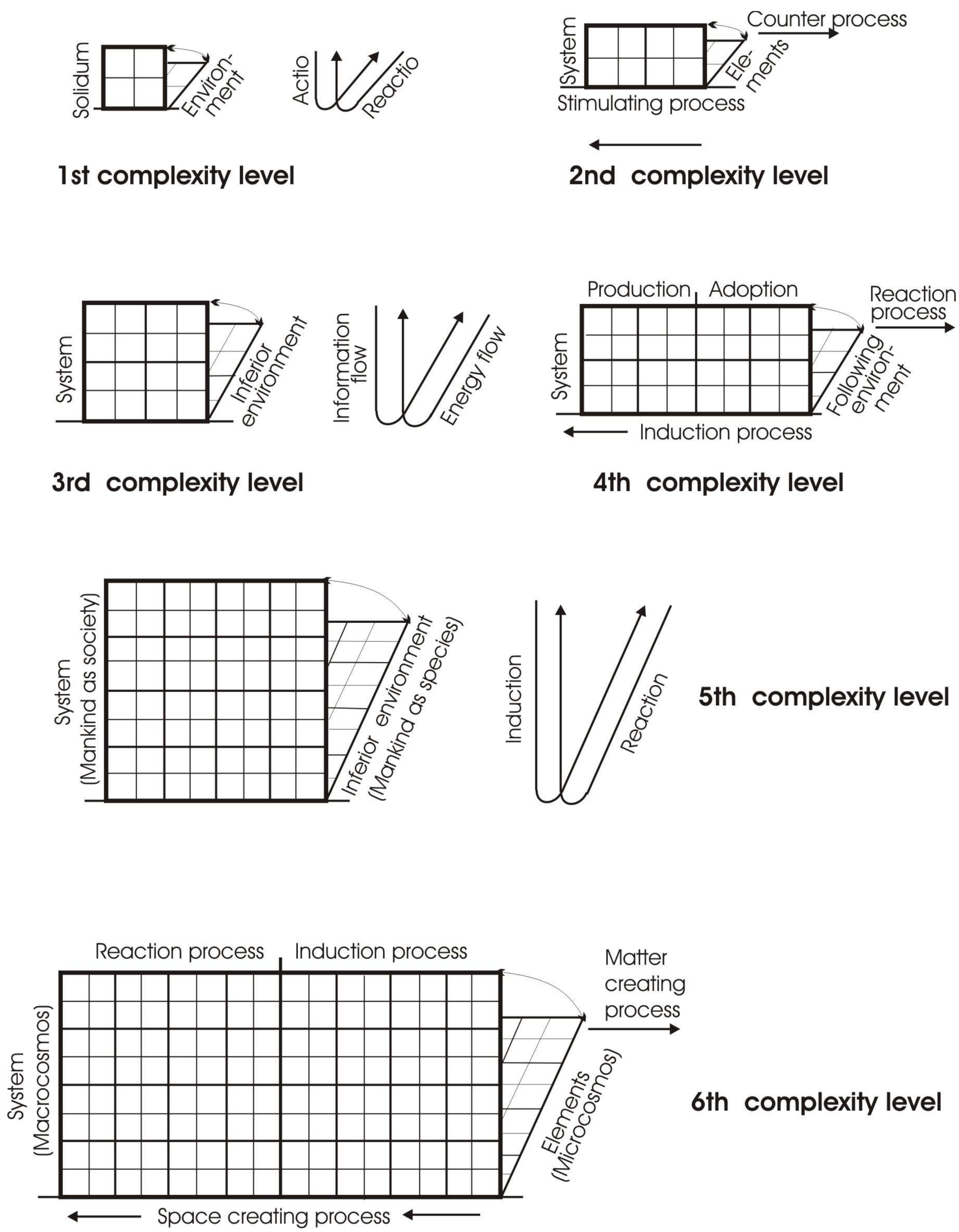

Fig. 143:
Folding in the 6 complexity levels.

another by folding, so that the subsequent flow of energy can take account of the now advanced development of demand (feedback).

4th level of complexity: The elements lose their independence. They now only play their role and are controlled by the system i.e. order followed by obedience. The induction process binds the system to the flow of information (adoption) and energy (production) in the environment. This is the 1st process train. In the 2nd process train the following chronological environment is involved, i.e. the structure-forming reaction process joins in. It serves as the counter part (twin processes).

5th level of complexity: The hierarchic induction process builds up the hierarchic system (e.g. the mankind as society). Here, the non-equilibrium systems are incorporated in accordance with order and obedience. The hierarchic inferior environment (e.g. the mankind as species) is involved as the energy source and serves as counter part (reaction process).

6th level of complexity: The macrocosmos is the stimulating system, it creates space. The microcosmos is the counterpart, it creates matter. Matter stabilises the system. The systems of the microcosmos serve as the elements of the systems in the macrocosmos (order-obedience relation). The space creating processes and the matter creating processes are brought together by folding. Thus it is possible that the autopoietic systems create themselves, not only structurally but also materially.

Epilogue

As already stated in the foreword, the decisive question for this treatise is as follows: how can it be that our reality does not end in chaos in spite of the increasing multiplicity in the course of cosmic, biotic and cultural evolution, but that ordering structures and spaces are created in which each element receives its place and carries out in a practical manner tasks on behalf of the whole?

The answer is: through folding. In the emergence process, every process receives its counterpart which controls it. Every process gives rise to a counter process at all six levels of complexity. This is the precondition for the creation of the ordered structures and spaces characteristic of our reality. It also means that all the simulation processes attempting to make complexity understandable, have to take account not only of the tendency "from the bottom up" (i.e. competition and struggle for life), but also the counter tendency "from the top down" (i.e. rules and order). This on the other hand requires an analysis of the processes at the individual complexity levels.

That is the quintessence of this treatise. In order to arrive at this conclusion, it was necessary, to describe the phenomenon of complexity in one unified theory. Previous theories (e.g. by JANTSCH 1979/92 and CAPRA 1996/99) attempt to bring together the manifold results obtained by traditional research into complexity. However, the various approaches refuse to come together to form a whole. They are impossible to reconcile because they are based on different objects and methods of study. If this is not taken into account, results become vague. The only way forward was by developing a completely new approach. The Process Theory allows insights into emergent processes and attempts to explain the background of the multiplicity of phenomena and structures. To this end, a number of decisions had to be taken with regard to procedure:

Decision 1: The social world is the medium of investigation:

Research into complexity is an interdisciplinary task.
For a long time the natural sciences were responsible for describing and explaining complexity. However, to determine the details of complexity it is first necessary to determine their links. This involves attempting to identify correctly and assess the importance of the tasks of the phenomena in the network of processes. Through the way they approach the problem and the methods they use, the natural sciences often find this difficult.

In social systems this is easier to establish than in biotic or inorganic systems. The enormous diversity of observable complex phenomena and structures in society provides an inexhaustible source of information. Many aspects of the processes are familiar to us and therefore, in principle, understandable, because we are the participants in the complex course of events and understand the associations more easily than scientists who often have to develop elaborate techniques of investigation to arrive at a firm basis for observation. For this reason, the field of "social being" has been selected as the actual medium of study.

On the other hand, any attempt to transfer the results of (natural) scientific to social phenomena seldom produces positive results. In principle, simpler processes are similar both in nature and in society (e.g. BALL 2004). However, serious problems arise in interpreting more complex social phenomena in this way (e.g. LUHMANN 1984 and 1998).

The difficulties in our own procedure should not be neglected either. Human beings are not involved in a clockwork mechanism functioning deterministically. They are free in their decisions. However, the self-determination of the individuals against outside control is restricted. Every human, it should be remembered, is a member of all types of process and system, i.e. he is subject to many constraints and obligations. Within these limits he is free to act according to the multitude of possibilities still open to him - but it is still debatable to what extent.

Decision 2: The structured process is the path of investigation.

In order to approach the phenomenon of complexity, the process itself becomes the central consideration. It is not only regarded (as so often before) as a phenomenon of increasing and decreasing intensity, but as a complex structure which is composed of qualitatively differing stages. Thus, in our description, the process have not only a definable beginning and end, but also a definable course.

Every process revolves around the four system dimensions which (in various combinations) are at the basis of the processes and determine their "progress". The processes and systems develop gradually as entireties, making it possible to understand the behaviour of the system as a whole and its elements. In this way, a scale of complexity appears, leading from the simple movement to autopoiesis. Complexity signifies not only the interlacement of a structure, but also the diversity concealed in the course of the processes.

But of course there are difficulties here too. If the process and its stages are not precisely analysed (which is often arduous and doomed to failure because of the scarcity of sources) it is easy to go astray. It must be clearly understood what significance the individual stages and observable phenomena (which are changed or preserved by the processes) have for the continuation of the process.

Some aspects may appear unusual, such as the fact that the possibility also exists of extending the processes into the future. However this is only possible with regard to the structure. If the initial situation is exactly known, it is possible to predict, in theory, the task to be resolved at the next stage in the process. However, this does not apply with regard to content. We are unable to determine which innovations will become established in future, but only understand them in retrospect.

Decision 3: The intertwining of the flows of information and energy is the aim of investigation:

Our reality appears as a finely veined fabric of process sequences possessing a complex structure. The process sequences represent the flows of information and energy. Starting from observation, the scientific method proceedes to explanation and/or formalisation. With wholes or entireties, this method has its limitations, because complexity involves structures which consist of many parts, which interact with one another and have their own place in the structure of a process.

The linking up of the course of processes to form wholes, particularly at the level of the flows of information and energy, is possible at a deeper more abstract level. The interwoven structure can become apparent here. It can be reached from the level of observation via the structural and functional level by means of reduction.

The following steps are required:
1) Identification and standardisation of the phenomena observed.
2) Definition of the tasks with regard to the superior system and process.
3) Integration in the network of the flows of information and energy.
4) Development of a model of the process sequence.

The enquirer is enabled (e.g. by simulation) to observe the possible steps more closely. In this way he is not led towards the determinism inherent in causality, is not exposed to the uncertainty of hermeneutic thinking, and does not have to follow the automatism at the root of many system models. However, dependable sources are necessary. This also means that research may have to take a new direction, which in many cases may be extremely complex and difficult.

Decision 4: The mesocosmos forms the framework for investigation:

The choice of the social systems as the basis for our discussion also defines the magnitude of the terms of reference. In Antiquity and the Middle Ages, only perceptible space was regarded as being the universe. The atom was the indivisible basis, the lower limit of our environment, while the solar system formed the outer limit (see fig. 128). The terrestrial sphere open to human experience was the space which was available for observation, research and knowledge. In the spatial sense too, mankind was the starting point for all scientific effort. The ability to imagine the universe declined with increasing distance.

Today this space can be regarded as equivalent to the mesocosmos, mankind's cognitive niche (VOLLMER 1985/86, I, pp. 77). At the same time, it forms his social, biotic and inorganic environment. It is the time spaces which are suited to our senses, in which we think and act, in which processes are rationally comprehensible.

The mesocosmos is the field of study for geographers and other geoscientists, but also for historians, anthropologists, economists etc. It is here that the natural and the social sciences encounter one another, approach one another in their methodology and fertilise one another on the basis of perception, experience and knowledge. The language of mathematics is by no means the only possibility for communication.

In the present work, the social, biotic and inorganic systems and processes in the mesocosmos are therefore examined using an interdisciplinary approach. In space and time beyond our human habitat we encounter realities whose characteristics have to be investigated by means of special methods and apparatus. Obviously there are many things discovered outside the mesocosmos in the micro or macrocosmos which appear strange to us.

Do similar phenomena not exist in the mesocosmos or do we find them so obvious in our daily life that they do not attract our attention? Do the measurements of physicists only reveal certain properties whose complexity and material significance we do not comprehend because of the limitations of our experience and therefore do not consider them worth enquiring into?

Perhaps the process theory will also contribute to understanding the processes in the micro and macrocosmos outside of the mesocosmos.

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Notes on the figures:

Fig. 5:
Marcel Duchamp: Nude descending a staircase.
Source: Zeit, die vierte Dimension in der Kunst. 1985, p. 190.

Fig. 6:
Intensity of current I in relation to time.
Source: Bunge 1959/87, p. 378.

Fig. 7:
Block diagram of a mountain-crest formation.
Source: Strahler and Strahler 1973, p. 227.

Fig. 8:
Land utilisation on the Teufelsmoor near Bremen (1965).
Source: Topographical map 1:25000, no. 2719 (Worpswede), edition 1965. Detail: Teufelsmoor (Hamme).
The map shows the situation around 1965 when the structure of the village was still clearly recognisable. Today, the Teufelsmoor is part of the catchment area of the city of Bremen and has changed considerably.

Fig. 16:
Auguste Chabaud: The Farmer.
Source: Chabaud, Auguste 1882-1955, p. 114.

Fig. 17:
Plant associations in the forest region of Bialowieza. Source: Schmithüsen 1959/68, p. 377.

Fig. 18:
Representation of a traditional low-German barn-type house ("Niederdeutsches Hallenhaus"), image and ground plan.
Source: Singer und Fliedner (1970), p. 100.

Fig. 19:
Urban regions in central Cardiff. About 1970.
Source: MURPHY 1971, p. 99.

Fig. 20:
Exiles and refugees in Niedersachsen (Germany) 1955.
Source: Fliedner 1974, p. 14.

Fig. 21:
Idealised cross section of a complex alluvial fan showing the change in geological composition with growing distance from the fan head.
Source: Strahler and Strahler 1973, p. 380.

Fig. 22:
Density of sherds and stone implements, found in fieldhouses at various distances from Pueblo Pecos as indication of the

intensity of agricultural and hunting activities. Sherds: n = ca. 600, stone implements: n > 2000 fragments.
Source: Fliedner 1981 (fig. 5, p. 52 and 273).
Field work in the years 1975/76.
Around the 1838 deserted Pueblo Pecos in New Mexico are the ruins of ca. 1200 small (mostly only one room) houses. Only identifiable rim-sherds of the P IV or modern period were taken into consideration, i.e. not Black-on-White or Culinary-Ware, because in the P III-period not Pecos (Quadrangle or North Pueblo) formed the central point, but the Forked-Lightning Pueblo approx. 300 m away. With the stone implements (resp. their fragments) a similar age differentiation could not be attempted. However, considering the small amount of fragments found near the pueblos, it seemed legitimate to neglect this aspect. Zones, each covering a distance of 200 m were set up around Pueblo Pecos and the fragments found in them counted.

Fig. 23:
Commuter catchment area of Uelzen (Niedersachsen/Germany) in 1961.
Source: Vogt 1968, attachment 28.

Fig. 24:
Catchment area for retail trade in Weißenburg (Bavaria).
Source: Heinritz 1979, p. 90.

Fig. 25:
The intensity of immigration to the town of Göttingen from the Federal Republic of Germany in 1960.
The first 15 days of each month are shown, divided according to occupational group, relative to the number of inhabitants in the areas of origin. n = 2697.
Source: Fliedner 1962b, p.28.

Fig. 26:
Model of the "Thünen rings". After von Thünen 1826/1921.
Source: Waibel 1933, p. 48.

Fig. 27:
Diagram of structure of the city of Chicago. According to Burgess 1925/67, p.53.
Source: Knox 1982, p. 38.

Fig. 28:
Isochronal map.
Source: Hundertmark 1965, Fig. 111.

Fig. 35:
The machine room of a cotton-weaving mill in the year 1927.
Source: City archives Gütersloh. Album Firma Niemöller und Abel, Depositum Ekkehard Niemöller. Repro Lakämper-Lührs.

Fig. 44:
Channel model in which various terms of information theory (fourth bonding level) are explained.

Source: Schwarz 1981, p. 59.

Fig. 48:
Equipo crónica: Concentration, or quantity becomes quality.
Quelle: Pop Art 1991, fig. 181.

Fig. 49;
Flow diagram of Lake Turkana in Kenya.
Source: Begon, Harper and Townsend 1991/98, p. 12.

Fig. 50:
The scheme of a feedback-Loop.
Source: Forrester 1968/72, p. 19.

Fig. 51:
Interaction of the compartments population, capital, agriculture and environmental pollution.
Source: Meadows, Meadows, Zahn and Milling 1972, p. 83.

Fig. 52:
Predator-prey relationship between the spider mite Eotetranychus and the predatory mite Typhlodromus.
Source: Begon, Harper and Townsend 1991/98, p. 239.

Fig. 53:
Example of a business cycle.
Source: Tichy 1994, p. 86.

Fig. 54:
The Kondratief cycle.
Source: Tichy 1994, p. 62.

Fig. 55:
Colonisation processes in the decennial rhythm in Central Europa.
Source: Fliedner 1981 (fig. 20 and p. 280/1). The graphs are based on the evaluation of historical and geographical studies quoted in the above work. The number of newly established settlements was taken as the basis.
Average of 10 years and maximum of the respective curves set = 100.
All the settlements within the above mentioned settlement areas have been taken into account in the graph.

Fig.: 56:
Spread of the covered bridges in the east of the USA in the first half of the 19th Century. Source: Kniffen 1951, p. 19.

Fig. 57:
Evolution of social networks of neighbours under rules [(G1), (M)] according to the model of the Artificial Society.
Source: Epstein and Axtell 1996, p. 41.

Fig. 58:
Spread of the sparrow in South Africa.
Source: Müller 1976, p. 58.

Fig. 59:
Ecotopes and agricultural utilisation (lower Rhine) 1966-68.
Source: Hambloch 1982, p. 260.

Fig. 60:
Household removals within Göttingen (and suburbs) in the year 1960. Converted according to the size of the various areas. (Source: Fliedner 1962a, p. 268).
2973 data sets were used to calculate this diagram. The statistical areas have quite different sizes, so that we may expect the number of movements to and from the area to differ in size. In order to determine the latent tendencies, the same initial conditions had to be created by converting these data. This was done in three stages.
1) First, the average number of moves to and from the areas were determined for the whole area under examination. Then, the real moves to and from each area were brought into ratio with this average figure. The areas with low figures were increased by multiplication and the areas with higher figures reduced by division.
2) The figures were then converted to vectors in a chart to show how the individual areas were related to the others by inward and outward removals.
3) The resultants were then determined for each area and the length of this vector transposed to the width.

Fig. 78:
Raoul Dufy: The orchestra.
Source: Malerei Lexikon 1986, p. 197.

Fig. 79:
Caspar David Friedrich: Morning (ca. 1820).
Source: Börsch-Supan 1975/80, fig. 24.

Fig. 80:
Max Slevogt: Forest landscape near Neukastel.
Source: Slevogt 1992, fig. 170.

Fig. 81:
Karl Schmidt-Rottluff: Bend in the path.
Source: Schmitt-Rottluff 1991, fig. 98.

Fig. 82:
Bernard Schultze: Deep in the forests (1978).
Source: Schultze 1981, p. 54.

Fig. 87:
Diagram of a steam engine.
Source: Kleiber and Jüngling, 1931, p.42.

Fig. 88:
A hurricane in the West Indias as an example of an inorganic non-equilibrium system (weather map).
Source: Strahler and Strahler 1973, p. 136.

Fig. 89, 90:
City-umland system Saarbrücken/Saarland, zoning of socio-economic activities (A and B).
Source: Fliedner 1987 (figs. 3 and 4, p. 115).
The needs of the fast-growing towns meant that a large proportion of the goods required had to be brought from other areas, in the same way as goods produced in the towns had to be sold in other areas, or even through international trade. In spite of this, the ring structure was preserved and in some cases even became more prominent. Map (a) and diagram (b) cover the utilisation activities which were carried out within the context of the task processes of the city-umland population, i.e. within the context of mankind as a society. The unspecified areas in the town area include activities carried out by mankind as a species (e.g. parks for recreation, hospitals, restaurants, hotels etc.).
a) The map:
The radial scale has been distorted according to the formula for wide-ranging effect (see section 2.4.3.1, no. 22) in such a way that each ring has the same width. If one moves from the centre to the periphery, the exponential diffusion with the increase factor k (according to formula no. 5, section 2.2.3) receives a potential growth a:
Step 1: $y_1 = y_0^a * k$
Step 2: $y_2 = y_1^a * k$
In the analytic representation, the radial scale is as follows:

$$y_n = y_0^{a^n} * k^{\frac{a^n - 1}{a-1}}$$

In the case of the city-umland population Saarbrücken, the values used are $(y_0 = 0{,}6; \quad a = 1{,}06 \quad k = 2{,}1)$. The centre is the crossroads Bahnhofstrasse and Sulzbachstrasse.

b) The diagram:
Around this centre, circles were drawn according to the radial scale. The individual land-use rings (1987, p. 113):
I. The demand for products from the superior environment is received (perception). The retail trade appears as an institution.
II. This information is passed to the manufacturing units (determination). Private offices, concern administration, banks etc. appear as institutions.
III. The individuals processing the information receive the instructions as workers (regulation). At the interface between the requirements of the system and those of the individual, public administration appears as an institution. It assures the general conditions.

IV. Passage of the information to the outer area. On the other hand, the products from the outer area are passed to the inner core area. The residential belt becomes established here.
V. The raw materials are processed to form products (dynamisation). Industry should be mentioned as an institution.
VI. The raw materials are transported to the place where they are processed (kinetisation). Short-distance traffic is an important institution here.
VII. The required raw materials are taken from the inferior environment if the resources permit. Agricultural units are located here, at the periphery of the city-umland system (stabilisation).

Fig. 92:
Time map using the example of rail travel in Germany. Source: Spiekermann und Wegener 1993, pp. 484-485

Fig. 105:
Joseph Beuys: Hierarchy in a "party state" and in a "true democracy".
Source: Tisdall 1979, p. 269.

Fig. 106:
The taxonomic classification of plants according to the „International Code of the Botanic Nomenclature".
Source: Weberling und Stützel 1993, p. 14.

Fig. 107:
Diagram of the hierarchy and peripheral areas around a central town.
Source: Christaller 1933, p. 71.

Fig. 108:
Rank-size rule. After Zipf.
Source: Isard 1956/68, p. 56.

Fig. 109:
Innovation centres in millennien rhythm.
Source: Fliedner 1993, pp. 367; Knaurs neuer historischer Weltatlas 1996; Holenstein 2004; Müller-Karpe 1998, especially Vol. 1; Propyläen Geschichte Europas 1975-76/98.

Fig. 110:
Processes in centennial rhythms. Source: Fliedner 1981 (fig. 23 and p. 281) and 1997 (fig. 17 and note 76). These sources are intended as an indication for reference purposes only. They are based on historical publications which permit evaluation of time sequences. In the diagram, the strongest growth was generally taken to be equivalent to one hundred to make comparison possible.
Note on the individual graphs (about the institutions see section 2.5.3.1):
- Perception: The data on the lives of Greek and Roman authors (philosophers, poets, grammarians, mathematicians, scientists, orators, geographers, historians) were used as indicators for

the institutions of art and science (Lexikon der Alten Welt 1965/95) Only data are used which can be fitted into periods of time each covering 20 years. This was simplest in cases where the biographies are known (dates of birth and death). However, in many cases, only information such as "around 300" or "beginning of 2nd century A.D." is given. In these cases, two periods each covering 20 years were entered which correspond to this information (i.e. for the above examples, 280 - 320 and 100 - 140). When only the date of a certain work by the author is known, this was used. On the other hand, no entry was made when only the century is known. The results were smoothed for 3 periods, i.e. a total of 60 years. In all, approximately 1500 single dates referring to around 600 persons were used in this one graph reflecting perception.
- Determination: Areas of Christian conversion (areal growth). Sources: Völker, Staaten und Kulturen 1970, p. 26; Bibel und Geschichte 1997, p. 74-81; Kirchengeschichte (1987/2004); Historischer Weltatlas 1997/2004, p. 33); Handbuch, Geschichte des Christentums, pp. 64-65; Knaurs neuer historischer Weltatlas 1999, pp. 92-93.
For Antiquity uncertain data.
- Regulation: Formation of states in Central and Western Europe (Franconia, Holy Roman Empire. Areal growth). Sources: Knaurs neuer historischer Atlas 1999, p. 106-107; Völker, Staaten etc. 1970, p. 30-31.
- Organisation: Emergence of cities in Central Europe. Source: Stoob 1956.
- Dynamisation: Acquisition of colonies outside Europe. Areal growth. Ten year averages. The number of new colonies acquired by political means on politically foreign ground, taking possession by means of peace treaties etc. The setting up of trading posts is assessed in the same light. The surface area involved was not of major importance for inclusion here; particularly for early centuries the area controlled cannot be established accurately. Moreover, the size of the area under command does not necessarily reflect the importance of the colony (cf. military bases are usually only a few sqare kilometers in size but of great strategic value). Sources: Propyläen Geschichte Europas 1975-76/1998; Knaurs neuer historischer Weltatlas 1996; Völker, Staaten und Kulturen 1970; Propyläen Technik Geschichte 1990-1992; Historischer Weltatlas 1997/2004, p. 162.

Fig. 111: Centres of European innovations in centennial rhythm. Sources see fig. 110.

Fig. 112:
Processes in decennial rhythm: Development of mining and other industries in Germany.
Source: Fliedner 1981 (fig. 14 and p. 276/7). The sources used by me are listed here. The graphs are based on historical and economic studies and handbooks. They are quoted in the above work.
a) Pre-industrial and early industrial activities: 10-year averages, unsmoothed. To assure comparability, the maxima of

the growth rates (foundation dates) were regarded as being equivalent to 100.
b) Mining and industrial production; five year averages, not smoothed. Related to the number of inhabitants.

Fig. 118:
The (deserted) Pueblo Pecos (New Mexico), oscillations in field exploitation.
Source: Fliedner 1981 (fig. 10, p. 75).
Position and dating of field houses: field work.
It was possible to date the periods of field utilisation by means of the ceramics found in the houses, but only in the ruins which really represent relics of field houses. Many of these contained datable sherds. However, many of the houses were used not only as shelter during periods of field work, but were also used as temporary accomodation for hunters, as is indicated by the (undatable) stone tools frequently found in them. Uncertain or unsubstantiated data (single houses after 1600, population numbers before 1620) have not be used because the population declined sharply through attacks by nomadic Indian tribes and the arrival of the Spaniards.
The sherds were dated by me in the Laboratory of Anthropology, Santa Fe. For details, literature on the subject and the support which I received, see Fliedner 1981.

Fig. 119:
Tangential rotation in agricultural land of the (abandoned) Pueblo Pecos (New Mexico) before the arrival of the Spaniards (Conquista).
Source: Fliedner 1997 (fig. 12, p. 74). The graph is based on field work, mapping of the field houses (see fig. 10).
Through the position of the field houses, it was possible to determine which parts of the potential field land was actually used at a particular time. Many houses were occupied over several (ceramic) periods. In all, it proved possible to assign around 1000 field houses to a certain period (multiple use counted accordingly). In order to obtain a cartographic picture of the rotation in field utilisation, the following steps were necessary (Fliedner 1997, page 165):
1. Compiling a 16-part compass rose in order to define in which direction (with reference to the main pueblo), i.e. in which sector the ruins of the field houses are located.
2. In order to eliminate statistically the edaphic differences (between favourable and unfavourable parts) in the land, it first had to be determined how many of the datable field houses were distributed over each sector. The average number of field houses existing in each sector was then calculated, thereby achieving the deviation of the actual distribution from the average distribution for each sector. In each case, this can be expressed by a factor.
3. The number of field houses for every sector and period, then had to be determined and the figures obtained multiplied by the appropriate factor. In this way, the statistically adjusted number of field houses in each sector for each period was obtained. The adjusted figure appears in the drawing.

Fig. 120:
The spanish colonisation of New Mexico 1692 - 1860.
Source: Fliedner 1975 (fig. 3, p. 25/26. For a more detailed description of procedure, see pp. 94/95).
Dating of settlements, migration links: Archives in Santa Fe (Spanish Archive) and Mexico (Archivo General de la Nacion). In addition, datable information in a number of publications listed in the above-mentioned book.
The entry of the individual settlements on the map is based on the first foundation. If a settlement area was abandoned for less than ten years, this was not taken into account.
Criteria for dating of settlement:
1. Written mention: the "Merced" documents (= "grant" documents) governing the allocation of land provide important points of reference. In many cases, it was not possible to take account of the fact that the first settlement did not take place until some years after the allocation. In most cases, the land would have been colonised relatively soon as the governor was empowered to re-possess land still uncolonised after a period of three years.
2. With the Merced areas of the 18^{th} century relating to around five settlements, it was assumed that the foundation of a settlement took around two years and that the ground was occupied piece by piece. This figure was deduced from the sequence of Merced allocations in relation to the number of settlements in the colonisation phases.
3. The criterion given in 2 above can only be used when all the settlements belong to a planned type of settlement (in particular fields divided into wide strips), and common planning is apparent. If several types of settlement exist and no definite names are mentioned in writing, the basis is less certain.
4. This applies in particular to the irregular small farm groups and block fields in the large Merced areas of the 19^{th} century. In these cases, points of reference are provided only by the censuses, which frequently included wide areas and did not always mention individual settlements by name. In these cases, the dates of foundation were distributed evenly over the period between the granting of the mercedes and the appropriate census date (1850 or 1860).
5. Forms whose dating basis is too uncertain, do not appear in the figures. These are relatively few in number (approx. 5 - 10%).
6. Outside the area shown, there were only very few places of settlement. The migrations between 1692 and 1700 were not entered as these involved mainly people who used Santa Fe as a staging point only, but who came from Mexico or El Paso. Also, the indian pueblos and missions were not shown from 1692, but only from 1700, as in many cases re-settlement took place immediately after the Reconquista.
7. Of the settlements in the border areas, especially in the north (Conejos, San Luis), some were only founded shortly after 1860. For more details on the settlements founded after the colonisation period, i.e. after 1860, see Nostrand 1995.

Fig. 121:
The phases in the colonisation of New Mexico by the Spaniards 1598 - 1860.
Source: Fliedner 1975 (fig. 25, p. 70). The sources used by me (historical plans and documents, literature data, aerial photographs, field work) are listed here (see also fig. 11). An important aid in identifying the type of settlement are the irrigation ditches dug during the settlement. Without these, definite classification would have been impossible in many cases. The ditches represent a stabilising factor in the development. Land consolidation was carried out wherever roads and railways were built, but these had no effect on the types of settlement.

Fig. 123:
Population-density profile along the main settlement axis in New Mexico 1776, 1860 und 1970.
Source: Fliedner 1981, p. 154.

Fig. 124:
The age structure of the population in the developing and industrialised countries around 1985. According to Bouvier.
Source: Bähr, Jentsch und Kuls 1992, p.183.

Fig. 125:
Diagram of the phases of demographic transition.
Source: Bähr, Jentsch and Kuls 1992, p. 481.

Fig. 126:
Model of population distribution according to coastal distance and degree of latitude on the ideal continent.
According to Staszewski.
Source: Hambloch 1982, p. 245.

Fig. 127:
Carrying capacity (population size) of the earth taking into consideration the development of foodstuff availability, mineral resources, industrial output and environmental pollution.
According to "Club of Rome".
Source: Meadows, Meadows and Randers 1992, p. 248.

Fig. 128:
The Creation as described in Genesis. Hartmann Schedel (1493).
Source: Schedel 1493/2004. Sheet VI.

Fig. 129:
Shoot and root shape occuring in coastal grasland ("Bottensimsen-Salzrasen") in the western Baltic region.
Source: Dierßen 1990, p. 88.

Fig. 130:
Ecological niche, population response to two environmental gradients.

Source: Whittaker 1970/75, p. 123.

Fig. 131:
The basic structure of the foodchain in the ecosystem.
The review of the processes in an ecosystem was already published in Ellenberg (1973), Fig. 1, p. 3.
This graph was used in simplified form by Klug, H. and Lang, R. (1983), Fig. 22, p. 85.
The drawing is based on this simplified graph.

Fig. 132:
Relative frequency of the chemical elements (characterised by their mass number) in the sun. (Sun and the other stars of population I, which form the greater part of our galaxy). This cosmic distribution frequency is obtained by quantitative analysis of star spectra and by sample (measurements) from our own solar system. The logarithmic scale of the relative frequency should be noted. The zero point (hydrogen) is fixed at 12 by convention.
Source: Meyers Handbuch Weltall 1994, p. 448.

Glossary

Acceptance: (According to the process theory) 2nd stage of the basic process.
Action motion: see movement.
Action project: see movement project.
Adoption: In non-equilibrium systems, the 1st stage of the main process in which the stimulus (information) is received and prepared for the production (first part of the induction process).
Alignment: 2nd operation of the emergence code. Here, the previously bundled systems and their former process structure are prepared for a task in the process sequence being formed for the system of higher complexity, i.e. they are aligned for the new system.
Artefact: A product made by man for improved adaptation to his environment, for acceleration and specification of actions and processes, for presentation etc. In the process theory, we distinguish between immobile ("earth-bound artefacts") and mobile artefacts ("media").
Atoms, sphere of: Sphere in the universal system (in the microcosmos, in the 4th sphere, seen from above in the hierarchy.
Autopoietic system: System of the 6th stage of complexity. It reproduces itself materially within the universal system. Example: living organisms, molecules, atoms, solar systems.
Basic process: Smallest process unit consisting of 4 stages. Input (from the environment) - acceptance (in the system) - redirection (towards outlet) - output (into the environment). The content of the stages materialises differently according to the type of process at the different levels of complexity.
Biosphere: Sphere in the universal system. The biosphere (in the spatial sense) is identical with the global ecosystem (in

the structural sense). Its position is in the transitional area between macrocosmos and microcosmos (in the macrocosmos the 7th sphere seen from above, in the microcosmos the first sphere seen from above). Probable task: stabilisation resp. perception.

Bonding level: System horizon and element horizon in flow-equilibrium and non-equilibrium systems exist according to their exposure to the flow of information and energy between the superior (energy-demanding) and inferior (energy-supplying) environment, each possessing two bonding levels.

Bundling: 1st operation of the emergence code. Here, the systems of each lower complexity level with their process structure are combined or bundled for the new system of higher complexity being formed.

Carrier: The material skeleton (hardware) of the system which gives the links and processes their stability. Thus, for example, the systems, processes, hierarchical structures and spatial links receive their stabilising framework from their substantial carriers (e.g. matter, populations, institutions).

Cell: Autopoietic system, according to the process theory, an element of a living creature in the biosphere (as part of the micro cosmos). See living creature.

Characteristic group: Statistical group of individuals, which, through 1 characteristic e.g. 1 task, obtains its specific peculiarity. Typical of equilibrium systems.

Chemosphere (chemical sphere): Sphere in the universal system (in the macrocosmos, in the hierarchy 6th sphere from the top). Probable task: kinetisation.

City-umland-population: Population (non-equilibrium system) of mankind as a society, belonging to the 4th uppermost level of the hierarchy. Task: organisation.

Coherence: The holding together of the elements in a system (e.g. of the individuals in a population) caused by the wish or compulsion to make and maintain contact.

Community: Population (non-equilibrium system) of mankind as a species (primary population) and as society (secondary population), belonging to the 5th uppermost level of the hierarchy. Task: dynamisation.

Compartment: Structurally, a flow-equilibrium system in the flow of energy, given material form by a carrier and earthbound artefacts (e.g. group of organisates which compete with one another).

Complexity: State of being all embracing, interwoven, difficult to comprehend, entangled. The term "complexity" has its roots in the greek "πλεκω", which means to weave or tie together, and in the latin "complico", which means to fold or wind together, i.e. different objects are connected with and arranged around one another in such a way that they yield something coherent which we can study in detail and as a whole. A complex formation can be represented as a system which is composed of many parts and elements interacting with one another, possibly showing co-operative behaviour. According to the process theory, this means a fabric of processes, information and energy are exchanged, the individual flows are channelled but also screened from one another. These flows join to form process sequences which maintain or alter the system. Depending on how strongly the flows of information and energy are interlaced with one another and the extent to which the systems demonstrate independence, we distinguish 6 different levels of complexity. Complexity in its actual sense exists when the system does not react linearly to a stimulus. This normally applies both to flow-equilibrium systems as well as more complex systems.

Control process: In non-equilibrium systems, a process at the 3rd process level consisting of 4 control-process stages. The control process regulates the internal relations of the system, especially between the bonding levels.

Conversion process: The process maintaining and altering the non-equilibrium system. The process transforms energy (matter) into products. It is divided into stages. The induction process with 7 task stages is market oriented while the following reaction process, also with 7 task stages, alters the system. The tasks must be solved in a certain well defined order. In this way, the system organises itself.

Cultural population: Population (non-equilibrium system) of mankind as a species (primary population) and society (secondary population), belonging to the 2nd uppermost level of the hierarchy. Task: determination.

Determination: 2nd task process stage. Decision on further proceeding, i.e. the stimulus is prepared for the system.

Dimensions, system(ic): (according to the process theory): Measurable extension of basic characteristics through which the size of a system or the position of part of a system can be defined. There are four system(ic) dimensions: energy (1), time (2), hierarchy (3) and space (4).

Division of labour: Action projects (equilibrium processes) and flow processes in the production process carried out by individuals or populations (in non-equilibrium systems, hierarchical systems, and the universal system) are divided and then re-assembled according to thematical criteria. They are not carried out by one person after another, but by several persons at the same time. The projects and processes of the various participating workers or populations are adapted to one another in accordance with a plan. The division of labour forms the basis for differentiation, among other things of mankind as a society.

Dynamisation: 5th task process stage: energy is supplied to the elements.

Earthbound artefacts: Immobile constructions and earthworks (buildings, roads, ditches, fields etc.) formed by man.

Ecosystem: Multifarious biotic system belonging to the 6th level of complexity and composed of different types of systems (equilibrium, flow-equilibrium-, non-equilibrium systems, hierarchical systems). Man also has his place within the ecosystem. From the point of view of mankind, the ecosystem is the most important energy resource. The global biosphere (in a spatial sense) is identical with the global ecosystem (in a functional sense).

Elements: 1. (according to the traditional system theory): Separable and measurable material and energetic components or parameters of a flow-equilibrium system. 2. (according to the process theory): parts (solida or inferior nonequilibrium systems) of which the system consists. Depending on system type, with varying degrees of independence in the system compound. Example: individual molecules in a liquid, individuals in their roles in a population.
Elementary process: In non-equilibrium systems, processes of the 4th process level consisting of 4 elementary process stages.
Element horizon: In flow-equilibrium systems and non-equilibrium systems the two lower bonding levels which bind the system to the (energy-supplying) inferior environment. Cf. system horizon.
Emergence: Etymologically, the term "emergence" is derived from the latin "emergo": to come to the surface, come up, appear. Here, it means the transition from one level of complexity to the next higher level. The elements form themselves into larger units without this process being explicable in terms of the elements themselves. These transitions can be simulated by 4 operations according to the emergence code.
Emergence code: Code which directs the transition from one level of complexity to the next higher level. 4 operations are necessary (bundling, alignment, interlacement and folding).
Emergence process: Process which executes the transition from a simpler to a more complex type of system.
Energy: The ability to do work. It occurs in various forms, is bound to material or particles of material (foodstuffs, electrical energy etc.) or to energy fields (electrical fields etc.). Energy can be transmitted, distributed (in flow-equilibrium systems) or transformed (in non-equilibrium systems). In the course of the flow of energy, energy must be supplied to the demander qualitatively according to his exact requirements. The quantity manifests the first system dimension.
Energy flow: Transmission, i.e. distribution and/or processing of qualitatively specific energy or matter containing energy (e.g. products) inside or outside the system. The flow of energy must be channelled and, to avoid dissipation, screened off from other flows of energy. In general, the flow of energy leads from the (energy supplying) inferior environment via the elements and the system horizon to the (energy demanding) superior environment which transmits it in turn to the higher system level. The systems are links in chains of energy transfer. The energy flow is optimised in the flow-equilibrium system (3rd complexity level). Examples are product chains in and between populations and food chains in ecosystems.
Entropy: The more differentiated the internal division of a system, i.e. the higher the order, the less risk there is that energy flows are mingled and that energy is lost. The entropy is a measure of disorder. The higher its value, the less the order. In the information theory by contrast, the term entropy is applied as a measure of order. From the point of view of the

process theory, we use the term (neg)entropy. The system can be re-ordered through differentiation, i.e. (neg)entropy can be supplied.

Environments: (According to the process theory):
The completing areas necessary for the existence of systems, divided according to the system dimensions:
1. (Stimulating, energy-demanding) superior resp. (stimulated, energy-supplying) inferior energetic environment.
2. Temporal environment preceding resp. succeeding the process.
3. (Controlling, ordering) hierarchically superior resp. (controlled, obeying) inferior hierarchical environment.
4. Spatial environment adjacent to the system or process (acting as an initial locality and/or an envelope).

Equilibrium process: Movement projects or a group of movement projects constitute the equilibrium system.

Equilibrium system: A system with its elements in energetic equilibrium. 2nd level of complexity. This system defines itself by the number of its elements. It responds linearly to a stimulus. It is altered by movement projects (e.g. action projects) or larger equilibrium systems. It orders itself. Examples: a statistically measurable characteristic group in a spatial context (e.g. members of a profession, commuters etc.).

Ethnic group: Population (non-equilibrium system) of mankind as a species, belonging to the 4th uppermost level of the hierarchy. Task: organisation.

Family: Population (non-equilibrium system) of mankind as a species, belonging to the 6th uppermost level of the hierarchy. Task: kinetisation.

Feedback: With flow-equilibrium systems or more complex systems, regulation of the subsequent course of the process by comparing the supply at the end with the demand at the beginning (e.g. of the induction or reaction process or a process stage).

Fit, accuracy of: Flows of information and energy must connect precisely to one another to avoid noise or dissipation.

Flow-equilibrium system: A system consisting of parts in the flow of information and/or energy, which regulates itself by feedback. 3rd level of complexity. It has tangible form, for example, as a compartment. Information and energy are distributed according to supply and demand. The flow-equilibrium system uses the inferior environment as a source of energy. Between the superior environment as energy demander and the inferior environment as energy supplier, the system is divided into 4 bonding levels. The system maintains or alters itself by means of flow processes and feedback (self regulation). Oscillations are created through a delay in supply (energy flow) in relation to the demand (information flow). Examples: quantities of predators or prey in predator-prey relationships in ecosystems, number of demanding or supplying organisates in markets in economic systems.

Flow processes: The flow-equilibrium system is altered or maintained by flow processes. Distribution process. The 4 bonding levels in the flow of information are passed through from top to bottom and in the flow of energy from bottom to top.

Folding: 4th operation of the emergence code. Here, the second part (e.g. the reaction process) of the newly created process sequence is folded behind the first part (induction process). In this way, the beginning and end of the process sequence are linked with one another in such a way that control becomes possible and the stabilisation of the process can be achieved (i.e. here, the system is created structurally).

Hierarchy: Arrangement of systems in levels. In non-equilibrium systems (individuals or populations) the hierarchy serves to control (through order and obedience) the process sequences. The superior non-equilibrium systems surround and control (usually several) inferior non-equilibrium systems. Manifestation of the 3rd system dimension. It is optimised in the hierarchical system (5th level of complexity).

Hierarchical system: Multiple-stage system, whose hierarchic levels are composed of flow equilibarium systems or/and non-equilibrium systems (sub-systems). The lowest stage is the level of the elements. For example, mankind as a society consists of 7 hierarchic levels composed of populations (at elementary level, of individuals). The hierarchical system creates itself structurally. 5th level of complexity.

- Specification hierarchy: Each level has a task for the hierarchical system in the vertical process, identified by basic institutions. Information and energy transfer by oscillations of flow equilibrium systems (Lotka Volterra relations).
- Scalar hierarchy: Non-equilibrium systems are subdivided, the hierarchical system serves to optimise control. Order and obedience should be equal to one another. A vertical process holds the different levels together.

Individual: Element in the hierarchical system of mankind as a species (as living creature) and as society (in its socio-economic role). Task: stabilisation.

Induction process: Process in non-equilibrium systems consisting of 7 task stages in which the stimulus is accepted from the superior environment (adoption) and the energy from the inferior environment is transformed according to the information (production).

Information: Message which stimulates a system (e.g. a population) to production, maintenance or alteration of itself. The information content reflects the novelty value (the surprise effect). Information can be processed (in non-equilibrium systems) or passed on and spread out (in flow-equilibrium systems).

Information flow: Passing on and/or processing and distribution of information which is qualitatively specific and therefore screened from other flows (of information and/or energy) in order to avoid noise. It may be demand, order etc. The flow of information generally leads from the superior environment down the hierarchy inside the system to the inferior environment.

Initial locality (place, region): Starting area of a stimulus or a process.

Input: (According to the process theory) 1st stage in the basic process. The stimulus is put in.
Institution: (Qualitative) material form of the tasks in a stage of a process in a population or a hierarchic system. Institutions are structered as flow equilibrium systems. In the hierarchy of mankind as a society and as a species, the basic institutions give material (thematical) form the tasks in the vertical process (e.g. religion as basic institution, task: determination).
Interlacement: 3rd operation of the emergence code. Here, the newly formed process sequence is (mathematically) reversed, either from the vertical to the horizontal or vice versa (depending on the type of the new system). In this way, the individual inferior process sequences are interlaced.
Ions, sphere of: Sphere in the universal system (in the microcosmos, in the 3rd sphere seen from above).
Kinetisation: 6th task-process stage, energy is transformed into products.
Living creature, organism: According to the process theory, an autopoietic system, part of the global ecosystem or the biosphere (as part of the macrocosmos; e.g. cell).
Long-range effect: Spatial and temporal influencing of systems and processes within the context of an equilibrium system. The intensity decreases with increasing distance from the initial location.
Main proceses: In non-equilibrium systems, processes of the 1st process level consisting of 4 main process stages.
Mankind as a population: Hierarchically the uppermost population (non-equilibrium system) of mankind as a species and as a society. Task: perception.
Mankind as a society: Highly differentiated hierarchical system which has come into being in the course of cultural evolution. The groups of humans and populations are divided up or linked with one another through processes and division of labour. Humans in their roles, through their social and economic involvement, are the essential factor constituting mankind as a society. Secondary populations form the sub-systems, the individuals in their roles, the elements.
Mankind as a species: Hierarchical system which has come into existence in the course of evolution. The man in its capacity as a biological being is the essential factor constituting mankind as a species. Primary populations form the sub-systems, individuals as living creatures the elements.
Market: Economic contact zone between two compartments (flow-equilibrium systems) in mankind as a society and mankind as a species, in which informations, energy and products of the populations (non-equilibrium systems) are demanded, supplied and divided.
Matter, substance: The perceptible material, capable of being shaped, transported, combined with other materials. A system or a structure is concretised through matter (see carrier). Every transfer of energy has to rely on substance.

Molecular sphere, sphere of the molecules: Sphere in the universal system (in the microcosmos, the 2nd sphere from the top of the hierarchy).
Movement, simple: Basic unit of energy transmission (1st level of complexity). A solidum is moved, controlled by the environment. Example: action motion.
Movement project: Basic unit of the processes forming an equilibrium system (2nd level of complexity). The movement project consists of many movements. It is ordered temporally and pursues a uniform aim. Example: action project.
Negentropy: see entropy.
Non-equilibrium system: Entity in the flow of information and/or energy, composed of parts (elements) remote from energetic equilibrium. Information and energy are transformed, products manufactured. The composition of the elements is heterogeneous, division of labour is characteristic. The non-equilibrium system maintains or alters itself through the conversion process which proceeds at 4 process levels which control themselves hierarchically. Through this differentiation of the process sequence, the non-equilibrium system optimises the time sequence. Examples: biological and social populations, as well as atoms, molecules, cells, organisms which likewise belong to the autopoietic systems.
Organisate: Population (non-equilibrium system) of mankind as a society of the 6th uppermost level of the hierarchy. In the organisate, production takes place in accordance with division of labour. Task: kinetisation. Examples: companies, shops, public offices.
Organisation: (according to the process theory) 4th task-process stage; the system is connected spatially with the inferior (energy supplying) environment. The main process stages of adoption and production or reception and reproduction are linked with one another.
Organism: see Living creature.
Output: (According to the process theory) 4th stage of the basic process.
People: Population (non-equilibrium system) of mankind as a species, belonging to the 3rd uppermost level of the hierarchy. Task: regulation.
Perception: 1st task-process stage: acceptance of the stimulus from the superior (energy-demanding) environment.
Planets, sphere of: Sphere in the universal system (in the macrocosmos, 5th sphere from the top in the hierarchy). Probable task: dynamisation.
Population: Carrier of a non-equilibrium system in the context of mankind as a species (primary population) or mankind as a society (secondary population). Populations consist of individuals who co-operate with one another on the basis of division of labour. They are spatially ordered and delimited, are distinguished by qualitative definability and have a certain task for mankind.
Primary population: Population (non-equilibrium system) of mankind as species (e.g. tribe, people, family). The individuals, as living creatures, are the elements.

Process: The term "process" is derived from the Latin "processus" which means proceeding, progress or from "processio" which can be translated as "advance".
1. In the flow-equilibrium system (possibly wave-shaped) diffusion process (e.g. spread of an innovation). The flow-equilibrium system is changed from one state to another (changing process).
2. In the non-equilibrium system (e.g. population) identical with the conversion process: sequence of stages arranged in a certain order with differing tasks in the flow of information and/or energy. It serves for production (e.g. for the market) and maintenance or change of the system size and/or structure. Through the division of labour and the differentiation of the course of the process (process sequence) the utilisation of time in the system is optimised.
3. Conserving and changing process in the various types of system (e.g. flow-equilibrium and non-equilibrium systems). Either only the quantity of the elements (and sub-systems) is preserved or changed (size-conserving or size-changing process), or the structure (structure conserving or changing process).
4. Main, task, control and elementry process (see appropriate definitions).
5. Emergence process (see appropriate definition).
Process level: Within the non-equilibrium systems, the main processes, task processes, control processes and elementary processes are carried out (depending on the system dimensions). The processes at the lower levels are assigned to the processes at the higher levels.
Process sequence: Sequence of task processes in which information and/or energy is converted or processed in the non-equilibrium system or more complex types of system (induction and reaction process).
Process theory: Theory which attempts to explain the flows of information and energy on the basis of the observation that every process is structured within itself and divided into phases, and of analysis of system structures and spaces, and to approach the problems of emergence and complexity in a new way. The starting point was formed by studies of social systems.
Process train: Path of the process sequences.
Product: Product with a certain content of information and energy supplied by populations as a result of the induction process. It is demanded by the superior environment and must fit exactly into the flow of energy.
Production: In non-equilibrium systems, the 2nd main-process stage in which energy is converted in accordance with the stimulus (information) (second part of induction process).
Reaction process: Process consisting of 7 task stages in which the non-equilibrium system is maintained or altered according to the results of the preceding induction process. The stimulus is received (reception) and the work executed accordingly (reproduction). The self-organisation of the non-equilibrium system takes place in the reaction process.

Reception: In non-equilibrium systems the 3rd main process stage in which the system is stimulated to maintain or alter itself according to the result of the induction process (planning of self organisation).
Redirection: (According to the process theory) 3rd stage in the basic process. Change in the process sequence in the system from inward to outward.
Regulation: 3rd task process stage. The stimulus is passed on to the elements (e.g. individuals). The elements are coupled to the system (e.g. population) by the stimulus.
Reproduction: In non-equilibrium systems the 4th main process stage in which the system is maintained or altered (concretisation of self organisation) according to the result of reception.
Rotation: Irregular rotation: Shifting of the activity centres (e.g. initial places) in the flow equilibrium systems. The tangential rotation leads around a centre.
Secondary population: Population (non-equilibrium system) of mankind as society (e.g. state, city-umland-population or organisate). The individuals in their roles are the elements. They are related to one another through division of labour.
Self-organisation: Non-equilibrium systems are able to organise themselves chronologically and spatially. See also reaction process.
Solar systems, sphere of: Sphere in the universal system (in the macrocosmos, 4th sphere from the top in the hierarchy). Probable task: organisation.
Solidum: Something created of substance, representing the lowest level of the scale of complexity. Solida move, act or react as a unit and is identifiable as a form. The solid is moved and/or altered (e.g. by humans through actions) thereby transferring energy.
Space: (According to the process theory) Through its attachment to a system type, through specific qualitative characteristics, through a certain position in a process sequence and in a hierarchy as well as through extension and outer limitatio defined order. Space manifests the 4th system dimension. The shaping of space is (in connection with matter) optimised in the universal system (6th level of complexity).
Sphere: According to the process theory, the universal system is composed of shells which enclose space and which are arranged hierarchically above one another, the so-called spheres. Each of these is formed by materially and spatially differing types of non-equilibrium systems (e.g. atoms, molecules, organisms, stars etc.). The result is that the universal system is constructed like the skins of an onion, seen from the point of view each non-equilibrium system.
Stabilisation: 7th task process stage. Release of products to the (demanding) superior environment.
State: Population (non-equilibrium system) of mankind as a society, belonging to the 3rd uppermost level of the hierarchy. Task: regulation.
Stimulation, stimulus: A process is stimulated by the input of information (e.g. demand for energy).

Structure: Arrangement of the elements of a whole.
1. The temporal structure of a system is identical with the process structure, i.e. the construction and duration of the process between preceding and succeeding environment.
2. The hierarchicaσl structure is formed in the flow of information between the superior and inferior environment. Within the flow-equilibrium and non-equilibrium systems, the system as a whole is hierarchically superior to the elements. In the hierarchical system and universal system, systems as sub-systems at higher levels are superior to those located further down.
3. The systems and processes also enclose the elements spatially. This is why we speak of a spatial structure.

System: The term "system" is derived from the Greek "συστημα", which originates in turn from the verb "συνιστημι" and therefore means something which is an unified whole which is assembled from several parts. Every system consists of a material carrier and possesses a temporal, hierarchical and/or spatial structure. Different types of system can be distinguished: equilibrium system, flow-equilibrium system, non-equilibrium system, hierarchical system and universal system. See appropriate definitions.

System horizon: The two upper inner-system bonding levels in flow-equilibrium systems or non-equilibrium systems which represent the whole of the system in close contact with the (demanding) environment. Cf. Element horizon.

Task: Typologically defined determination of the content of a system, process, or process stage (perception ... stabilisation). It has to be fulfilled in order to maintain or alter the structure of a superior entity (a system, a process).

Task process: The 2nd process level in the non-equilibrium system process, consisting of 4 task process stages in each main process stage. By combining these, process sequences of 8 (through overlapping of the final and initial stages 7) (induction or reaction process) or 16 stages (total process) may exist.

Time: (According to the process theory) Succession of events in a system which is divided up by the process sequence in the course of the flow of information and/or energy. Time manifests the second system dimension and is optimised in the non-equilibrium system (4th level of complexity).

Tope: Smallest non-divisible delimited unit in the flow of energy at the corresponding level of scale, concretised by a carrier (e.g. a department of an organisate) and permanent artefacts (e.g. work room). Ecotope is the smallest unit of landscape with an internally unified functioning ecological structure.

Tribe: Population (non-equilibrium system) of mankind as a species, belonging to the third and/or fourth uppermost level of the hierarchy. Task: regulation and/or organisation.

Twin processes: Conversion processes consist of induction and reaction processes which follow two different process trains. These cooperate with each other.

Universal system: (According to the process theory) The whole of the universe composed probably of 16 spheres (or 13, due to overlapping) in the macro and microcosmos. 6th level of complexity. The spheres are distinct from one another materially and spatially (e.g. the sphere of the molecules from the biosphere) and have their specific task as elements in an overriding process sequence. Materially, the spheres are composed of autopoietic systems (e.g. molecules, organisms). A hierarchical order exists. The biosphere has the position of an intermediary between the microcosmos and the macrocosmos. The spheres of the macro and microcosmos are linked with one another functionally and spatially in pairs in such a way that the autopoietic systems in the microcosmos are the elements of the autopoietic systems in the macrocosmos (e.g. the cells are the elements of organisms, molecules the elements of chemical systems). Thus, the universal system creates itself as a substantial and spatial whole.