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Processes Constitute our Complex Reality

A Theoretical Investigation

(2nd Edition)

Saarbrücken 2005

To Bettina, Annette and Arne

Preface

Complexity and emergence, self organisation, systems and processes form a set of notions which represents a particularly promising area of modern interdisciplinary research. Whether we are concerned with the reactions of molecules in chemical substances, the movement of flowing gases and liquids, the co-existence of living organisms in biotic populations and ecological ensembles, or the behaviour and actions of human beings in social groups, in each of these cases, the interplay of individual elements is examined within the context of the whole.

A number of attempts have been made to approach these problems scientifically. These are based on the actual observations made in the various scientific fields.

The question is how the elements act with one another and how entireties can be explained from this interaction. In the studies it was observed that under certain circumstances forms come into being which possess new characteristics and which are reminiscent of wholes, for example living cells or social populations. The development of this new behavior of systems is then regarded as "emergent". All these approaches can be summarised by the term "complexity research".

The methods and results are presented in a number of good detailed descriptions (BAR-YAM 2003; HOLLAND 1998; MAINZER 1991/2004; COHEN and STEWART 1994).

A certain degree of disillusionment has now set in (HORGAN 1995). Perhaps the research results show us cooperative or egoistic behaviour of the elements. Certain patterns are apparent, but no organised forms such as are characteristic of our life and are familiar from our environment. These highly complex forms were formed in the course of cosmic, biotic and cultural evolution. But why do these evolutionary processes not lead to chaos governed by chance? There must be processes and structures which prevent the processes from this ending and which bring the elements together in such a way that they can carry out useful tasks for the overriding whole.

It seems that the solution of this problem requires a different basis, a new concept. The aim of this book is to present a theory dealing with this topic. In this concept, special importance is given to the internal structure of the systems and the course of time. The process is the main subject of our considerations. Thus, we describe this new approach as "process-based theory of complexity" or for short "process theory". The intention is to indicate a feasible path to be taken by complexity research.

The book is the result of several decades of study in this field. Some results of the work completed by 2001 have already been summarised and published in the Internet (2001b). The text has been considerably extended and a number of smaller corrections made.

I can only hope that there will be a broadly based objective discussion which will bring some progress in the questions on hand.

I am indebted to several people who have assisted me in compiling my manuscript, among others, to Mr. Thomas Fläschner for information on recent literature and to Mr. Neil A. Waugh (Meschede) for the English translation.

Dietrich Fliedner

(November 2005)

Content:

1. Introduction

Our objective is to highlight and analyse the complexity of our reality in all its diversity. Complexity means the interweaving of different things to form a whole. Our task is to identify and describe the rules by which such structures are maintained or altered. Thus, it is the processes on which our attention will be centred. The system concept, on a general abstract level, facilitates our understanding of the interplay of different components and the formation of wholes.

Once we have gained a picture of the processes which are peculiar to the different types of complexity, it will be possible for us to approach the phenomenon of emergence.
Up until now, processes have received too little attention in complexity research.

A metaphor may help us to understand the current situation: Let us take a ball of wool as representing a complex system. The strand is then the process. It seems to me that when we use the current methods of research and attempt to penetrate into the ball to analyse it, we receive the impression of a confusing tangle of portions of the strand. My suggestion is to take the strand at its end und follow it like Theseus who followed Ariadne’s thread to find the way out of the Minotaur’s labyrinth.

Processes are divided into stages. In particular, we have to investigate what is happening at these individual process stages and what the stages signify as an entirety in the overall process. Processes of this kind have been the subject of study in the field of geography for some considerable time, but without having any definite objective in mind.

The first impulses go back to the 1960s. For example, in his study of the foundation of small ports („Sielhäfen“) on the North Sea coast of Central Europe, SCHULTZE (1962) found a sequence in the development of this type of settlement which passed from irregular early forms to perfectly regular forms following a certain scheme, and then back to poorer irregular forms. Similarly, in my examination of settlement areas to the north of Bremen (1969), I noted that the shaping of the cultural landscape, the formation of the traffic network, the growth of the cities, etc. in the Middle Ages and in modern times had gone through the same type of development.

In the further course of my inductive historical and social-geographical work, I put forward a first version of the process theory (1981). It recognises process sequences and non-equilibrium systems as the most important structures, i.e. self-organising wholes in time and space, structured according to division of labour.

From the start, the aim was to arrive at results which revealed fundamental natural and economic structures in human society and whose findings possessed a level of logical objectivity which was also acceptable to the natural scientists. Human beings consist not only of mind, a fact which is not given enough consideration by the protagonists of a hermeneutical-phenomenological social science. On the contrary, a considerable part of his actions are determined by physically and socially based necessities. Human resources are limited and the will to act is subject to constraints. This alone poses the question as to how actions may be organised individually.

This aspect of human existence leads to the general problem of the effective use of energy. Thus we arrive at another level of cognition where laws apply to which humans as well as biotic and inorganic phenomena must submit. This entitles us to give some thought to more general explanations of certain phenomena in nature beyond the social reality. The flow of information and energy, the structure of processes and systems, qualitative thematic differences in matter, space, time and hierarchies, form characteristics which are valid for all areas of existence.

To date, the strongest impulse for research into complexity has come from the natural sciences, and the social sciences (in the wider sense, including the human geography) adopted some of the methods and results, naturally in a modified form. The question now arises as to whether the discussion could not receive impulses from the social sciences which would be of interest to the natural sciences. The social processes in question allow us an insight into the phenomena of our order of magnitude.

The human geographer works on a scale corresponding to our own experience in an environment in which we ourselves act and are acted upon. This is the "Mesocosmos" (VOLLMER 1985/86, 1, pp. 57). We know where we stand (from a systematic point of view), what we want, to whom we are answerable and what we achieve. The object of research with which human geography is concerned, human society in the ecumene, offers especially illustrative examples of complex structures.

In the mesocosmos in particular, complex processes are easy to observe, not only from the point of view of quantity. In particular, the qualitative differences can be examined for their meaning and historical sequences interpreted. These are possibilities which the objects of study of the natural sciences only offer to a very limited extent, if at all. Thus, in the context of the process theory, such questions as the thematic position of individuals within the whole are unavoidable. Events and processes have a specific meaning for the structure of populations and processes. These have to be identified and plausibly interpreted.

At the start, there is the attempt to understand the object under study, i.e. what has occurred and been formed in the past. We are dealing with human beings who have formed the processes of history, through their actions. Trying to determine their motives in detail would be a hopeless task. However, their actions are subject to a number of different preferences and constraints, and these indicate the path to be taken by the analysis, because they arise frequently in the context of superior processes and populations. Individuals are embedded in these, they belong to systems which expect certain behaviour from them which are essential to their self-preservation and self-organisation. In other words, seen in a systemic context, actions and processes have specific tasks for the whole. The purpose of an analysis is to identify these tasks and categorise them.

This applies for events which took place in the past and whose results we know. We thus avoid the difficult question as to the motives and purposes of the actions and processes which, even at that time, pointed into the future. In the examination of present structures this is different. For example, we cannot identify in advance the technical innovations which will be adopted in fifty years‛ time. With systems geared towards a purpose, e.g. individuals and populations we can however predict the quantitative course of developments which have already begun (e.g. economic cycles) with some degree of accuracy. We can also say that such processes will normally end in a result which is predictable with a certain probability (unless affected by outside intervention), but only within a typological framework and at structural level. Thus we can perhaps predict the approximate form which will be achieved by a living organism or a population if we are aware of the structural data („equifinality“; see DRIESCH 1908/28, p. 133 f.; v.BERTALANFFY 1950, p. 25). The individuality of the process and therefore the quality of the results are however unknown.

Thus, it is correct to speak not of teleology but of teleonomy (PITTENDRIGH 1958, after WIESER 1998, p. 331). In a teleological process, an individual or a smaller organisation knows a definite aim, whereas in teleonomic processes the individual aim is not normally known, although the general aim is fixed structurally in the program.

Now the most important conditions of the framework within which the discussion will proceed, have been described, at least in outline form. The aim of the argument is to obtain an intrinsically logical concept. The statements made must support one another mutually. Taken on their own, some interpretations may not appear plausible. They must be seen within their context. If everything fits together, the structure will be self-explanatory.

Two different steps are taken:

- First the matter is introduced from a systematic point of view using eloquent examples (see section 2). We will attempt to define the various possibilities of coexistence between the components of systems according to the various degrees of complexity. In the course of the text, we are drawn more and more deeply into the complex subject matter. Thus we proceed inductively from the individual observation to the more general results. Only in this way is it possible for us to approach the phenomenon of complexity and emergence. In doing this, we will establish the archetypes of the processes and systems in order to arrive at an intrinsically consistent and complete typology.

- Thus the basis is created for describing a model to illustrate the interconnections in greater detail (see section 3). In this chapter we will attempt to link the various levels of complexity logically with one another. In this way, we obtain an insight into the processes at the root of emergence.

2. Six levels of complexity

In this chapter we will progress systematically from the simple to the complex because that appears to be the most logical approach from a didactic point of view. Thus, levels of complexity can be identified which are characterised by certain types of processes and systems. In addition, in each section devoted to a level of complexity, an inductive approach will be adopted, i.e. progressing from the individual to the general, and from the concrete to the abstract:

To begin with, as an example, we will take an industrial company, a small weaving mill which continued working into the 1970s.
1) The observations will then be transposed to a more general level. This is demonstrated in models.
2) Then, other examples will be presented.
3) In order to render the process of emergence understandable, the results at the various levels of complexity must be reduced to a common denominator. For this reason, the process sequences, at the end, are transported to the level of information and energy flow and shown in relation to the system dimensions.

2.1. Simple movements and solida

2.1.0. Instead of an introduction: The textile factory as physical form

In a Westphalian town, a small weaving mill which manufactured damask materials and cotton blankets, continued in operation into the 1970s. It stood apart from important railway lines and roads in a mixed residential and industrial area and covered 3/4 of a hectare (see fig. 1). The single and double-storeyed red-brick buildings were grouped around a small yard with a flower bed in the centre, thus forming an enclosed unit with a factory building containing the looms and a boiler house with a brick chimney, offices, workshops, store-rooms, a garage for carriages etc. A paved road passed along the front of the buildings, linking them with one another.

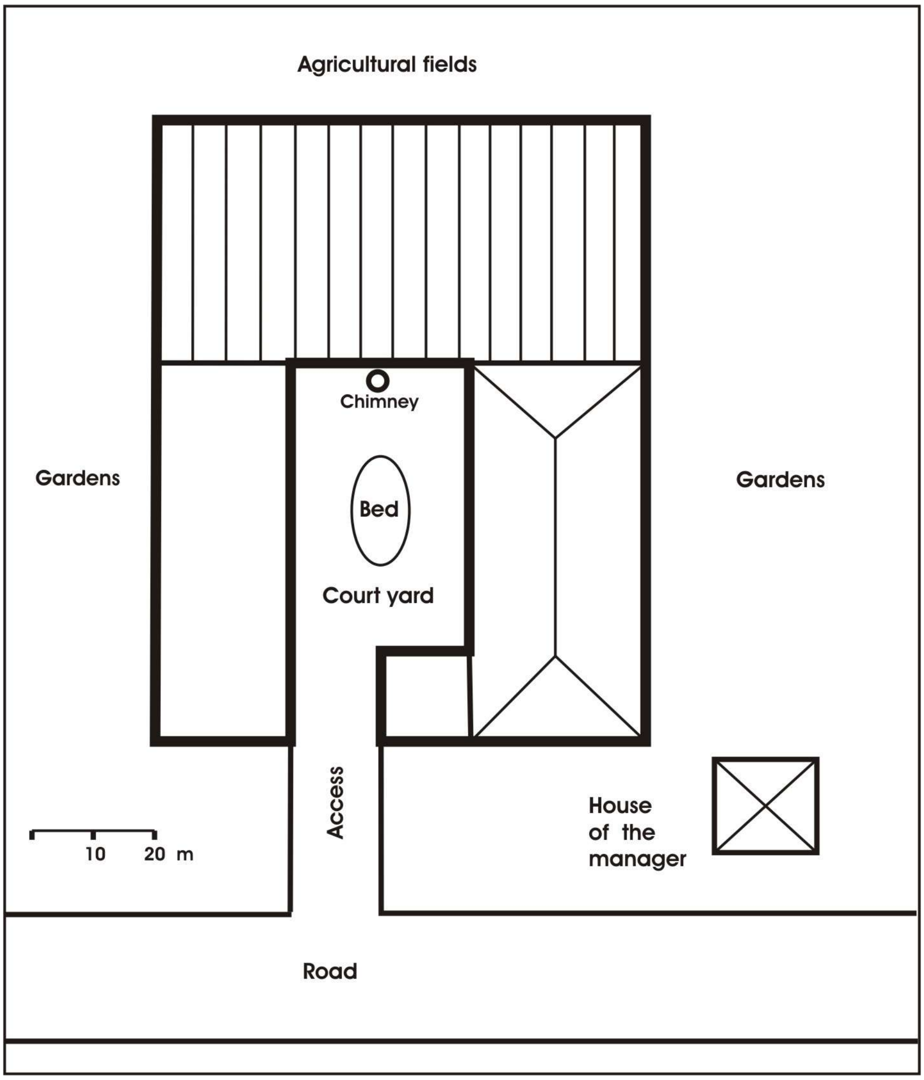

Fig.1:
Map of the textile factory.

The factory had around 200 employees, most of whom lived in the neighbourhood. The company itself was founded by a Wesphalian businessman and his partner at the end of the 19th century. It was forced to close during the slump in the textile industry in the 1970s.

2.1.1. General considerations

2.1.1.1. Solidum and movement

Forms:

We may describe the factory as a concrete, materially definable "form". Forms have their own properties which make them resemble or differ from one another. They are individualised, unique through their position. As a general principle, wherever a form exists, no other can be present at the same time, provided that we remain in the same order of magnitude, i.e. that the one does not include the other (e.g. meadows as part of a valley, or a street as part of a village). Here, everything depends on the degree of generalisation. (The cartographer and the geographer are constantly faced with this problem.)

So, forms occupy spaces and to this extent content and form should be considered together. In order to define the content, it is necessary to typify, i.e. to reduce the individual variety to categories which are understandable as concepts. Around the turn for the 20^{th} century, the study of geography was concerned with the scientific investigation of tangible space with its forms. This view reflects the state of scientific research at that time.

Here at the first level of complexity we are at the lowest level. The objects with which we are dealing here should be seen as compact units, as "solida". Although they may be complicated in shape and structure, the important thing is that they appear as units, unlike the composite systems and processes which are characteristic of the higher levels of complexity.

Causal explanation:

The solida are capable of causal explanation. From the result (the existence of the factory in its shape) the existence of the "forces" (who themselves have causes) is inferred. The forces which led to the setting up of the factory: the Westphalian businessman and his partner who built up the company in accordance with the state of production technology at the time, the construction workers, the manufacturers and suppliers of the machinery, the shop-floor and office workers who kept the factory running etc. The causes of the forces: a strong rise in demand for textile products during the 19th century which was itself caused by an increase in the population, the growing wealth of the population which permitted the purchase of the factory's products, the liberalisation of world trade which facilitated the import of cotton, etc.

This is of course highly generalised and not very definite.

If we do not know what happened between the time of causing (the establishment of the factory) and the object of investigation (e.g. at the time of the closing of the factory in the 1970s), we can only gain a very vague idea of the cause of the object. A possible solution would be to divide the developments into periods in which uniform or at least understandable changes took place. The development of the factory also proceeded in periods. A number of investments were made in the machine park. In particular, new looms were purchased after the Second World War, thereby producing two different periods which should be assessed differently. The times of change themselves can also be treated as periods. The establishment phase is naturally of particular importance. If we regard the periods as proceeding uniformly within themselves, our task is to explain the difference between the two states (of the factory site) at the beginning and the end of the period. The first state is transformed into the second state by means of forces. This means that the second state is the result of forces which go back to causes at the time of the first state. The more transparent and the shorter the periods are in their development the closer we come to achieving a satisfactory causal explanation.

Actions and movements:

In our search for a phenomenon from which it is possible to deduce a cause from the effect, we come to the simple movement. If we again take the factory as our example, we arrive at the individual action. Strictly speaking, the individuals transformed the factory from the first into the second state by means of their actions. Thus, the fundamental "process" which we wish to study more closely here, is the action.

Through a multitude of actions, the natural spatial environment and the "earthbound artefacts" created by human beings are altered in form and energy content and transformed into a new state. The factory is one of these earthbound artefacts i.e. buildings, earthworks etc. created by man for specific purpose (e.g. houses, roads, fields). They give the cultivated landscape its appearance. Man forms nature, shapes and modifies the landscape for his own purposes. He alters existing characteristics and transforms it from one state to another. He may well use machines or tools ("media") in the process. They receive and transmit energy.

Much has been written about actions and from the point of view of many different disciplines (LENK 1977-82; POSER ed. 1982). But what interests us here is as follows:

Actions constitute and shape the individual environment, they lead from one state to another. There is a "before" and an "after", an action is begun, executed and ended. Something immaterial (information) or material is created, or something is altered which had been created (by someone or other) beforehand. Two types of action can be distinguished: action motion and action project.

"Action motions" are simple movements, they take seconds or fractions of seconds. They can carried out consciously and goal oriented by the individual. However, they also include affective actions guided by instinct or unconscious reactive actions or movements. Action motions are the smallest units which cannot be differentiated further in this respect. The "action project" on the other hand is a planned piece of work to achieve a specific purpose (e.g. the ploughing of a field, the writing of a book etc.). Action projects demand longer periods of time (see section 2.2.1.1, p.38).

Here, in this chapter, we will deal more closely with the action motions. With these, in contrast to the action projects time is not regarded with any differentiation. The action motions are of interest only to the extent that they are open to causal explanation. They have a cause and create effects. Action motions must physically affect the environment in some way. They do not necessarily have to be executed by hands. Speaking and stepping are also action motions in the sense of our word. However, reflections, or concentration of the senses on something in the environment are not yet an action motion, although they may well prompt an action motion. An action motion serves to fulfil an instantaneous purpose and is bound up with one person, the "agent" from beginning to end. Thus it is a (possibly preconceived) movement carried out by a person, which, by using force (energy) achieves an effect, and moves something else e.g. a stone, in the environment.

Solida and movements:

The alterations concern the shape, size or quality and quantity of the objects without these having to lose their identity. To alter means to make or become different. As a rule, this takes place on the spot. The alteration of an object can be regarded as a movement on the micro-level. Alteration in location on the other hand involves the movement of a person or an object from point A to point B. As stated above, actions are movements carried out by persons. The term "movement" is therefore more comprehensive in its meaning. Thus, we have roughly defined the basic unit from which emergence and complexity can be derived.

According to the process theory, it is important that the solida absorb energy from the environment and release it again through the movements within the context of motion or change. Every movement is associated with an effect on the environment and vice versa, every change in the environment is associated with movements.

In the scale of complexity, movement and solidum are located at the beginning, and although neither a complex process nor a complex system is involved, we will refer to it as the 1st level of complexity for the sake of uniformity of scale.

2.1.1.2. The model

The environment affects the solid, the solidum reacts passively. The movement is completely controlled by the environment. The environment in its turn is altered by the solidum when it is moved. In the last resort, this is due to the influence of the environment. The environment is responsible for the behaviour of the solidum.

Laws of motion:

The movements can be described using the well-known equations of motion in mechanics. Mass (of the solidum) is accelerated and for this purpose, force is required. The formula is as follows (where $\vec{p}$ = force, *M* = the mass of the body, $\vec{v}$ = speed and *t* = time):

$$\vec{p} = M * \vec{v}/t \ ,$$

The accelerating force converts the potential energy in the mass into kinetic energy.

The following definition applies: Energy is the ability to do work. The kinetic energy is calculated using the formula

$$\vec{p} * s = \frac{1}{2} M * v^2$$

(*M* = mass of the body, *v* = speed, *s* = distance).

Let us take the simplest form of energy transmission: the movement of a uniform reacting object, a solidum. E.g. if a stone receives a stimulus from outside, from a body in the environment: The (kinetic) energy is received by the solidum (stone). The solidum moves in a certain direction, it is accelerated. On the other hand the energy is passed on, transmitted to the environment. Because the movement is slowed down by friction and/or by another body being struck. It is the most simple form of energy flow.
The force $\vec{p}_1 = M * v_1 / t$ should therefore be opposed by an obstructing force of $\vec{p}_2 = M * v_2 / t$. The result is

$$p * s = \frac{1}{2} M * v_1^2 - \frac{1}{2} M * v_2^2$$

Put more precisely, the kinetic energy is defined as the power which a mass *M* moving at a speed *v* can exert against an obstructing force before the mass comes to rest, i.e. the power is ended.

The movement itself is the expression of an asymmetry. On the other hand, a symmetry can be detected which is explicable by Newton's third law of motion: the effect is always equal to the counter effect or the effects of two bodies on one another are always equal and opposite in direction:

Actio => Reactio.

The "Basic process":

To be able to compare the movements and processes of the various levels of complexity with one another it is necessary to find a common language. We must attempt to reduce the movements and processes to the essentials necessary for our purposes, i.e. to those principles which make all the movements and processes, solida and systems characterising the levels of complexity comparable and therefore distinguishable and capable of being linked. In this way, we arrive at the level of cognition of the flow of information and energy:

Let us now try to explain what exactly happens in the solidum. The path of the accelerating force is described as follows:
First of all the stimulus moves inwards:
1) The stimulus from the environment is put into the solidum (which has a certain inert mass and potential energy): "input";
2) The solidum cannot move immediately, it must first absorb the energy. It accepts the stimulus: "acceptance";
The stimulus then moves outwards again, i.e.
3) The stimulus is reversed in direction (the internal stress now occurring in the solidum is converted into kinetic energy): "redirection";
4) The stimulus is again taken to the environment (the kinetic energy is now conducted to the environment): "output".

This sequence of 4 stages forms the basic unit of any process structure, even in the systems at higher levels of complexity. Therefore it is described as the "basic process" (even if the movement of a solidum here is not yet a process in its true sense). In more complex systems the basic processes join up to form sequences of different kinds. In this way, the basic process can be comprehended as a module affecting the entire process and system-related structure of reality.

We interpreted at this level of complexity the factory as a solidum, i.e. as the result of a cause only - although we know that it is composed of parts (several buildings, a yard, a flower bed, a paved road etc.). The only thing of importance here is that it behaves as a unit. The parts are regarded as being permanently connected with one another. However, if we look at the path of the stimulus in the solidum, both the whole on the one hand, and the parts on the other, have to be taken into consideration.

In order to obtain a formal framework, we will use the coordinate system (see fig. 2) and assume that the y-positive half symbolises the whole (here the solidum and at the higher level of complexity the system) whereas the y-negative half is represented by the parts (or elements). Each of the 4 quadrants represents a stage on the way of the stimulus (or the process). We now allow the stimulus to pass through the quadrants in succession. The starting point in each case is the f(x) quadrant.

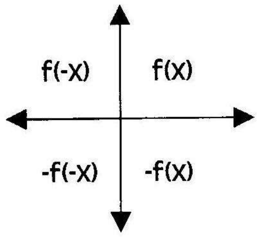

Fig. 2:
Model of a coordinate system.

There are two possible ways to represent the flows of information and energy. The progress takes us either in a clockwise (mathematically negative) or anticlockwise (mathematically positive) direction through the coordinate system. In the first case, the way through the coordinate system is vertically from the top downwards and from the bottom upwards, i.e. it traces the path of a U in Latin script. In the second case, the stimulus moves from right to left and from left to right, thereby describing a C. For the sake of simplicity, we will call case 1 the U connection and case 2 the C connection. Mathematically, the transition from case 1 to case 2 is equivalent to a reversal on the axis x = y (see fig. 3). For the convenience of the reader, the numbers of variant 1 (U) are shown upright and those of variant 2 (C) in Italic script.

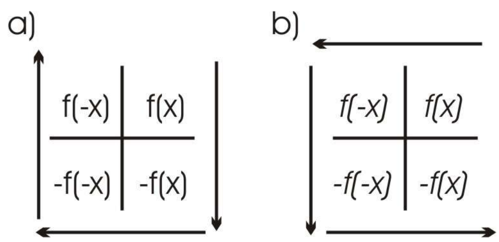

Fig. 3:
Basic process in the coordinate system.
a) vertical variant (U connection), b) horizontal variant (C connection).

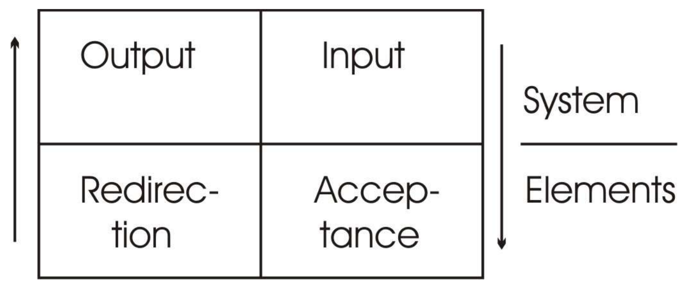

Fig. 4:
The processes in the coordinate system with the 4 stages input (system) - acceptance (elements) - redirection (elements) - output (system). Basic process, vertical (U variant).
Course of the stimulus in a clockwise (right-hand) oriented system.
In the top half of the diagram, the system is shown as a whole, and in the lower, the quantity of parts (elements).

At the first level of complexity under consideration here, where the whole and the parts are permanently connected to one another, the vertical variant (U connection) of the basic process applies:
In the [f(x)] quadrant, the stimulus is entered ("input") and is received by the parts in the [-f(x)] quadrant. The redirection then takes place where the first to be affected is the [-f(-x)] quadrant and then the [f(-x)] quadrant, the "output" (see fig. 4). I.e. the impulse proceeds vertically into the solidum from the whole to the parts and then back.

For guidance:

Reality is materially definable. It consists of forms which can be defined and classified in groups (e.g. objects such as houses, furniture, technical appliances, or forms such as mountains or townships, and humans as statistically quantifiable units). We describe these phenomena as solida. In the form defined here they have a causal explanation, i.e. they can be traced back to a cause, are its effect.

This explanation is only satisfactory when beginning and end of the development can be definitely related to one another. At the human level however, this is only the case with action motions which are executed as single movements, e.g. a blow with an axe, or a step as part of a walk. These action motions or (more generally) movements can be described by deterministic physical formulae.

These are not yet processes, the solida not yet systems, but it is still possible to describe the movement as a four-stage succession consisting of input, acceptance, redirection and output. We describe this sequence as the "basic process" because it forms the basis for all the processes and process sequences at the 6 levels of complexity.

2.1.2. Other examples

2.1.2.0. Instead of an introduction: Movements as seen by an artist:

Fig. 5:
Marcel Duchamp: Nude descending a staircase. This picture represents a sequence of movements.
Source: See „Notes on the figures".

The basis of the first level of complexity is the action, or, more generally, the movement. Art has dealt with this problem in a number of ways. In his painting "Nude descending a staircase" (see fig. 5), Duchamp tried to include a chronological dimension in a way similar to the futurists. It shows a person going down a staircase step by step. He has tried to create a static image of movement (DRECHSLER in: Zeit, die vierte Dimension 1985, S. 190). In this case, movement is an abstraction, a conclusion expressed within the picture, and one does not have to know whether a real figure is descending a real staircase. The model has been various stroboscopic photographs in which abstract geometrical diagrams of movement, e.g. of walking or stepping human or animal figures. In the picture, 3 or 4 steps can be seen, and each of the movements represented takes the figure one step downwards.

In the context with which we are concerned, each step is an action motion or movement, which, when added together, make up the process, action project or movement project of "descending the staircase".

Taking a technical process as example, the following will show how tight the limits are, within which a causal explanation is possible. The other examples demonstrate how forms were formerly explained in geographical research, and why today's studies have to be conducted much more cautiously.

2.1.2.1. An example from the field of technology:

To define the limits of the principle of causality more precisely, let us imagine an idealised process (see fig. 6), the operations taking place in an electric circuit which is fed by an accumulator (BUNGE 1959/87, pp. 376). When the current is switched on at point A in time, the intensity of the current *I* does not rise immediately to the intended constant C, which is not reached until point B. Because while the intensity of the current increases, a magnetic field is generated which acts on the current flowing through negative

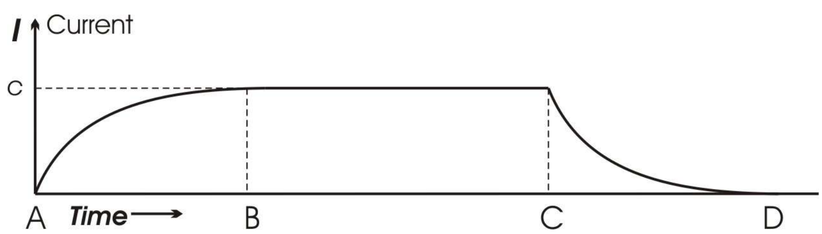

Fig.6:
Intensity of current I in relation to time.
Scheme for explaining causality. A - B: non-causal area, B - C: causal area, C - D: non-causal area. According to Bunge.
Source: See „Notes on the figures".

feedback (self induction). The overall effect (flow of current) does not proceed directly from the cause (voltage) and therefore the principle of causality cannot apply at this stage. The second stage B - C on the other hand is exclusively causal in nature (if we disregard the external effects or the processes taking place in the micro range). Because the cause (the voltage) and the magnetic field remain constant and the resistance is determined according to Ohm's law. The result is that the effect (the flow of current) is maintained. Thus, at point C, a conclusion can be drawn on the cause from the effect. At the third stage C - D however, causality no longer applies. The cause (voltage) is switched off, but the effect only diminishes slowly – a process which is due to the decline in the magnetic field, which follows other non-linear laws.

2.1.2.2. Examples from geography:

The question why a thing is as it is, is the first step on the way to knowledge. This question can (hypothetically) be asked for each definable tangible form, and one will frequently be able to infer the cause from the recognisable object.

Landforms:

For the geographer, the landforms of the earth are solida, which are studied in the sub-discipline of geomorphology. Mountains, plateaux, terraces, slopes, valleys, plains are shaped by endogenous and exogenous forces, i.e. they are "forms". Geomorphologists regard it as their task to describe these and to study the "forces" which have shaped them as well as their causes.

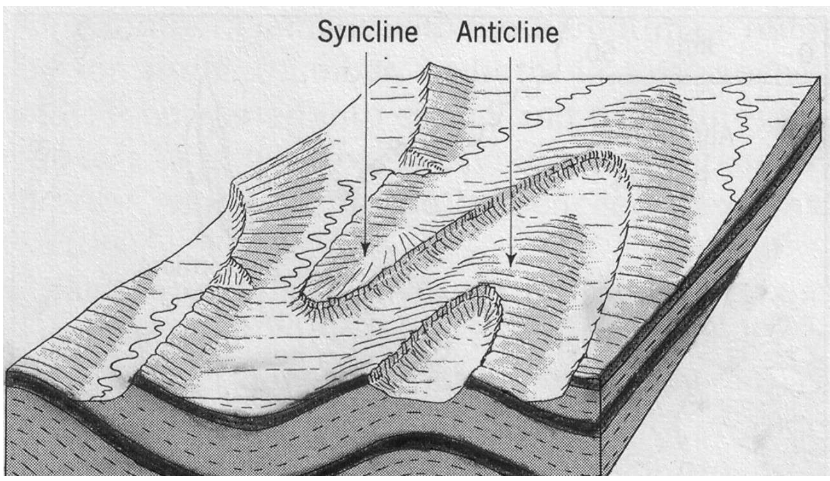

Fig. 7:
Block diagram of a mountain-crest formation. In the subterranean areas, hard (black) and soft layers alternate. The diagram permits a preliminary explanation of the reason for the surface formations. According to Strahler and Strahler.
Source: See "Notes on the figures".

This can be explained by taking an example. The block diagram in fig. 7 shows an undulating mountain landscape in relief. The extended ridges are arch-like in shape, inclining gently on one side and more abruptly on the other. Two rivers follow the valleys between the ridges and break through them at certain points. Looking at the rock formations and their stratification in more detail, it can be seen that they are gently folded sedimentary structures. The strata offer differing degrees of resistance to erosive forces. The "hard" strata (e.g. of limestone) form steep ridges which drop away in anticlines with the steep side towards the axis of the anticline while the surfaces of the strata dip away into the basins where there are deposits of rubble. Beneath the more resistant strata there are strata of softer rock (e.g. marl). The erosion has plainly been strongest at the highest points of the ridge with the result that the rock has been removed from here fastest. The soft rock has been eroded in the process. The superimposed harder strata have been forced to give way but have retained their steep edge. The geomorphologist calls these formations cuestas (when the rock is in flat strata) or crests (when the rock drops away steeply). This type of relief is very widespread on the surface of the earth.

From a methodical standpoint, this example shows that the visible landscape may be regarded as an effect. It is first described and then the explanation should indicate the cause. The rocks, the endogenous and exogenous forces (tectonics, weathering, erosion) are the most important components. The causal explanation leads to the cause, always assuming that the effect of the forces has been constant over the whole period.

This explanation is based on the principle of actuality (or "actualism") attributed to the 19th-century English geologist C. Lyell. This theory states that the forces and phenomena of earlier geological eras are in principle not different from those of the present day. This hypothesis made it possible to use processes observable in the present to draw direct conclusions with reference to past. This kind of causal explanation dominated the concepts and approaches in geomorphology well into the first half of the 20th century.

In geography, the actualism thesis was maintained until it became apparent that our present geographical relief still contains distinct traces of previous reliefs attributable to a different climate, e.g. the periglacial climate of the ice age or the tropical climate of the tertiary era. This means that the surface forms seen in the present day have a complex history and that causal explanations are therefore questionable or of only limited validity.

A settlement:

In principle, every substantial thing which can be moved and altered may be regarded as a solid. This includes everything tangible, for example the cultivated landscape with its

Fig.8:
Land utilisation on the Teufelsmoor near Bremen (1965). An example of the proximity of concrete forms (here plots of land with differing utilisation).
1 deciduous forest; 2 coniferous forest; 3 mixed forest; 4 bush country; 5 marsh meadow; 6 marsh, heath; 7 moor, peat cutting; 8 gravel, sand, rubble; 9 arable land.
Source: Topographical map 1:25000, no. 2719 (Worpswede). Detail: Teufelsmoor (Hamme). Reproduced by permission of the publisher: LGN - Landesvermessung und Geobasisinformation Niedersachsen.
See also "Notes on the figures".

universe of forms. These forms can cartographically documented. Apart from natural forms, all earthbound artefacts at every level and on every scale such as urban and rural settlements, roads, bridges, fields, mining and industrial areas are some examples. MEITZEN (1895) linked the most important forms of rural settlement in present-day Germany with the peoples and tribes living here in the past. And for many years (into the 1920s and 30s), geographers also tried to explain the settlements causally. The illustration (see fig. 8) shows the rural community of Teufelsmoor. It permits a topographic identification and (in combination with the type of ground), a preliminary causal explanation. It is a so-called "Moorhufensiedlung". The farms are erected on man-made mounds ("Wurten") and are situated at a short distance from the main road ("Moordamm") on long plots of land ("Hufen") at right angles to the road and the river Hamme, which are separated by ditches. Each plot has a share in the Moordamm and the Hamme and the various natural characteristics of the ground. To the south east (Hamme lowland) grassland is predominant while to the north west peat is removed. The regularity of the layout indicates that the settlement was planned systematically and the map makes it possible to deduce the reasoning used by the settlers in determining the shape of the settlement. To this extent, we are using causal explanation.

However, if we go into more detail this method is misleading. It has now been realised that these forms have undergone a very complex process of change. From documents, we know that the settlement has been in existence since the 14th century. The fundamental form has remained unaltered since that time, but many changes have taken place in detail. The farms were originally closer to the Hamme in the south east of the community. In addition, the social character of the population has changed radically.

It is not possible to examine these settlements using exact methods, in the same way as a physicist. The more complicated the form, the more varied may be their history, the more vague the results of causal explanations. The development could be divided into periods and these causally examined. In practice however this does not work because insufficient documents exist to support a detailed study. It would also be possible to examine each minor form causally. However, that would mean going to absurd lengths.

In the sense of our process theory, we would say, that these forms were created by action motions or movements which in their turn can be explained causally. The solida which are perceptible in our order of magnitude represent an archive. Every action motion, every movement has left its traces which can be investigated hypothetically and explained causally. Naturally, the results do not explain much. They do not explain the peculiar nature of these solida or their specific shape. Here, analysis of the complex process sequences is the only way forward.

2.1.3. Process sequences and systemic dimensions:

Numerical sequence:

The progress of the stimulus in the solidum can be represented as a sequence of numbers or a "numerical sequence". In the following, the stages of the basic process are given the numbers 1 .. 4 (see fig. 9). We are concerned only with the transfer of stimulus (energy) in the solidum, the internal relationship of cause and effect (see section 2.1.1.1, pp.17). The temporal sequence is not yet under scrutiny (this variant is only characteristic of the higher levels of complexity).

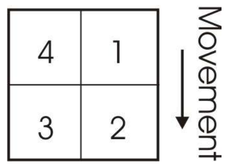

Fig. 9:
Scheme of the way of the stimulus of a movement in a coordinate system. Numerical sequence. *1 = Input; 2 = Acceptance; 3 = Redirection; 4 = Output. See fig. 4.*

The way of the stimulus in the solidum is opposed by a counter stimulus - the "actio" by the "reactio" (see section 2.2.1.2, p.21). Both are directly causally connected. The counter stimulus leads the same way back. For this reason, it is not shown expressly in this diagram (and in the corresponding diagrams of the higher complexity levels).

Route diagram:

The course of the stimulus of the movement in the solidum can be shown as a route diagram (see fig. 10). In the centre, the contact to the stimulating or receiving environment is indicated (entrance and exit). The stimulus then moves into the solidum (1 .. 2) and out again (3 .. 4). (The course of the counter stimulus is not shown.)

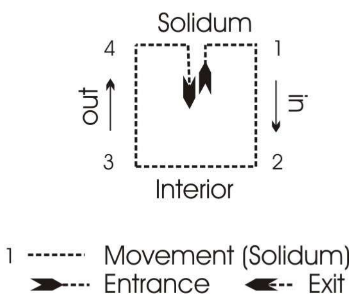

Fig. 10:
Scheme of the way of the stimulus of a movement (solidum). Route diagram.

Both types of description: numerical sequence and route diagram, complement one another. These two models form the basis for all the corresponding models in the more complex processes and systems. The configuration of the two models is similar at this level of complexity. However, at higher levels they take on different shapes.

Systemic dimensions (see fig. 11):

In themselves, the solida may well be complicated structures, as already mentioned. In this way, the factory can also be defined as a solidum as we have done above. As with the movement or action motion, only the stimulus entering (cause) and the result (effect) are significant.

The movement of a solidum represents the physical implementation of cause-effect connection. The reason (antecedens) is the logical condition for the result (consequens). Such relationships of conditions are an expression of regularity, not as a succession of stages in a process, but as a framework of deterministic laws. Nevertheless, if we look at the movement more closely, several fundamental facts can be established which are important for the discussion which follows:

So, the above equations (see section 2.1.1.2, pp.20) also show that the movement is determined by 4 dimensions.
1) First, there is the "quantity" of energy of a certain kind which is expressed in the accelerating force, resp. which is contained in the mass M of the solidum.
2) Then there is "time", which is expressed in the speed v.
3) Another dimension is indicated in the condition relationship antecedens-consequens. The "hierarchy" is the dimension. The stimulus from the environment represents an order which has to be obeyed, thus producing movement or changing of the solidum.
4) Moreover there is the distance which is also expressed in the speed v. Distance is a property of "space".
From a general point of view, these "systemic dimensions" are the vectors which define not only the movements in the solida but also the processes which structure the systems at the higher levels of complexity.

But the system dimensions are not of equal importance. The equations shown above reveal 2 fundamental conditions on which every movement is based:
a) the quantity of energy and b) how the energy is fed in and utilised. This "how" is information which (like the energy itself) is transferred from the environment to the solidum.

From the above it follows that at the first level of complexity, it is the amount of energy entering which makes the behaviour of the solidum possible. This dimension is dominant. Dominant systemic dimensions are vectors which dictate fundamentally the behaviour of the system. The remaining dimensions (time, hierarchy and space) are joined to it. Their values change in relation to the energy entering. In the course of the discussion, we will see, that with each step from one level of complexity to the next, a new dominant dimension is exposed.

Fig.11:
The quantity is the dominant system dimension in the solidum.

Outlook:

Solida are phenomena which are controlled from outside. They act and react as units and are subject to causal explanation. However, the causal method is only accurate enough if one can assume that between the time of the cause and the time of the effect there is no differentiating process of change between a first and a second state. For solida with complex stuctures which have become historical, the causal method is very imprecise. Above all, with this type of explanation, the temporal dimension is of no importance in the description. Only at the superior levels of complexity do we interpret the development of the object as a process.

To take the view demanded by the process theory, more emphasis should be given to different aspect. It is not only the outer form which is important, but also the structure. Only in this way is it possible to ascend the ladder to the various levels of complexity. This takes us to the next level of complexity.

2.2. Equilibrium process and equilibrium system

2.2.0. Instead of an introduction: The textile factory as a functioning plant

We will now look at the cotton factory from a functional point of view. From the road, the entry to the factory led past the gatekeeper's lodge (see fig. 12). The right-hand front of the

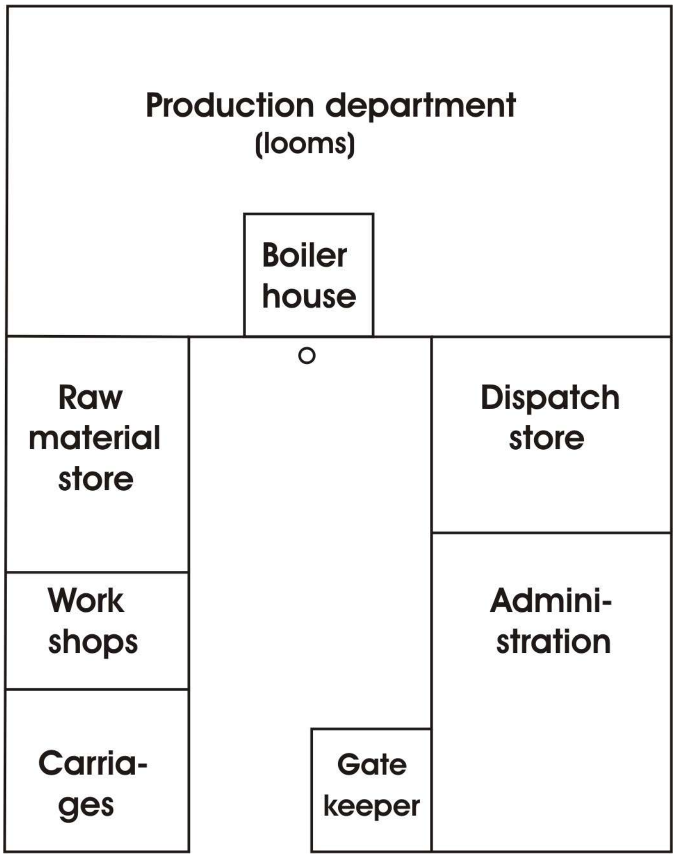

Fig. 12:
The textile factory. Functional division in departments.

central yard was occupied by the two-storey administration building, with management, marketing, purchasing, planning, design offices etc. The building on the left of the entry housed the garages for vehicles and the workshops. In the rear part on the left, the raw-material store was located and at the rear on the right, adjoining the administration section, the dispatch store. Both of these were equipped with loading ramps.

At the rear centre, the boiler house was situated, with a steam engine, a chimney and a coal bunker. On the left and right, paths led past the actual production shop containing the looms.

The various buildings and rooms were easily accessible from the central square and arranged in such a way that the distances to be covered for the production process were as short as possible, but also that the production workshop with its noise did not directly adjoin the administration building and the free area. The company was able to function efficiently and prosper as a production unit. And the company as a whole was also able to maintain an energetic balance between supply and demand.

The raw material, especially cotton yarn of various qualities was generally delivered to the factory from various spinning mills in neighbouring towns. The raw material was transported to the factory by rail and the finished fabrics taken away by the same means. Within the town, they were transported by horse and cart as this was the most economical method. The feed for the horses came to the stables from a farm a few miles distant which also belonged to the owner of the company.

In the working units each employee had his own well-defined task to perform. He had his working space and worked according to his capabilities. The workload on the one hand was balanced by the possibilities for consumption and recuperation on the other. The factory was organised on partriarchal principles but no exploitation of the employees took place. The wages provided the workers with a modest but adequate living. In terms of energy, the individual was constantly in a state of balance between energy supply and energy consumption.

Most of the workers lived close to their place of work. From most of their houses, the factory was easily reached on foot or by bicycle. As yet, no car park was required. The catchment area for the workers was therefore small, only very few of them living in outlying communities. Greater distances would have meant greater expenditure of (costs and) energy.

2.2.1. General considerations

2.2.1.1. System and process

The description shows that we are dealing with the company as an entirety on the one hand and the employees on the other. Considered abstractly, we may speak of the company, as an integral whole (represented by the owner), as a system, and of the employees, as the elements. The term system should be understood here in an all-embracing sense, i.e. it includes not only the structure and links, but also the substance (especially the elements as carriers), the process flow, the internal linking of the elements and the space required (BERTALANFFY, BEIER and LAUE 1953, page 29 use the expression "concrete system" in a similar sense for flow-equilibrium systems. See section 2.3, pp.69). The elements are the individuals in their roles which compose and operate the system. Each of the various departments of the company had a number of employees co-operating with one another in the same functions, for example those employed at the loom, in the stores, in the marketing department etc. Thus, the employees can be assigned to certain characteristic groups depending on their activities or functions.

Characteristic groups or classes are homogeneous within themselves and characterised by one particular feature. They can be analysed statistically from various points of view, e.g. the number of employees with a certain level of income, the specific kind of agricultural land-use, industrial areas from the point of view of the products they manufacture, their size, etc. In this way, we obtain information on the functional division of the research object.

Generally spoken: The elements function within the aggregate of the system, which itself fits into a structure, which in turn (as with the factory) has a higher degree of complexity (see section 2.4, pp.119). The elements fit into these specified structures and assume certain functions for them. At the same time, they have their own interests in order to secure their own survival. The whole is a composite but well-balanced structure in which every detail is incorporated in a useful, i.e. functioning, network. System and elements strive for a state of equilibrium. We are dealing with the "equilibrium system" resp. "equilibrium process" ("conservative systems"; PRIGOGINE 1979, S. 37 f.).

Functional explanation:

Since about the 1920s, geographers have been studying the multifarious aspects of the economic and settlement structure in a given area, dividing the object observed according to functional criteria. In this way, more attention came to be focussed on the human being himself. When investigating the arrangement of such structures, it is obvious that causal explanations have very little sense. Rather, the object requiring explanation (explanandum) has to be placed in its functional context.

To arrive at an explanation, it is important firstly to consider the individuals as members of social groups and the groups themselves as characteristic groups within their environment, i.e. that the details become understandable by their integration in the whole, and the whole by the arrangement of the details. All the knowledge available on the object being explained must be placed in a coherent, logical and accurate context.

This functional approach is reminiscent of the hermeneutic method which has dominated interpretation in the humane disciplines since the 19th century. However, the hermeneutic interpretation is not connected only with a certain type of systems. The aim of the functional explanation is to interpret the structures and spatial patterns of the equilibrium systems, thereby throwing light on the effective structure and giving particular attention to the social groups and their specific activities.

The process functions at the system level and the action at the element level. If one uses the context of sense or meaning for the purpose of explanation, this also means that one assumes that human actions have a sense and that they are functionally understandable. The actions concerned here are "action projects" (see section 2.1.1.1; p.19) which are carried out principally with intent.

The action project of the individual is only an example. The more general term is the movement project. Action projects are the movement projects of the social systems. It is mainly action projects which we will examine here, because they make it easier to study the characteristics of the movement projects than other projects do.

Action (movement) project:

The meaning or the sense of the action project is manifest in its task. Each action project is devoted to a task, e.g. the transport of goods from the factory to the station, the preparation of a meal, the operation of an electrical appliance etc. Such projects consist of many action motions and can be carried out in different ways. They may take hours, days or years. Each individual (as agent) is faced with the problem of carrying out his work, i.e. his action project, as efficiently as possible. The efficiency of human action depends on the possibilities open to the person in question. In detail, we can state that in this process, 4 stages have to be passed through. The basic process is reflected here (see fig.13 and section 2.1.1.2, p.21):

1. Input: The individual receives the order from the superior and preceding environment, i.e. from the company management, to carry out the action project "weaving of cotton cloth".
2. Acceptance: The individual accepts the order and demands the energy required from himself to carry out the work;
3. Redirection: The individual procures the necessary raw materials;
4. Output: The individual executes the work and delivers the result.

Stages 1 and 2 can be interpreted as flow of information and stages 3 and 4 as flow of energy.

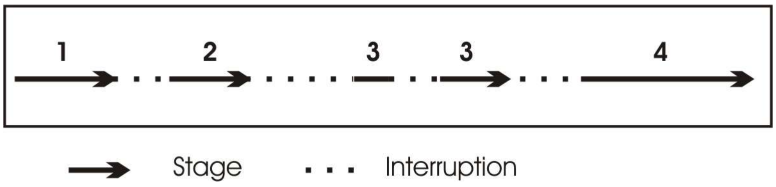

Fig. 13:
Diagram of an action (movement) project. The 4 stages differ in length and can be interrupted.

In the project many simple action motions or movements (see section 2.1.1.1, p.19) are integrated. They are what consume the energy. During the execution of the action (movement) project, the energy is withdrawn successively from the organism, which was previously supplied with energy independently of the work, as permitted by the resources. Contrary to the action motion (movement), energy consumption and time consumption are separate.

Thus, if necessary, intervals may occur during this project according to individual requirement. Each movement (or action) project can be sub-divided into many small individual projects. The personnel may be changed or replaced. In this way, the individuals maintain an energetic equilibrium between the energy available to them and the work to be carried out.

All action projects, all processes come to an end. (This is indicated in fig. 14.) As those performing the process, the elements consume energy, whether through the work of the employees in the factory or the day-to-day travel of the commuters. It is this which may be likened to the mechanical friction in inorganic systems. In this way, an apparent counter process comes into being which controls the course of the process.

Action projects and equilibrium process:

Attempts have been made to make actions conceptionally useful in understanding our reality. In the field of geography, this was pursued be WERLEN (1995-97). However, he was unable to proceed forward from the microlevel of actions to the macrolevel of processes. Only by interpreting the individual actions as processes, i.e. action projects, and the individuals (as suppliers of energy) in their tasks and roles as elements in a system, does it become possible to move from the micro to the macrolevel. Because the action projects serve certain tasks which are set by the system of a higher complexity level.

The action projects are frequently carried out in groups of individuals. Like seeks like. These groups execute equilibrium processes. Action projects, like the movement projects in a more general way are simply the equilibrium processes of the elements. Equilibrium systems are accordingly formed from the sum of the elements. In this way, these form the above-mentioned characteristic groups i.e. equilibrium systems. When the infrastructure in the chronological, spatial and structural environment is favourable, the individuals either assemble to form systems, or, as in the case of a factory as a superior system, consciously concentrated in departments. In both cases, the system arranges the action projects.

From this point of view, the individual action projects fits into the superior system, e.g. the factory, while the factory with its rhythm of work takes account of the individuals. The individual action projects must adjust to the process of the system in accordance with his capabilities and limitations, thereby ensuring that both he and the factory function as smoothly as possible and achieve the maximum effect. The individual and the factory are then in a state of balance. (In reality, this is not quite so simple as industrial disputes between employers and employees show.)

Not only the work at a fixed place (e.g. at a loom), but also overcoming distance demand time and energy, i.e. the effort involved in the transport process must be added to the effort necessary to execute the actual work. This also applies for the system. In the textile factory, this was taken into account in the arrangement of the departments, administration, stores, production etc. Within these departments, the individuals worked, as mentioned above, with the same aim in view, they had to cover the distances to the department coming after theirs in the production process. Consequently, the departments were arranged in such a way that they could co-operate with one another as effectively as possible, i.e. if possible without any waste of time (see also section 2.4.1.2, pp.123).

Larger equilibrium systems:

Understanding the movement projects forms the essential condition for understanding larger equilibrium systems as well. As already noted, movement projects can also arrange themselves in larger units without any direct central control. They adjust themselves to the environment, e.g. to the existing infrastructure (e.g. the factory, an attractive town,

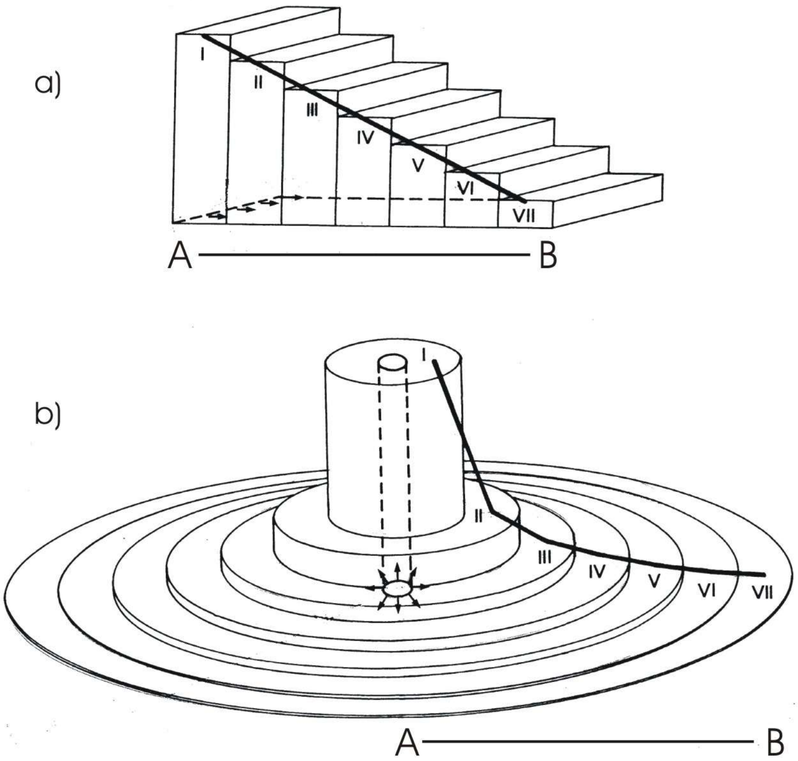

Fig. 14:
Long range effect (damped) under different spatial conditions.
Diagram illustrating the shape of equilibrium systems.
a) Initial region extended in length, linearly inclined structure, uniformly wide towards the outside.
b) Initial region locally concentrated, expanding in an outward direction (umland).
Each stage I, II ... has the same content in both models.

a restricting boundary). So, different types of space come into being depending on this arrangement of movement projects:
- Some systems have the basic structure of a homogeneous "region" (BARTELS 1968, pp. 74). The characteristic groups are present in approximately the same density. Examples are areas of uniform agricultural utilisation such as the wheat and sugar-beet producing area known as the Magdeburger Börde in Germany or the winter wheat cultivation area of the Great Plains in the USA.

Frequently the elements move from a point A to point B. Here, we are concerned the long-range effect, i.e. the longer the distance travelled is, the less it is preferred, because it demands more time and usually more energy. If many such movement projects are aligned in this way, this can be understood as an equilibrium system. It is an addition of movement projects in space. These systems have the basic structure of a "field" (BARTELS 1968, pp. 108). There are 2 possibilities (see fig. 14):
- If we assume a line with many points A (as the edge of an initial region), we receive a inclined structure with many points B. The long-range effect from A to B can be described as a linear relation (see fig. 14a). Patterns of this kind arise, for example, at borders.

- The carriers of movement projects move between a point A at the centre (as an initial location) and a point B in the "umland", i.e. the surrounding country (see fig. 14b). More and more space is available radially from the centre towards the periphery (similar to the Law of Gravity). Thus, the density of these movement projects is very high in the vicinity of the centre and declines towards the outside, very rapidly at first and then more and more slowly. As an example, let us look at the catchment area for the weaving mill as indicated by the area within which the employees live (as commuters). In view of these circumstances, the positions closer to the centre are more attractive for the elements than those further afield. For this reason, the characteristic groups tend to concentrate in the centre.
- At a second level, characteristic groups can become structured in rings according to the distance from the centre, frequently developing as a consequence of the radial structure, e.g. homogeneous regions added around the city.

2.2.1.2. The Model

Stages of equilibrium processes:

In contrast to the solidum and the movement, the equilibrium system and the equilibrium process are not compact units. Instead, we are dealing with a system with many elements and a process divided into stages. At this level of complexity it is, as described above in the discussion of the action projects (see section 2.2.1.1, pp.38), the chronological sequence which is of primary importance. Equilibrium process and equilibrium system are adapted to one another. However, the stages are not fixed in their temporal rhythm (c.f. on the other hand, conversion process, sections 2.4.1.2, pp.128, and 2.4.2.1, pp.147). Rather the process is only the temporal succession which is ordered structurally here. The equilibrium process is a four-stage process in which information or energy is transformed. Each of the 4 stages has a function in the whole. Or, put differently, at each stage a task is solved.

We will treat this from a abstract point of view and reduce the process to the level of information and energy flow. From outside, the system is stimulated to change, i.e. from one state of equilibrium to another. The elements arrange themselves accordingly, although the necessary distance between the elements has to be observed. Neighbourhood contacts play an important role here. In the system, the stimulus is converted into an increase in the number of (potential) work units which is either identical to or proportional to the number of elements. First of all, we will show that the progress of the stimulus in the system involves a change in mathematical method in each of the four stages:

- Stage 1 (input): The transmitting of a stimulus from the preceding environment to the system composed of elements takes

place at this stage. This stimulus may be an input of energy. The quantity is asked for. The energy must be distributed with its elements in the system, because only then can it be effective for the following process. The energy is exchanged in equally large portions (quanta) between the elements. The possibilities for combination between the elements therefore have to be taken into consideration. It is a logarithmic relation which describes the distribution of energy to the quantum states of a system (see also section 2.3.1.2, pp.81).
- Stage 2 (acceptance): How much energy the elements (as the potential adopters) can still accept is determined by rational functions.
- Stage 3 (redirection): The stimulus now has to be diffused into the elements (adopters) themselves. This is described by exponential functions.
- Stage 4 (output): In the last stage the relation adopters and all the elements of the systems is demanded (relative frequency). The formulae describing this are probabilistic.

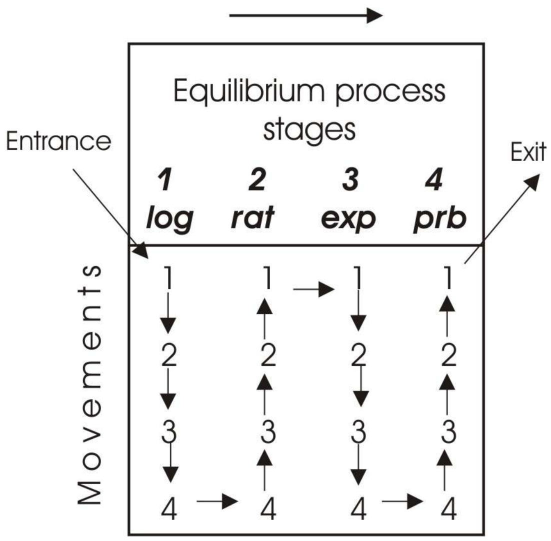

Fig.15:
Path of a stimulus through the equilibrium system.
The numbers signify the stages of the basic processes.
Abbreviations: log = logarithmic, rat = rational, exp = exponential, prb = probabilistic.
It is necessary to distinguish the first-rank process (entire system, italics) and the movement stages (2nd rank processes).

Thus, two hierarchic levels should be distinguished. The process in its entirety (with its four stages 1-2-3-4) and the elements. Here too, we can distinguish four stages, which we will also term 1-2-3-4. Now we join system and elements i.e. equilibrium process and movements, together. It should be remembered that the elements function
1) as parts of the system (*1* input and *2* acceptance), and
2) as (subordinate but) self maintaining systems (*3* redirection and *4* output). In this way it is possible to represent the double path through the system in a table (see fig. 15).

The direction of the vertically oriented stimuli of the adjacent movements alternates (see section 2.2.3, fig.31, C variant, p.66). Thus the transmission of data at the corner stages (1 resp. 4) during the process is faciltitated. A structural symmetry is described here. We will encounter this symmetry in the context of energy transmission (which itself is asymmetric) again and again (law of symmetry).

For guidance:

Mankind as a society is the object of study. The individuals carry out action (movement) projects, i.e. they work towards a specific goal in order to complete a certain enterprise. Four different stages can always be identified (C variant):
1) Input: a stimulus is received in the system;
2) Acceptance: the stimulus is accepted in the system;
3) Redirection: it is now implemented into the elements;
4) Output: the final emergence of the result (elements).
These stages (constituting the basic process) may be interrupted (e.g. by rest intervals or absorption of energy), or continued by other individuals, depending on the circumstances or, more strongly, by the (energetic) possibilities available. In this way, the individuals are enabled to remain, more or less, in an energetic equilibrium.

Individuals acting in the same manner may collaborate or form groups (characteristic groups), e.g. individuals may act alone or be involved in a work process. The spatial coexistence depends on the infrastructure. As a general rule, the individuals subordinate their action projects to the rules of overriding structures and support these. In this case, they are the elements in an equilibrium system. Four fundamental types may be distinguished. These are:

1) Homogeneous areas, in which the characteristic groups are present in approximately the same density;
2) Characteristic groups, whose density declines linearly from a borderline;
3) Characteristic groups, whose density decline radially from a central point outwards;
4) Ring structures, frequently developing as a consequence of the radial structure.
In all these cases, the characteristic groups may possess functions for the overriding structures.

2.2.2. Other examples

2.2.2.0. Instead of an introduction: A movement project as seen by an artist.

In painting, movement projects are a common subject. Especially work is perhaps the most important factor in our existence. The following rural subject is a good example.

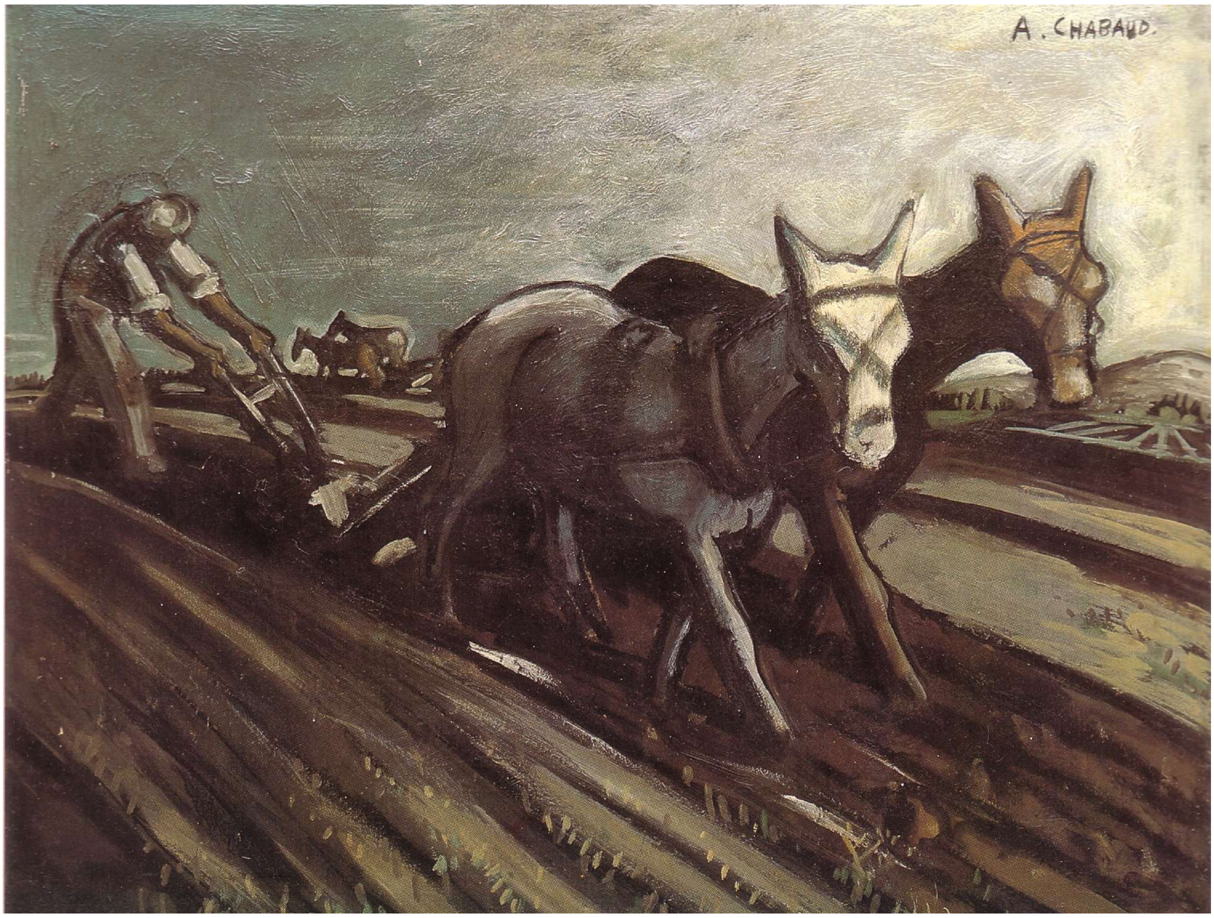

Fig.16:
Auguste Chabaud: The Farmer. Ploughing a field, an example of the representation of a movement project.
Source: See "Notes on the figures".

Chabaud painted a farmer ploughing a field, walking bent behind his team as he makes a furrow in the soil (see fig. 16). Two horses are pulling the plough, seemingly obeying the farmer without the use of reins. A second team is seen in the background. It is autumn and the sky is dark and overcast.

The artist painted the picture in 1910 while living in the Provence. His intention was expressive. His work has a close affinity to artists like Heckel or Kirchner, with whom he exhibited in Berlin in 1910 (CHABAUD 1993, p. 214).

Seen formally, the movement project "ploughing the field" consists of several inferior movement projects, such as stepping in the furrows, watching the horses, steering the plough and pressing it in the soil etc.

In the following, equilibrium systems are described which are good examples of the characteristic groups in their varied spatial structure.

2.2.2.1. Homogeneous structures:

Landscapes:

The equilibrium systems are extensively studied. Expansive regions characterise the surface of our earth. The lowlands of northern Germany, the Alps, the Plains in North America and the Andes are well-known examples. The earth is divided up in this way. On a smaller scale too, it is geographical regions from which we take our bearings. These regions are often characterised by prominent features such as their shape (e.g. Vogelsberg, the Russian lowland), their geology (limestone Alps), population (Poland), climate and vegetation (tropical rain forest) etc.

In the 1920s, landscape science ("Landschaftskunde") developed in German geography (SCHMITHÜSEN 1976). The forms and quality of the earth's surface were studied in detail, with emphasis on homogeneously structured regions. A number of studies appeared in collaboration with botanists, in which vegetation was shown in its spatial distribution. This led to the conclusion that different plant associations have formed according to the natural characteristics of the ground (soil, water supply, inclination of terrain etc.), climate (especially of the air close to the ground) and human influence, and that these associations may be regarded as characteristic groups. The plants co-exist with other plants in the manner and density dictated by the nutrition base which assures their survival. To ensure reproduction, a certain minimum population must be involved. The cellular structure favours this striving to attain a balance.

A good example are the plant associations (or "ecotopes"; see section 2.3.2.1, p.96) in the forest area of Bialowieza (see fig. 17). This is an undulating base moraine and sander area in Eastern Poland which was formed in the Elster and Saale ice age and in which the ground-water level has a decisive influence on the vegetation.

Examples of inorganic equilibrium systems of this type include dune areas, marshes, oceans, but also geological strata, granite massifs etc. These are (typologically) homogeneously

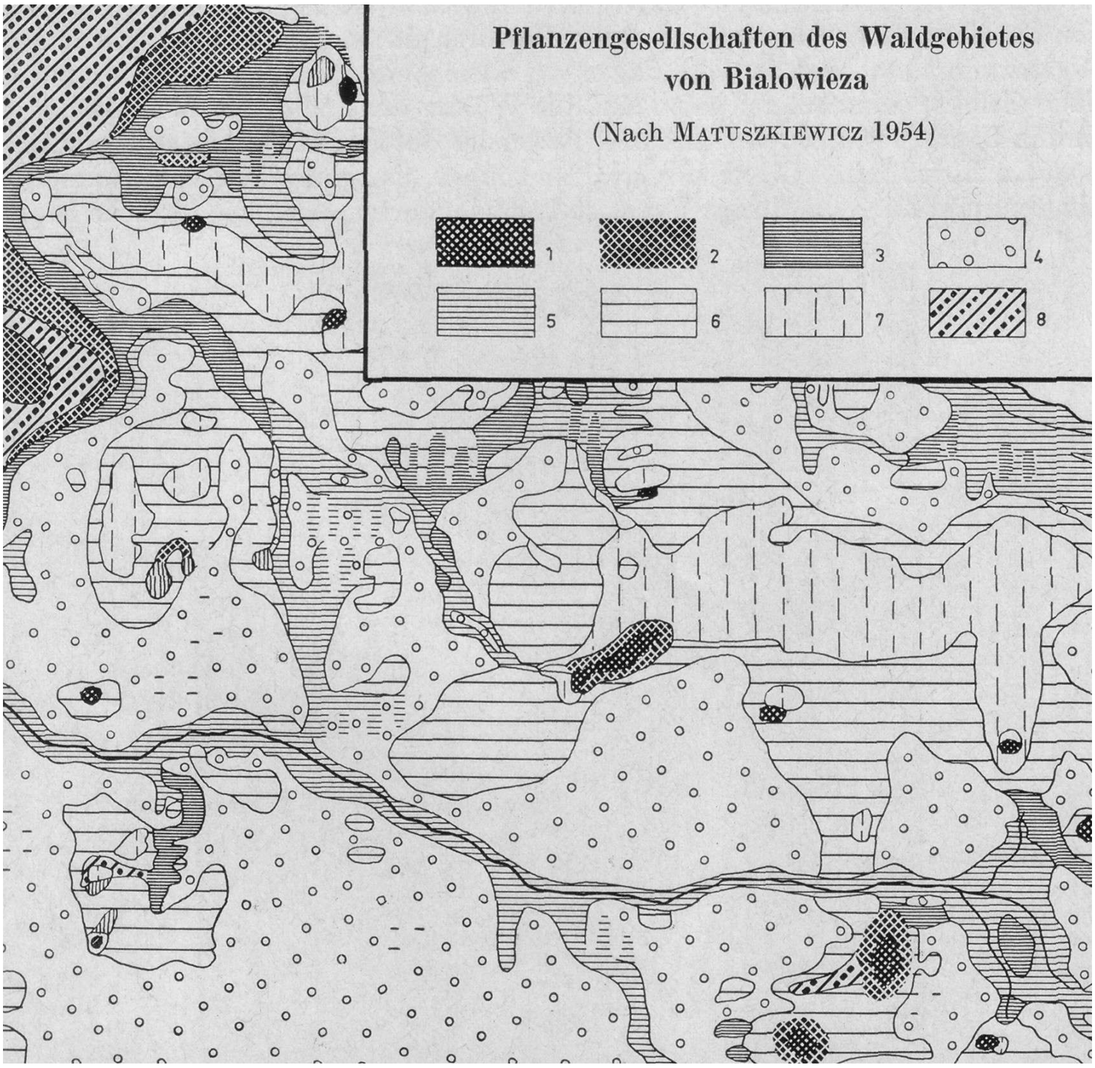

Fig. 17:
Plant associations in the forest region of Bialowieza. Example of the cellular division of a natural unit into various ecotopes (equilibrium systems). 1 = raised bog (Sphagnetum medii pinetosum); 2 = flat bog (Salix aurita-Frangula alnus Ass.); 3 = flat bog (Alnetum glutinosae); 4 = wood (Querceto Carpinetum medioeuropaeum); 5 = wood (Circaeo-Alnetum); 6 = wood (Querceto-Betuletum); 7 = wood (Pineto-Vaccinietum myrtilli); 8 = wood (Pineto-Vaccinietum uliginosi). Source: See "Notes on the figures".

shaped forms and parts of the earth's surface or the upper lithosphere. These equilibrium systems can be enlarged or reduced in scale, elements can be added or taken away without the remaining parts being affected.

A farm in Germany:

Farms have always had to rely particularly on the various activities being functionally separated. A good example is the traditional lower German farmhouse (see fig. 18). The larger front part is devoted to the work of the farm. There is a functional division into departments or rooms where certain action projects are carried out. At the time of their action, the farmers working here are "carriers" of functions and as such are members of characteristic groups. Through a large door in the gable wall, access is gained to a large vestibule ("Diele") where the various jobs in the building or in the field were coordinated. The large attic was for storing hay or straw. On both sides of the vestibule were the stalls for cattle, pigs and horses and above these the rooms for storage of threshed grain, animal feed, tools, etc. The sleeping quarters for the labourers were often to be found here. The back part of the building was the living quarters of the farmer and his family as well as female servants, and was divided up into kitchen/living-room, pantry, bedrooms etc. In front of the forward gable wall, there was a large yard for dung, preparation of field work, e.g. harnessing of teams, or threshing of grain.

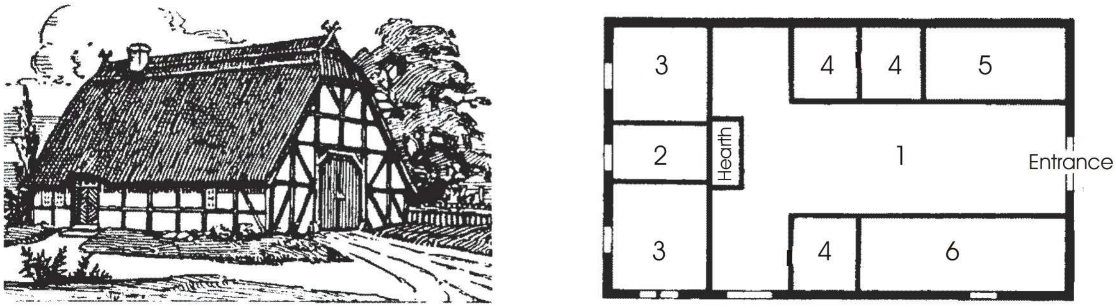

Fig. 18:
Representation of a traditional low-German barn-type house (Niederdeutsches Hallenhaus), image and ground plan. Example of practical division of a farmhouse. 1: Vestibule; 2: Kitchen and hearth; 3: Living and bedrooms; 4: Chambers; 5: Horses; 6: Cattle.
Source: See "Notes on the figures".

Nowadays, several modern buildings and structures are grouped around the yard, for example a dwelling house, garages for machinery and vehicles, stalls, barns, grain, bins, tanks for liquid manure etc. The old building is still integrated in this assemblage but now functions as a barn, repair shop, tool store, storage of farm products etc.

The rooms and buildings of the farmstead and the plots of land were arranged in such a way that work could proceed as simply as possible, i.e. according to the principle of the "shortest possible routes". This principle applies to the running of the entire farm. The area under cultivation is arranged so that the plots used most frequently and intensively were closer to the farm buildings while those used less frequently were located at a greater distance, where this was permitted by the quality of the land (e.g. marshy lowland or dry hill terrain). Closest to the farmstead is a kitchen garden and decorative garden where vegetables, fruit and flowers were cultivated for the use of family. Oaks, beeches, limes, chestnuts and spruce trees provide shade and protection from the wind. The farmstead is therefore surrounded by greenery while beyond this lie the fields. The more distant plots are used as pasture land for cattle in summer, as well as for meadows for growing hay (see also section 2.2.2.4, pp.57).

Functional areas in a city:

Cities have divided themselves into districts or quarters with more or less homogeneous structures, e.g. in business, banking, governmental, and residential districts of varying quality and ethnic composition. Innsbruck (BOBEK 1928) and other cities were studied and mapped from a functional point of view by geographers and sociologists in the 1920s. In the

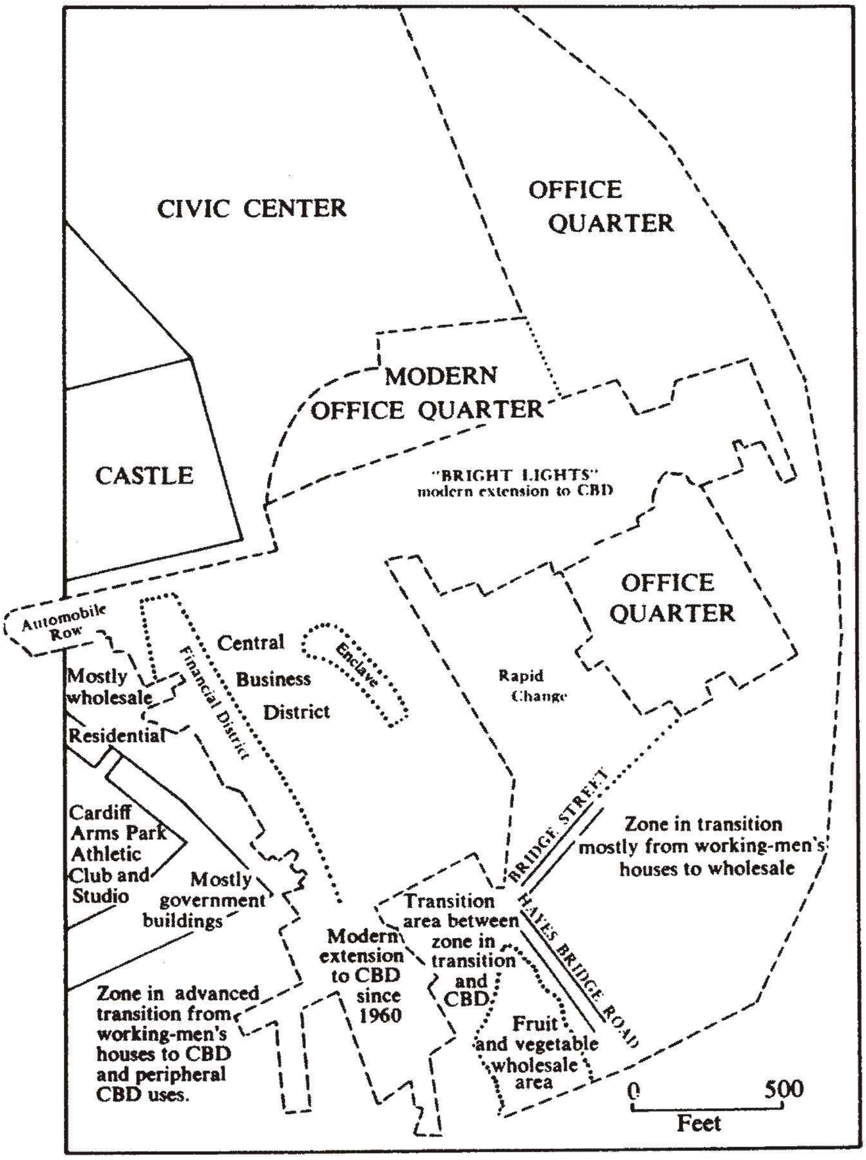

Fig. 19:
Urban regions in central Cardiff. Example of the organisation of an urban area into uniformly utilised areas. Source: Carter and Rowley. (See: "Notes on the figures").

meantime, this type of division has become an accepted fact and is used as an effective instrument in town planning.

Our example shows a division of the city of Cardiff around 1965 (see fig. 19). All the elements of the same kind, industrial companies, shops, offices, inhabitants etc. are characteristic groups, i.e. groups or classes of elements with uniform features. The areas have a function in an overriding whole. This refers to the (horizontal) co-existence, the arrangement in space. The elements arrange and demarcate themselves depending on the surrounding circumstances. For example, shops have to be accessible for as many customers as possible (in central business districts or in shopping centres). Industrial companies however prefer locations with good infrastructures (e.g. roads) which make expansion possible and where real estate is reasonably priced.

2.2.2.2. Linearly inclined structures

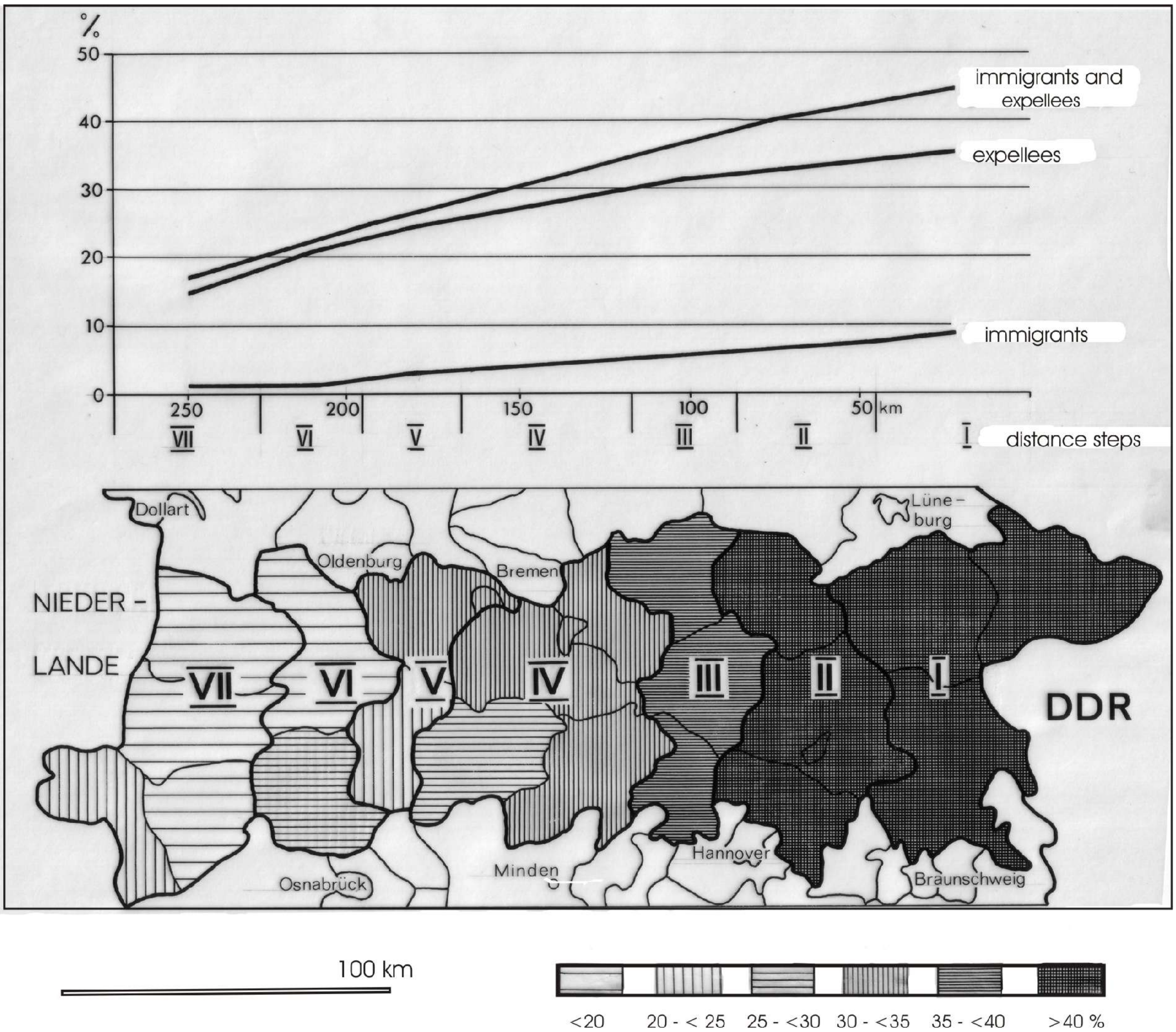

Fig. 20:
Exiles and refugees in Niedersachsen (Germany) 1955. Number per inhabitants.
Source: See "Notes on the figures".

Special attention has been devoted to equilibrium systems in which an additional horizontal "force" acts on the elements. Here, asymmetrical structures come into being.

Settlement of exiles and refugees in Niedersachsen (Germany):

Using the settlement of the exiles from the former eastern regions of Germany (East Prussia, Pomerania, Silesia, Sudetenland) and the refugees from the former German Democratic Republic the influence on central Lower Saxony of the areas east of the demarcation line will be illustrated. This area was chosen because of its substantially uniform rural character. In 1955, the movement of population towards the growing towns was not yet pronounced enough to cause a secondary change in the spread caused by the migration from east to west. The areas north and south of the areas examined which are not cross-hatched in the diagram, were not included in the study.

The former eastern regions of Germany and the German Democratic Republic represent the areas in which the long range effect originated i.e. the initial area. Central Lower Saxony represents the settlement area. In the diagram above the map, the proportion exiles and immigrants in the population is shown on the ordinate. The distance from the demarcation line (as starting point) is shown on the abscissa. The influence appears to diminish approximately linearly from east to west.

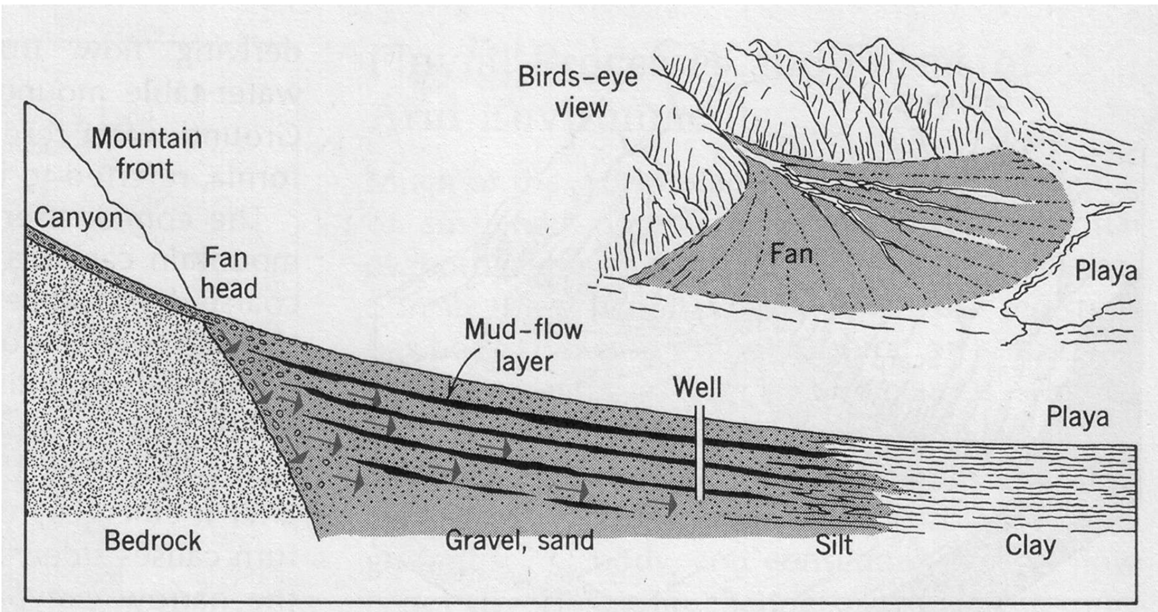

Fig. 21:
Idealised cross section of a complex alluvial fan showing the change in geological composition with growing distance from the fan head. After A.N.Strahler. Source: See "Notes on the figures".
An alluvial fan:

The terrain at the foot of mountain ranges often forms sloping plains composed, among other things, by numerous alluvial fans. These originate at the mouth of a mountain valley and spread out in the shape of a fan. At the foot of the mountain, boulders and coarse rubble are deposited, giving way to gravel and sand as we move towards the plain, and finally depositing only silt and clay (see fig. 20).

The different particles can be interpreted as elements in equilibrium systems. They are controlled by a superior asymmetric structure in the energetic environment. It generates a gradient and initiates movement projects. Thus, the compulsion to execute the movement projects comes from outside. The elements move themselves (in accordance with gravity) in their resting position.

The single alluvial fans are in a transitional position to the radial structures:

2.2.2.3. Radial structures

Central-peripheral arrangements are demonstrated by, for example, volcanoes and the rocks of which they are formed, in particular the tephra. Close to the crater, large volcanic bombs are deposited while the number of finer particles increases with increasing distance until only dust is sedimented right at the outside. We will present a number of anthropogenic examples.

Activity in pueblo land:

First we will look at agricultural use by an Indian population around the (now abandoned) pueblo Pecos in New Mexico. The fields were cultivated and guarded from so-called field houses, which were scattered over the terrain. The occupation of these houses indicates the way in which the surrounding area was cultivated. The duration and frequency of their occupancy reflects the intensity of cultivation. This is shown by finds of ceramic materials used by the inhabitants. A study of the land around Pecos (1981) produced the largest amounts of ceramic sherds in the areas closest to the Pueblo. That means that the intensity of cultivation decreases with growing distance from the village (see fig. 22). By contrast, most stone tools (arrow heads, scrapers, knives etc.) used for hunting and preparing game were found further away from the settlement towards the uncultivated wilderness. This indicates that hunting was still the principal livelihood of the Indians in the outlying districts and beyond.

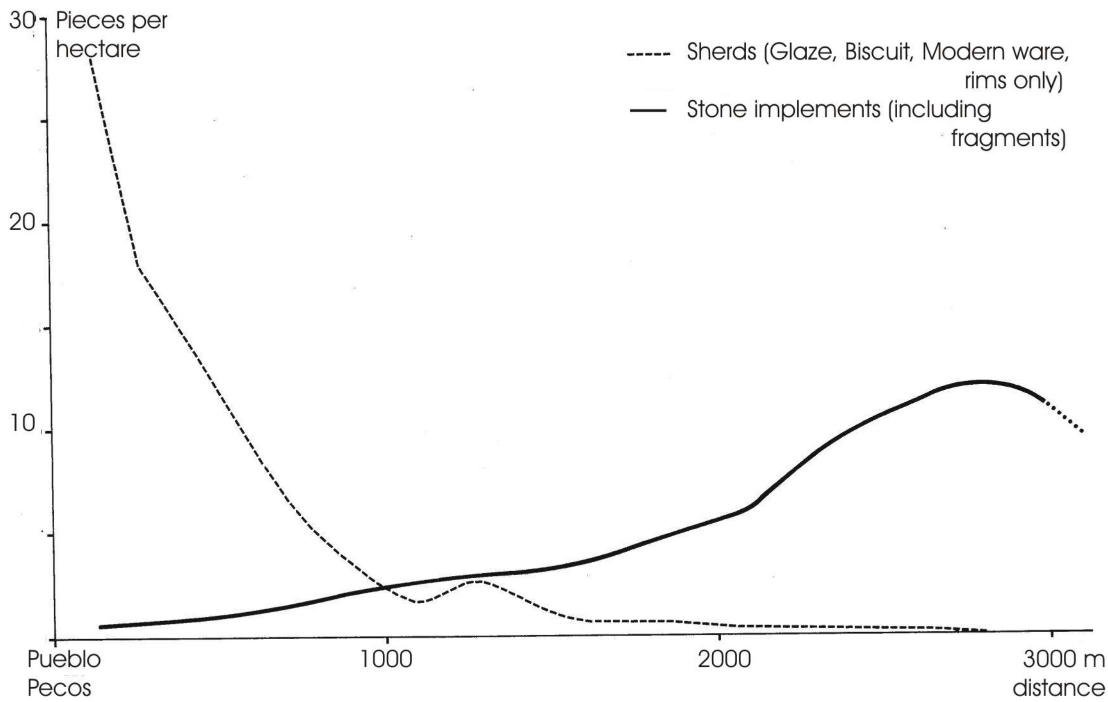

Fig. 22:
Density of sherds and stone implements found in fieldhouses at various distances from Pueblo Pecos as indication of the intensity of agricultural and hunting activity.
(Source: see "Notes on the figures").

Commuter catchment area:

A particularly good example of a central-peripheral arrangement of an equilibrium systems is the town and its surrounding neighbourhood. The elements are e.g. economically motivated commuters. Their action projects are directed towards the centre. The commuters who have to travel into the town more frequently live close to the town than at greater distance from it.

Thus, the densities are highest in the immediate vicinity of the town and decline rapidly at first as we move towards the contryside, and then with increasing slowness (see section 2.2.1.1, p.41). An example is the commuter catchment of Uelzen, a small town in northern Germany (see fig. 23).

Catchment area for retail trade:

Another example of the long-range effect is the retail trade. Of particular interest are shops which cater not only for day-to-day needs, but also sell goods which are required periodically or in episodes. These are located at central

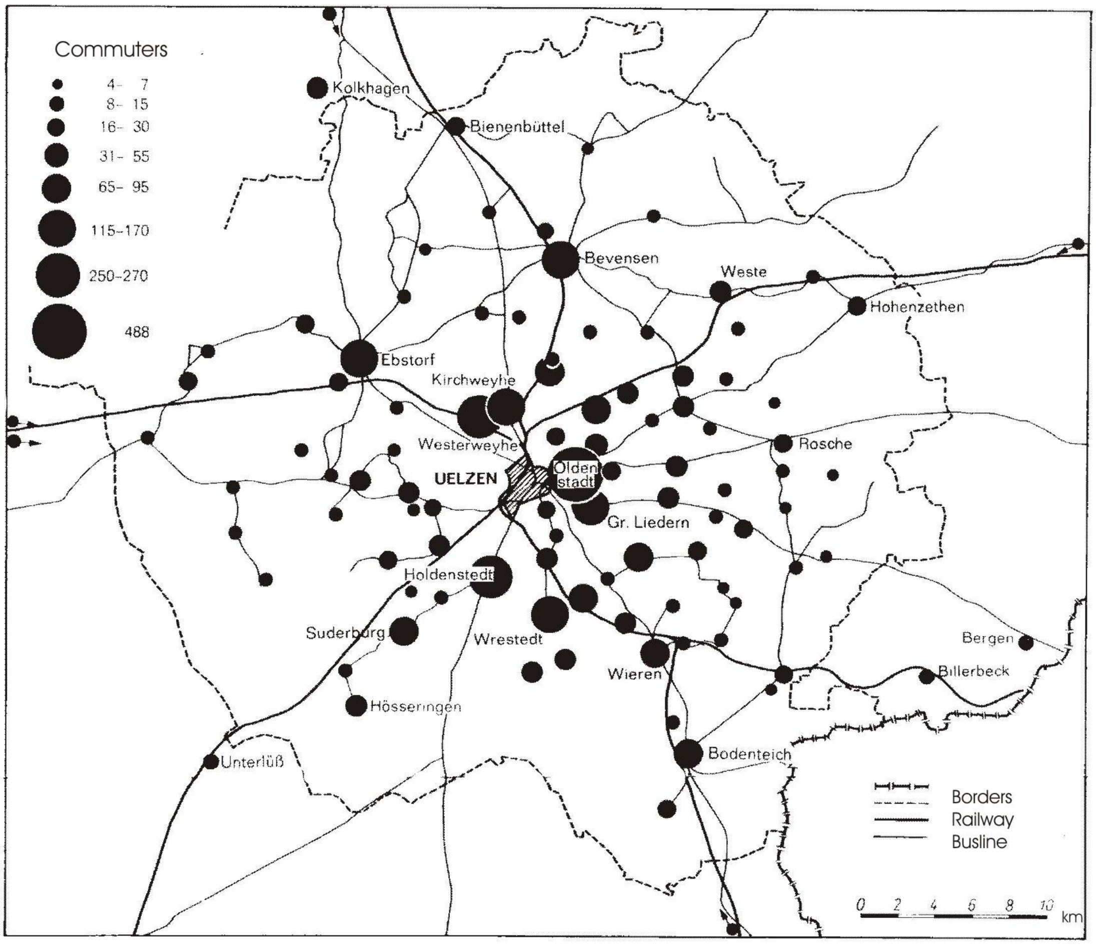

Fig. 23:
Commuter catchment area of Uelzen (Niedersachsen/Germany) in 1961. Commuters are a good indicator of the distance to which urban influence extends. The place of residence and the number of commuters are shown.
Source: See "Notes on the figures")

locations, especially in the towns, and are visited by customers from the surrounding area (umland). Fig. 24 gives an impression of the catchment area of a "county town" (Weißenburg in Bavaria). In 1977, a survey of 16000 customers of selected shops was carried out regarding the communities in which they lived. If the results are converted per 100 inhabitants of the communities of residence, it becomes apparent that the density of customers is greatest in the immediate vicinity of the town and decreases outwards per unit of distance, in accordance with the long-range effect.

Migrations:

In the case of migration of the population into the university town Göttingen (Germany), a differentiation according to social status is visible. Workers prefer shorter distances while higher earners (white-collar workers, civil servants,

Fig. 24:
Catchment area for retail trade in Weißenburg (Bavaria).
Customers' communities of residence (survey of 21.03-26.03.77) per 100 inhabitants.
Source: See "Notes on the figures".

self-employed persons) are willing to move over greater distances. In the case of academics, much greater average distances were observed, a fact which is related to the relative scarcity of jobs of this kind (see fig. 25).

The choice of living area also involves a process of selection and separation. Ethnic separation (e.g. formation of ghettos) and separation according to income (working and middle-class

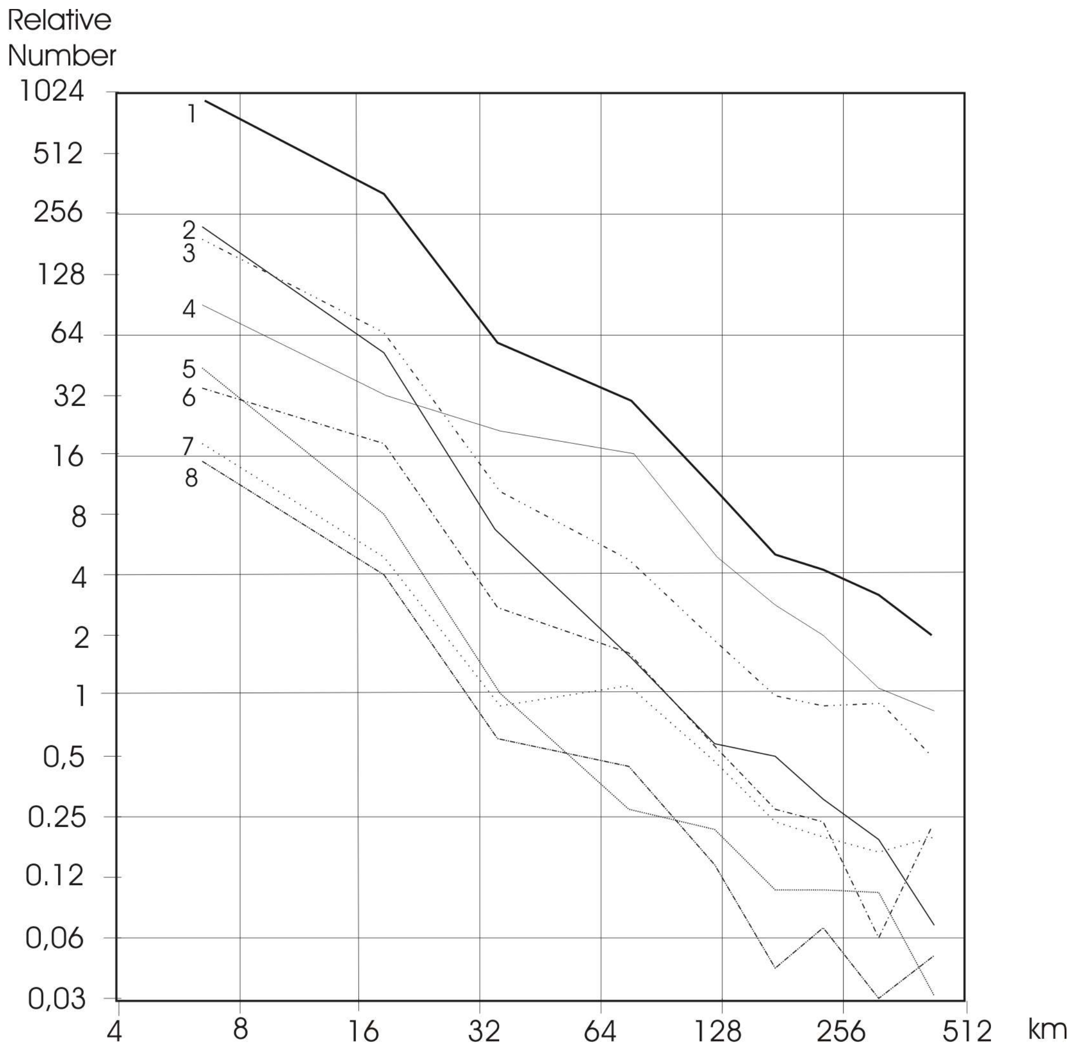

Fig. 25:
The intensity of immigration to the town of Göttingen from the Federal Republic of Germany in 1960. Radial cross section through the radially organised immigration area. Numbers per inhabitants.
1 all removals; 2 blue-collar workers; 3 white-collar workers; 4 students; 5 self-employed persons; 6 retired persons; 7 civil servants; 8 academics.
(Source: See „Notes on the figures")

areas etc.) also play an important role. Single persons often tend towards the city centre and one-person households are over-represented there. Families with children on the other hand prefer the suburbs and surrounding country.

2.2.2.4. Ring structures:

Agricultural regions, model of Thünen:

The asymmetry of the structure in town and its umland also affects the economic use of the land. As with the above-mentioned farmstead, more effort is concentrated on utilising the space in the neighbourhood of the city as the initial locality. The transport costs which increase proportionally to the distance from the town (or the market), have an impact on the structure of settlement and the local economy in the surrounding area.

In the 19th century, the Mecklenburg landowner von THÜNEN (1826/1921) developed a model showing the utilisation of land at varying distances from the market (see fig. 26). In those days it was most efficient to grow vegetables or run a dairy farm in the direct vicinity of the town (the market). Moving outward, these were followed by forestry (at that time, municipal woodland was intensively used, e.g. for grazing, wood supply etc.), rotating cultivation of root crops and cereals, paddocks, three-field cultivation (with fallow land) and pasture land on the outside.

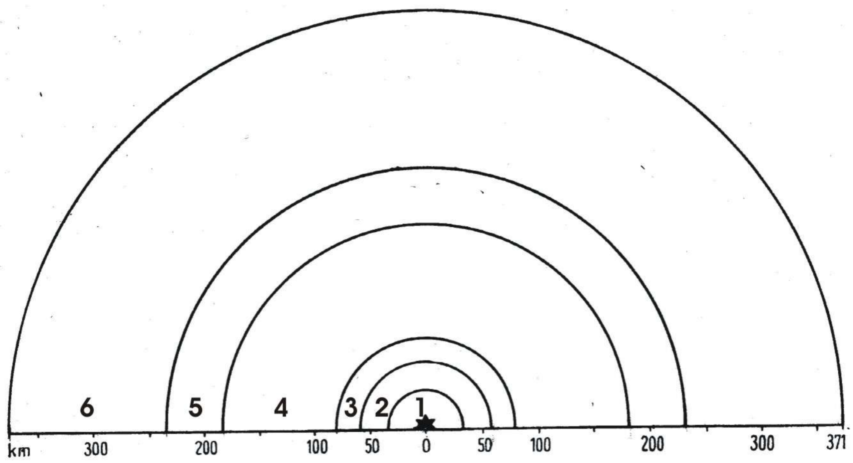

Fig. 26:
Model of the "Thünen rings". Agricultural utilisation with reference to transport costs. After von Thünen 1826/1921.
1 = Market gardening and dairying; 2 = forestry; 3 = rotating cultivation of root crops and cereals; 4 = paddock farming; 5 = three-field cultivation with fallow land; 6 = Ranching, livestock.
Source: See "Notes on the figures".

As we noted above these phenomena are the result of cumulative effects. Each participant should be interpreted as an element which is trying to maintain itself and its desire in an energetic equilibrium.

The city, model of Burgess:

BURGESS (1925/67; see fig.27) observed in the city of Chicago that the areas were arranged around the centre in the form of rings. Because Chicago is located on Lake Michigan, its hinterland has developed to one side only. The areas adjoining the city are therefore arranged in a semicircle. The central business district ("Loop") occupies the centre close to the shore. It is surrounded by residential districts populated by different social groups. Around the periphery of the CBD, the older buildings (many of them, for example, have no lift) with lower rents are inhabited by immigrants and other low-earning groups while the better living areas extend outwards from these. This is the interior zone of a "city-umland system".

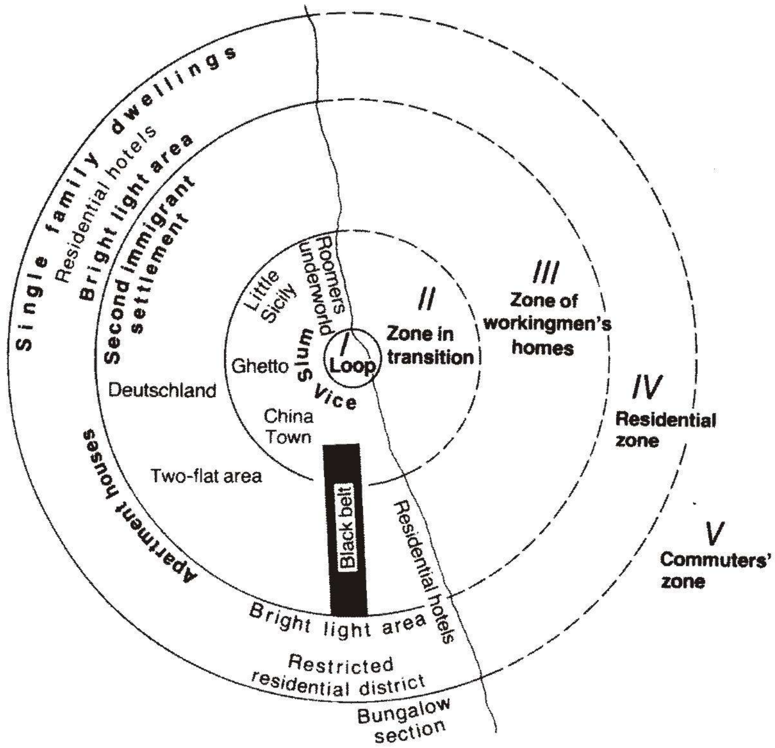

Fig. 27:
Diagram of structure of the city of Chicago.
According to Burgess. Example of a ring-shaped city-umland system. Source: See „Notes on the figures".

The geographical position of the various districts corresponds to the predominant ways in which they are utilised, e.g. central business district, residential area, industrial area etc. (see section 2.4.2.2, pp.191). The intensity of utilisation is highest in the city centre, which is (hypothetically) easiest to reach from the remaining parts of the town and the surrounding area, but which also has the least space available for its users. The town appears as the "central place".

2.2.2.5. Isochrones:

An important problem in many applications is to record accurately the available means of covering distance. In regional research for example, the accessibility of certain points (e.g. cities) in the region from other points or regions is an important subject. To obtain a general picture, maps can be drawn to help quantify this problem.

Isochrones are lines indicating equal duration of travel or approximately equal "time required" measured from a certain

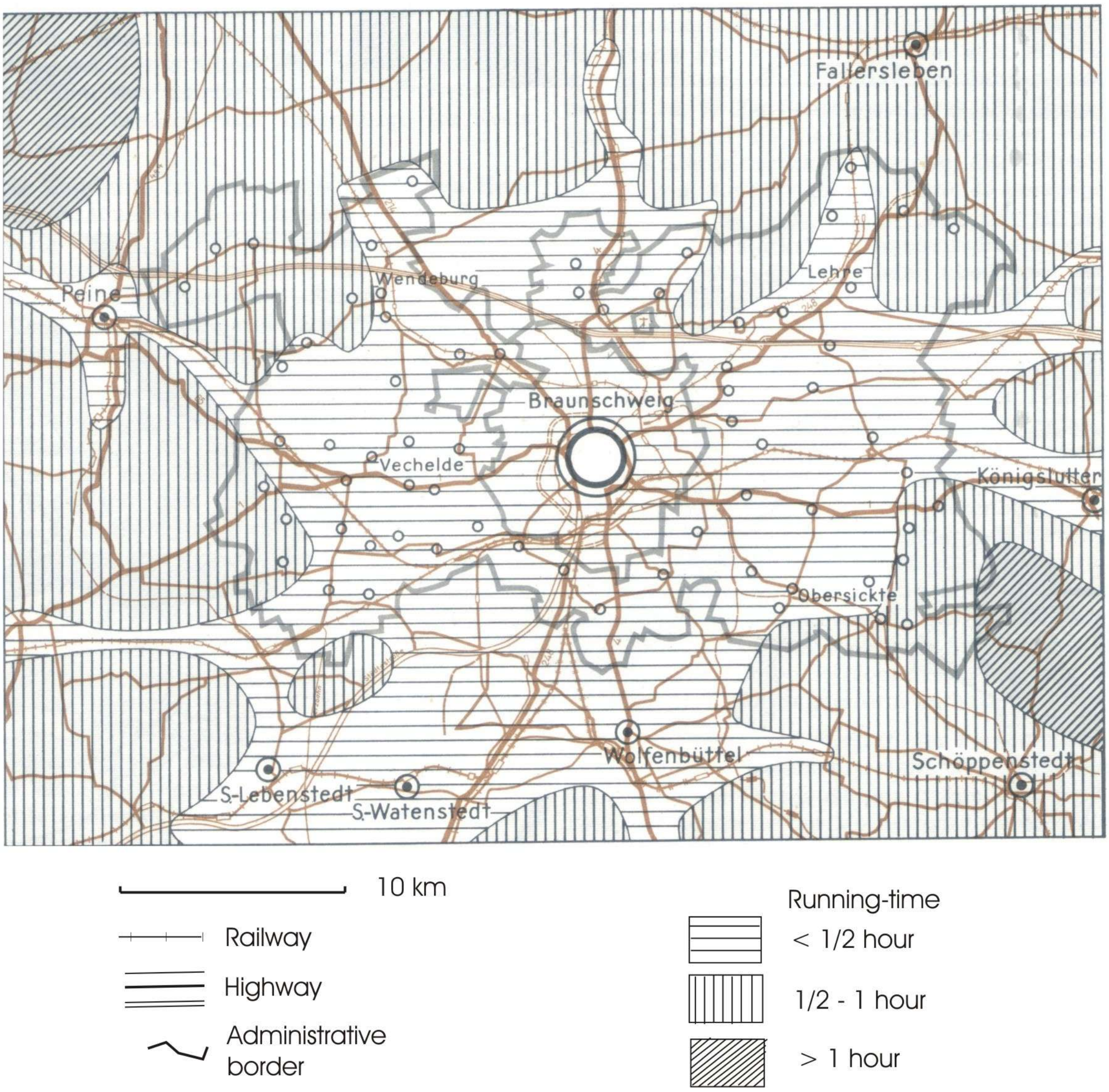

Fig. 28:
Isochronal map. Braunschweig (Niedersachsen in Germany) as destination in 1961.
Source: See "Notes on the figures".

point (distance time). This may be a town which can be reached from the surrounding district. The difference means of travel, e.g. on foot, by car, by rail etc. have to taken into account. In the enclosed map (see fig. 28) Braunschweig (Germany) is the centre of the surrounding area (umland). As we see, the railway lines and roads shift the isochrones outwards.

2.2.3. Process sequences and dominant systemic dimension:

Numerical sequence:

Compared to the movement and the solidum at the first level of complexity, at the second level of complexity a structure begins to take shape: a system as a whole is composed of elements. Both time and space are structurally separated from the transfer of information and energy. In this way it becomes possible to represent the transfer of energy in stages, thereby creating a process. However, that is only possible if the movements at element level are concentrated and constantly re-involved. As parts of the equilibrium processes, the elements can adjust to the environmental conditions, thereby remaining themselves in energetic equilibrium (see section 2.2.1.1, pp.38).

The system as a whole is represented by the "system horizon". It represents the basic alignment of the system. In the "element horizon", the desire of the elements to take part in the activity of the system is apparent. The participation (e.g. in work of a certain kind) benefits the element itself.

Although this type of system should be seen as the sum of the elements, it still forms a unit. The process first concerns the whole and then the parts (see fig. 29). If, for example, in a commuter catchment area (see section 2.2.2.3, pp.54) the conditions of the town-country ratio (i.e. the environment) change, the system is affected first, then the commuters as the elements respond in their own way. The stimulus comes in our model from the horizontal, i.e. the temporal and spatial

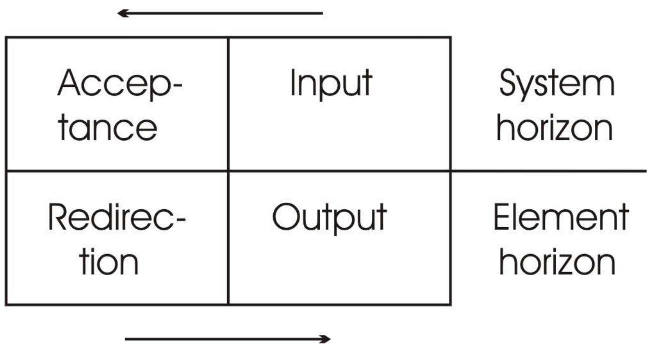

Fig. 29:
The processes in the coordinate system with the 4 stages input (system) - acceptance (system) - redirection (elements) - output (elements). Course of process in an anti clockwise (left-hand) oriented system. Basic process horizontal (C variant).
In the top half of the diagram, the system is shown as a whole, and in the lower, the quantity of elements.

preceding environment. Considered geometrically, the first two stages are directed inwards (input - acceptance) and the two

following ones outwards (redirection - output). This means that in the coordinate system, the two [+y] quadrants (system as a whole = system horizon) are passed through first, then the two [-y] quadrants (elements = element horizon). The direction is therefore anti-clockwise (C variant). The system orders itself in this way:
[f(x)]: Input of stimulus (information and energy) from the spatially and temporally preceding environment (e.g. that the town-country ratio changes);
[f(-x)]: Acceptance of the stimulus in the system, i.e. the conditions for the elements (the commuters) change.
Up to here, the process is directed inwards. The system horizon is affected. The outwardly directed part of the process now follows. Here the element horizon is meant.
[-f(-x)]: Redirection, i.e. the stimulus is diffused and adopted by the elements (the commuters).
[-f(x)]: Output, the elements react individually (several commuters move, others not).

Thus, the first half of the overall process stimulates the system. The second half originates from the elements which execute the movements. They react according to their individual interests and capabilities, thereby representing an individually controlled counter process.

The emergence code:

A comparison of the stimulus and process sequences in the movement and movement project (or equilibrium process) reveals the following:
1) Here, we are dealing with a process. Whereas with the movement changes take place under the regime of a cause-effect relationship, in the movement project or equilibrium process, they are temporally positioned behind one another as part processes or stages.
2) Movements are shaped by the energetic environment, i.e. the stimulus passes through the solida from the top downwards and from the bottom upwards, i.e. vertically (U variant; see section 2.1.1.2, pp.22). By contrast, in the equilibrium process, the stimulus comes from the time environment and proceeds horizontally in both directions through the system (C variant).

This transition can be described by means of a code. This code applies for all transitions from one level of complexity to the other and represents the key to understanding emergence. It could therefore be termed the Emergence Code.

In the treatment of the first level of complexity, we attempted to reduce the course of the process to a simple sequence of numbers which may also serve as a pattern for the other levels of complexity. The numbers 1-2-3-4 describe a basic process. Both the U variant (vertically aligned) and the C variant (horizontally aligned) are involved. This can be explained by means of the transition from the first to the second level of complexity. Four different operations are necessary (see fig. 30):

- 1st operation: Each single element (solidum resp. movement) can be represented by a system of coordinates (see section 2.1.1.2, p.22). It appears with its 4 stages as an indivisible unit. The first operation stands for an accumulation of these coordinate systems (see fig. 30a): "bundling".

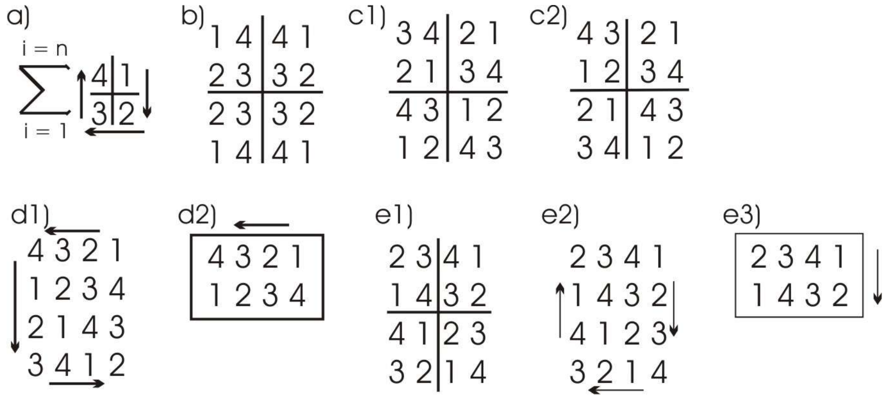

Fig. 30:
Numerical diagram of the emergence process from the first to the second level of complexity.
a) Bundling: the equilibrium process (movement- or action-) project comprises n movements (action motions). The sum of the 4 parts of a movement (action motion) is shown. The numbers indicate the sequence (U variant, see arrows).
b) Alignment: the bundled movements (action motions) are arranged in four groups for the new process. A new coordinate system (of the first order) is set up. In each quadrant, special coordinate systems appear for the bundled movements (action motions) as processes of the second degree.
c) Interlacement: the vertically aligned sequence (U variant) is horizontally oriented (C variant). Description of the reversing operations: c1) Reversal of the smallest process units (in the quadrants) each containing four figures. c2) Re-arrangement of the figures in these process units depending on their position in the coordinate system of the first order.
d) Folding: d1) the coordinate system is dissolved, the outlines of a movement project appear. d2) Now the folding takes place. The lower part is folded behind the upper part by a horizontal hinge. The arrows show the course of the process of the first order.
e) The corresponding movement-(action motion-) processes are arranged according to the U variant. e1) Reversal of the c2 sequence. e2) The coordinate system is dissolved. e3) Folding.

- 2nd operation: The elements have to take their place in the whole. They are therefore re-arranged to form the new whole of the equilibrium process ("alignment"; see fig. 30b). Thus, it is necessary to distinguish two levels, the whole and the elements. The whole must perform the equilibrium process, each part (i.e. element) its simple movements. This can be depicted by a comprehensive system of coordinates (1st rank) which symbolises the basic structure of the operations. The quadrants contain the partial (2nd rank) processes:
(1) The "input" of the stimulus from the environment in the system as a whole (quadrant [+x,+y]);

(2) the "acceptance" of the stimulus or energy impulse (quadrant [-x,+y]);
(3) the "redirection" of the energy impulse (quadrant [-x,-y]), and
(4) the "output" to the environment (quadrant [-x,+y] resp. [+x,-y]).

In addition the elements with their own movements must be considered. As all of them are subordinate to the system and involved in its movements, the movements are integrated in the whole. This can be represented by 2nd rank coordinate systems. In average, the individual elements participate in the four movements of the 1st rank system (i.e. the equilibrium process) symbolized in the quadrants of the overriding coordinate system. This can be represented in such a way that the subordinate coordinate systems (2nd ranking systems) of the average single movements are inserted in each quadrant of the overriding (1st ranking) system. Depending on their position in this coordinate system the subordinate process stages 1-2-3-4 are reflected at the abscissa and the ordinate.

- 3rd operation: Now we are not only dealing with just a transfer of energy as in a simple movement. Instead, the temporal sequence has gained in importance. The elements in their own movements are connected with the system to form a process ("interlacement"). In our treatment of the solidum, the movement was represented in the coordinate system vertically (in clockwise direction, U variant). If we wish to comprehend the whole system and the elements in their temporal sequence, we must align them horizontally (in anti-clockwise direction, C variant). Thus the coordinate systems have to be inverted. This has to take place in two operations (see fig. 30 c1 and c2).
a) Firstly the numbers representing the individual stages of the movements in each of the four (2nd rank) coordinate systems of the elements have to change their places, i.e. on the diagonal y=x. Then
b) these values are again converted according to their position in one of the 4 quadrants of the superior (1st rank) coordinate system.
The result: the upper part represents the system as a whole, and the lower part the quantity of the elements.

- 4th operation: The last stage is the "folding" stage (see fig. 30 d), the coordinate systems are resolved; new connections arise. The horizontal process of the system takes place from right to left. The (2nd rank) element processes, however, are vertically ordered. The elements as the carriers of the movements damp the stimulus because of their limited energetic capacity. The stabilisation of the process is represented by the actual process of folding: The former y-negative quadrants include the counter process which slows down and controls the process. It is "folded" behind the former y-positive quadrants. In this way, the complex structure is consolidated, the process creates a system as a permanent structure. The transitions between the other levels of complexity can be represented in basically the same way.

However, these 4 stages (bundling-alignment-interlacement-folding) describe only the course to the equilibrium process, i.e. to the new entirety. This is the 1st rank process, which aligns the second-rank process. The stages of this second-rank process now appear in reverse order. To compensate for this, two additional operations are necessary:
1) At the transition, a change takes place from the C variant to the U variant. The interlacement stage is once again the starting point (see fig. 30 c2) and the coordinate system is reversed at the axis y = x. This is shown in fig. 30e1.
2) The coordinate system is dissolved, the result is seen in fig. 30e2.
3) Folding, see fig. 30e3.
The sequence of these operations applies in all the cases where a change takes place from the C to the U variant (second, fourth and sixth levels of complexity). When the change is in the other direction, from the U to the C variant (third and fifth levels), the folding has to take place first, followed by the reversal.

Let us return to the first-rank process. We have already described the transition from the first to the second level of complexity, from the U variant to the C variant. If we take the third operation (interlacement, see fig. 30 c2 and d1) as a basis, the result is a cross table containing 4 x 4 = 16 numbers. The transition from the C variant to the U variant can be imagined in the same way. Here too, we arrive at a cross table with 16 numbers but on an imaginary diagonal x = y reversed. These cross tables represent the basic components of the processes because they reflect the way in which energy and information flow. Each of the 16 numbers represents one of the formulae presented in section 2.3.1.2, pp.81. The lines of the tables show the chronological stages as described above (see section 2.2.1.2, pp.42). In the sequence, the numbers 1 mark the logarithmic, 2 the rational, 3 the exponential and 4 the probabilistic equations. In the columns, the vertical, i.e. the hierarchic structure of the process (according to the 4 bonding levels, see section 2.3.1.1, pp.75) is shown. In other words, the tables combine the chronological and hierarchical links of the components making up the processes and systems, i.e. the chronological (T) and hierarchical (H) dimension (see section 2.1.3, p.33).

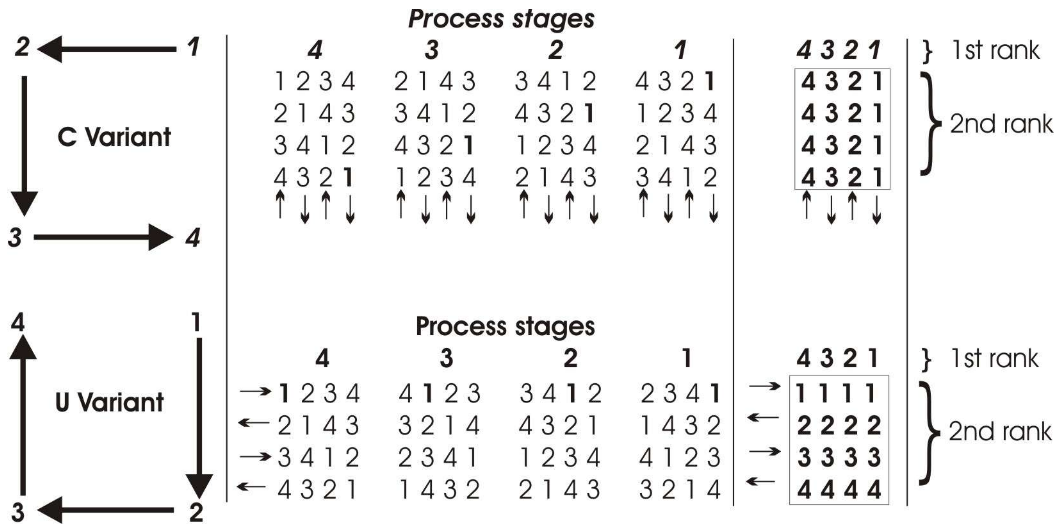

Fig. 31:
Diagram of the course of the process (C variant and U variant).
The individual 1st rank process stages (1 .. 4) show, how the 2nd rank numerical sequences develop step by step. For example: The bold (2nd rank) numbers show the respective position of the 1st stage (summarised on the right). Arrows: Direction of the numerical sequence 1 .. 4.

Fig. 31 shows the course of the processes. Depending on whether the U or C variant (1st rank, left) is being considered, the 2nd rank process runs through the table in different ways. We see how these processes are continued step by step. Through the structure of the tables, it is ensured that the tasks (according to the 16 formulae) can be completed in the correct sequence at every stage.

In the course of the following discussion it will become clear that the differences in the processes and systems at the various levels of complexity can be described with the assistance of these tables, thereby making it possible to understand the processes on which emergence is based. (The size of the processes and systems, i.e. the quantity of information and energy flowing (Q) and the space occupied (S) are not considered.)

Route diagram:

In the arrangement of the numerical sequence it becomes apparent which individual steps are necessary. Everything has to be worked through. This becomes even clearer if we depict the routes of the (information and energy) flows. They determine the course of the process within the different complexity levels (see fig. 32). To do this, we must "unfold" the sequence again. First of all the four stages of the

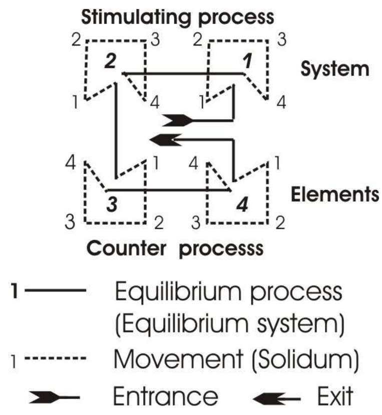

Fig. 32:
Route diagram of the equilibrium process. The course of the 1st rank process through system and elements is marked by the arrow. Upper part system horizon, lower part element horizon. The stages of the equilibrium process are structured according to the C variant. Each of the basic processes shown in the diagram represents a large number of individual basic processes.

equilibrium process (movement project) can be recognised. The succession of the chronological process is of primary importance here. The 1st rank process is oriented to the left (anticlockwise), i.e. we are dealing here with the C variant of the basic process.

The processes of the first complexity level (also consisting of 4 stages each) which are formed by the crowd of participating movements are assigned to these (2nd rank). They are aligned to the right (U variant). The sequence of theses processes now alternates at the level of the movements (1-2-3-4/4-3-2-1). For us, it is of importance that the structural symmetry is described here. We will encounter this symmetry in the context of energy transmission (which itself is asymmetric) again and again (law of symmetry). [This model of the route diagram on the 2nd complexity level can be compared with the model of the path of the stimulus described above, see fig. 15. However, it should be remembered that the use of the coordinate system makes reversal of sides (left-right) inevitable.]
Thus, there is a general rule that 4 determinants define the process routes:
1) a division of each process into 4 stages 8corresponding to the basic process),
2) a symmetrical process structure,
3) a circular course of the process, and
4) an internal hierarchy.

The dominant systemic dimension (see fig. 33):

System dimensions have greater importance in the explanation process at the higher levels of complexity than with the solida because structuring and shaping is of greater significance in the more complex systems and processes. At the first level of complexity, i.e. the solida and movements (action motions), quantity (of energy) was the dominant dimension. The other dimensions were firmly linked with it (see section 2.1.3, p.33). At the 2nd level, we now see a first step on the way to separating the activities according to the dimensions. The stimulus triggers a differentiated reaction.

Fig.33:
Time is the dominant systemic dimension in an equilibrium system.

The most obvious innovation with reference to the first level of complexity is the introduction of time as a dimension (see fig. 33). The equilibrium process is composed of many movements which may be combined in different ways. A succession is established and time appears as the dominant systemic dimension.

Outlook:

It is the elements which organise and consume time in the course of movement projects. Thus, the efficiency of an equilibrium system is dependent on the elements. They are all of equal importance in the system. Through them, the system receives its homogeneous structure. If the system also wants to be efficient as an entirety, energy also has to be acquired, i.e. from the environment. At the same time, the elements must be interlinked, or in other words, become a complex unit. In this way, the efficiency can have its effect on the whole consisting of system and elements. This takes place at the next higher level of complexity, the third.