Dietrich Fliedner

Processes Constitute our Complex Reality

A Theoretical Investigation

Third Edition

Saarbrücken, Oktober 2010

Foreword to the Third Edition

The fundamental question underlying this treatise remains: how can it be that our reality does not end in chaos in spite of the increasing multiplicity in the course of cosmic, biotic and cultural evolution, but that ordering structures and spaces are created in wich each element receives its place and carries out in a practical manner tasks on behalf of the whole?

Unfortunately this simple question cannot be fully answered at one attempt. The more one devotes oneself to the problems discussed here, the more roads open up which may take us to "new country". In this text, the intention was to take account of new insights concerning the course of the process of emergence and the structure of the autopoietic processes. I am convinced that new questions will also arise in future, especially since the methods are becoming more refined and our knowledge base is constantly being extended.

(Summer 2010)

Preface to the Second Edition

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 as such 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.

(November 2005)

Content

Prefaces 2

1. Introduction 8

2. Six levels of complexity 12
2.1 Simple movements and solida 13
2.1.0 Instead of an introduction: The textile factory as physical form 13
2.1.1 General considerations 14
2.1.1.1 Solidum and movement [forms; causal explanation; actions and movements; solida and movements] 14
2.1.1.2 The model [laws of motion; the "Basic process"]..........17
For guidance...21
2.1.2 Other examples...22
2.1.2.0 Instead of an introduction: Movements as seen by an artist 22
2.1.2.1 An example from the field of technology..................23
2.1.2.2 Examples from geography [landforms; a settlement]........24
2.1.3 Process sequences and systemic dimensions [numerical sequence; route diagram; systemic dimensions]............29
Outlook..31

2.2 Equilibrium process and equilibrium system 32
2.2.0 Instead of an introduction: The textile factory as a functioning plant 32
2.2.1 General considerations 34
2.2.1.1 System and process [functional explanation; action (movement) project; action projects and equilibrium process; larger equilibrium systems] 34
2.2.1.2 The model [stages of equilibrium processes] 39
For guidance...41
2.2.2 Other examples...42
2.2.2.0 Instead of an introduction: A movement project as seen by an artist 42
2.2.2.1 Homogeneous stuctures 43
2.2.2.2 Linearly inclined structures [settlement of exiles and refugees in Niedersachsen(Germany); an alluvial fan] 48
2.2.2.3 Radial structures [activity in pueblo land; commuter catchment area; catchment area for retail trade; migrations] 50
2.2.2.4 Ring structures [agricultural regions, model of Thünen; the city, model of Burgess] 55
2.2.2.5 Isochrones 57
2.2.3 Process sequences and dominant systemic dimension [numerical sequence; the emergence code; route diagram; the dominant systemic dimension] 58
Outlook..63

2.3 Flow process and flow equilibrium system 64
2.3.0 Instead of an introduction: The textile factory in the flow of energy 64
2.3.1 General considerations...................................66
2.3.1.1 System and process [large and small compartments; systemic explanation; 1st process train (the internal hierarchy, bonding levels); 2nd process train (feedback; oscillations; diffusion; rotation)]......................66
2.3.1.2 The model [1st bonding level; 2nd bonding level; 3rd bonding level; 4th bonding level; the course of the process]..76
For guidance...88
2.3.2 Other examples...89
2.3.2.0 Instead of an introduction: Flow process as seen by artists 89
2.3.2.1 Vertical information and energy flow [the cultivation of a field; a complex ecosystem; a complex economic system, the Forrester feedback model; complex social systems; oscillations (predator- prey relation; business cycles; colonisation phases)] 91
2.3.2.2 Horizontal processes [processes of spreading (diffusion; the model of Artificial Society; processes of spreading in ecosystems); rotation (irregular rotation; tangential rotation)]......100
2.3.3 Process sequences and dominant systemic dimensions [numerical sequence; route diagram; the dominant systemic dimensions]......................108
Outlook...111

2.4 Conversion process and non-equilibrium system............113
2.4.0 Instead of an introduction: The textile factory as an organised unit 113
2.4.1 General considerations...................................115
2.4.1.1 System and process [products and division of labour; structure conserving and structure changing processes; process explanation].......115
2.4.1.2 The model [1st process train; transition from the 1st to the 2nd process train; 2nd process train (main process; task processes; control processes; elementary processes; reaction process); course of the processes (process sequence as an entirety, structure of the process course: demand-supply-relation and twin processes)]...................................117
For guidance..137
2.4.2 Other examples...139
2.4.2.0 Instead of an introduction: Conversion process and non-equilibrium system as seen by an artist 139

2.4.2.1 Example of a complex conversion process: The cultural evolution in Europe since 1800 [about the method of the investigation; the material stage (painting in the Romantic period; philosophy; geography); the functional stage (Impressionist painting; philosophy; geography); the system stage (Classical Modern painting; philosophy and interdisciplinary theories; geography); the process stage (evolving) (art in the Present; philosophy and interdisciplinary theories; geography); summary and interpretation (process development; interpretation of content; the processes in the superior context]....................140
2.4.2.2 Examples of other non-equilibrium systems [a technical system; organic and inorganic non-equilibrium systems; individuals as elements and as non-equilibrium systems; city-umland system; time maps]..179
2.4.3 Process sequences and dominant systemic dimensions [numerical sequence; route diagram; the dominant systemic dimensions]........................190
Outlook..193

2.5 Hierarchy processes and hierarchy systems................195
2.5.0 Instead of an introduction: The textile factory as a member of mankind as society 195
2.5.1 General considerations...................................197
2.5.1.0 Introduction 197
2.5.1.1 System and process [the catalogue of tasks and institutions, the populations as carriers; the hierarchy of processes; the hierarchy of subsystems (introduction; specification hierarchy; scalar hierarchy; secondary order-obedience relationship, upper and lower levels); the hierarchy of spaces (spaces occupied by the populations themselves; areas of influence of populations)]..........197
2.5.1.2 The model...213
For guidance...216
2.5.2 Other examples...218
2.5.2.0 Instead of an introduction: hierarchy as seen by an artist 218
2.5.2.1 Hierarchy of the systems [hierarchy of the living world; central place hierarchies; Rank-size-rule]........219
2.5.2.2 Hierarchy of processes: the cultural evolution [millennium rhythm; centennial rhythm; decennial rhythm; several years' rhythm; yearly rhythm; monthly or weekly rhythm].................225
2.5.3 Process sequences and dominant systemic dimension [numerical sequence; route diagram; the dominant systemic dimension]........................233
Outlook..235

2.6 Autopoietic processes and universal system..............237

2.6.0 Introduction...237
2.6.0.1 Foreword...237
2.6.0.2 The employees of the textil factory in their life spheres...239
2.6.1. General considerations..............................241
2.6.1.0 Instead of an introduction: The Universe as seen by an artist...241
2.6.1.1 Systems and elements................................242
2.6.1.2 The tasks of the systems in the universal process; an approach..243
2.6.1.3 The processes between macro- and microcosms.............250
2.6.2. Individual examples.................................252
2.6.2.0 Introduction: About the shaping of materially defined spaces..252
2.6.2.1 Living organisms [autopoietic systems; genetic expression, some considerations; the ecosystm]..252
2.6.2.2 The behaviour of populations [an Indian population in its habitat (oscillations; rotation); processes of spreading (land occupation and colonisation; colonisation by the Spanish in New Mexico), migration (the importance of socio-economic differentiation; country-to-town migration in New Mexico)]..261
2.6.2.3 The mankind as a primary population.....................269
For guidance..274
2.6.3 Process sequences and dominant systemic dimension (preliminary considerations) [numerical sequences; route diagram; the dominant systemic dimension]..........276

3. Emergence...280
3.1 About the term "emergence"..............................280
3.2 Six levels of complexity................................281
3.3 The emergence code......................................285
3.4 Emergence and systemic dimensions.......................286

Epilogue [Decision 1: the social world is the medium of investigation; decision 2: the structured process is the path of investigation; decision 3: the interwining of the flows of information and energy is the aim of investigation; decision 4: the mesocosmos forms the framework for investigation].289

References...293
Notes on the figures.......................................309
Glossary...317

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 environment, 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.

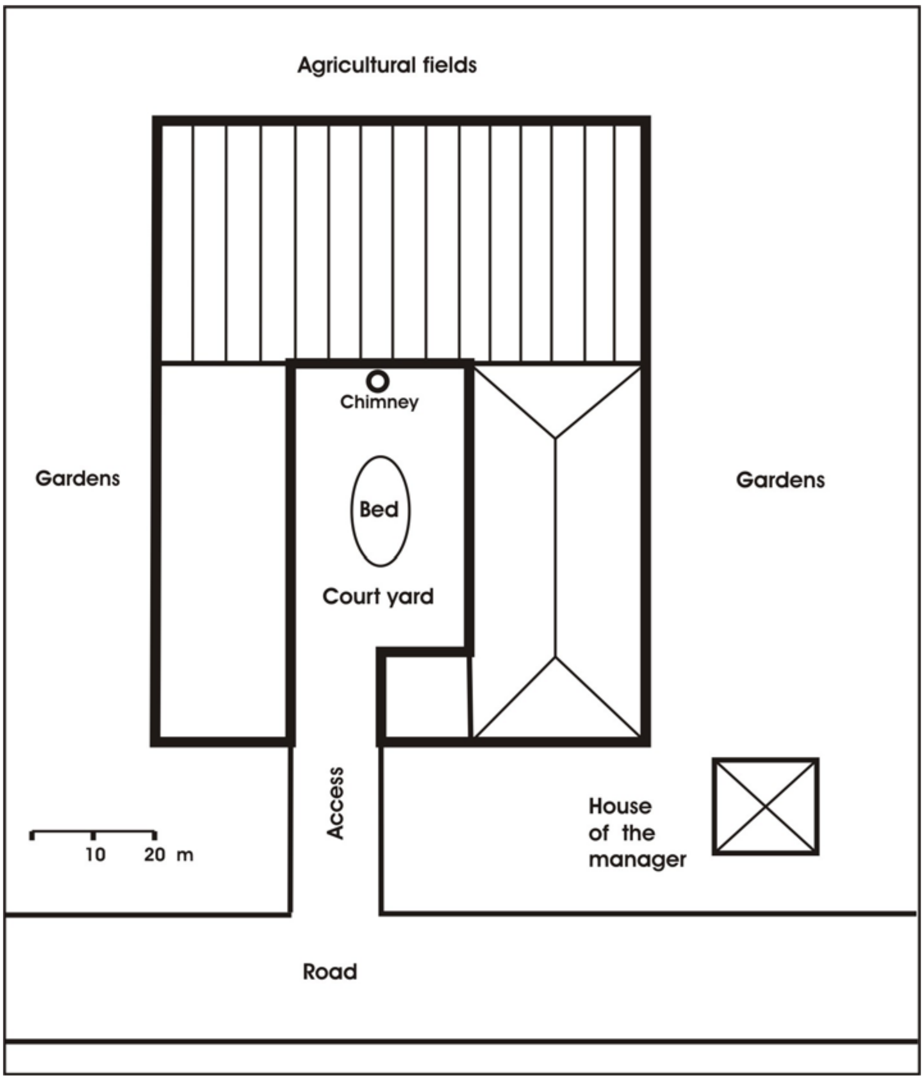


Fig.1: Map of the textile factory.

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 20th 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.

Both of these – the factory with its structure and its equipment, machines, vehicles etc. on the one hand, and the group of persons working there – necessitate one another, i.e. they make up one form. They should however also be regarded as two forms, each of which developed according to its own criteria. The factory as such and its material equipment, which would have decayed slowly according to its own laws, was utilised, conserved and developed by the workforce. The workforce formed, so to speak, the cause for the effect, i.e. for the shape of the buildings and their equipment.

Causal explanation:

Let us now attempt to create a platform for our theoretical remarks on the complexity of our reality:
The forms 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.

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:

Within the scope of this theoretical treatise, the people occupy the central position. Here, the solida are the individuals which define themselves as "indivisible" and which must integrate themselves into structures and processes, thereby occupying their place in the group of the workers. By regarding the individuals as solida, we descend one level on the scale.

Here at the first level of complexity we are at the lowest level. 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 a very large number 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).

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: The individual (in his role) as a solidum is associated with the action as a movement.

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):

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

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 simplest 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:

Although the movement as a unit as well as the solidum are undivided, we are able to analyse them because the solidum has to be considered from different angles. It is surrounded by an environment from which the stimuli originate and it possesses

exterior surfaces and a materially definable (if not differentiable) interior.
Let us try to explain what exactly happens in the solidum. The path of the stimulus is described as follows:
First of all the stimulus moves from the superior and the preceding environment inwards (actio):
1) The stimulus from the environment is put into the solidum at the "front side" (see section 2.2.3): "input";
2) The interior of the solidum accepts the stimulus, it must absorb the energy: "acceptance";
The stimulus then moves outwards again (reactio):
3) The interior reacts, 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, and therefore the area of contact with the stimulating environment, whereas the y-negative half is represented by the stimulating mass in the interior. Both units (with the higher levels of complexity, (system and elements) are positioned opposite one another. 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 (“Front side”) in each case is the f(x) quadrant.

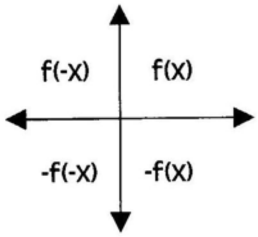


Fig. 2: Model of a coordinate system.

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 (or U-variant) and case 2 the C connection (or C-variant). 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.

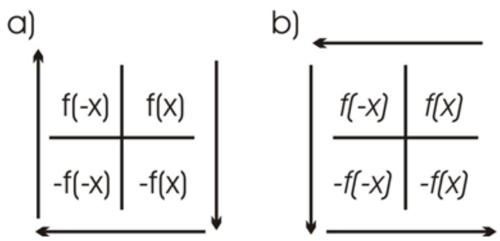


Fig. 3: Basic process in the coordinate system.
a) vertical variant (U connection), b) horizontal variant (C connection).

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.

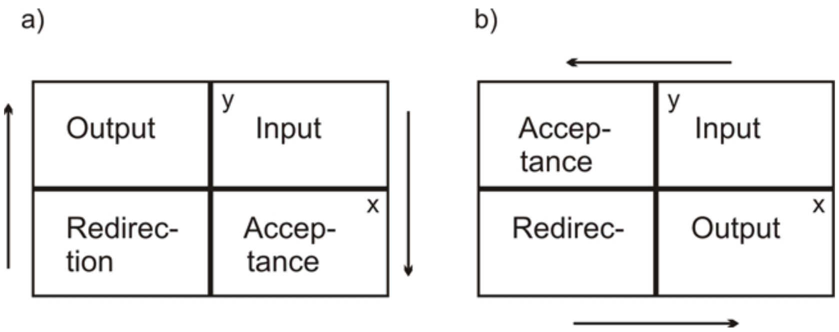


Fig. 4: *The processes in the coordinate system with the 4 stages input - acceptance - redirection - output*. *Basic process a) vertical: U variant, b) horizontal: C variant*.
This diagram applies for the solida, but also for the higher levels of complexity; in the top half of the diagrams, the solidum or system is shown as a whole, and in the lower, the quantity of the interior, or elements.

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). 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. However, the forces affecting a change cannot be conceived in this way. We must go into greater detail: At the human level, this is 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. With the anthropogenic forms, the vehicles of these movements are the individuals as "solida".

The movements are not yet processes, the solida not yet systems, but it is still possible to describe the movement as a 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

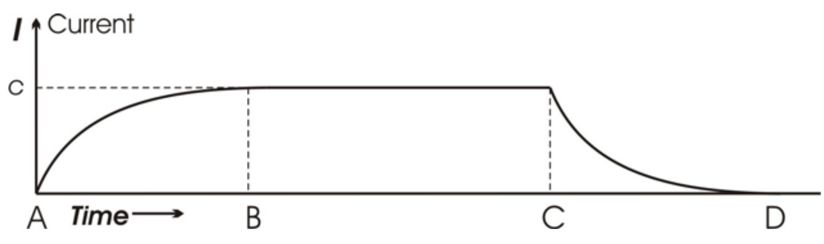


Fig.6: Intensity of current I in relation to time.
Scheme for explaining causality. A - B: non-causal area, B - C: causal area, C - D: non-causal area.
According to Bunge. Source: See „Notes on the figures“.

negative 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.

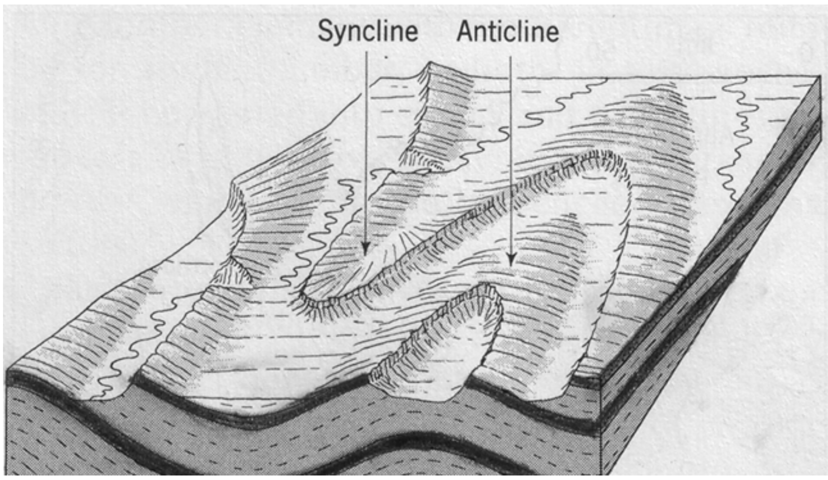


Fig. 7: Block diagram of a mountain-crest formation.
In the subterranean areas, hard (black) and soft layers alternate. The diagram permits a preliminary explanation of the reason for the surface formations. According to Strahler and Strahler.
Source: See "Notes on the figures".

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 actual movements can be traced only vaguely. The rivers cut into the rock, thereby deepening the erosion base. This process of erosion is accompanied by wide-ranging removal re-depositing of topsoil, mudslides during periods of heavy rainfall etc. 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 universe of forms. These forms can cartographically be 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 buildings 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 (in the north of Bremen). 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. These are questions which interest us within the context of such a study. The processes are initiated and accomplished. What were the forces? How were they implemented? In other words, who planned the settlements and who performed the work?

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.

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).
Abbreviations: 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".

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 settlers are the solida. 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. We can trace the processes where written records and the study of remains (the shape of forms, the age of datable ceramics etc.) enable us to do so. These topics are dealt with in the following section (2.2).

2.1.3. Process sequences and systemic dimensions

Numerical sequence:

As explained above, solida are considered to be undifferentiated units. However, these too have an interior and an exterior. The progress of the stimulus in the solidum can be represented as a sequence of numbers or a "numerical sequence"; the result is the basic process. The framework for description is the system of coordinates. 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 the stimulus (information and/or energy) between environment and solidum and (in the solidum) the internal relationship of cause and effect (see section 2.1.1.2). The transfer takes place directly. The chronological sequence is not yet under scrutiny (this variant is only characteristic of the higher levels of complexity). The path of the stimulus passes to the right of the ordinate and into the solidum (1, "Input"). It is then accepted in the interior (2 "Acceptance"). The way back is to the left of the ordinate. The stimulus is re-aligned under the abscissa (3, "Redirection") and then conducted back to the environment (4 "Output").

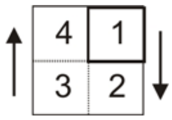


Fig. 9: Scheme of the way of the stimulus of a movement in a coordinate system.
Numerical sequence: 1 = Input; 2 = Acceptance; 3 = Redirection; 4 = Output. See fig. 4.

So the way of the stimulus in the solidum is opposed by a counter stimulus - the "actio" by the "reactio" (see section 2.1.1.2). Both are directly causally connected. The counter stimulus leads back out of the solidum, i.e. the stimulus describes (in this type of depiction) a circle in clockwise direction [f(x) > -f(x) > -f(-x) > f(-x)]. It is oriented to the right and follows the path of the Latin letter U ("U variant"; c.f. second level of complexity, section 2.2.3).

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).

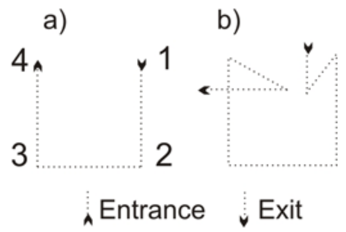


Fig. 10: Route diagram. The way of the stimulus of a movement in a solidum. a) free-standing, b) in a group.

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. One example is the individual. Another is the factory as a whole, seen from a general point of view, which can 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) also show that the movement is determined by 4 dimensions.
1) First, there is the "quantity" (Q) 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 the difference between "before" and "after", i.e. a step along the "time" axis takes place, between input and output.
3) Another dimension is indicated, by the fact that the "antecedens" is necessarily followed by a "consequens". Thus, a "hierarchy" (H) exists between something "superior" and something "inferior".
4) Moreover there is the distance between the environment and the interior of the solidum. Distance is a property of "space" (S).
From a general point of view, these "systemic dimensions" are the vectors which define not only the movements in and around 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:
a) the quantity (Q) 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 solidum or system. The remaining dimensions (time T, hierarchy H and space S) are joined to it. Their values change in relation to the energy entering as well as the material nature and size of the solidum. 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 movement or 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. Above all, with this type of explanation, the temporal dimension is of no particular 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 aspects. It is not only the outer form which is important, but also the structure. Only in this way it is 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

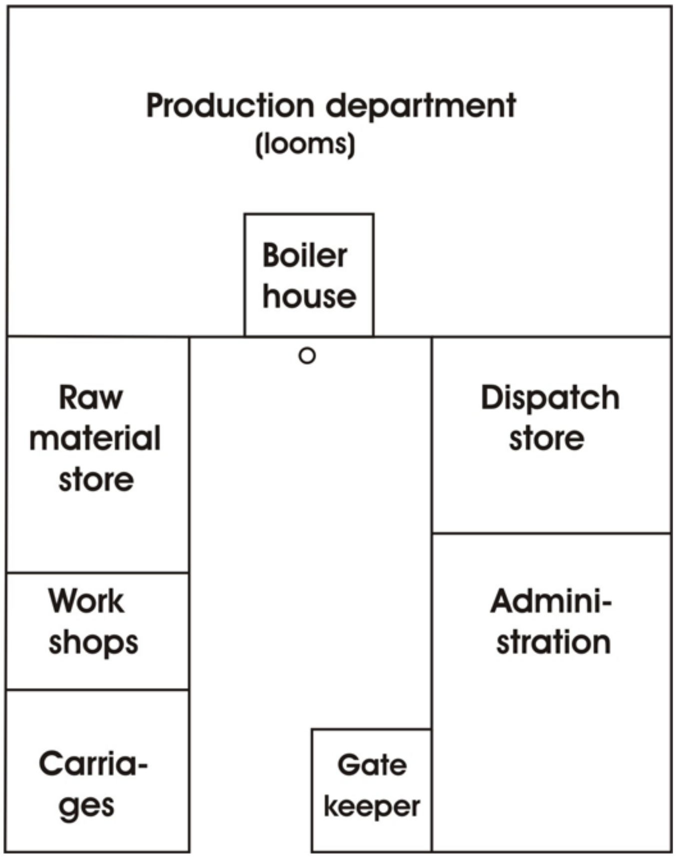


Fig. 12: The textile factory. Functional division in departments.

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 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).

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). 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.

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) 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 section 2.1.1.2):

1. Input: The individual receives the information from the superior and preceding environment, to carry out the action project "weaving of cotton cloth".
2. Acceptance: The individual accepts the information and asks for the energy required from himself to carry out the work;

3. Redirection: The individual procures the necessary raw materials and executes the work;
4. Output: The individual delivers the result.
Stages 1 and 2 can be interpreted as flow of information and stages 3 and 4 as flow of energy.

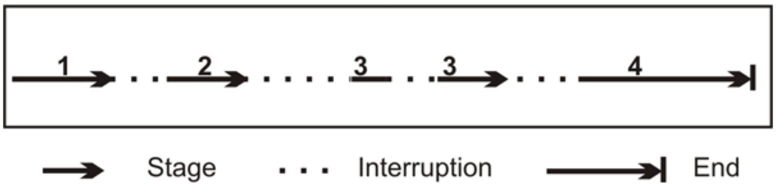


Fig. 13: Diagram of an action (movement) project.
The 4 stages normally differ in length and can be interrupted.

In the project many simple action motions or movements (see section 2.1.1.1) 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 (see fig. 13). 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. 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 did not 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 (which should be assigned to a higher level of complexity; see section 2.4.1), 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.

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).

Larger equilibrium systems and processes:

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, 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 wheat cultivation area of the Great Plains in the USA.

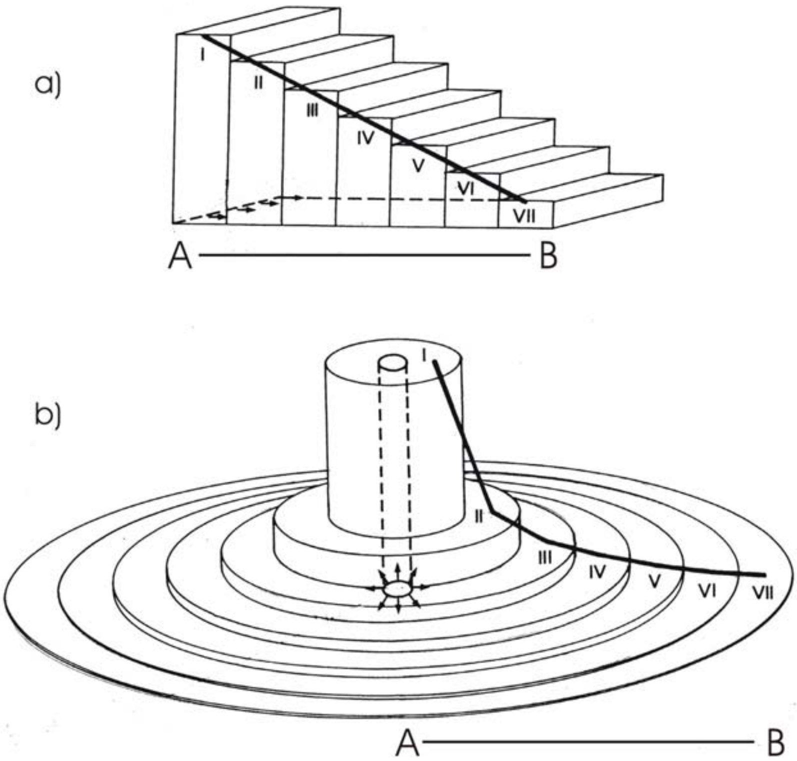


Fig. 14: *Long range effect (damped) under different spatial conditions.*
Diagram illustrating the shape of equilibrium systems.
a) Initial region extended in length, linearly inclined structure, uniformly wide towards the outside.
b) Initial region locally concentrated, expanding in an outward direction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

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 (“Thünen Rings”; see section 2.2.2.4).

The diffusion of stimuli (e.g. information concerning innovations) takes place both in "regions" and in "fields" (according to Bartels, see above) step by step in this equilibrium system, i.e. through horizontal communication (as far as order and demand by the superior environment are concerned, see section 2.3.2.2. and 2.5) namely through contacts between equals. In addition to the actual neighbourhood contacts, today's modern communications should also be mentioned which have completely changed the meaning of distance. As a general rule, the dissemination of information through the system (system horizon) takes place much more rapidly than the implementation of activities by the elements. Thus two speeds can be distinguished. The contrast between system and elements is apparent here.

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), 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, and 2.4.2.1). 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 an 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. 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).
- 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.

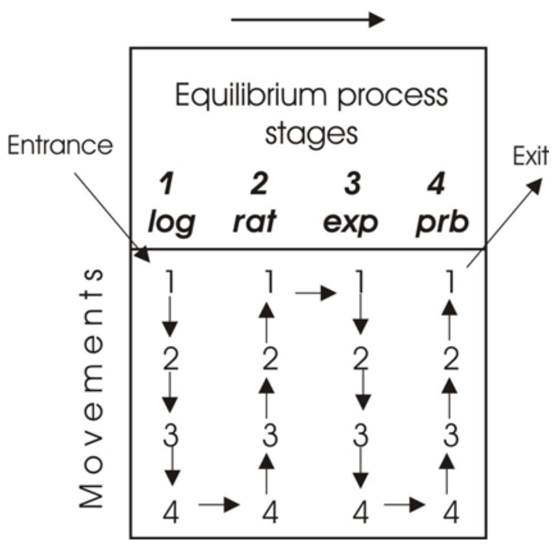


Fig.15: Path of a stimulus through the equilibrium system.
The numbers signify the stages of the basic processes.
Abbreviations: log = logarithmic, rat = rational, exp = exponential, prb = probabilistic.
It is necessary to distinguish the first-rank process (entire system, italics) and the movement stages (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). Thus the transmission of data at the corner stages (1 resp. 4) during the process is facilitated. 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:

With reference to our remarks on the first level of complexity (section 2.1.1) in which we discussed the causal method of explaining phenomena, it may be said with regard to the second level of complexity that it is the diversity of human society and the process between cause and effect, i.e. between stimulus and result which is beginning to come to the fore now.
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, they react;
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 and the sum of individuals (system) 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 tangentially 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.

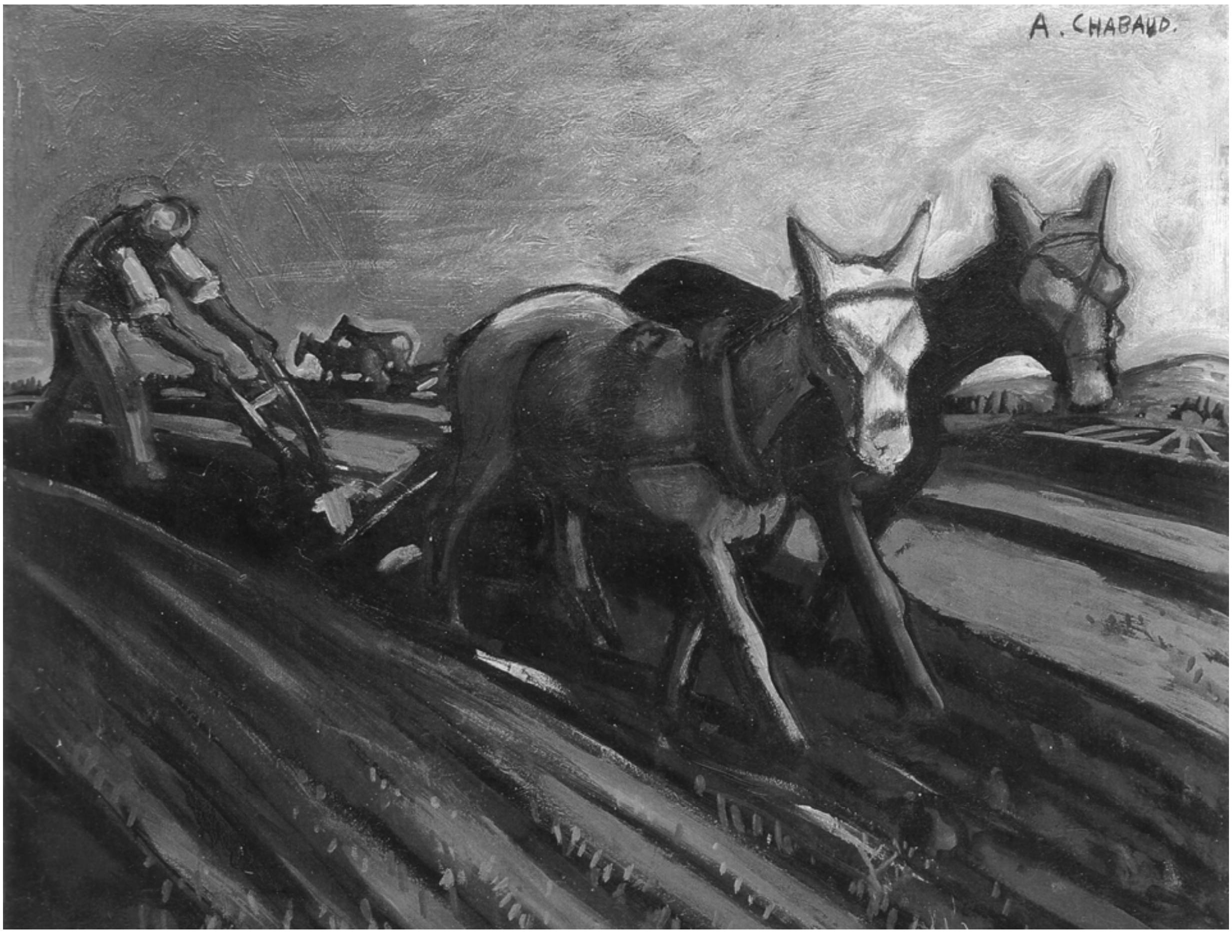


Fig.16: Auguste Chabaud: The Farmer.
Ploughing a field, an example of the representation of a movement project.
Source: See "Notes on the figures".

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. They are the result of the processes which they ininiated. Homogeneously structured forms come into being where the conditions for action and existence of the solida (as the elements) are the same over the entire area – whether these are areas of sedimentary stone, tectonic massifs, uniformly assembled associations of plants or areas in which humans pursue the same aims and are subject to the same conditions at work, at home or in the town.

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.

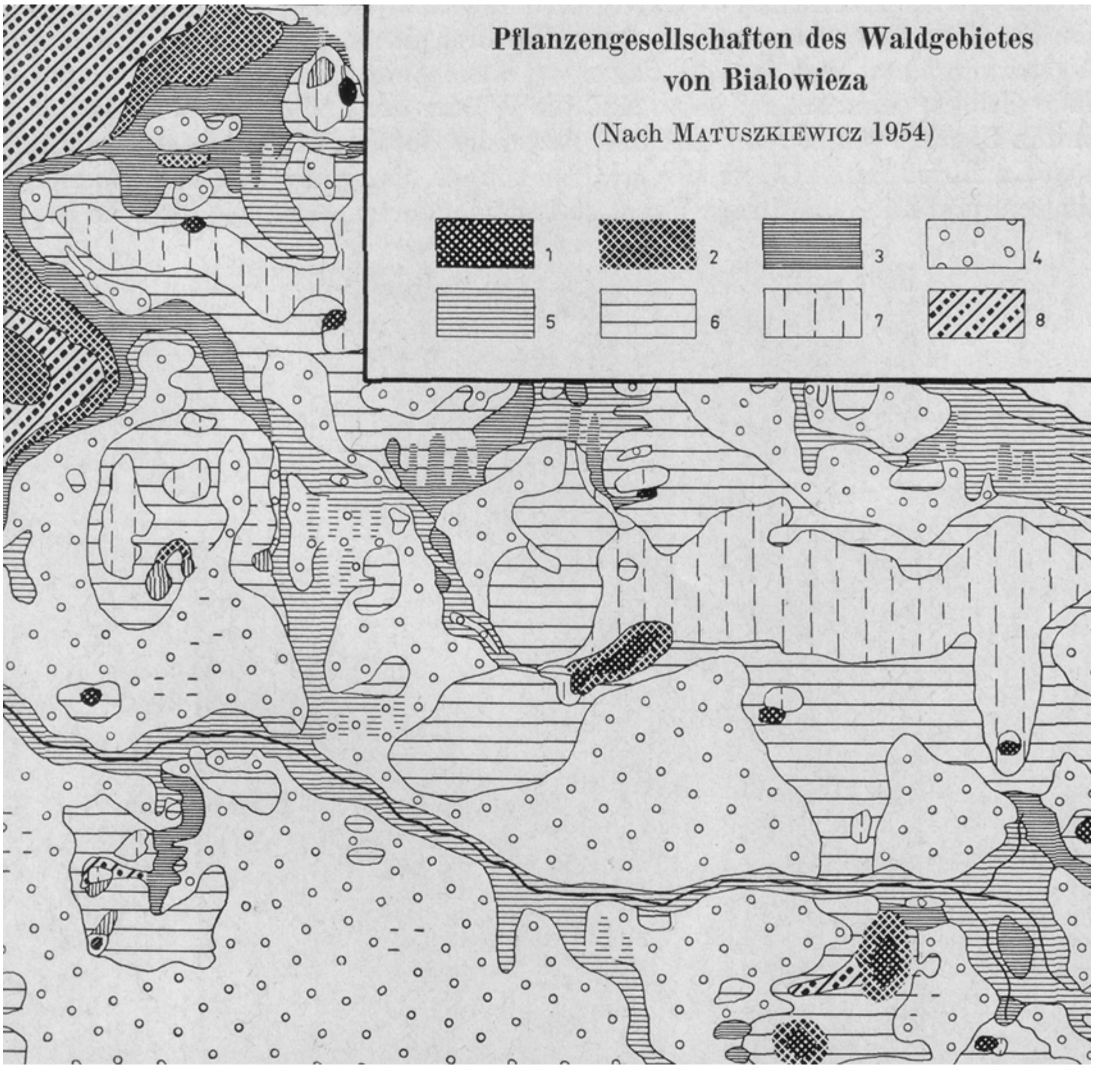


Fig. 17: Plant associations in the forest region of Bialowieza.
Example of the cellular division of a natural unit into various ecotopes (equilibrium systems). 1 = raised bog (Sphagnetum medii pinetosum); 2 = flat bog (Salix aurita-Frangula alnus Ass.); 3 = flat bog (Alnetum glutinosae); 4 = wood (Querceto 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".

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 ("Bodennahe Luftschicht") 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 is the plant associations (or "ecotopes"; see section 2.3.2.1) 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 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.

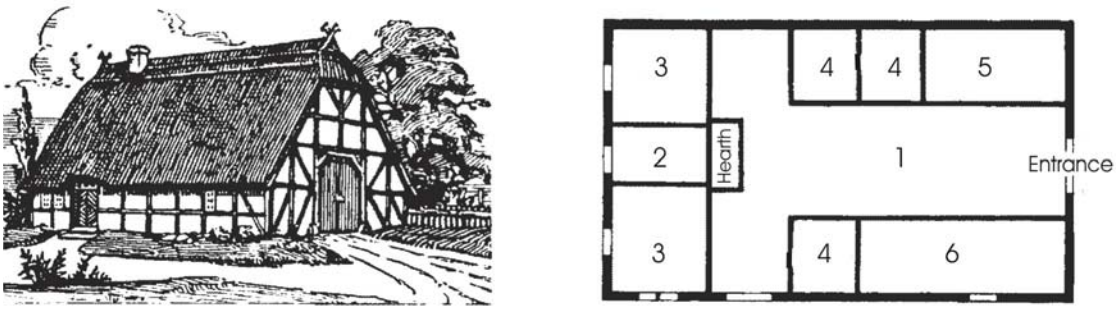


Fig. 18: Representation of a traditional low-German barn-type house (Niederdeutsches Hallenhaus), image and ground plan.
Example of the practical division of a farmhouse: 1: Vestibule; 2: Kitchen and hearth; 3: Living and bedrooms; 4: Chambers; 5: Horses; 6: Cattle. Source: See "Notes on the figures".

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.

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).

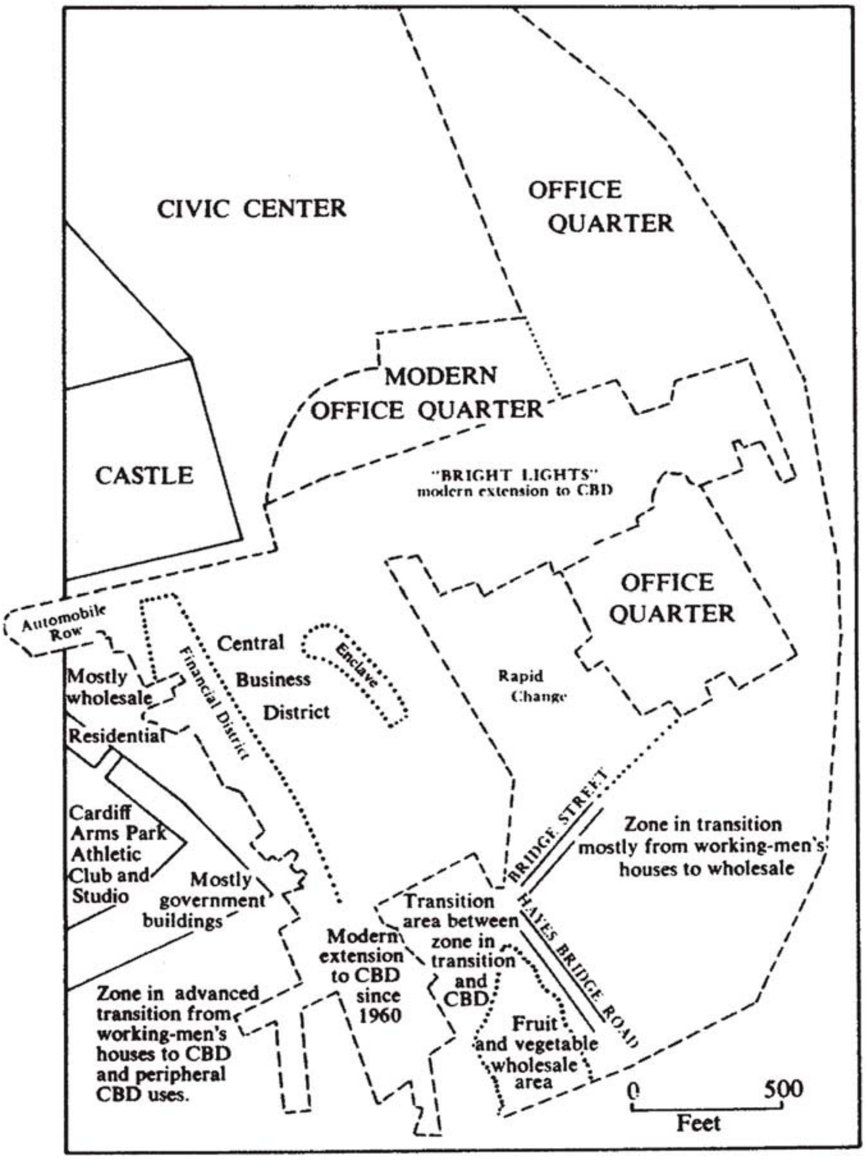


Fig. 19: Urban regions in central Cardiff.
Example of the organisation of an urban area into uniformly utilised areas.
Source: Carter and Rowley. See: "Notes on the figures".

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 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.

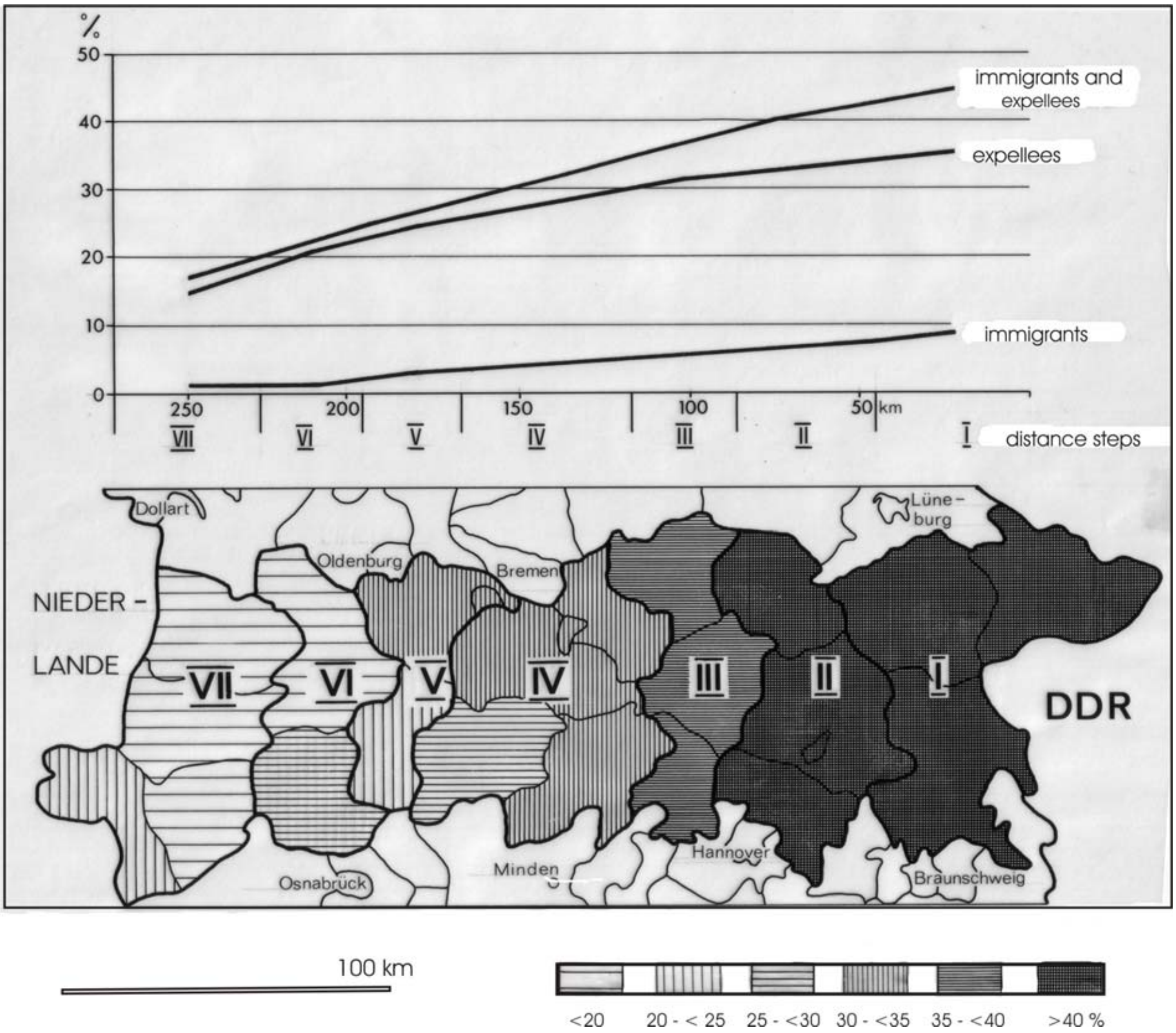


Fig. 20: Exiles and refugees in Niedersachsen (Germany) 1955.
Number per inhabitants.
Source: See "Notes on the figures".

2.2.2.2. Linearly inclined structures

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.

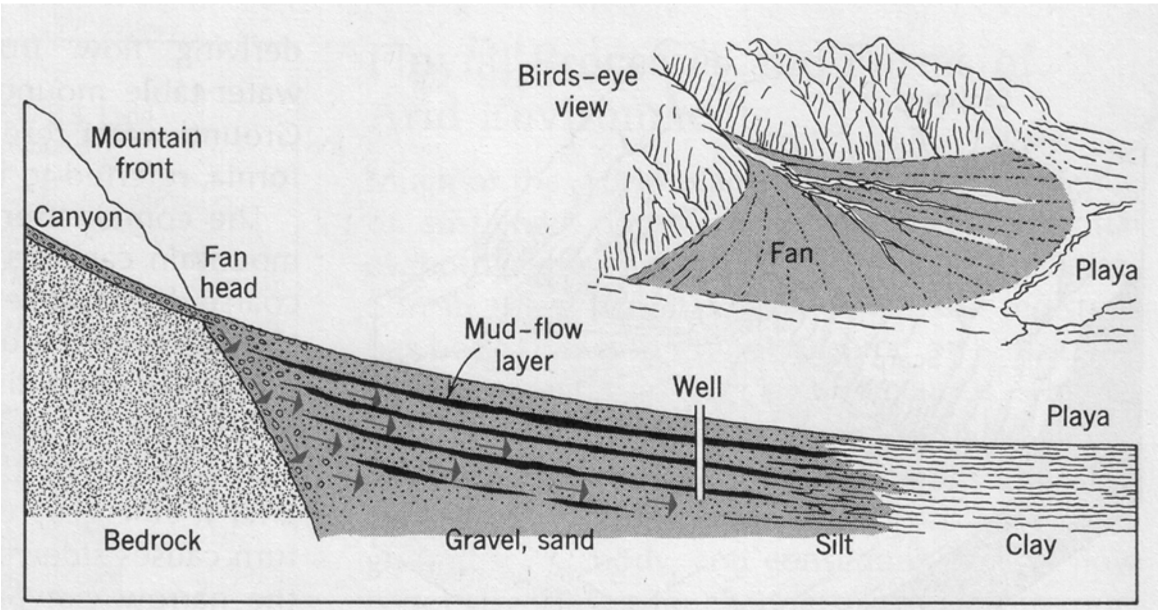


Fig. 21: Idealised cross section of a complex alluvial fan showing the change in geological composition with growing distance from the fan head.
After A.N. Strahler. Source: See "Notes on the figures".

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.

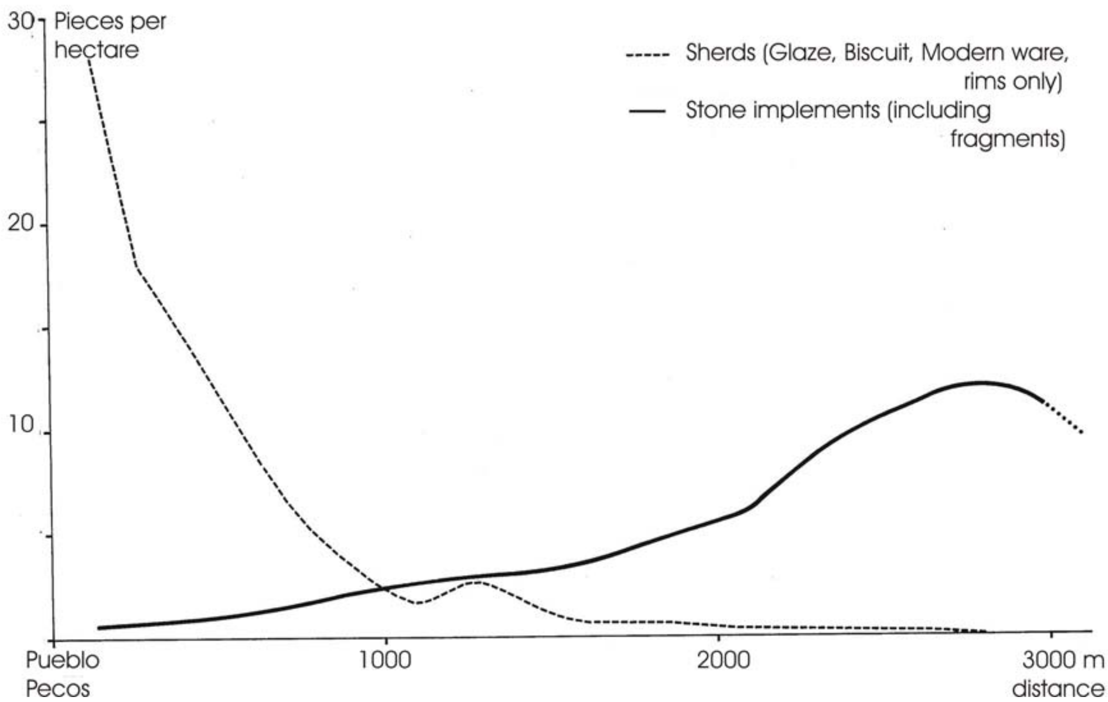


Fig. 22: Density of sherds and stone implements found in fieldhouses at various distances from Pueblo Pecos as indication of the intensity of agricultural and hunting activity.
Source: See "Notes on the figures".

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.

Commuter catchment area:

A particularly good example of a central-peripheral arrangement of an equilibrium system 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). An example is the commuter catchment of Uelzen, a small town in northern Germany (see fig. 23).

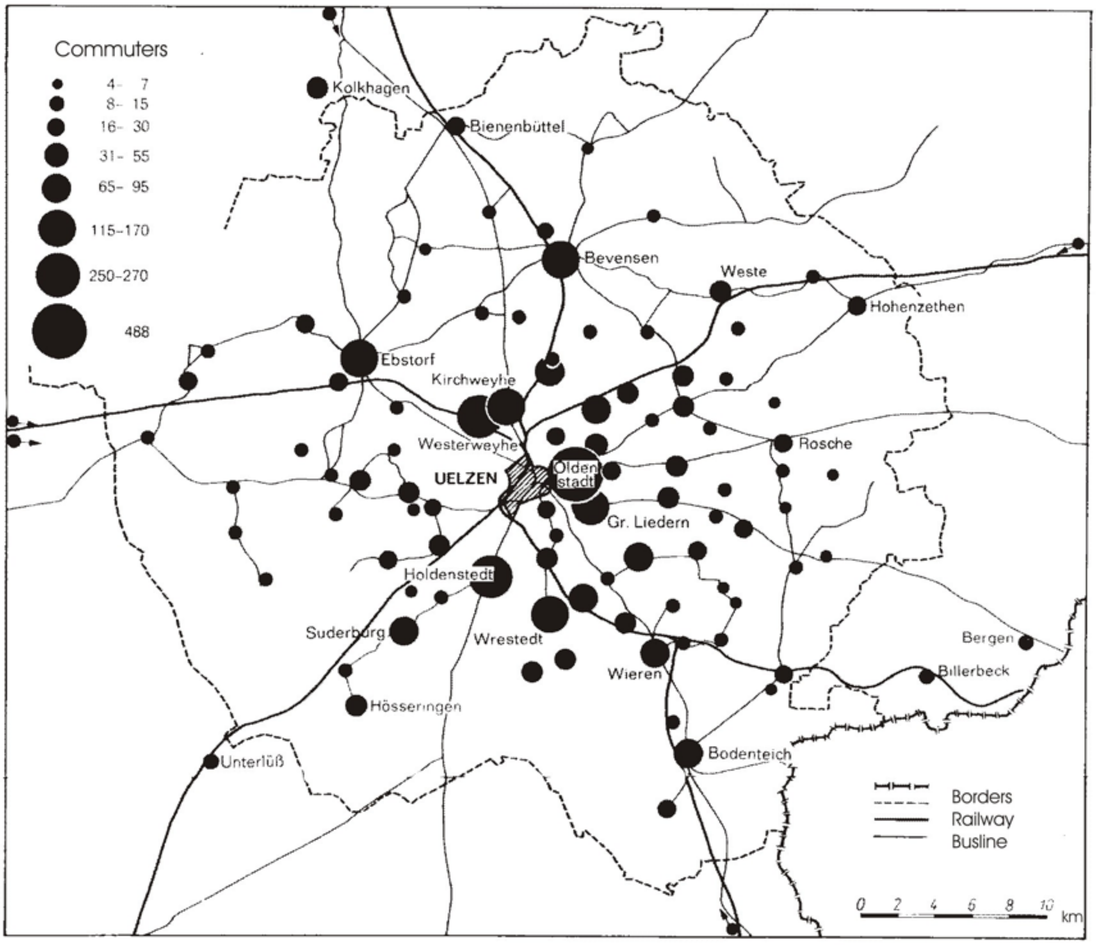


Fig. 23: Commuter catchment area of Uelzen (Niedersachsen/Germany) in 1961.
Commuters are a good indicator of the distance to which urban influence extends. The place of residence and the number of commuters are shown.
Source: See "Notes on the figures".

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 locations, especially in the towns, and are visited by customers from the surrounding area (umland). Fig. 24 gives an impression of the catchment area

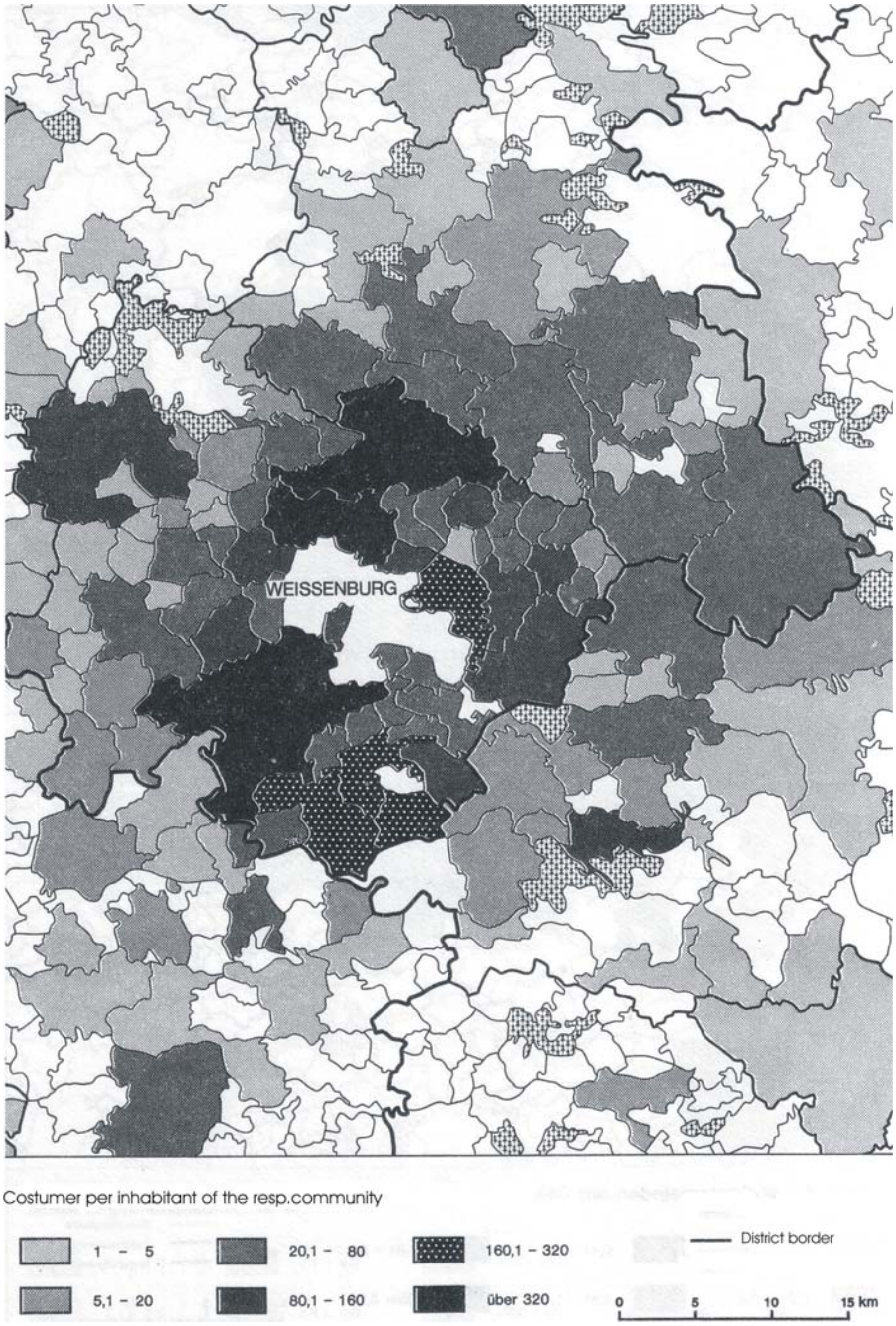


Fig. 24: Catchment area for retail trade in Weißenburg (Bavaria).
Customers' communities of residence (survey of 21.03-26.03.77) per 100. inhabitants. After Heinritz 1979.
Source: See "Notes on the figures".

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, 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 areas

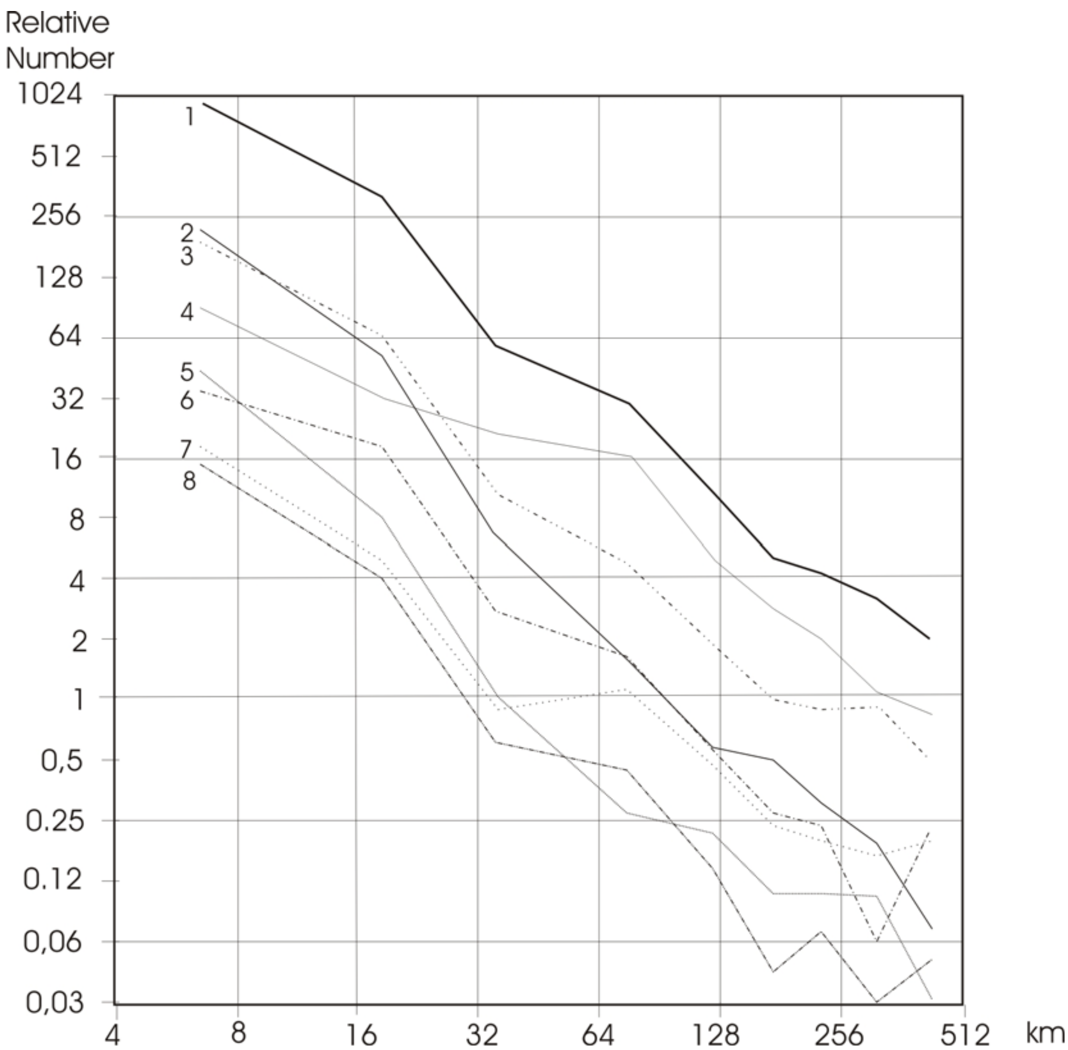


Fig. 25: The intensity of immigration to the town of Göttingen from the Federal Republic of Germany in 1960. Logarithmic representation. Radial cross section through the radially organised immigration area. Numbers per inhabitants.
1 all removals; 2 blue-collar workers; 3 white-collar workers; 4 students;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

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.

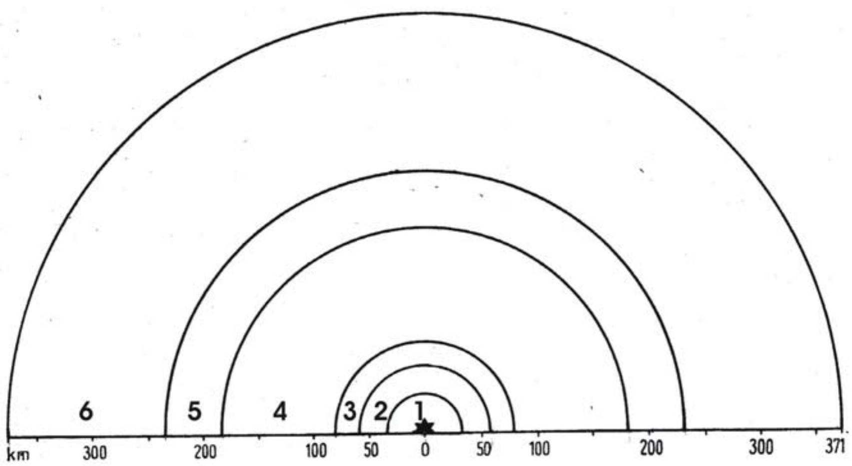


Fig. 26: Model of the "Thünen rings".
Agricultural utilisation with reference to transport costs. After von Thünen (1826/1921).
1 = Market gardening and dairying; 2 = forestry; 3 = rotating cultivation of root crops and cereals; 4 = paddock farming; 5 = three-field cultivation with fallow land; 6 = Ranching,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

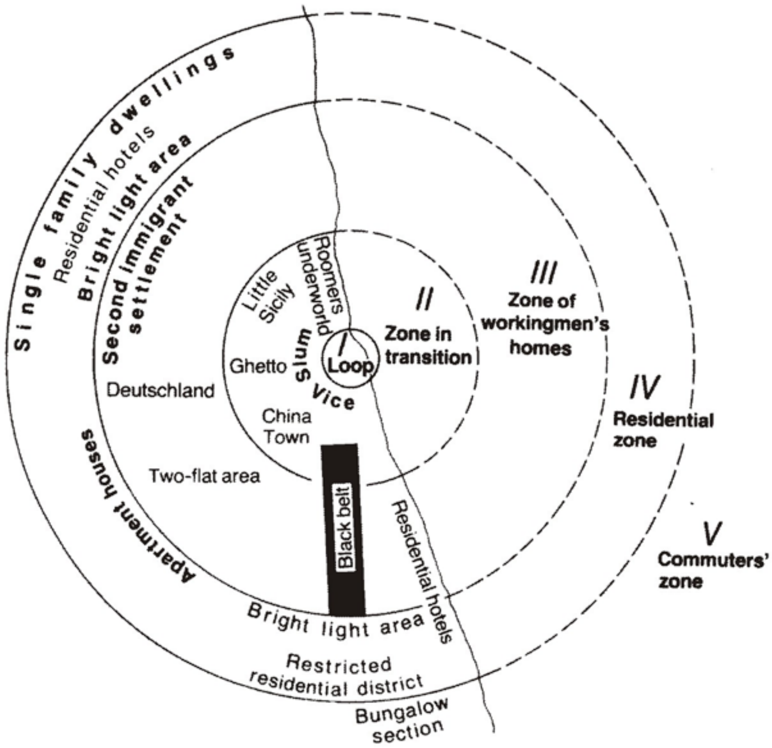


Fig. 27: Diagram of structure of the city of Chicago.
According to Burgess. Example of a ring-shaped city-umland system.
Source: See „Notes on the figures“.

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). 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 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.

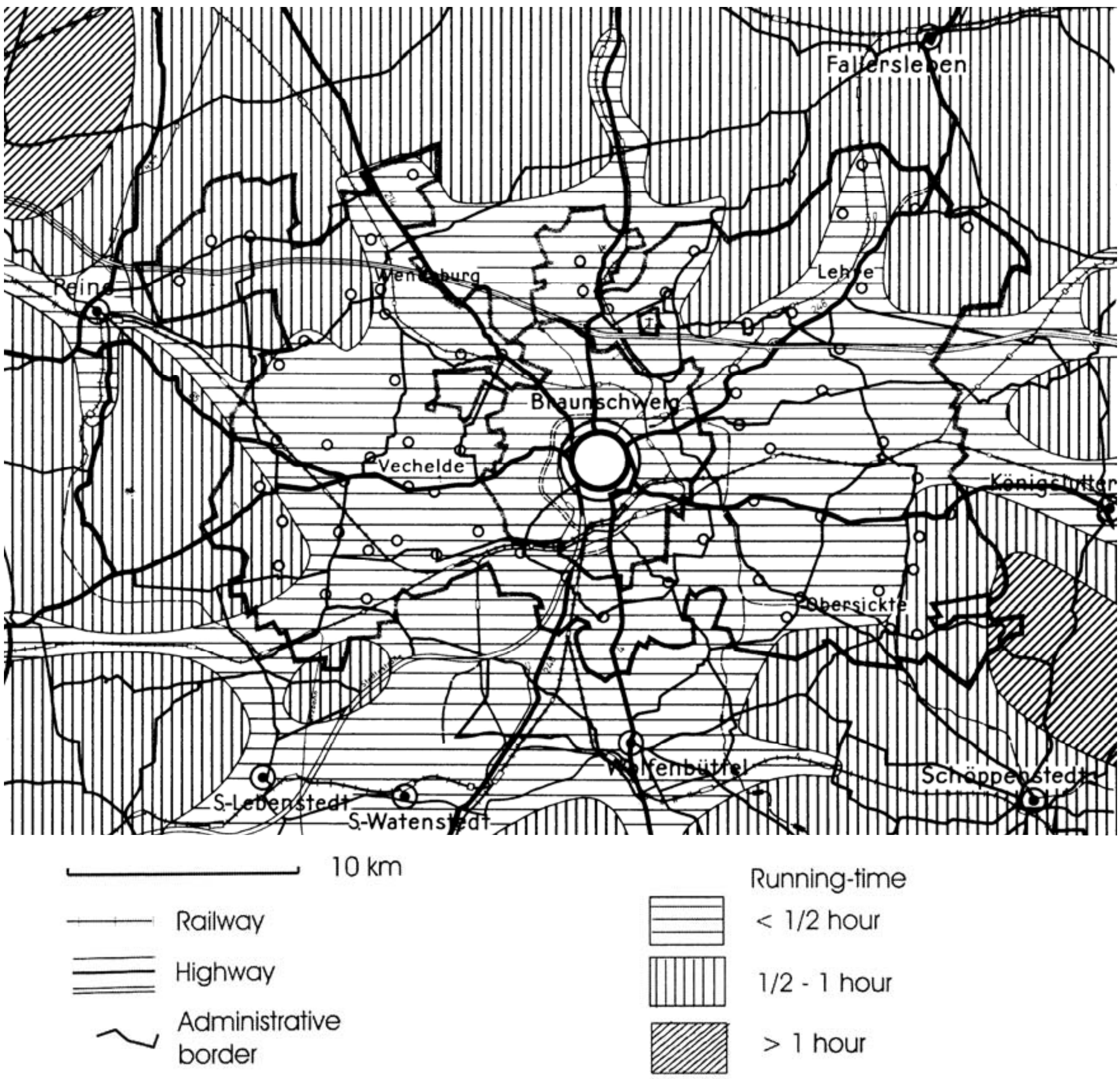


Fig. 28: Isochronal map.
Braunschweig (Niedersachsen in Germany) as destination in 1961.
Source: See "Notes on the figures".

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 the stimulus (information) and/or energy. In this way it becomes possible to represent the transfer 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).

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) 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

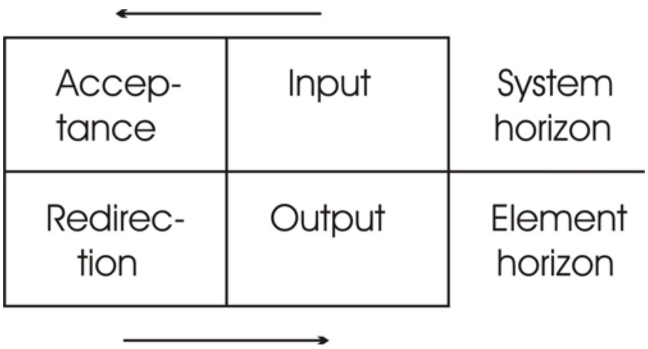


Fig. 29: According to the basic process: The process in the coordinate system with the 4 stages input - acceptance - redirection - output. The path leads from the preceding to the succeeding environment.
Course of process in an anti clockwise (left-hand) oriented system. Basic process horizontal (C variant).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

their own way. The stimulus comes in our model from the horizontal, i.e. the temporal and spatial preceding environment. In the

coordinate system, the two [+y] quadrants (system as a whole = system horizon) are passed through first, then follow 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) from the spatially and temporally preceding environment (e.g. that the town-country ratio changes). To take the example of the commuters:
[f(-x)]: Acceptance of the stimulus in the system, i.e. the conditions for the elements (the commuters) change.
Up to here, the system horizon is affected. The process now leads to the element horizon:
[-f(-x)]: Redirection, i.e. the stimulus is 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 (“induction”). The second half originates from the elements which execute the movements. They respond according to their individual interests and capabilities, thereby representing an individually controlled counter process (“reaction”). The stimulus leaves the system in the succeeding environment.

The emergence code:

How does this picture fit into the process of emergence, i.e. how does the transition from the first to the second level of complexity develop?

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). By contrast, in the equilibrium process, the stimulus comes from the chronologically preceding environment and proceeds horizontally in both directions through the system (C variant).

The 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, fig. 9). 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".

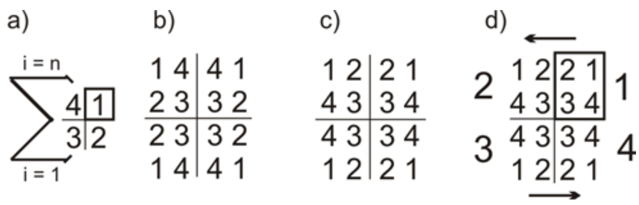


Fig. 30: Numerical diagram of the emergence process from the first to the second level of complexity.
a) Bundling: the equilibrium process (movement- or action-) project comprises n movements (action motions). The sum of the 4 stages of a movement (action motion) is shown. The numbers indicate the sequence; No. 1 is the initial location.
b) Alignment: A new coordinate system (of the first order) is set up. The bundled movements (action motions) are arranged in four groups for the new process. 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).
d) Folding: The f(x)quadrant (1) becomes the front side. The lower (4 and 3) and the left (2) parts are folded behind it, they are "concealed". The arrows show the course of the process of the first order.

- 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).
- 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.
- 4th operation: The last stage is the "folding" stage (see fig. 30 d). The horizontal process of the system takes place from right to left. The f(x) quadrant becomes the front side and the other three quadrants are folded behind the front side, i.e. they are "concealed". The front side contains the material structure of the system. The stimuli are introduced (input) here. The remaining process stages (acceptance, redirection und output) take place at

the concealed sides with the material framework being used in each case. In this way, the four process stages are placed in ordered succession and can be read like a book.

The transitions between the other levels of complexity can be represented in basically the same way.

In the numeric sequence (Fig. 31a) the "front side" now appears in the upper right corner of the coordinate system (1). It is the sum of the solida. Their structure appears to have been taken from the first level of complexity in reverse form. The participating individuals in the system then assume the stimulus in the second stage of the induction process. This stage is "concealed" as is the reaction process in the opposite direction in the lower part. Depicted linearly (Fig. 31b), the equilibrium process (1st order) proceeds horizontally from right to left. The movements (of the individuals: 2nd order) are aligned vertically.

The processes of the 2nd order alternate in their direction, i.e. the U and C variants replace one another like gear wheels. In this way the dynamic equilibrium is maintained and the transmission of the stimulus ensured.

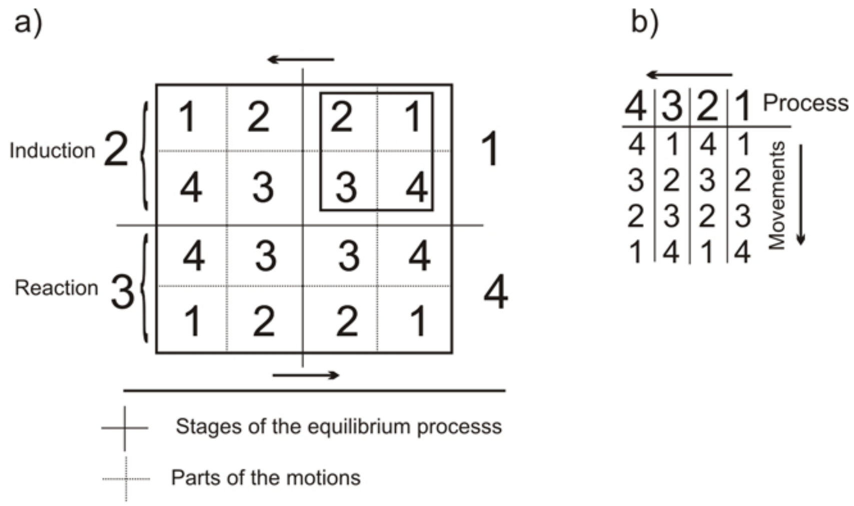


Fig. 31: Numeric sequence of an equilibrium process. The large numbers show the course of the process (1st order), and the small numbers the movement of the elements (2nd order). a) At stage 1 (front side) the movement of a stimulus in the solidum depicted in Fig. 9 (section 2.1.3) appears after reversal. b) The processes of the 1st and 2nd order are shown here in linear representation.

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).

Whereas the numeric sequence within the coordinate systems represents the formal transitions from one quadrant to the next, it is the course of the internal processes themselves which is illustrated here. For reasons of simplicity, we will allow the processes to begin at the centre.

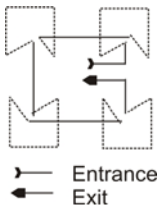


Fig. 32: Route diagram of the equilibrium process.
The course of the 1st rank process through system and elements is marked by the arrow. The stages of the equilibrium process are structured according to the C variant. The hierarchy of the processes of the 1st order (central rectangle) becomes apparent with reference to those of the 2nd order (movements added to the outside in the diagram). Each of the basic processes shown in the diagram represents a large number of individual basic processes.

First of all the four stages of the 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 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 (Q) was the dominant dimension. The other dimensions were firmly linked with it (see section 2.1.3). 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 (T) 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 (see section 2.3).

2.3. Flow process and flow equilibrium system

2.3.0. Instead of an introduction: The textile factory in the flow of information and energy

The textile factory was integrated energetically in its environment. It received a demand (from the market) and attempted to satisfy it by supplying the products demanded. In order to do this, it required, in addition to labour, raw material and energy. Broadly speaking, this means that the textile company was located in the flow of information (demand) and energy (supply).

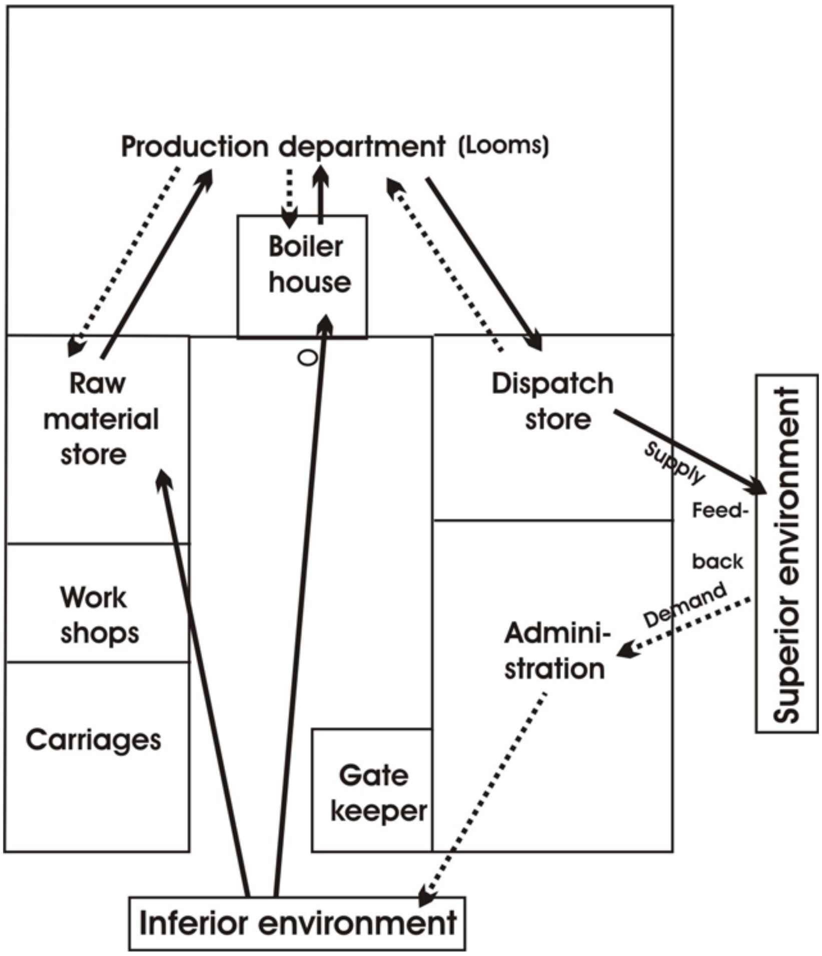


Fig. 34: The textile company in the flow of information and energy (demand and supply).
Dotted arrows: flow of information. Extended arrows: flow of energy.

Moreover, it was in competition with other companies supplying similar products. Together with these, it formed (through its products) an objectively definable unit of a higher order. This unit of companies was the supplying side of the market. Through the market, these companies received the demand for woven products from other companies which used them in other ways (further processing, sale etc.). This is the "superior environment". On the other hand, the textile manufacturers received the raw materials, electricity, water, etc. which they required for their processes from other companies and organisations. This is the "inferior environment".

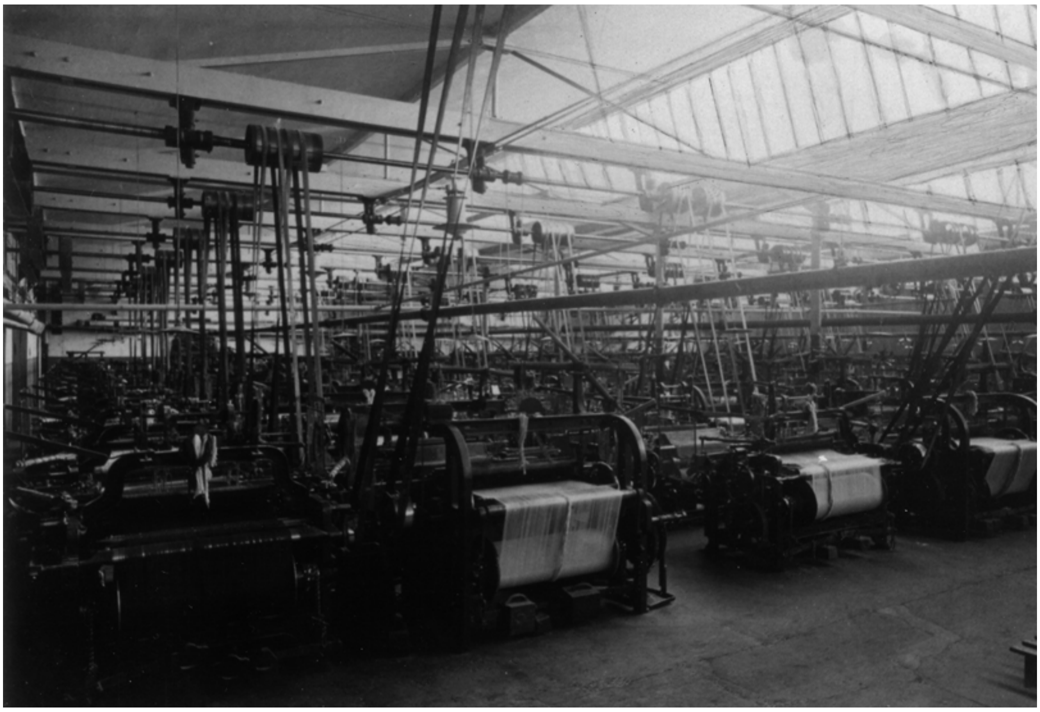


Fig. 35: The machine room of a cotton-weaving mill in the year 1927.
Example of a department in the factory. Transmission of power centrally via mechanical arbours and drive belts. This is a striking example for the contact between boiler house and production department with its weaving looms.
Reproduced with kind permission of the Gütersloh city archives.
Source: See "Notes on the figures".

The "whole" of the textile companies (weaving mills) of a region formed a "compartment". This term originates in the field of ecology (ELLENBERG 1973, p.3). A formation of this kind is distinguished by a material uniformity like the characteristic groups of the equilibrium systems (see section 2.2.1.1). The single textile factories are the elements. Their number may vary according to market situation.

Within the textile company, the jobs (or action projects) were thematically ordered and, as already seen (see section 2.2.0), divided into specific departments such as stores, production and planning. These departments were spatially separate from one another, and each grouped together in certain buildings and rooms. It was expected of them by the company that they fulfil their task in co-operation with the other departments. In this way, each department receives demand from other departments (flow of information), and, in response to the demand, supplies the demanded product, information or goods (see fig. 34). From the point of view of the company, the departments were sub-systems, parts of the organisation.

However, taken individually, the departments could also be regarded as small compartments, similar to the large compartments which represent the entirety of the textile mills in a region. But they are one magnitude smaller. The elements belonging to them were the workers with their action projects. They competed with one another. They had to maintain their position if they did not wish to fail or be removed. On the scale being considered, they and the earth-bound artefacts and media used by them (buildings, rooms, equipment) represented the smallest units of utilisation.

Here we are looking at the compartments only in their capacity as receivers of demand (information) and providers of supply (energy). The opening of the systems to the energy environment also opens the systems to the fluctuations of the market and gains access to innovations at the same time. The production department of the textile mill is an example. Originally, the machines were connected with the steam engine by transmission belts via a common drive unit (see fig. 35). After the Second World War, the old looms and the steam engine were taken out of service and were replaced by modern looms driven by electric motors. Through constant effort, these systems can maintain themselves between supply and demand in the environments.

To fulfill its tasks, the company was (as described above) a clearly delimited unit which was internally ordered in such a way that it could organise itself. That was its intended purpose. We will return to this subject in the next section (see section 2.4).

2.3.1. General considerations

2.3.1.1. System and process:

Large and small compartments:

From the above remarks, it is convenient to distinguish between large and small compartments (see fig. 36).

In the small compartments of the textile factory, the action projects (see section 2.2.1.1) are bundled. In general, seen from outside, these are small areas which are uniformly utilised within themselves. Besides the departments in companies, small compartments include e.g. rooms in a house (such as kitchen or living room; see section 2.2.2.1, fig. 18) or topes like cultivated fields in agricultural areas (see section 2.3.2.2, fig. 59) or ecotopes in the landscape (see section 2.2.2.1, fig. 17).

Unit	Structural position
Larger compartment (e.g. market)	System
Factory	Element
Smaller compartment (e.g. department in a factory)	System
Individual (in his role)	Element

Fig. 36: Large and small compartments as structural units.
The factory as an example.

The uniform utilisation appears to be perfectly natural, but it is necessary to take a closer look. In the case of the small compartments, the individual action projects can be conveniently joined together and channeled in this way. To allow the small compartments to fulfil their purpose as efficiently as possible within the company, they are equipped with various types of technical equipment (office machines, looms etc.). Then, the events and processes which occur in the small compartments depend on the information required for its task (e.g. the demand from the company management as the "superior environment"). Moreover, the small compartments can only fulfil their task when they receive a regular supply of the energy they require (thermal energy, electricity, possibly also with raw materials). This in turn requires links with the "inferior environment", i.e. the actual source of energy in the wider sense.

Compartments must satisfy the demand through their supply with the assistance of efficient equipment. Media and earthbound artefacts facilitate the processes and the adaptation of the systems to the necessities of the environment (see section 2.1.1.1). To secure the supply of energy, the environment supplying energy becomes involved. For its part, it is interested in joining up with the system because it is dependent on the demand. In this way, supply and demand unite and strive to achieve an equilibrium within the flow of energy.

We are dealing with a certain type of process and system. Whereas temporal (and spatial), i.e. horizontal links make up the equilibrium processes (or movement resp. action projects) and equilibrium systems, for this type, it is the energetic vertical connection between the demanding system (e.g. the factory) and the source of raw material and energy (e.g. from the supplying companies).

What applies to the small compartment, also applies for the larger compartment (e.g. a group of textile factories). On the one hand, it must have access to the inferior environment supplying the energy (e.g. the raw materials delivering companies). On the other hand, the system also supplies its (demanding) superior environment (e.g. the market), thereby creating a chain of demand and supply. Thus, these systems are enabled to structure themselves in such a way that the flow of information as a consequence of the demand and the flow of energy as a precondition of supply can take place efficiently. The systems are parts of a chain of flow equilibrium systems which are coupled to one another through these flows.

In general, each system tries to maintain itself as an entity. It can be said that a flow-equilibrium is sought, and that consequently the processes can be termed "flow processes" and the system a "flow equilibrium system". Thus, although the systems are capable of delimitation, they are open from an energetic point of view, i.e. they have input and output relationships with the outside, the environment.

Systemic explanation:

These relationships cannot be explained by the causal method or the functional method. Through the dependence of the systems on the environment and the freedom of decision of the individuals as the elements in the systems, probabilistic links are usual because the reactions of the systems in the environment cannot be determined. Thus, in the 1950s, probabilistic models were used in sociology and human geography, such as had been common in the natural sciences for a considerable time. Surveys provided the basic data necessary.

In subsequent years however, it was realised that this often provided only very general guidance, and in many cases only a slight improvement on deterministic models. In order to obtain more accurate information, it was necessary to examine the system structure. Examinations based on the system theory, such as those developed in the fields of biology (v.BERTALANFFY 1950), mathematics (WIENER 1948/68), economy (FORRESTER 1968/72) and later geography (BENNETT and CHORLEY 1978) make some progress possible (see also section 2.4.2.1). Indeed, a precise examination of the flows and the links between the individual compartments is required. The flows of material and energy must be measurable, e.g. food or chemical substances in ecosystems, sums of money, goods, raw materials in economic systems etc. These flows can be depicted in structure diagrams. Besides these, flows of information which determine the demand also have to be taken into account. They take effect particularly in retroactive loops and control the flow of materials etc.

Systems reflect the situation of a moment. They change and are different at different times. Changes in the input-output ratio are accompanied by changes in the system relations. The different system states can be understood by means of simulation, thereby achieving an image of reality. This implies the possibility, through modifying individual components, of showing a way which may lead to an improvement in actual conditions if this is what is being sought.

The system theory therefore deals with structures which are already very complex and which consist of several compartments (often designated as "elements" by system theoreticians). However, for the purposes of this study, we will (for the present) restrict ourselves to what happens in the smaller and larger compartments in order to understand the "mechanisms" more closely and to gain an insight beyond the purely superficial input-output relations. In particular, we are interested in system-internal flows of information and energy between demand and supply, the regulation of these flows, and the oscillations and the spatial changes caused by the processes of diffusion.

With the equilibrium processes (see section 2.2.1.1), an internal division into stages has taken place at element level (movement projects) depending on the chronological sequence. The equilibrium processes are made up additively of such movement projects. Here the situation is now different to the extent that the system as an entity receives a weight of its own (as mentioned already). Although the elements (individuals) still have their own interests, as parts of the system, they are subordinate to the whole. The flow of information and energy rooted in the superior or inferior environment requires an internally controlling hierarchy.

Thus, 2 structuring tendencies should be distinguished which find their expression in process trains. The first process train organises the internal structure while the second process train controls the flow of information and energy stemming from the environments.

1st process train:

The internal hierarchy, bonding levels:

Let us try to understand what happens in the system (e.g. compartment of textile factories) between the superior and inferior environment. First of all, the system forms a link in a chain of systems. The demand comes from the superior environment, i.e. from (one system or various) systems of the superior environment, and then passes through the system to the inferior environment, i.e. to (one system or) various systems in the inferior environment. From there comes the energy, i.e. in our case, the system formed by the textile companies demands the raw material, electricity etc. This energy is also fed through the system to the superior environment where it is supplied to the demanding systems.

We can divide the entry of a stimulus into the system into 2 stages, which are the equivalent of partial systems. The first partial system covers the system (as a whole) with its elements and is determined by the superior environment. The demand is entered into the system and then accepted by it. This is the "system horizon". It is defined by the size, i.e. the quantity of elements and the capacity of the whole of the system. The individual elements have their own interests, they need the demand for their own existence, so they also demand on their part. They now have to pass the demand on to the inferior environment to allow sufficient energy (raw material) to be supplied by it. The elements form the second partial system, the "element horizon" (see fig. 37). [In the factories, system horizon and element horizon assume, so to speak, the function of employers and employees. The employers must ensure that sufficient demand enters the factories so that the employees can be supplied with work they "demand" for their own.]

For their part, these partial systems are again divided. The system and element horizon are represented in their different capacities.
1) The system horizon as the entirety of the system:
- Input: the information from the superior environment encounters the system. The quantity of the elements is an indicator of the size of the system;
- Acceptance: The system, i.e. the quantity of the elements absorbs the information. The system is limited in its capacity.
2) The element horizon as defined by the individual elements and their capacity:
- Re-direction: the information is input, the elements themselves are stimulated;
- Output: the elements absorb the information according to their capacity and offer them to the inferior environment as a stimulus. This is the information flow (energy demand). Here we again recognise the basic process (see section 2.1.1.2).

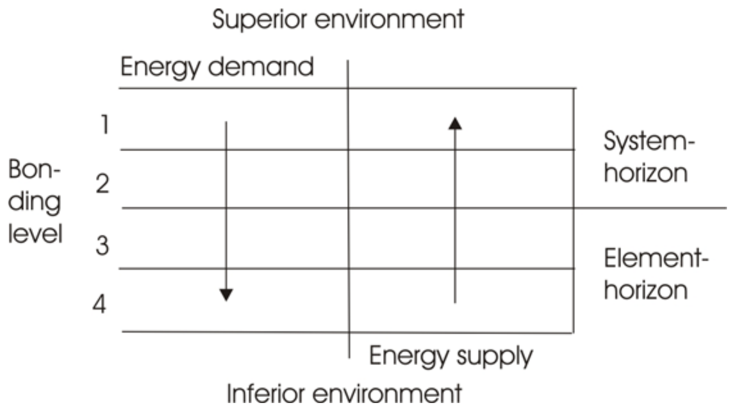


Fig. 37: The four bonding levels (system horizon: entry and exit, element horizon: entry and exit) in the flow of information (demand for energy) and energy (supply of energy).

The density of the bonds increases from the top downwards, i.e. the information is increasingly bound up in the system and its elements. The four levels are arranged hierarchically one above the other, we will call them "bonding levels". The flow of information with the stimuli takes place from the top in a downward direction, from the whole (system horizon) to the elements (element horizon). A hierarchy is created which allows a control.

The inferior environment with its systems decides independently whether and to what extent the demanded energy (raw materials etc.) is supplied. Then the energy flows from the elements to the system as a whole which supplies the market:
- The elements as such receive energy from the inferior environment (4th bonding level).
- The elements absorb energy (3rd bonding level).
- The system as a whole receives energy from the elements (2nd bonding level).
- The system as a whole releases energy to the superior environment (1st bonding level).
Thus, the system involves step by step the inferior environment.

The system is influenced on the one hand by the energy demand of the superior environment, and this has a special influence on the system horizon. On the other hand, the energy-supplying inferior environment influences the element horizon. The system horizon controls the element horizon by way of the demand/supply-relationship. On the other hand, the elements differ in their possibilities and constraints and are therefore independent up to a certain point. Thus, it may be said of the flow equilibrium system that the whole is more than the sum of the elements (in contrast to an equilibrium system).

At the various bonding levels the information and the energy are distributed. These processes are interpreted as the equilibrium processes. Thus, the processes take place horizontally one bonding level after another within the flow of information and within the flow of energy. In doing so, the elements follow the four stages of the basic process. The process involves the elements at the bonding levels, so that processes come into being at the individual level. This affects the vertical structure (bonding levels) in the system. So the system is moved from one state into another (see section 2.3.1.2).

2nd process train:

The contact with the inferior environment, i.e. the demand for and the supply of energy, takes place at the fourth bonding level as explained above. The way in which the system is controlled by contact with the superior environment can be described by the terms feedback, oscillation, diffusion and rotation.

Feedback:

The vertical flows of information and energy have to be coordinated with one another to ensure that the system can keep itself in a flow equilibrium. This is assured by the feedback (see fig. 38).

The market demands specific products in certain quantities at different times. Many companies demand, many supply in competition with one another with the result that no central control can take place. To carry out their tasks leading to the delivery of the goods, the companies require time. The market changes constantly with the result that a temporal hiatus arises between demand and supply. [In recent times companies have attempted to bind their

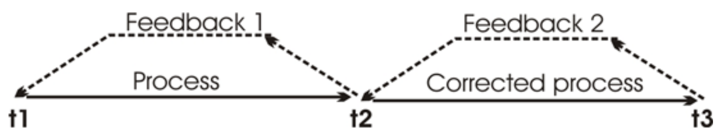


Fig. 38: Feedback taking the process sequence into account.
t1 the moment at which stage 1 begins, t2 the moment at which stage 1 ends, beginning of the second stage (with corrected process).

suppliers by contract ("just in time")]. The compartments with the companies competing against one another on the market (superior environment) can only check that the desired goods comply with the requirements of the demand with regard to quality and quantity when they are supplied. This takes place at the borderline between system and superior environment. Demand and supply are then linked with one another and can be measured and compared. This is the "feedback".

If the expectations of the demander are fulfilled, the companies as the elements of the compartment receive the assurance that their supply is accepted. Some companies are perhaps unable to compete and are forced to give up. Thus, selection takes place, the number of companies in the compartment fluctuates. In this way, the system (compartment), i.e. the whole of competing companies as elements producing the same goods, regulates itself.

Oscillations:

As stated above, on the free market, demand is frequently not equal to supply at the time of supply (output). Fluctuations take place through the delay intervening between demand and supply. Sometimes too little is supplied and then perhaps too much (see fig. 39).

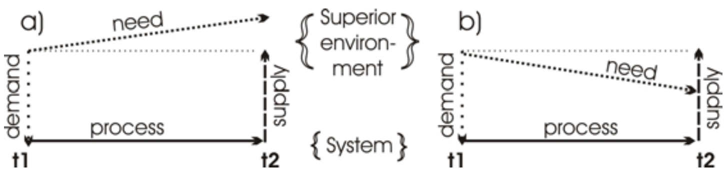


Fig. 39: Possible tendencies in the development of the requirements of the superior environment (the market) in the course of the process.
a) demand exceeds supply;
b) supply exceeds demand.

Accordingly, the capacity of the companies as elements of the compartment, is sometimes fully stretched and at other times partially idle. As no complete balance can be established between demand and supply, the fluctuations are perpetuated. Here, we may speak of "oscillations". They force the system to accept a certain rhythm. In this way, demand and supply correspond to one another only in the mean (see fig. 40).

In times of economic boom, the system is especially open to innovation and the introduction of an innovation gives the boom additional impetus. In this way innovations are frequently introduced at regular intervals which correspond to the oscillations (SCHUMPETER 1939/61; MENSCH 1975; see section 2.3.2.1).

On the other hand, times of slump are associated with crises and processes of elimination. In the case of our textile mill, the crisis in the industry on the 1970s altered the market to such an extent (foreign competitors were able to supply cheaper products through lower labour costs) that no further balance could be established and the company had to close down.

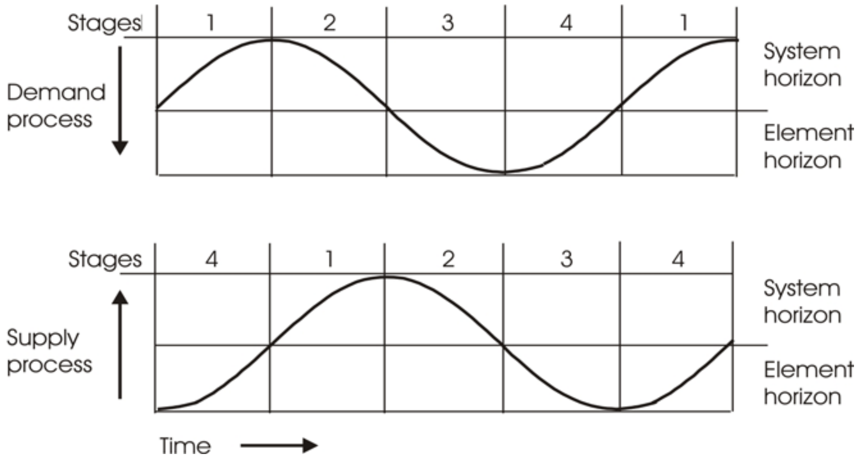


Fig. 40: Delay in the supply process with reference to the demand process.
The numbers indicate approximately the stages 1 - 4 of the process (see section 2.2.3).

Diffusion:

Within the individual bonding levels, all the elements are equal. They are equilibrium systems (see section 2.2.1.1). In a small system (or compartment) like a department, the horizontal transfer of a stimulus (equilibrium process) is simple. The time factor plays virtually no part. Besides, the departments of the textile mill are dependent on instructions. With the larger systems (like the market), this is not so. In this case, innovations are spread by diffusion, which takes time. When one company adopts the innovation and is successful, the others follow if they do not want to drop behind on the market. This innovation passes from company to company in the compartment. Such innovations are generally spread by different routes - partly through neighbourhood contact, and partly via modern means of communication - by being adopted gradually by those interested.

Diffusion assumes a homogeneous structure of the system, since the innovations which are transported by diffusion, have to be adopted by materially suitable elements. An essential condition for all diffusion processes is
1. that the stimulus comes from the superior environment (c.f. section 2.2.1.1), i.e. from the market, which indicates that there is a greater requirement for products (e.g. woven goods),
2. that the system as a whole is ready and able to adjust accordingly (i.e. to diffuse an innovation, e.g. better looms),
3. that the elements are able, after adoption, to put the innovation into practice, and
4. that the inferior environment provides sufficient energy resources.

The process of diffusion is controlled not only from below, i.e. from the inferior environment and the supply of energy, but also from above, from the superior environment, i.e. the market. It must be remembered that each flow-equilibrium system is located in a vertical flow of information and energy (e.g. product or food chain) and both have to be controlled vertically by the system and its elements (see above and section 2.3.1.2). Since innovations generally correlate with upward trends in oscillations, they spread over the system in waves.

Rotation:

When an innovation diffuses, the process normally spreads to other areas of the compartment away from the "initial place". However, when the intrinsically homogeneous systems proceed around a centre (e.g. the Thünen rings; see section 2.2.2.4), the innovations are diffused in a tangential direction (example: proceeding of cultivation around an agricultural settlement; see section 2.6.2.2). We call this process "tangential rotation" (see fig. 41).

In the case of "irregular rotation" the centres of innovation jump from one population to another, a spatially regulated progression is not recognisable. However, the passage from one to another is often prepared by the preceding population in their area of influence (e.g. through closer trading contacts etc.). In each case, one population becomes predominant as a centre of innovation, which proves to be most suitable for the task in hand for a certain period of time.

The structural and spatial spread of the flow equilibrium system is limited wherever the vertical environmental conditions change, i.e. where other things are demanded from the superior environment, or where too few or no resources are provided by the inferior environment.

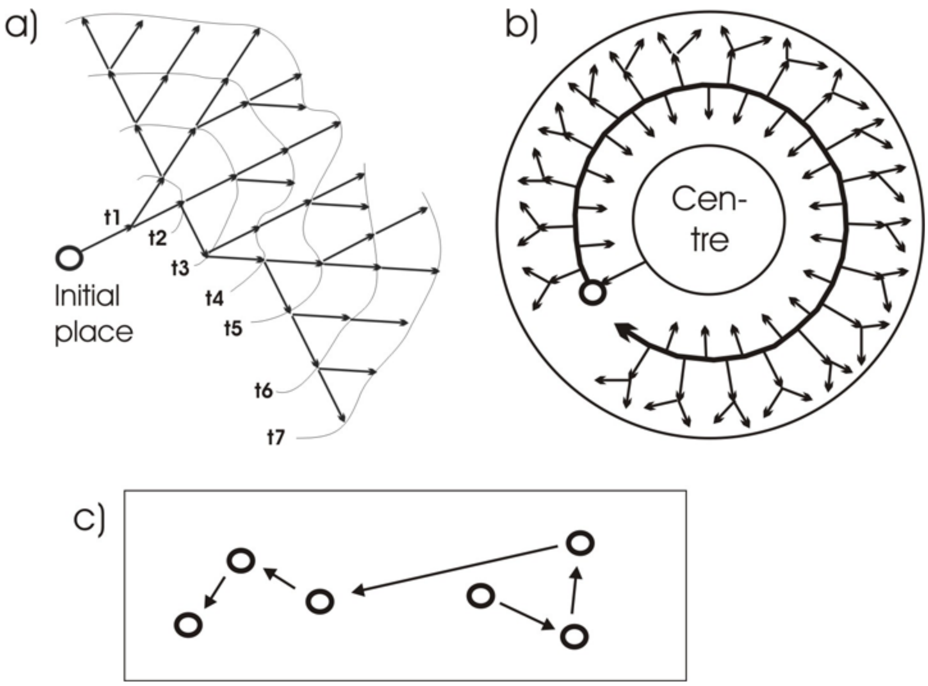


Fig. 41: Diffusion and rotation - Diagram.
a) Diffusion from an initial site into an outland. t1...n moments in time
b) Tangential diffusion starting from a centre (e.g. a town): tangential rotation,
c) Irregular rotation. The initial sites shift.

As we will see later (sections 2.4.2.1, and 2.5.2.2), the diffusion of innovations is a type of process which leads to social change, and on a more general scale, cultural evolution.

2.3.1.2. The Model

A suggestion for describing the above mentioned flows mathematically is made below. We follow the flow of information in the system, a) by dealing with the bonding level step by step and b) by examining the various stages of the diffusion processes (logarithmic -> rational -> exponential -> probabilistic) within these levels (see section 2.2.1.2).

1st bonding level:

The demand is entered into the flow equilibrium system. The system defines itself here exclusively as a quantity of elements. These are by themselves, without restriction by a specified system:

1st stage: The demand for energy should be regarded as information which has to be introduced into the system in the same way as energy (see section 2.2.1.2). Energy and information have to be exchanged between the elements of a system, otherweise it loses its character as energy resp. information. This means that the same laws regarding structure and the ability to stimulate apply to both (EIGEN and WINKLER 1975, pp. 165). In the theory of information, the information content of a message is defined in the same way as entropy from an energetic point of view. The strength of the stimulus is expressed by the information content. Thus, the formula table for the theory of information (SHANNON and WEAVER 1949/76; SCHWARZ 1981) can be used to describe the flow of information or energy. Every single element has to be reached.

The stimulus from the superior environment – measured in element equivalents **-** is entered into the system. The information content may be represented by the formula

$$I = \log r \text{ ,}$$

where I is the information content of a message and r the number of micro-states. It should be noted that each of the r micro-states appears with the probability $p_i = \frac{1}{r}$. Through the selection of the logarithm for the base 2, we obtain the dimension *bit.* So the formula for the information content is

[1]

$$I = -ld\, p_i = ld \frac{1}{p_i}\, bits \text{ per symbol}$$

The value I indicates the stimulus strength for each symbol. Where the information has M symbols, the term must be multiplied by M.

2nd stage: The stimulus is absorbed in the system. The absolute value must now be opposed by the number of elements. The required relative value d represents the extent to which the system, on average, becomes stimulated. 1 represents all, W the elements becoming stimulated. The greater the number of elements, the smaller the part of the stimulus received by the individual elements. This produces the formula

[2]

$$d = 1/W$$

3rd stage: The stimulus is diffused into the bulk of the elements. The quantity of the elements adopts the stimulus. The diffusion is based on the simple positive exponential equation (discrete form):

[3]

$$N_n = k * N_{n-1} \quad \textit{adopters}$$

where N is the number of adopters, n the number of time steps; k is a constant (increase factor).

4th stage: The relation between the new stimulating elements (element equivalents) to all elements is asked for. Let us assume that the event that in a quantity of n elements appears anew equals E. In a sequence of x_n tests the event E occurs x_m times. X is the random variable. So the equation is

[4] $$f(x) = P(X = x) = \frac{x_m}{x_n}$$

The individual new (stimulating) elements all occur with the same probability. When the number of tests is high enough, *m* approaches the number of the new elements.

2nd bonding level:

The elements have their position (and function) in the system, and appear as components in a limited system. Each of the elements strives individually to achieve an equilibrium in the system as a whole:

1st stage: The stimulus (element equivalents, information symbol *A*) is conveyed to the elements (information symbol *B*) of a limited system. The probability of the appearance of the symbols *A* and *B* is *p(A)* and *p(B)*. The probability *p(A) = 1 - p(B)* applies. If the symbols of both categories occur with the same frequency, i.e. if *p(A) = p(B)*, the probability that a representative of category *A* or *B* will occur is 0,5. That means that the information content (stimulation strength) is then highest. If however *p(A)* = 0, then *p(B)* = 1 [or if *p(B)* = 0, then *p(A)* = 1]. The information content is *I* = 0. Then there is no flow of information and no stimulus. The formula for the average stimulation strength *I* of the system which is formed by both categories *i = A* and *i = B* is

[5] $$I = \sum_{i=A}^{i=B} p_i * ld(\frac{1}{p_i}) \quad \textit{bits}$$

This is the formula of the "(neg)entropy" (here with 2 categories only) as intended by the information theory (SHANNON and WEAVER 1949/76).

2nd stage*:* The system has a limited number *c* of elements. Of these, w elements cannot be stimulated for a number of reasons, e.g. because they are already stimulated. Thus, *(c - w)* is the number of elements which can be stimulated. *d* reflects the capacity of the system to absorb stimulae. The lower the number *w*, the more stimuli can be absorbed for each element. If *w* = 0, then *d* = 1. If, on the other hand, *w* = *c*, then *d* = 0. The graph decreases linearly.

[6] $$d = \frac{c - w}{c} = 1 - \frac{w}{c}$$

3rd stage: The system (under consideration of the stated capacity) adopts the stimulus and changes its state. The diffusion of the stimulus into the quantity of elements of the limited system is performed. The quantity of interested elements is now limited. Thus, the diffusion of the demand is also limited. The positive exponential development is braked by a negative exponential counter trend. This can be done in two ways. Either the development is limited by the inferior component, i.e. a negative exponential term $M_n = M_{n-1}/a$ hampers the increase with each step (a constant):

[7a] $$N_n = N_{n-1} + O_n;\ O_n = O_{n-1} * M_n;\ M_n = \frac{M_{n-1}}{a} \text{ adopters}$$

Or the development is limited by the capacity of the system as a whole; the "Logistic function" is applied (see fig. 42). Then the size of the system is assumed to be known. The constant K defines the quantity of the potential adopters (a constant):

[7b] $$N_n = N_{n-1} + N_{n-1} * \frac{K - N_{n-1}}{a} \text{ adopters}$$

In both cases, the graph is S-shaped.

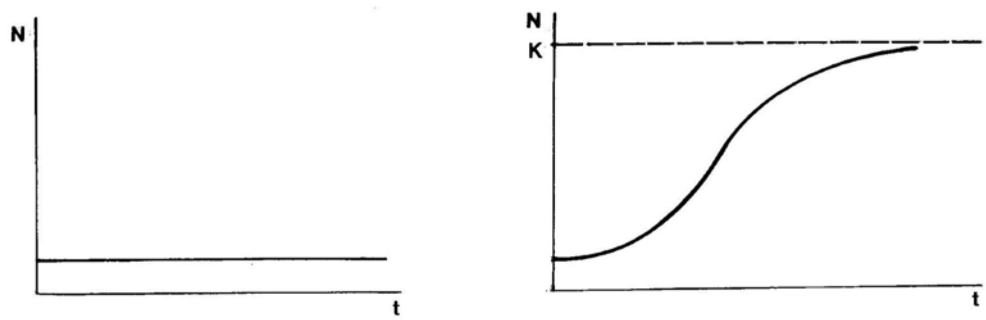


Fig. 42: Conserving and changing process in the flow equilibrium system.
In the conserving process (left) the amount of production or the number of elements N remains constant over the course of time, whereas if a change takes place (right, "logistic curve"), the value of N has an S-shaped curve, i.e. leads upwards from the first state until it has reached a second state at value K. The diffusion of an innovation is a changing process.

4th stage: The "new" elements (i.e. the adopted quantity of information, measured in element equivalents), now have to be opposed to the "old" elements. Both appear with equal frequency. We will arrange these in a sequence of numbers and place them to two scales (see fig. 43 a). When we push these past one another, the numbers meet one another in pairs. Every meeting means that a new element stimulates an old element. For reasons of simplicity, we will take six representatives of each of the groups and move them past one another in steps, first one each, then two each etc. until all six members of each group are arranged opposite one another. Then the system is stimulated. If we continue to push the scale, the number of encounters decreases accordingly. We can convert this combination into a probability function (see fig. 43 b). So two sequences are joined together in the same way as a game with two standard dices. With each cast, a pair of numbers results: (1,1), (1,2), ... (z,z). The sum x_i can be at least the number 2 and at most the number $z+z$ (with standard dices, 12 spots). The result is that the random variables X_1, X_2 ... are arranged symmetrically to a centre $x = m$ (average or anticipated value, for ideal dices 7 points), the points located symmetrically to this value ($m + k$, $m - k$) have the same probability P, thus

$$P(X = m + k) = P(X = m - k) \text{ for } k = 0, 1 \ldots m - 2.$$

This results in the probability function:

[8] $$f(x) = P(X = x) = \frac{x_z - |x_z + 1 - x|}{x_z^{\,2}}$$

(x = the sum of the elements or points; $f(x)$ = probability)

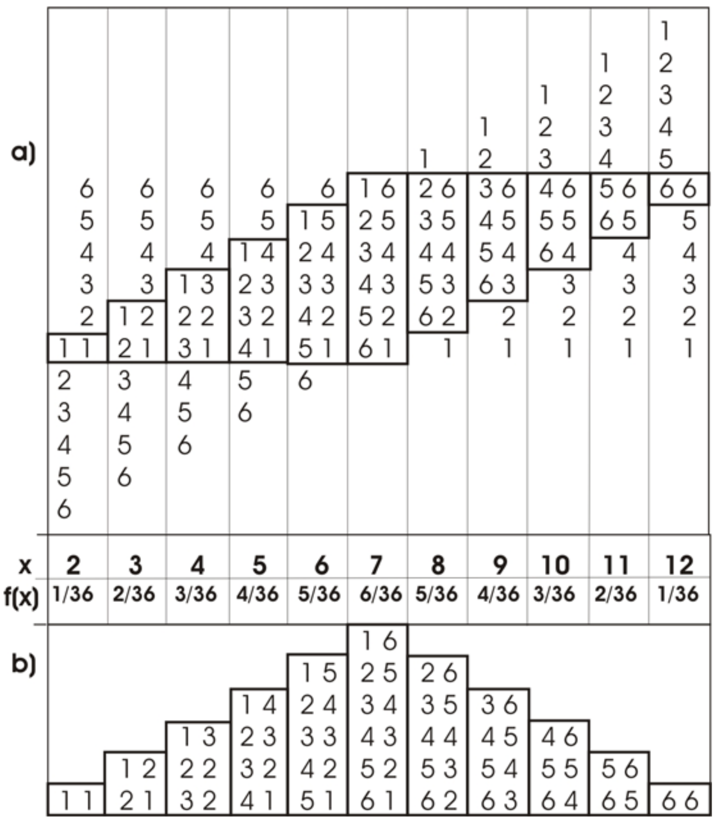


Fig. 43: Illustration of the probability function at the second bonding level (formula 8).
a) Sum of encounters between stimulating ("new") elements and elements to be stimulated ("old") in a limited system ("framed" sequences of numbers).

b) Sum of the points of two ideal dices. Elementary events. The lefthand number in each case indicates the sum of the stimulating elements or of the first dice, and the right-hand number the sum of the elements to be stimulated or of the second dice.

3rd bonding level:

The elements (or parts of the element horizon) are dependent on the stimulation by the system horizon. But they themselves also strive actively to obtain a place in the flow of information. Thus, the demands of the system (as system horizon, see section 2.3.1.1) are opposed to those of the elements.

1st stage: The stimulus is put to the elements, which, in their turn, desire the stimulus to assure their own existence. The stimulus is represented by the system horizon and the elements requiring the stimulus are represented by the element horizon. The elements with their own dynamics also come to the fore.

Thus, the grouping of the 2nd bonding level is again sub-divided. Information flows in both directions. The factory as an example: The system horizon offers potential work (supplied demand, characteristic *A*), divided into *i* categories (*i* = 1, ..., *m*). The elements ask for a certain amount of work (demanded demand, characteristic *B*), divided into *j* categories (*j* = 1, ..., *n*). The degree of correspondence between work demanded and work supplied is required. Here a symmetric bivariate investigation (according to the information theory) is needed, because the objects are measured on 2 scales. The frequency distribution may be shown in a cross table, where the lines represent characteristic *A* (categories *i*), and the columns characteristic *B* (categories *j*). We call the probabilities of the product tables p_{ij}. We then obtain the following marginal distributions:

$$p_i = \sum_{j=1}^{j=n} p_{ij} \quad \text{resp.} \quad p_j = \sum_{i=1}^{i=m} p_{ij}$$

Then the demanded (neg)entropy has the information content (SCHWARZ 1981, pp. 43.):

[9a]

$$I = \sum_{i=1}^{i=m} \sum_{j=1}^{j=n} p_{ij} * ld \frac{1}{p_{ij}} \quad bits$$

From this is derived the transinformation which reflects the degree of connection between characteristics *A* and *B.* We must take "noise" into account, because a certain part of the information transmitted is usually lost. When the equivocation is subtracted from this sum, one obtains the strength of the stimulus finally transferred, i.e. the transinformation

[9b]

$$T(A,B) = \sum_{i=1}^{i=m} \sum_{j=1}^{j=n} p_{ij} * ld(\frac{p_{ij}}{p_i * p_j}) bits$$

2nd stage: We must distinguish between 2 different levels: the level of the system as a whole (the system horizon) and the level of the elements (element horizon). Both the (demand supplying) system as a whole on the one hand, and the (demand demanding) single elements on the other hand become stimulated. The system as a whole reacts in the same way as in the 2nd bonding level. The totality of all elements is *c, w* elements cannot be stimulated. Thus, in the system, *c - w* elements can be stimulated. If we assume that the system consists of *c* = 10 und *w* = 0 elements, the initial value is *d* = 1. At the 1st step (*w* = 1) we subtract 1/10 from 10/10, so that 9/10 remain. This yields *d = 1 - w/c*. This is the 1st term. Now, we must also consider that each element, i.e. 1/10 of the system, can be stimulated further in the same way as the system as a whole. Thus, 1/10 of 9/10 must be added, i.e. (9/10)*(1/10). As the 2nd term, *(1-w/c)*(w/c)* must be added. Thus, the amount of stimulation per element is

[10]

$$d = 1 - \frac{w^2}{c^2}$$

(*w* = not to be stimulated, *c* = all).

3rd stage: The growth of demand is received by the elements which require it for their own existence, and then it is removed to be transmitted to the inferior environment. Thus, the system-internal increase of the positive exponential development is not only slowed down negative exponentially (by the term M_{n-1}/a, as at the 2nd stage), but additionally reduced by a term N_{n-1}/b. The result is a hill shaped graph (*n* is the x-variable):

[11]

$$N_n = N_{n-1} + O_n - \frac{N_{n-1}}{b}; O_n = O_{n-1} * M_n; M_n = \frac{M_{n-1}}{a} \quad \textit{adopters}$$

(*a* and *b* are constants).

4th stage: The system horizon is opposed to the elements. Thus there is an attempt to achieve an internal flow equilibrium between the stimulation which is supplied from the system as a new whole, and the stimulation which is demanded from the elements. The well-known “binomial distribution” is applied. It describes an internal equilibrium between the work which is supplied from the system horizon, and the work which is demanded from the elements. The aim is the greatest collective profit. There are fluctuations in detail, but around a constant average value (expected value).

The probability that a demanded element appears as part of the system horizon (event *E*) is taken as *p*. The probability that a demanding working person appears from the group of elements is taken as 1-*p.* For *x* stimulating elements and *n*-*x* elements to be stimulated, the result is

$$\binom{n}{x} = \frac{n!}{x!(n-x)!}$$

different permutations. Thus, the required probability function is

[12] $$f(x) = P(X = x) = \binom{n}{x} * p^x * (1-p)^{n-x}$$

(x = 0, 1....n).

4th bonding level

The system makes contact with the inferior environment, in order to receive energy according to the stimulation. The whole system is now integrated in the flow of information.

1st stage: The demand, i.e. the information is passed from the system to the inferior environment. According to the information theory, we may regard the system as a transmitter

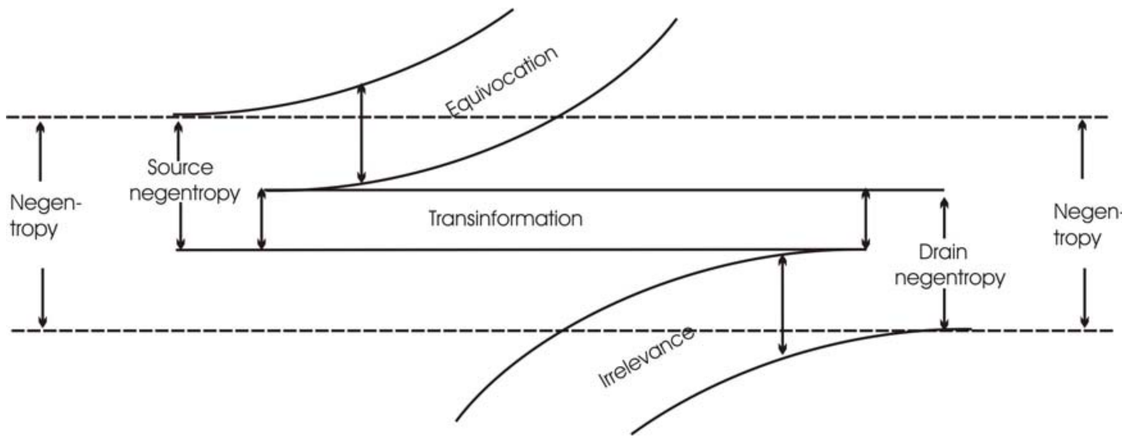


Fig. 44: Channel model in which various terms of information theory (fourth bonding level) are explained.
After Berger. Source: See "Notes on figures".

or source (characteristic *A*) of the stimulus (or demand for energy), and the inferior environment as receiver or drain of the stimulus (characteristic *B*). To each of the 2 characteristics *A* and *B* are assigned categories (i = 1, ..., m; j = 1, ..., n). The transmitted information will be received with a certain probability. So here the source (neg)entropy I_S is confronted by the drain (neg)entropy I_D. These can be represented in a table as lines and columns (= asymmetric channel as per information theory; see fig. 44; SCHWARZ 1981, pp. 58). It is necessary to take account of "noise" in the transmission process. A certain part of the transmitted information does not pass from the source to the drain (equivocation). On the other hand, information which has not been transmitted may arrive at the drain from outside (irrelevance). The negentropy consists of the source (neg)entropy and the irrelevance, or of the drain (neg)entropy and the equivocation. The information content is expressed in the following formula:

[13] $$I_v = \sum_i \sum_j p_{ij} * ld \frac{1}{p_{ij}} \quad \textit{bits}$$

(Indices for the source (neg)entropy *i* = 1...*m*, for the drain (neg)entropy *j* = 1...*n*; probability of the product categories p_{ij}).

From this, the transinformation which reflects the extent of the connection between characteristics *A* and *B* can be derived. The equivocation has to be deducted from the source entropy and the irrelevance from the drain entropy (see fig. 44).

2nd stage: The system *A* and the inferior environment *B* influence one-another in their development. The value of *c* again indicates the average number of all elements. We return to the 3rd bonding level (see formula no.10). Whereas in that case the value of the stimulus increases both with part A (system as a whole) as well as with part B (elements), in this case it is different. What part A (the system) gives, is taken by part B (the inferior environment) and vice versa (see formula no. 14 below).

Both system *A* and inferior environment *B*, relate to one another. So, in contrast to the 3rd bonding level, a mean value is sought here. We have to take the geometrical mean:

[14] $$d = \pm\sqrt{1 - \frac{w^2}{c^2}}$$

[The formula is reminiscent of the so-called Lorentz Contraction which is used for calculating the transformation of the coordinates and time from one uniformly moved inertial system to another (assuming that the speed of light c is constant) (EINSTEIN 1905/1974, pp. 32).]

3rd stage: Each element of the system must obtain raw material etc. from the elements of the inferior environment. Thus, two systems oppose one another, system *A* and system *B*. The demand from system *A* is passed to the inferior environment (system *B*). This stimulus is adopted. The demanded energy itself is supplied afterwards (in the non-equilibrium system at the "production" stage, see section 2.4.1.2). System *A* and system *B* are interacting with one another. The elements *N* constitute the demanding (demand transmitting) system *A*, and the elements *M* the demand receiving (and afterwards energy supplying) systems *B* of the inferior environment. Because the providing of the reply (and afterwards

[15]

$$N_n = N_{n-1} + \frac{N_{n-1} * M_{n-1}}{a} - \frac{N_{n-1}}{b} \qquad \textit{adopters A}$$

$$M_n = M_{n-1} - \frac{N_n * M_{n-1}}{c} + \frac{M_{n-1}}{d} \qquad \textit{adopters B}$$

(*n* = temporal steps, i.e. the *x*-variable; *a, b, c, d* constants).

the demanded energy) by the inferior environment needs time, transmitting and receiving are delayed (see section 2.3.1.1). Oscillations are created which may be described by the Lotka-Volterra relations (predator-prey relations; LOTKA 1925/56, p. 88. See fig. 45).

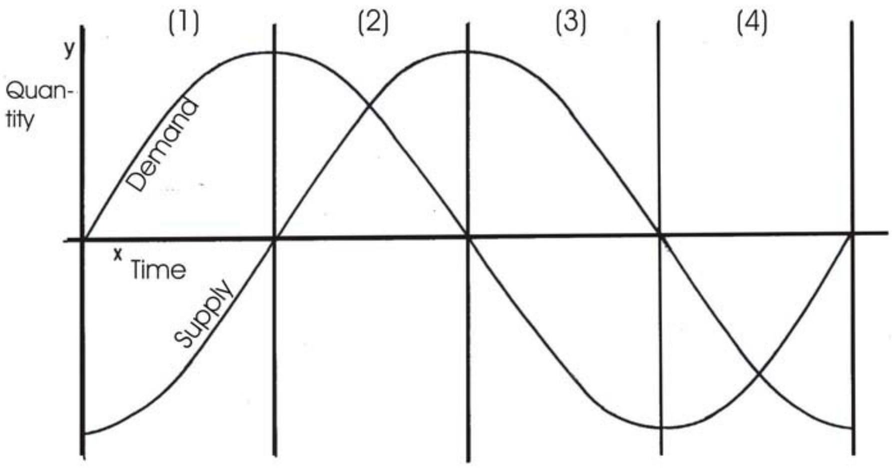


Fig. 45: *Oscillation of a flow-equilibrium system*.
The demanders and suppliers (e.g. in a market) stimulate each other mutually. The first group demands energy, the second group supplies the energy. As the supplying group requires time to make the energy available, a delay occurs which leads to oscillations (around a central value, oscillation axis).

These oscillations give the processes in the system their continuity and their rhythm, the flow-equilibrium systems regulate themselves by attempting to keep demand and supply in a flow equilibrium with the help of feedback mechanisms.

Through these oscillations, the inferior environment is stimulated, activated as an external energy source, and coupled to the system. It supplies the energy. The flow of energy takes place in an upward direction, from the bottom to the top. As already stated (see section 2.3.1.1), the process passes through the bonding levels in the opposite sequence. At the transition point from the first bonding level to the superior (demanding) environment, the feedback takes place through comparison of the supply with the demand. Through its ability to regulate itself, the system demonstrates independence with reference to the externally guided equilibrium system and in particular with reference to the solidum (see sections 2.1.1, and 2.2.1).

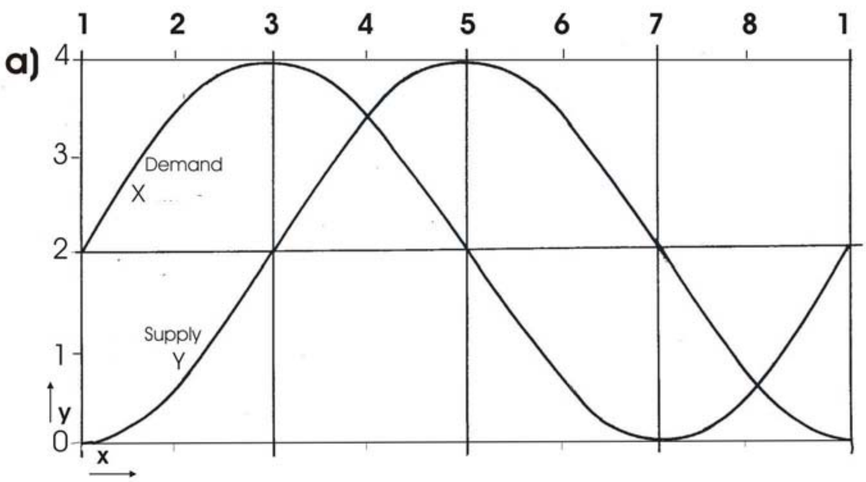
4th stage: The elements of the system *A* and those of the inferior environment *B* appear with a certain degree of probability. The question now to be answered is that of the discrete two-dimensional distribution (variables *X*, *Y*). In the sense intended by the theory of probability, *A* and *B* are independent of one another. This describes the multinomial distribution (FISZ 1976, pp. 195). In a sequence of *n* single contacts, the elements of the system appear exactly *x* times (event *A*, random variable *X*) on the one hand, and the elements of the inferior environment exactly *y* times (event *B*, random variable *Y*) on the other hand. The corresponding probabilities are $p_x + p_y$, if we assume $p_x + p_y + p_{n-x-y} = 1$. From *x, y* and *n-x-y* elements there are

$$\frac{n!}{x!\,y!(n-x-y)!}$$

permutations. So the probability function is

[16]
$$f(x,y) = P(X = x; Y = y) = \frac{n!}{x!\,y!(n-x-y)!} * p_x^{\,x} * p_y^{\,y} * (1 - p_x - p_y)^{n-x-y}$$

As a result, we obtain a circular movement in connection with the oscillations (see fig. 46).



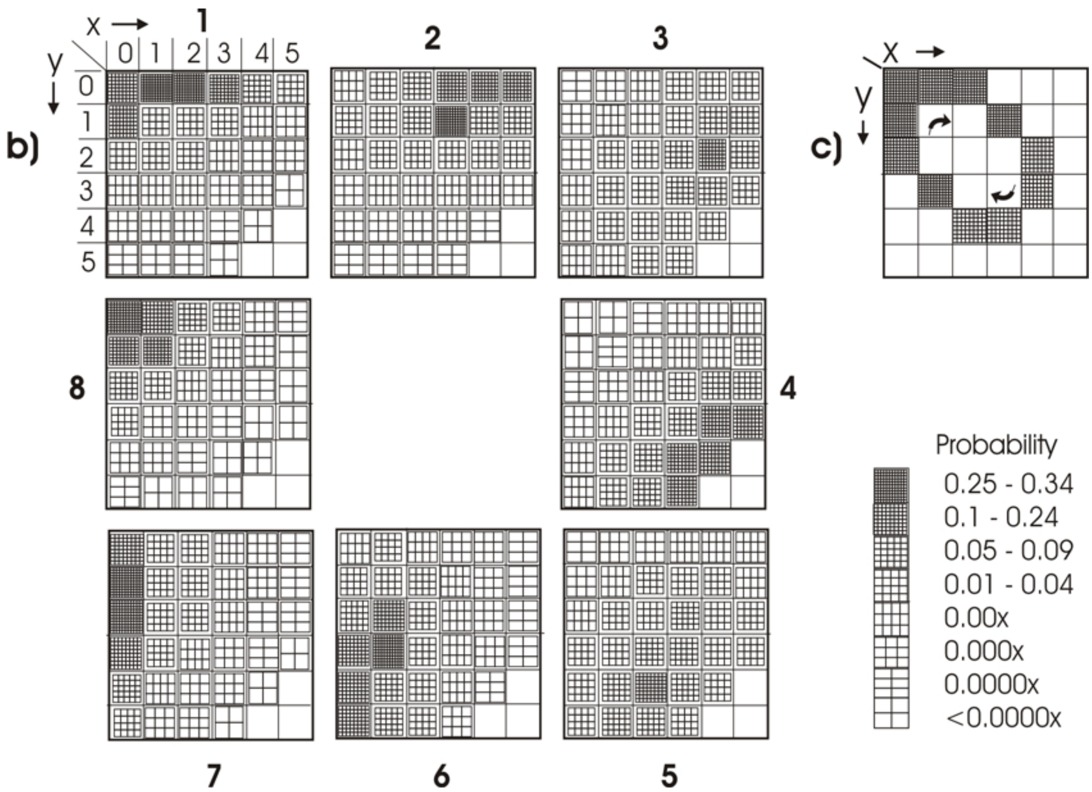


Fig. 46: Combination Lotka-Volterra-equations and multinomial distribution.
a) The course of the oscillation process according to the interaction between demand und supply (Lotka-Volterra-relations; see fig. 45). 8 cross sections are laid where demand and supply have a special relationship to one annother. b) Probabilities according to multinomial distribution.
c) The maxima of the 8 distributions are transferred to a separate grid.

The course of the process:

As has been shown (see section 2.3.1.1), energy is demanded by the superior environment and supplied by the inferior environment. The inferior environment, for its part, also demands energy and is supplied by its own inferior environment. In this way, the flow of information (demand) from the top downwards and energy (supply) from the bottom upwards, are conducted through several hierarchic levels. The condition is that the oscillations which make these flows possible, have phases of the same length.

With reference to the continuation of the process, it is remarkable that it is by no means certain that the energy can be supplied in the desired form and quantity by the inferior environment. This cannot guarantee the possibility of "latching into" the flow of information and energy. Thus, when we say that at this level of complexity the inferior environment is involved as a supplier of energy, it is not securely coupled to the contact hinge (fourth bonding level). Otherwise it would mean that the quantity of energy supplied is predictable in the deterministic sense. Instead, the bond is based on the mutual interest above and below the hinge, because only this bond assures the survival of the participants (i.e. the elements). The feedback provides information as to whether the inferior environment has supplied sufficient energy. The result forms the basis for the level of demand in the next round (see section 2.3.1.1).

The vertical flow of information and energy from bonding level to bonding level is the first-rank process, and the involvement of the elements at the bonding levels takes place through the processes of the second rank.

The linking of the above described formulae or stages takes place through change quotients which pass the change on to the following stage. At the end of each process at the bonding level, the

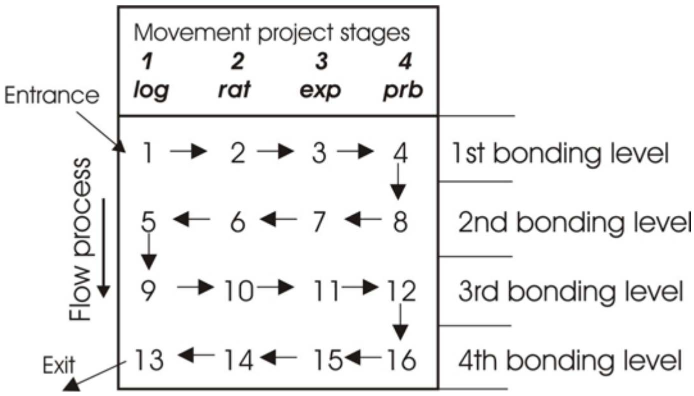


Fig. 47: The *course of the information flow in the flow process, i.e. the formula sequence in succession.*
The figures representing the individual stages are the numbers of the formulae (see above). Abbreviations: log = logarithmic, rat = rational, exp = exponential, prb = probabilistic.

stimulus (information flow) is passed on to the following process in the next deeper bonding level. At the individual bonding levels, it is possible to join the stages at the beginning or end. The fourth bonding level forms the hinge between the demanding and supplying system (the involved inferior environment). From here, the process leads up to the first bonding level. The flow of energy proceeds in the opposite direction from the elements to the system, i.e. from the fourth to the first bonding level.

For guidance:

The flow equilibrium systems are thematically defined, i.e. they have a certain task in superior (i.e. economic or ecological) system structures. The systems are composed of similar elements and define departments or topes (e.g. ecotopes) and compartments. They may be, for example, a number of cotton mills. These exist in the vertical flow of information and energy. The flow of information (=demand) comes from the superior environment (market) crosses the system (the quantity of factories), thereby reaching the inferior environment. From here (e.g. the suppliers) energy is acquired and transported upwards to the demanding superior environment (=supply).

In the ecosystem, this corresponds to the predator-prey relationship. Predator and prey interact with one another. Oscillations occur. In social systems the supply follows the demand by about one quarter phase. A number of systems may succeed one another, thereby forming chains. Since both the system as a whole and its elements depend on one another, a flow equilibrium takes place between the two as between superior and inferior environments. The system regulates itself by means of feedback.

Internally, the system as a whole is divided into system and element horizons, which in turn are also divided into two, thereby producing 4 bonding levels. This internal division is controlled from inside (first process train) whereas the oscillations are controlled from outside (second process train). The demand and the innovations are passed on horizontally (e.g. through neighbourhood contact) by diffusion and rotation.

The processes can be described by mathematical formulae which are arranged according to the four bonding levels and reflect the flow of information and energy.

2.3.2. Other examples

2.3.2.0. Instead of an introduction: Flow process as seen by artists

A process is shown here – something which is very difficult for a painter to portray and therefore very seldom attempted. "Equipo crónica" has given us a sequence of paintings showing the stages in the assembly of a crowd (see fig. 48).

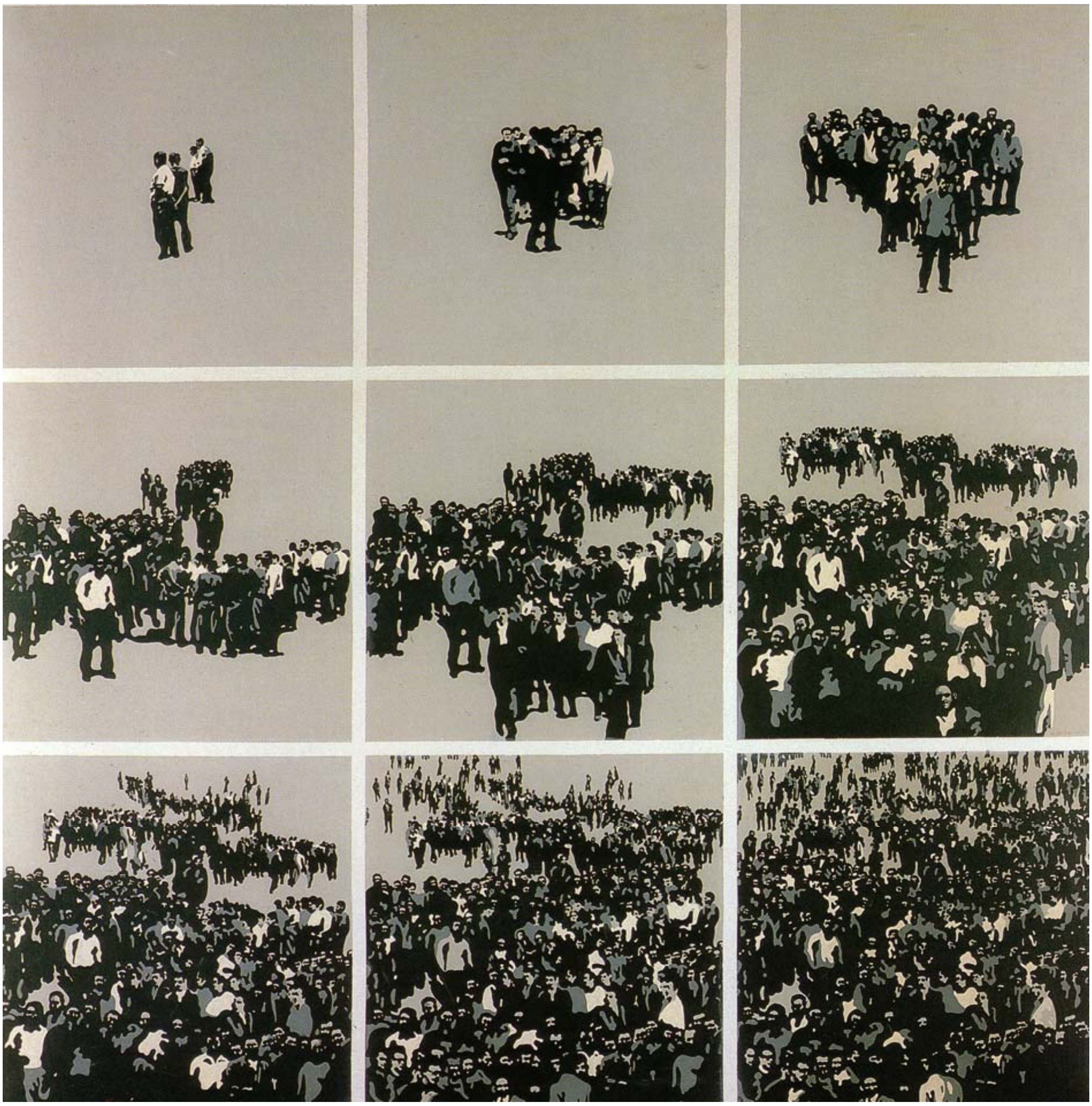


Fig. 48: Equipo crónica: Concentration, or quantity becomes quality.
An example of an exponentially growing process. Source: See "Notes on the figures".

The title "Concentration, or quantity becomes quality" should be taken in a political context. The two artists (originally 3) joined together to form the "Equipo crónica" in 1964 in order to resist the Franco dictatorship whose suppression of human rights and obstruction of progress was at its height in 1966 when the picture was painted (POP ART 1991, p. 274/275). Its message was that only by mass demonstration is it possible to defend oneself against tyranny and dictatorship. The assembly takes on the quality of a signal of the will of the people, and even of insurrection.

Seen formally, what we see is the exponential growth of a process in a flow-equilibrium system which takes its meaning and power from the dissatisfaction of the people with the prevailing political conditions. This message is the information. The anger of the people releases the energy which sets the process in motion.

2.3.2.1. Vertical information and energy flow

The study of flow equilibrium systems depends on the possibilities available and these are dependent on the constitution of the system. One frequently has to deal with complex systems consisting of different types of compartments. In such cases, these compartments must be analysed as component parts of the entire system. In complicated ecological, social and economic systems, some compartments can be identified. They occupy certain positions in the flow of energy (e.g. biotic producers or consumers in ecosystems, institutions in social systems, economic branches). Here, input-output studies (among other things) would seem to be the obvious way to proceed.

If however the individual compartments can be isolated, many of the processes within the system can be studied, in particular when the individual elements are identifiable and can be counted (e.g. persons in their roles, companies in the compartments as described above). This includes the study of the behaviour of the elements, the mechanisms of their cooperation. Feedback and oscillations are important objects of research.

The cultivation of a field:

Let us now look at the cultivation of a field. Seen structurally, a field is a small compartment (see section 2.3.1.1), but it can only be analysed in combination with other subordinated compartments. They each occupy their own place in the flow of energy. Spatially a field is a piece of landscape which is delimited and unified in its ecological structure and which cannot be subdivided further within the scale concerned. These spatial units are called "topes". The term "tope" originates in the field of ecology (LESER 1976, p. 212; SCHMITHÜSEN 1976, p. 207 called them "Fliesen", tiles; see also ecotopes, section 2.2.2.1, fig. 17).

Small and large compartments are flow equilibrium systems whose input-output ratio and other characteristics can be studied. Through their own feedback systems, the processes are non-linear, i.e. the output is linked to the input in a non-linear and frequently unpredictable way.

The fields are delimited on the land mostly in such a way that they have natural homogeneous characteristics (e.g. sand content, moisture, slope of terrain etc.). The farmer tills the soil to make it produce crops which are then harvested. The soil is an ecosystem which consists of billions of living organisms and a multitude of compartments. The farmer must cause it to produce the desired crop in accordance with the demand and the labour at his disposal. He is primarily interested in the ratio of input to output.

First of all it is ensured that the requirement of the farm as the superior environment is input into the field. This includes the working of the soil (fertilising, ploughing, harrowing etc.) and of course the sowing of seed. For the ecosystem of the soil, this is the information to supply a certain crop. At the same time, the inferior environment of the ecosystem is supported as energy supplier through fertilisation.

The ecosystem of the soil of the field responds to the information by providing nutrients to allow the seed to flourish. The growth of the crop in the cultivated field is accompanied by other activities such as the removal of weeds or pests. The crop is harvested i.e. removed from the field by harvesting machinery and taken over by the farm system and stored there until they can be supplied to the market. This is the flow of energy. The energy, i.e. the crop comes from the ecosystem (and its inferior environment). Due to the fact that the flow of information into the system is increasingly accurate (i.e. improved methods of working the soil), the flow of energy becomes more abundant. [For the problem of overcropping, see section 2.6.1.2: "Rotation"].

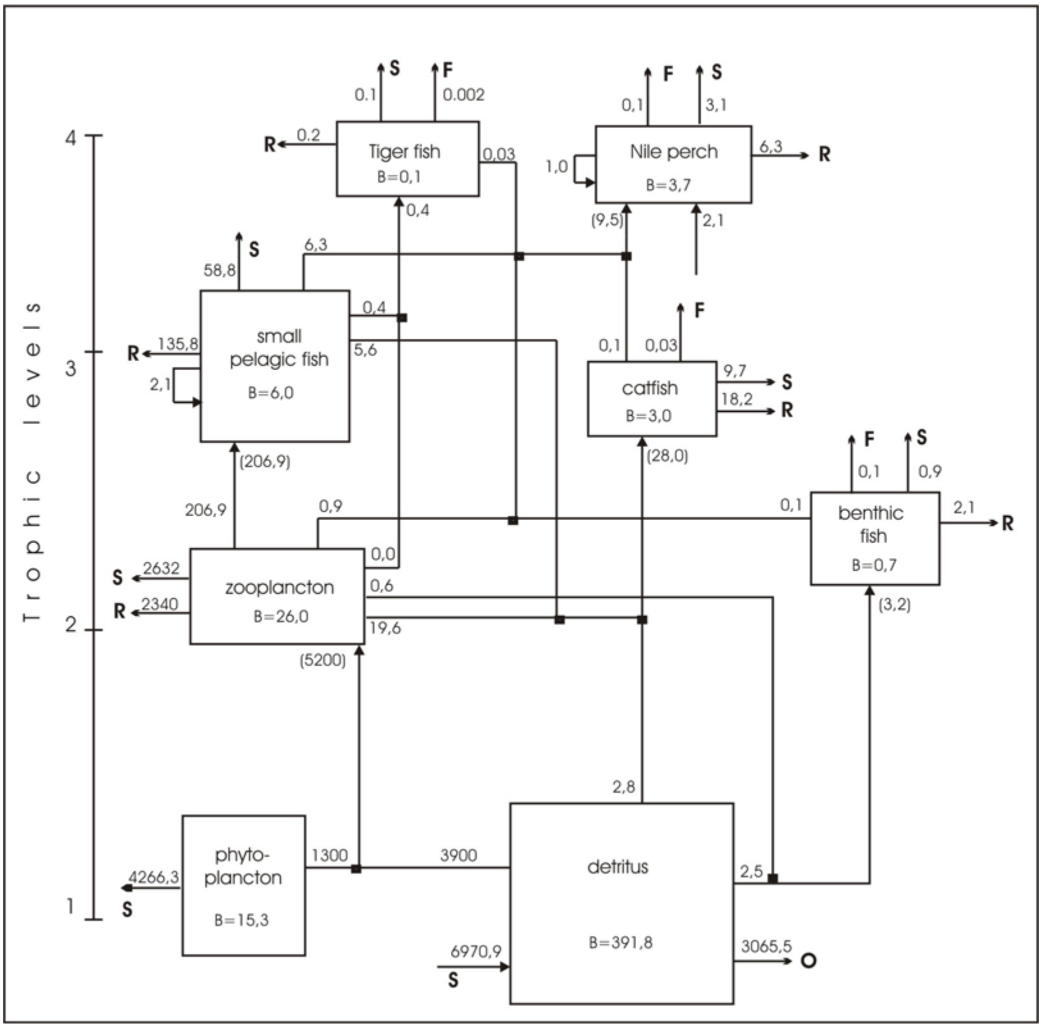


Fig. 49: Flow diagram of Lake Turkana in Kenya.

Example representation of an ecological flow equilibrium system. Each of the 8 trophic subsystems listed here (compartments represented by boxes) shows inputs (nutrients, represented by arrows) and losses through fishing (F), respiration (R), sedimentation as detritus (S) and other outputs (0).B = biomass.

Subsystems: catfish, Nile perch, tiger fish, small pelagic fish, zooplancton, phytoplancton, benthic fish, detritus.

Source: See „Notes on the figures“.

A complex ecosystem:

As already noted, every flow equilibrium system depends on the supply of information and energy, otherwise it will disintegrate. Both have to be supplied by other systems. This opens up the way to understanding the food and production chains as they are studied in ecosystem research and economic sciences.

In research into ecosystems, the complexes are divided into as many quantifiable compartments (as partial or sub-systems) and other components as possible, e.g. in aquatic systems into the different types of flora and fauna (but also temperature, chemical composition, suspended material etc. are measured), in order to understand how they are co-ordinated and linked together. Terrestrial ecosystems are studied in a similar way. The flow of energy is seen primarily in the food chains and takes place between communities of the same species which occupy their ecological "niches", but also between the living creatures and the inorganic environment. The plants withdraw nutrients from the soil or the water and they themselves form nourishment for animals. Consequently, we may use the term "producer" (plants, suppliers) and "consumer" (animals, demanders) in this context also. Certain autotrophic plants provide the nourishment on which certain herbivore species depend, while these species may themselves be eaten by others (carnivores). The important thing is to realise that the ecosystems are not only flow equilibrium systems. Ecosystems also contain conversion, production and self reproduction. In this way they also belong to a higher level of complexity (see section 2.6.2.1, fig. 123).

The calculation of the flow of energy in an aquatic system is used as an example of a study of an ecosystem (see fig. 49; BEGON, HARPER, TOWNSEND 1996/98, p. 513). Lake Turkana in Kenya is fished. In order to determine the ratio between the annual fishing quota and the nutrient base, the various subsystems of the system were taken together and their significance for the balance of energy studied by means of a flow-equilibrium model. The fishing quota, the food chains and their links as well as the detritus production were then isolated in order to describe the flow of energy or biomass.

In this way it was possible to balance the input into and losses from the compartments. With the help of studies of this kind it is possible to determine with a fair degree of certainty whether fishing rates are sustainable or stocks are being over exploited.

A complex economic system, the Forrester feedback model:

Economic systems can be analysed in basically the same way, e.g. the development of towns. A number of variables (inhabitants, birth rate, migrations, occupation, unemployment, industrial production, tax yield, dwelling construction, slum development etc.) were combined as compartments and other components by FORRESTER (1969; 1968/72) to form a model with which development can be simulated. The feedback mechanism is decisive for understanding the processes in the system (see fig. 50). The present and future behaviour of the system is affected by its own past. The feedback loops use the results of previous actions as information to regulate future actions. This information may be wrong, but it is still decisive for future behaviour. We should distinguish between positive and negative feedback loops. With the positive feedback loop, the process is continued positive-exponentially. Developments can get out of control quickly. With the negative feedback loop, the process is continued negative-exponentially with the result that it comes to a standstill after some time (see formulae 7 and 17, sections 2.3.1.2, and 2.4.1.2).

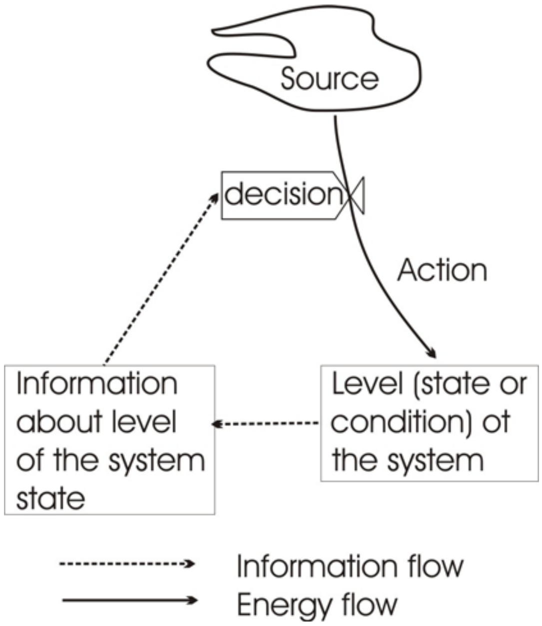


Fig. 50: The scheme of a feedback-loop.
According to Forrester. The process ("action") requires time. The stimulus (demand) is introduced with the "decision". The result (supply) is supplied later to the superior environment. It is here that the feedback begins. If the level ("state or condition of the system") does not correspond to expectation, this information is passed to the "decision" valve. The correction then takes place and is introduced as stimulus for the subsequent process run.
Source: See „Notes on the figures“.

The availability of resources also affects the feedback loop. In addition, constants are involved which mark the objectives and the process of time. In creating the model, different feedback loops generally have to be linked to one another. At the same time, it has to be clear how the internal hierarchies are made up. The system changes step by step and the changes are accumulated.

This model has also been used to simulate mankind as a whole and was used by the "Club of Rome" (MEADOWS, MEADOWS, ZAHN and MILLING) 1972 as the basis for its assessment of the state of humanity on the earth with reference to the resources available (see also section 2.6.2.3). Among the parameters used were the population, mining, industrial and agricultural production, service industries, the quantity of known mineral resources, environmental conditions etc. A partial system is shown in fig. 51. The model has been improved in subsequent years (e.g. by VESTER and HESLER 1980; MEADOWS, MEADOWS and RANDERS 1992).

Complex social systems:

Because of their many different forms, social systems are particularly difficult to analyse. A number of qualitative theories have been developed by the social sciences dealing with the complex structure of society on the basis of the system theory. LUHMANN (1984; 1998) in particular developed an elaborate theory which has had considerable influence on the theoretical sociological discussion. For him it is especially the problem of differentiation of the social system, i.e. its formation in its environment, which is decisive.

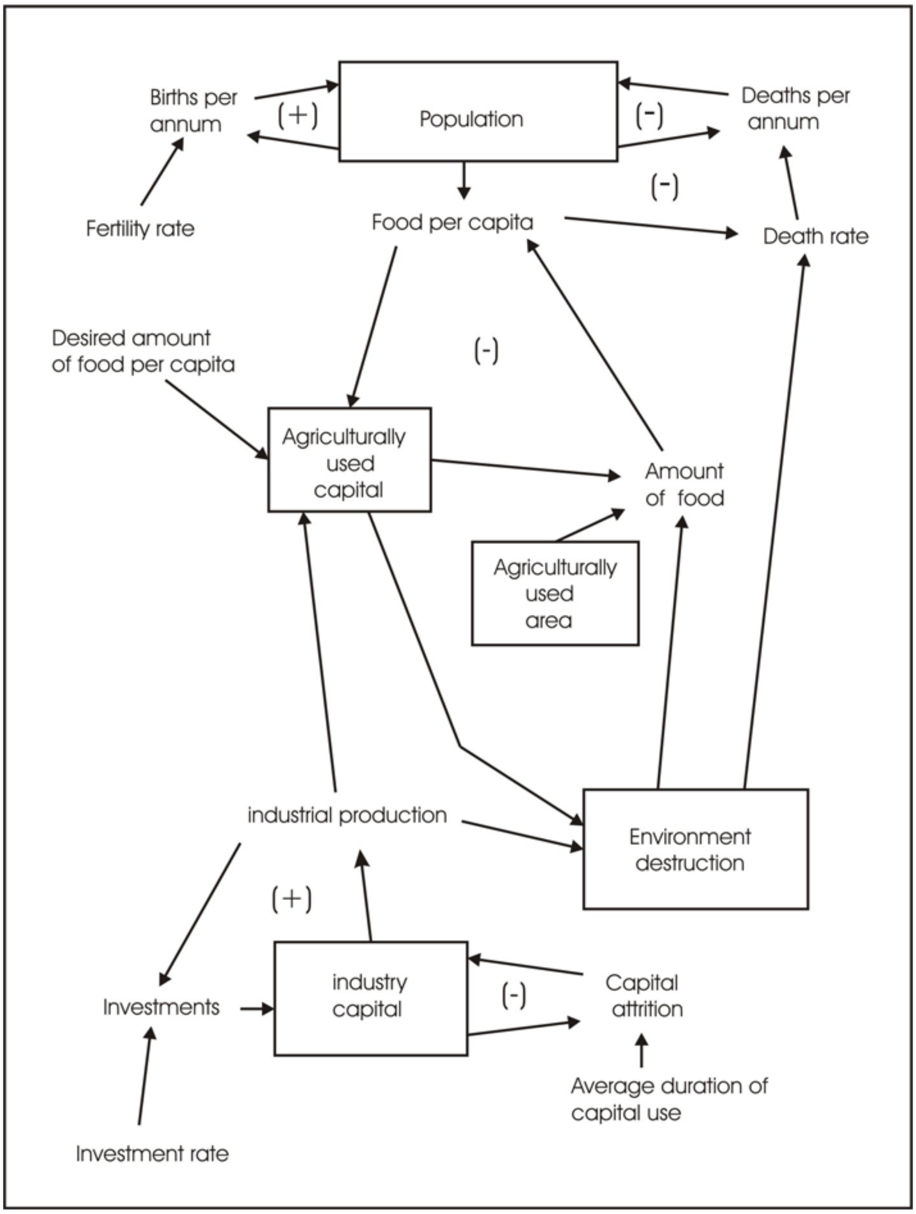


Fig. 51: Interaction of the compartments population, capital, agriculture and environmental pollution.
Example representation of an economic flow equilibrium system. From the Global Model of the Club of Rome (according to Forrester's model). (+) and (-) indicate positive and negative feedback loops.

Source: See "Notes on the figures".

In general, it can be said that LUHMANN illuminates already familiar terms and other terms used by other authors in the social sciences from a number of angles and arranges them in such a way that they can be combined with one another without contradiction. The selection is made by himself. Some of the terms are taken from the natural sciences and interpreted in his sense. This means that the theory can only be checked to verify its intrinsic accuracy. Frequently, the terms are not defined in the way originally intended by the issue in point. Thus the term "autopoiesis" is not defined in its genuine scientific sense (MATURANA & VARELA 1984/87; see section 2.6.0.1), and the expression "self-organisation" also appears rather vague. No clear distinction is made between flow-equilibrium and non-equilibrium systems and it is therefore not apparent how the systems are structured. For this reason, LUHMANN's ideas do not represent a true stimulus to the natural sciences, as they are much too vague for these disciplines (see also section 2.4.2.1).

Oscillations:

The delayed reaction of the supplying inferior environment to the demand from the superior environment creates fluctuations which can develop into periodic oscillations. The fluctuations in the work of farmers in the day-to-day and seasonal rhythm may be interpreted as the oscillations of a self-regulating system where the rhythms dictated by nature provide the general cadence. Demanders and suppliers can also stimulate one another in other ways so that oscillations of a lasting nature may commence and take on a certain rhythm. This capacity for rhythm applies to almost all flow-equilibrium systems, wherever certain goods are demanded by the superior environment and supplied by the inferior environment. The duration of the period may be days, months, years or decades (see sections 2.5.1.1, and 2.5.2.2). Many economic cycles can be interpreted as oscillations of this kind.

Predator-prey relation:

The predator-prey relationships are often quoted to demonstrate how the ecosystem tries to achieve a flow equilibrium between supply and demand. One example of such a relationship is that between the spider mite Eotetranychus as prey and the predatory mite Typhlodromus (see fig. 52). The growth of the prey (supply) gives rise to the growth of the predator (demand). In this case the order is different to that in economic systems where the supply normally follows the demand. The reason for this may be that it is not only the production of the systems which is affected but the very existence of the systems.

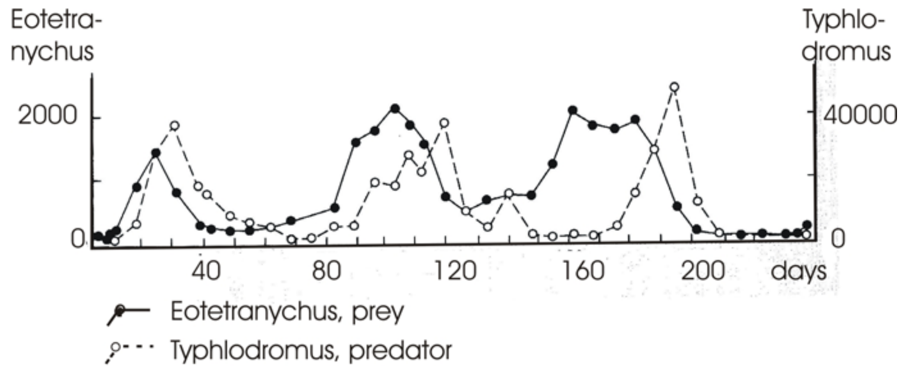


Fig. 52: Predator-prey relationship between the spider mite Eotetranychus and the predatory mite Typhlodromus.
Oscillations testify to a striving for flow equilibrium between two populations. Source: See "Notes on the figures".

Physics in particular has an infinitely wide spectrum of examples of oscillations and waves which are not discussed in detail here. The most important point is that energy is passes from one medium to another without any one medium being extinguished.

Let us return to the social and economic systems:

Business cycles:

Economic development is characterised by periodic rise and fall. Fluctuations can be seen which cover several years (see section 2.5.1.1 and fig. 53). These fluctuations are explained by the constantly changing relation of supply to demand.

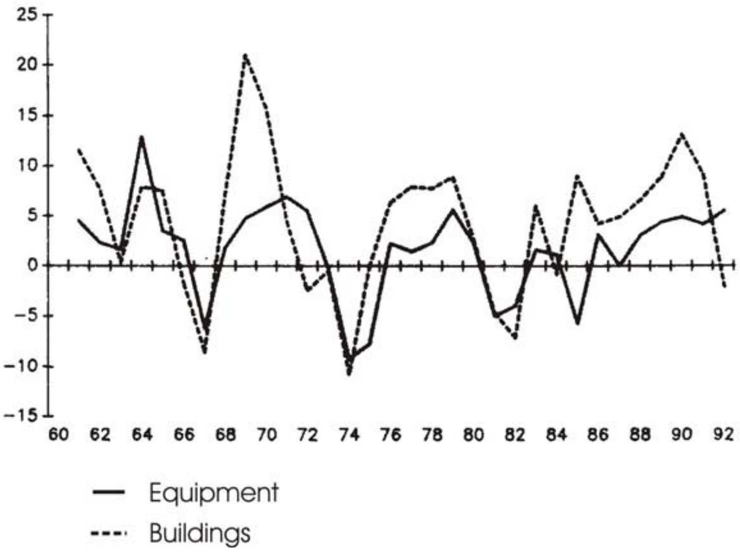


Fig. 53: Example of a business cycle.
Several year cycle (see section 2.5.1.1). Investments in the Federal Republic of Germany (machinery and buildings). Change in relation to previous year in percent.
According to Tichy. Source: See "Notes on the figures".

However, the Kondratief cycle, which lasts about 50 years (see fig. 54), is particularly striking. According to Schumpeter, the economy is stimulated by innovations which manifest themselves in new consumer goods, new forms of organisation, products and transport as well as the

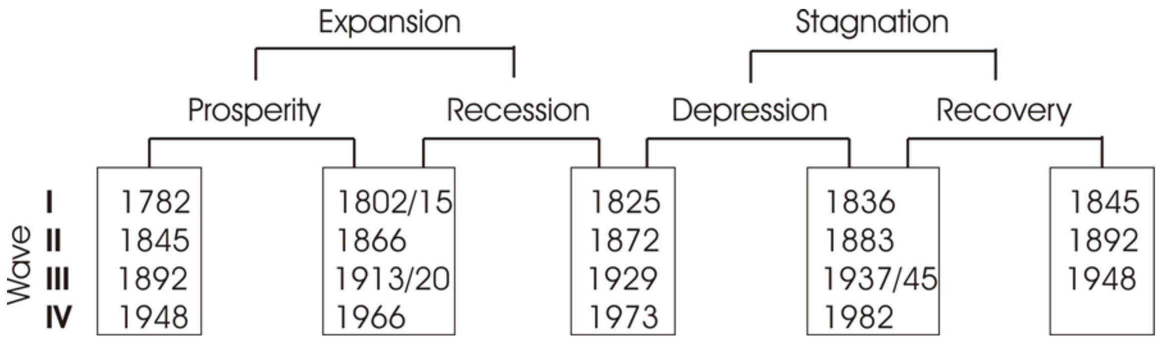


Fig. 54: The Kondratief cycle. The 4 waves in the industrial age. After van Duijn. Source: See "Notes on the figures".

development of new markets. MENSCH (1975, p. 15, pp. 76, pp. 170) also emphasises the importance of the interaction between stagnation and innovation. Stagnation, or a decline in the capacity for improvement of older technologies, suppresses the profitability of further work and capital investment in many fields of activity. This in turn concentrates the attention of science which leads to greater inventive activity. These phases are essential for the development of innovations, which are then applied industrially and new markets developed for them.

Colonisation phases:

Processes of colonisation also appear to depend on economic development, especially on the Kondratieff cycles. These also take place in phases corresponding to approximately 50-year cycles. Fig. 55 shows the phases of colonisation within Germany since the 16th century.

It is striking that the phases of colonisation are almost contemporary with the colonisation of New Mexico by the Spaniards (see section 2.6.2.2). This indicates that the rhythm is dictated by developments in the world economy. The phases of colonisation frequently begin when the world economy loses impetus, i.e. in the phase of stagnation. Perhaps the rising unemployment in the industrial sector in these years increases the importance of the rural economy.

As a rule it may be assumed that growth in population increases the pressure to expand foodstuff production. When a certain point is reached, the process of colonisation begins. Once the basic supply of foodstuffs is secured, it gradually ebbs away. Besides the pressure of population growth as a reason for colonisation movements (which are generally encouraged by ruling elite) historical literature also cites religious and political reasons (e.g. refuge for victims of religious persecution, or hoped-for increase in revenue).

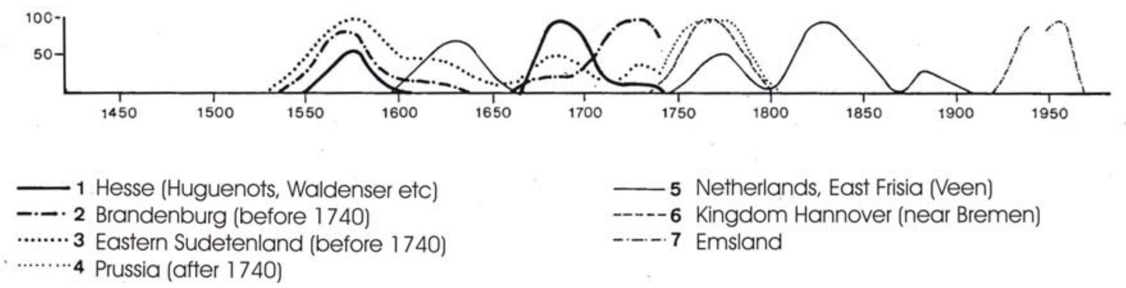


Fig. 55: Colonisation processes in the decennial rhythm in Central Europe.
See section 2.5.1.1. Highest rate of growth in each case = 100.
Source: see "Notes on the figures".

2.3.2.2. Horizontal processes:

Processes of spreading

Diffusion:

As described above changes of the state in social and economic reality take place in flow-equilibrium systems through the diffusion of innovations. Such a process is irreversible, because knowledge which has been released or diffused can no longer be taken back. Examples are the diffusion of cultivated plants and domestic animals over the earth since the neolithic age, and in more modern times, the spread of technical inventions such as that of the automobile (HÄGERSTRAND 1952; ROGERS 1962/83; WINDHORST 1983). The spread of artistic styles and patterns of thought has recently been described (DUMONT Weltatlas der Kunst 2004; HOLENSTEIN 2004). The division of history into periods is based to a considerable extent on the adoption of innovations by peoples and civilisations which then gave rise to structural changes and developments (see section 2.4.2.1).

One well documented example of this is the spread of covered bridges in the USA in first half of the 19th century (see fig. 56; KNIFFEN 1951). These historical structures are a striking feature of the landscape in the east of the country. The reason for the roofing of the bridges lay in the climate. At that time, bridges were made of wood and it had been noticed that the lifespan of covered bridges was around three times that of uncovered ones. They were first erected in the southern states of New England, in eastern New York State and Pennsylvania.

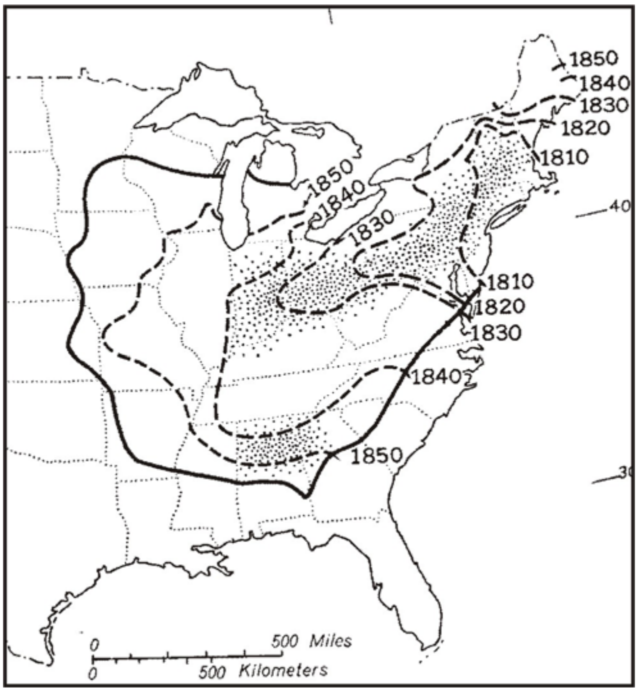


Fig. 56: Spread of covered bridges in the east of the USA in the first half of the 19th Century. *Example of a diffusion process. Source: See "Notes on the figures".*

From here, the innovation spread westwards and southwestwards as the colonisation of the continent proceeded, and became less frequent around the edges of the drier plains. From the mid 19th century, covered bridges also made their appearance in California and Oregon, where they continued to spread until about 1890.

The model of Artificial Society:

The treatment of the spread of innovations and colonisation leads to the field of complexity research. Of special interest is the model of Artificial Society, which leads from the level of the flow-equilibrium system to that of the non-equilibrium system. This is a simulation model. It is true, the simulation produces spatial patterns which may look like processes of self-organisation which are otherwise typical of non-equilibrium systems. However, with regard to methodology, we are dealing with a flow-equilibrium system.

This model attempts to understand highly complex structures "from the bottom up" and to simulate them (EPSTEIN & AXTELL 1996). The "agents" as the elements act in a spatial environment according to certain rules. What is new, is the fact that each of them is equipped with certain characteristics and rules of conduct (e.g. sex, sight, metabolic rate, individual economic preferences, affluence, cultural identity, health). Thus, in addition to the dependence on the inferior environment ("landscape"), we also have dependence on the horizontal neighbouring environment. To be more precise:

The "landscape" appears as a grid over which the resources (e.g. foodstuffs) are distributed measurably as with the cellular automata. In this way, the operations can be expressed by rules which describe the behaviour of the agents and the reactions of the environment. The agents can interact indirectly with the environment via a communications network whose spatial configuration may change in the course of time. In this way, the agent is bound to his environment (agent-environment rules). Besides this, there are rules which govern the relationships between the agents, e.g. in cases of conflict or commercial activity (agent-agent rules). Moreover, every locality in the landscape may be linked to its neighbours through rules. Thus, the rate of the renewal of resources in one place may be a function of the quantity of resources in the neighbouring locality (environment-environment rules).

In the simulation, it is possible to see how macroscopic patterns form, e.g. there are more or less distinct concentrations of agents with certain features, or currents begin to form. The patterns change or become more stable. According to the interpretation of the authors wealth or poverty accumulate in certain places, social relationships come into being between neighbours or friends, co-operation and trading relations develop and diseases also spread. The simulation processes are regarded as activities and processes which are more or less typical of human society.

A good example is the evolution of social networks (see fig. 57). One precondition is the structure of the "landscape". The raw material vital to the agents (under the abbreviated term "sugar") is distributed over this landscape. In two areas of this "sugarscape" it is concentrated in "mounds", at the bottom left (south west) and top right (north east). The agents move over the landscape towards these mounds, and when they have arrived there, they use up as much sugar as they can eat.

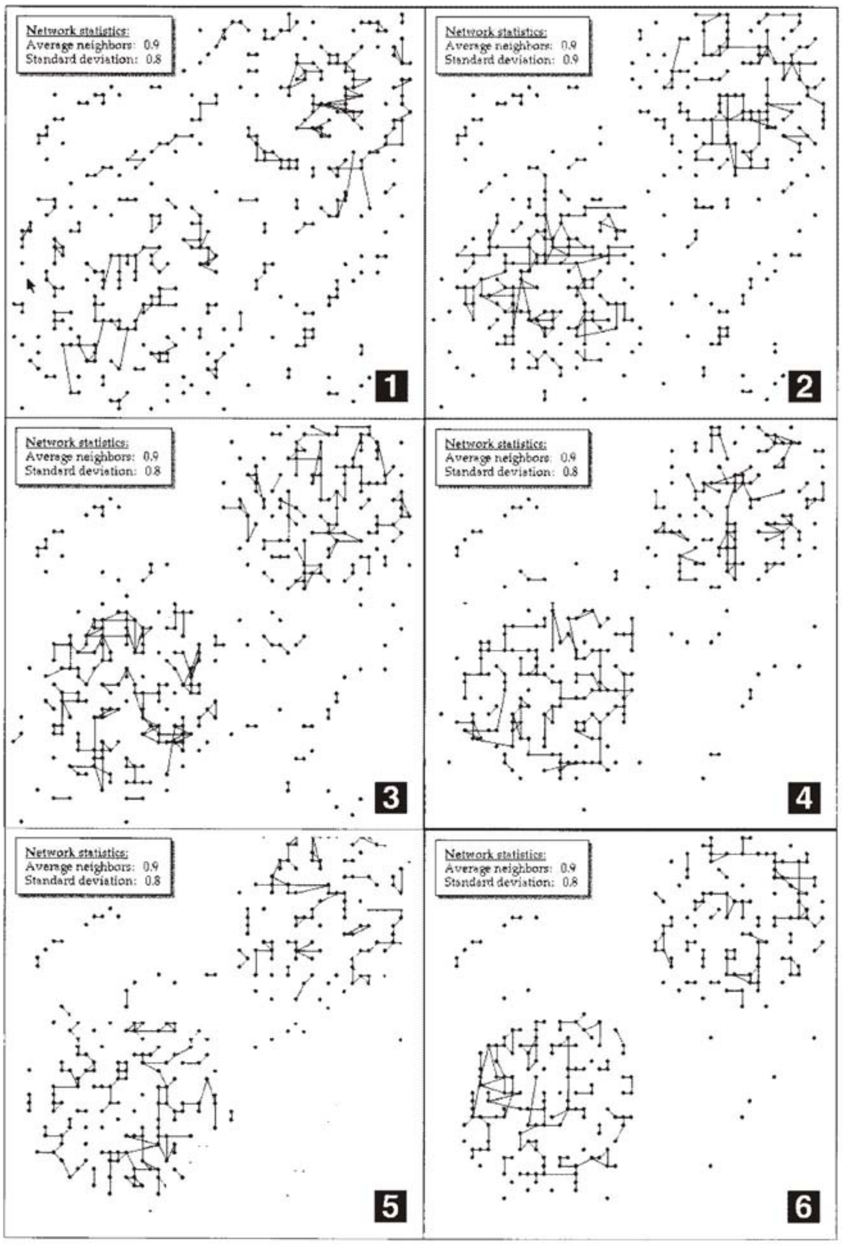


Fig. 57: Evolution of social networks of neighbours according to the model of the Artificial Society.
Source: See "Notes on the figures".

The method of simulation of patterns has also proved its effectiveness in other ways. New results continue to be achieved in widely varying areas of research. The model is a step towards representing the individual diversity of desires and activities, i.e. raising it to a higher level of complexity. However, it is still not possible to achieve "artificial societies" in this way. Human society forms populations which are distinct from one another (see section 2.4.1.1). In these, production takes place, flows of energy are recognisable and are channeled and linked with one another to fulfil practical purposes. These groupings, non-equilibrium systems, organise the time at their disposal (process sequences) and shape their space themselves. Only they can supply energy to the superior environment more rapidly and more precisely because they produce products which make the flow of energy more precise and more effective, thereby reducing the dissipation of energy.

With the help of the model, it can still be ensured that the agents reach the most favourable position between the specific societal constraints and the landscape, i.e. the inferior environment. This is the pre-condition for the actual emergent processes which lead to the formation of populations.

Processes of spreading in ecosystems:

An area of application of importance for medicine is the spread of diseases (pandemics), the study of which is crucial to their prevention. Ecologists study the spread of new species of

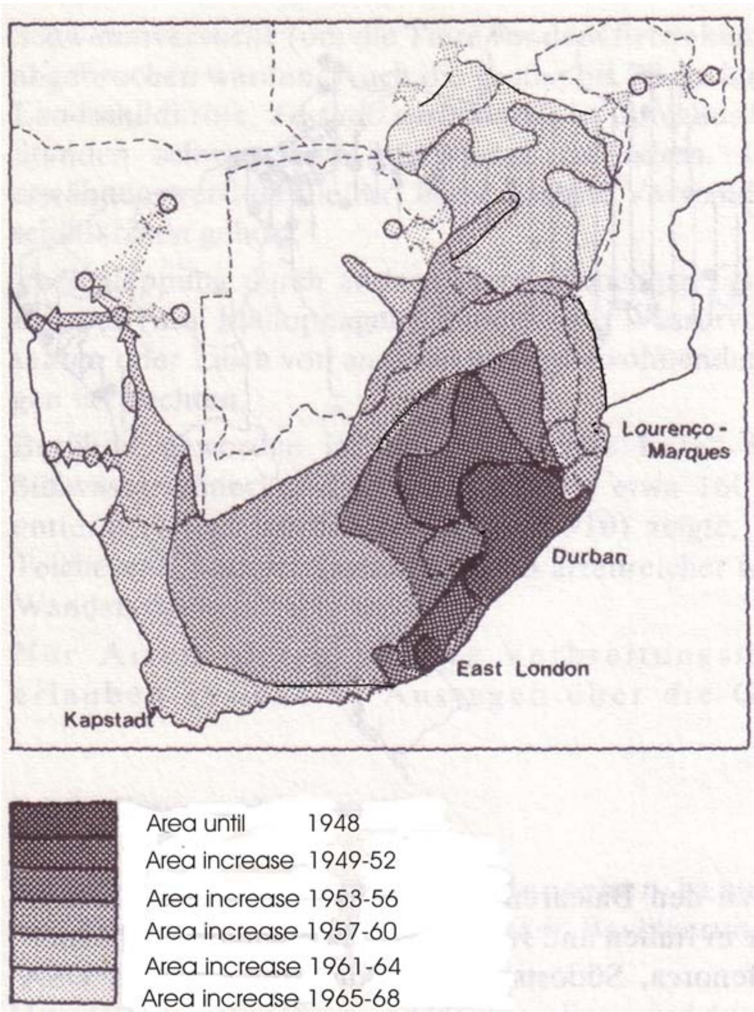


Fig. 58: Spread of the sparrow in South Africa.
After Vierke. Source: See "Notes on the figures".

plants and animals within ecosystems, e.g. the introduction of the rabbit in Australia or the horse in North America. These are comparable with colonisation processes. Spreading is directly observable, because it is not only information but the elements themselves which enter the environment. Changes are particularly noticeable when, due to international trading activity, new plant or animal species replace native ones. The flow equilibrium of the given ecosystem can be substantially altered by diffusion processes of this kind. One example of this is the breeding success of the house sparrow in South Africa (see fig. 58). The birds were probably brought to the ports of Durban and East London in the 1940s and spread over all of South Africa in just two decades. Obviously they had no natural enemies.

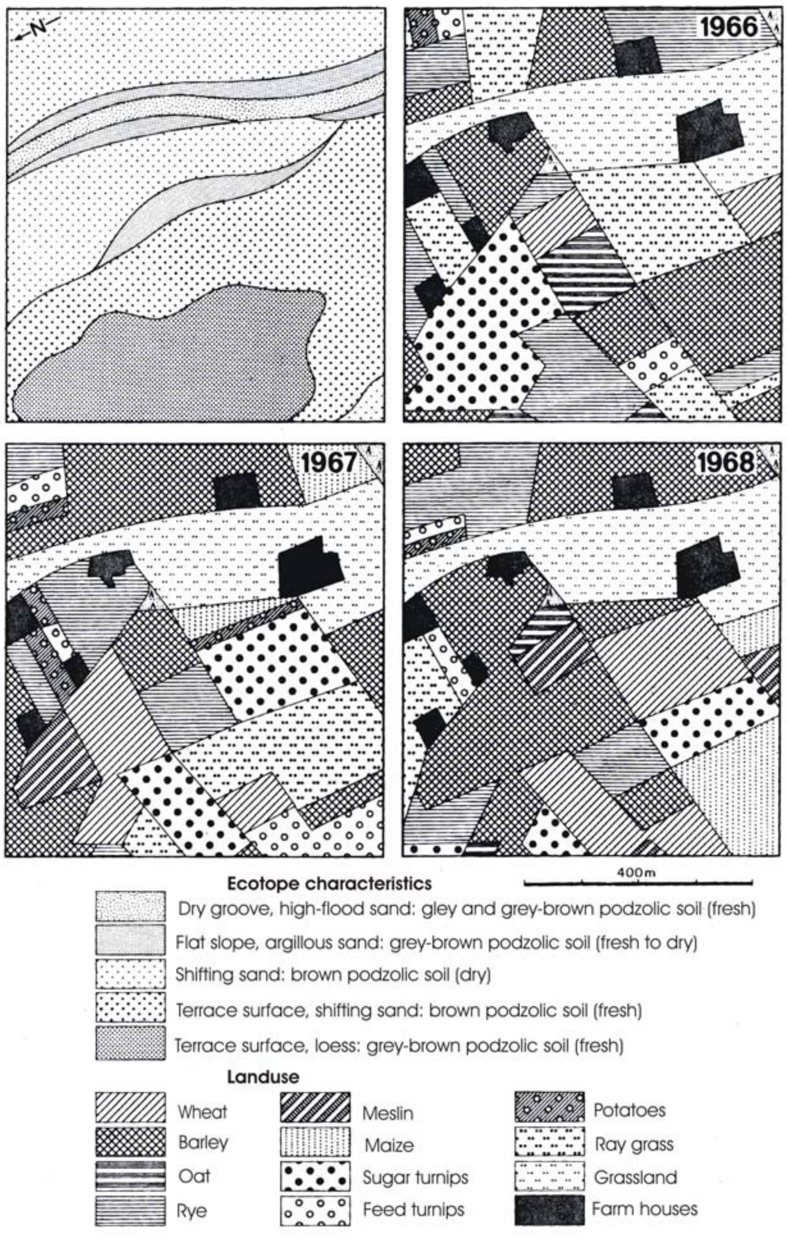


Fig. 59: Ecotopes and agricultural utilisation (lower Rhine) 1966-68.
Example of an irregular rotation.
According to Hambloch. Source: See "Notes on the figures".

Rotation:

Irregular rotation:

Let us return to the farm (see above). The soil is only able to support a population as long as its fertility is maintained, i.e. its ecosystems remain intact. Through skilled cultivation, the farmer is able to take the necessary energy from the soil over longer periods of time. I.e. the ground as inferior environment must "adopt" the stimulus to supply the demanded fruit. Through the cultivation rhythms (oscillations) dictated by the days and seasons, the soil is able to recuperate and prepare for a new phase of production. However, in the long term, this in itself is insufficient. Besides the use of fertilisers, it is also advisable to change the crop because the different plants utilise different spectra in the scale of mineral nutrients in the inferior environment. In most cases, crops are altered in a certain rhythm, e.g. tubers (potatoes, turnips) and cereals. This regularly recurring change is a certain kind of "rotation" (see fig. 59; also section 2.3.1.1). It is a temporal-spatial sequence in cultivation, because each field, as a tope, produces a different crop at (generally) yearly intervals (unless a forced monoculture takes place through intensive use of fertilisers). The farmer then changes the previous crop to another field. After a number of years, the sequence is concluded and a new one begins. In this way the ecosystem in the soil can recuperate and is protected from over-exploitation. The spatial and temporal character of the processes is seen in this rotation. In pre-industrial times, the principle of three-field cultivation was widespread. The open field belonging to the village was divided into three parts and each peasant had his share of each part. A process was agreed among the inhabitants of the village whereby winter and summer crops and fallow periods alternated.

Further examples of irregular rotation are offered by the movement of centres of innovation in the course of cultural evolution in Europe (see section 2.5.2.2).

Tangential rotation:

A tangential rotation is apparent in the long-term utilisation of the land of the Pueblo Pecos (see section 2.6.2.2). But tendencies of this kind can also be seen in highly differentiated populations. Migrations within the precincts of a city are dictated primarily by supply and demand in accommodation. This is confirmed by an analysis of the officially reported household removals in Göttingen in 1960 (see fig. 60). In the old-town (areas 11 to 13) with its shopping district, very little new living accommodation was created in the year studied. On the contrary, much of it was sacrificed to the increasing requirement for commercial, industrial and office space. Many households living in rented accommodation in the central area moved to newly built property in the suburbs. There were therefore more removals outwards from the old town than into it. On the other hand, areas 21 and 22 at the outer edge of the town and the suburbs (areas 31-33) experienced more inward than outward movement.

In addition, certain latent tendencies are also noticeable. With the assistance of statistical analysis, it was attempted to compensate spatial imbalances produced among other things by the differing sizes of the statistical areas. It was shown that the movements had a latently tangential deviation from the anticipated radial direction leading to (and from) the centre.

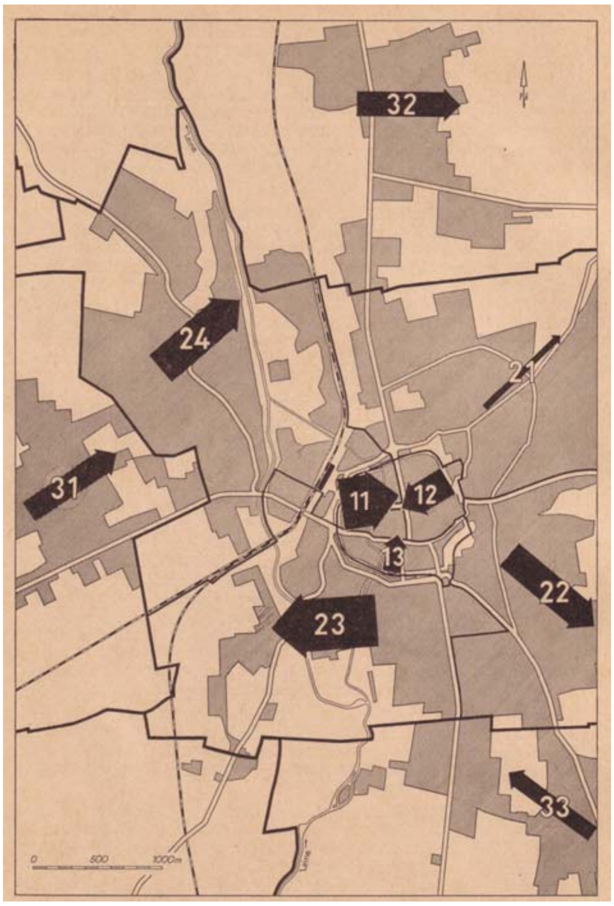


Fig. 6O: Household removals within Göttingen (and suburbs) in the year 1960.
An example of a tangential rotation. Converted according to the size of the various areas. Resulting direction: the length of the determined resultants has been transposed to the width.
Source: See "Notes on the figures".

Similar trends can also be seen in the development of commuter and general road traffic. These deviations from the radial direction would seem to indicate a certain degree of tangential rotation. Unfortunately, very few studies exist on the phenomenon of rotation, although corresponding observations could be made in completely different environments and orders of grandeur.

2.3.3. Process sequences and dominant systemic dimensions

Numerical sequence:

At this 3rd level of complexity, the energy from the environment is integrated into the system. In the processes of the 1st order the vertical component comes to the fore (demand against supply). This means that the co-ordinate system is run through in clockwise direction (U variant) (see fig. 61a). The flow of information (demand) and energy (supply):
1. Input: The stimulus (quantity of demand) from the superior environment enters the system (front side).
2. Acception: The stimulus (quantity of demand) from the system enters the inferior environment.
3. Redirection: Energy is absorbed from the inferior environment.
4. Output: The energy is taken to the system and the superior environment.

That is, the energy (supply) now flows in the opposite direction from the inferior environment against the flow of information (demand) to the superior environment. The lower part of the number table is folded behind the upper part. In this way the system is formed, receives its stability and forms the structure for the predominant process of the energy flows of the first order.

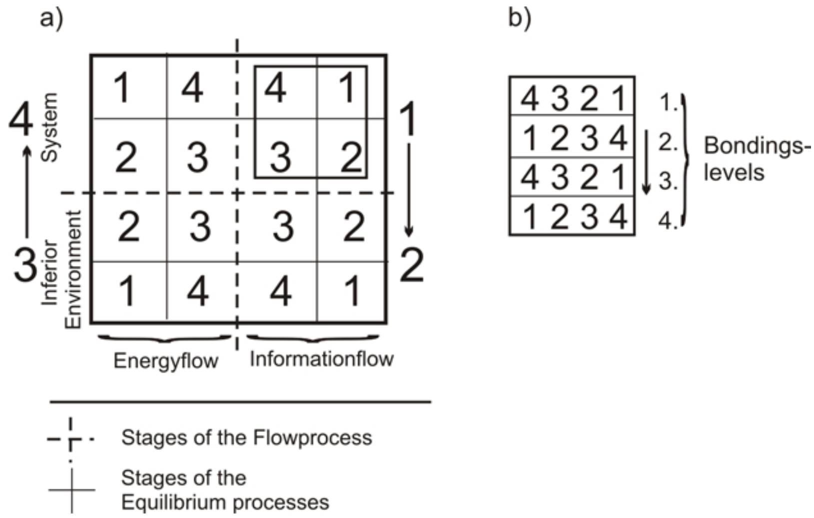


Fig. 61: Diagram of the numerical sequence of the flow process.
a) large numbers (1 .. 4): Process 1st order: U variant. The right-hand half (1 and 2) contains the flow of information (demand). The only part of the system discernible from outside, is the part which absorbs the information (front side, framed). It is here that the equilibrium process shown in Fig. 30d (section 2.3.3) appears after its reversal. The left-hand half (3 and 4) shows the flow of energy (supply) contrary to the flow of information. Stage 1 is the front side. b) This illustrates the equilibrium process (second order) joining the four bonding levels and the movements using them within these levels (third order, solida) in linear arrangement.

The processes of the second order on the other hand form the bonding levels, they proceed horizontally. Each bonding level stands for a specific type of element bonding (section 2.3.1.1). In fig. 61b these processes appear. Here we refer again to the diagram showing the course of the flow of information above in fig. 47.

Route diagram:

The route of the process sequence in its 3 levels is shown in fig. 62. Here, the folds are not taken into account with the result that the process sequence as a whole can be seen. The contact with the demanding and receiving (superior) environment is again located at the centre in this diagram. The flow process tends towards the right and therefore takes place in a clockwise direction (U variant).

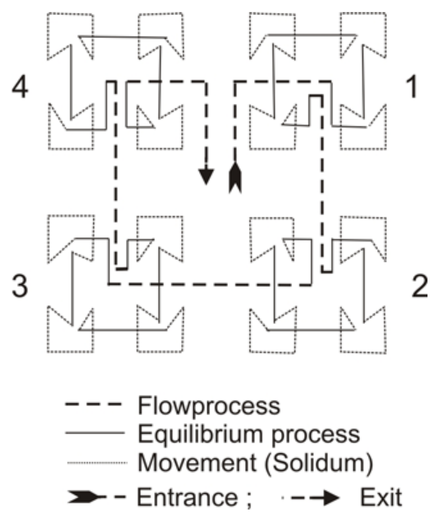


Fig. 62: Route diagram of the flow process (flow equilibrium system), with the systems and processes of the lower levels of complexity assigned.
The first rank process is structured according to the U variant.

Here, a 3-level hierarchy can already be seen. The two upper stages of the flow process (Fig. 62: 1 and 4) define the energy demanding part of the system and the two lower stages (2 and 3) the energy supplying part. The information (i.e. the demand) from the superior environment is received in the system and via (1) and (2) conducted downwards (flow of information). Here, energy from the (involved) inferior environment is made available. It is then directed via the element horizon (3) and system horizon (4) to the superior environment (energy flow). The (involved) inferior environment and system therefore face one another and regulate one another mutually.

The dominant systemic dimensions (see fig. 63):

Quantity: On its own, the equilibrium system is not able to differentiate itself further. At this level of complexity, additional energy is taken from the environment. The flow-equilibrium system is integrated in a higher flow of energy. This means that it receives a demand for energy from the superior environment, which it passes on to the inferior environment (flow of information). From the inferior environment, it receives the demanded energy, which it supplies to the superior demanding environment (flow of energy). How much energy can enter the system depends on the (systems of the) inferior environment and this environment is not directly subject to the control of the system. The relation between the superior environment and the system is similar. The demand can enter the system as stimulating information from the superior environment, but the system itself is not bound by the order of the superior environment. With reference to the outwardly oriented structuring of the system (2nd process train), the quantity dimension is dominant. It is the principal vector. The activities following the other dimensions are directed by it.

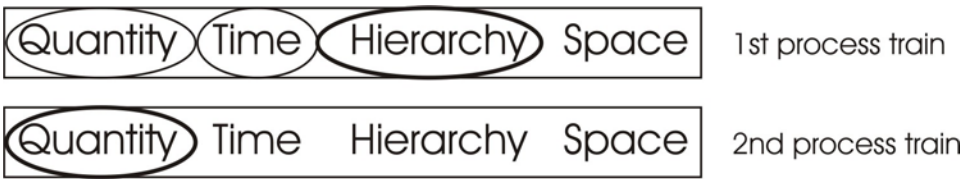


Fig. 63: The quantity of energy appears as the dominant systemic dimension in the second process train and the hierarchy as the dominant systemic dimension in the first process train.

Hierarchy: The flow of information and energy must be apportioned in such a way that the system is able to maintain itself. Thus, the system reacts to the demand and supply of the environments by structuring itself internally and hierarchically between system and elements (1st process train). Four bonding levels are created. In this way, all the elements are involved in the process which itself is essential for the installation of a feedback mechanism. In this way, the flows can be regulated. Whereas the quantity of the flows can be seen as being predominant for the outward structure, it is the hierarchy which dominates the internal formation of the system.

Outlook:

If a clear structure can be postulated for our reality, the question then arises as to whether everything which happens in the world fixed and pre-determined in advance down to the last detail, or is it undetermined. Or put differently, do certain laws exist which govern the course of events in nature and in thought, or do chance, arbitrariness, freedom, or whatever we choose to call it, prevail (at least up to a certain point). MAX PLANCK (1938/48, p. 4) posed this question in view of the problems unresolved in his time, such as the assumed irreconcilability of wave and particle representation in atomic physics. However, the problem "determined or undetermined" is of much wider importance, affecting, among other things, the freedom of will which is central to the subject of this book, which discusses developments in the history of thought. Planck is only one (albeit important) voice among many.

The broad spectrum of opinion on this subject cannot be outlined and discussed here, but a few remarks would seem to be appropriate in view of our results.

Processes which are pre-determined are defined in advance. The doctrine of Determinism embraces all the events taking place in the world including human action, i.e. there is a clear causal relationship between cause and effect (see section 2.1.1.1). Processes which are not defined in advance are undetermined. Between these two extremes there are numerous positions, and the process theory in particular reveals different kinds of non-determination. The question therefore has to be put more precisely. First of all it should be said we are always dealing with situations of transition from one state to another. It is not the states themselves which are pre-determined or undetermined, but courses of events and processes. But that also means that we are also confronted with a problem of control. Fully (i.e. in every detail) controlled transitions are without doubt pre-determined. On the other hand, if no control exists, chance prevails, and the system is in danger of disintegration.

There are various ways of controlling a process sequence. The feedback indicates only one way. Flow equilibrium systems are distribution systems. However, the elements of the compartments, e.g. the textile factories in the market, can also process the energy and manufacture products. The energy is "informed", so to speak. The products can be designed in such a way that they correspond exactly to the demand. This result is an increase in effectiveness, or in other words, a saving in the amount of energy in the flow. Thus, the flow of energy can be controlled much more precisely.

This assumes a re-structuring of the flows of information and energy – a new type of system. The development of a model is a challenge which cannot be met using the methods of traditional complexity research (see Foreword). This therefore takes us to a new level of complexity.

2.4. Conversion process and non-equilibrium system

2.4.0. Instead of an introduction: The textile factory as an organised unit

Let us now look at the factory as a unit consisting of departments whose purpose was the manufacture of products, i.e. textiles. Thus, the process itself is at the centre of the examination.

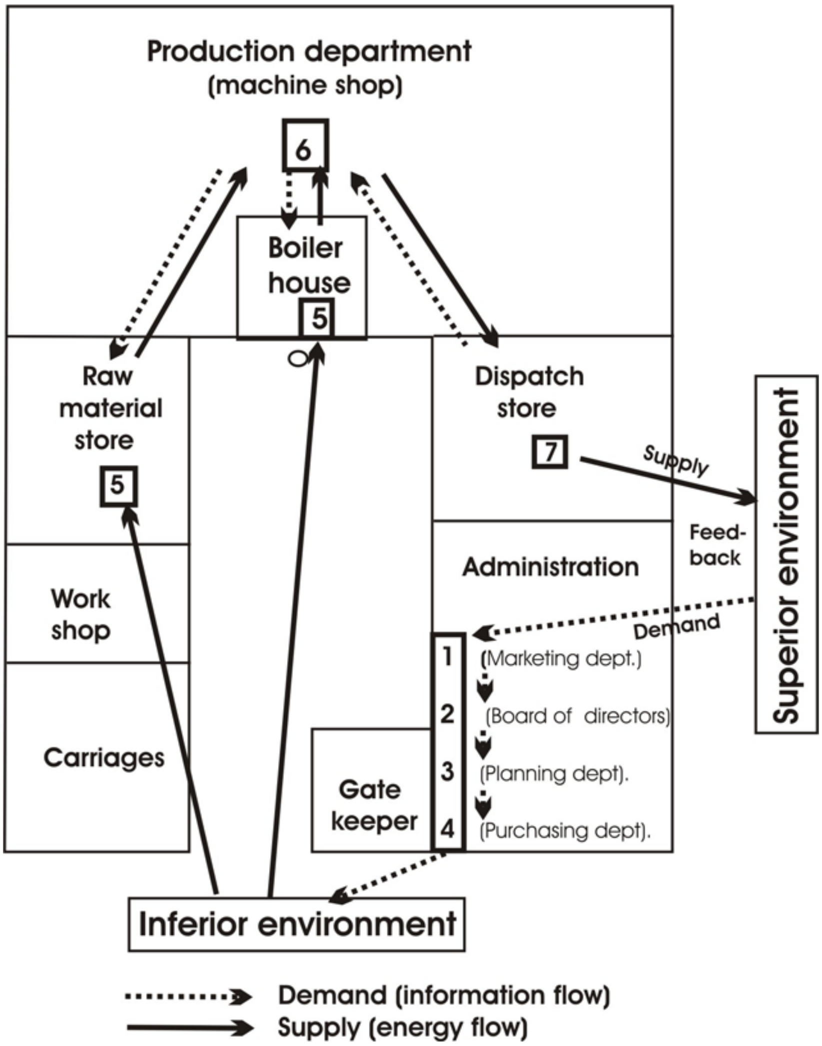


Fig. 64: Production sequence in textile mill. Diagram.
The principal departments involved directly in the production process are all linked with one another. This is shown by the numbering.

The various departments of the textile mill with the buildings as its earthbound artefacts were organised in relation to one another in such a way that they allowed the smooth co-ordination of the departments resp. the action projects of the individual workers. The factory was the place of economic activity of a group of workers who carried out tasks with one another, thereby shaping the framework for their own activities. The earthbound artefacts formed the framework by means of which organised work was made possible. On the one hand, the operations are dedicated to the production, and on the other, to maintaining the company itself (in fig. 64 localised e.g. in the department workshop).

The workers communicated with one another on the basis of a division of labour, i.e. different information and materials were altered and joined to form new products (the woven products) which could be sold on the market. Each piece of textil material was the product of many units of information and actions.

A clear, balanced and understandable structure of work and inspection formed the framework necessary for production. Precisely this is the advantage of division of labour - that the action projects and the flow processes in the departments within the factory are perfectly co-ordinated with one another in time. The preceding work and raw materials required for the production are available at any time with the result that there are no difficulties in adaptation, and the various tasks dovetail directly into one another and follow one another without delay. The result is a circular process. Thus, the control of the processes resp. departments is structurally different than self regulation based on feedback (see section 2.3.1.1).

The structure of control and inspection requires a hierarchy within the mill. The board of directors, of which the proprietor was the chairman, represented the mill as a unit. The stimulus (information) for the processes was received by the commercial administration from the market (superior environment) in the form of demand. Here, the decisions were taken and planning carried out. The suppliers (as inferior environment) supplied the factory with raw materials, electricity, thermal energy, water etc. The actual physical work took place afterwards, especially in the production department of the mill.

2.4.1. General considerations

2.4.1.1. System and Process

Products and division of labour:

In our treatment of the first, second and third levels of complexity, the compactness of the plant was described as being perhaps its most striking feature. It provided the framework for the structures and processes described. It is now apparent that the reason for this lies in the structure of the processes themselves – in the necessity of keeping the various very different operations as close together as possible to facilitate contact. The processes depend upon a closed system which is organised essentially in rings in which the different operations follow or precede one another. The individuals (in their roles) as the elements engaged in the factory represent the "carriers" of the processes, i.e. they permit the practical implementation of the systemic links and process sequences with the assistance of the media and earthbound artefacts (see section 2.1.1.1). The concentration of the different departments is contrasted by the wide field in which the factory has built up networks of sale and supply.

This isolation of the production process from the outside world as well as the links maintained by the plant with the surrounding environment have one purpose: the manufacture of a product.

Products can be defined as energy (matter) loaded with information. They serve the receiving systems as the energy required from the inferior environment in each case. In this way, the factories intervene between the market (the superior environment providing the information) and the supplier of raw material (the inferior environment providing the energy). As already outlined (see section 2.3.1.1), they are parts of compartments, i.e. flow-equilibrium systems, and like these they are located in the flow of information and energy. However, these flows are given specific form by the transformation of energy or raw material into (more or less complicated) products so that they can be passed on to the markets, i.e. to the demanders, in precisely the form required. Put more generally, the material in the form of products becomes precisely "fitted", i.e. qualitatively specified transportable energy (for accuracy of fit, "Paßgenauigkeit", see VOLLMER 1985-86, I, pp.59).

As a production company structured on the basis of a division of labour, the textile mill as a structural type was on a level with other industrial companies, farms, medical clinics, food stores, lawyer practices, public offices etc. From an economical point of view, these were companies ("Betriebe") or offices. However, the fact can be emphasised that the companies (or offices) were shaped co-operatively by people, i.e. by a population. Subsystems such as departments may intervene, but not necessarily. These subsystems (in the sense of flow-equilibrium systems) play a kind of mediating role between the whole and individual worker. They have certain well defined tasks for the whole and the individual action projects were concentrated in these accordingly. From the social point of view, we may speak of "organisates". The organisate represents the persisting "non-equilibrium system" which is preserved and modified by the "conversion process". We are at the 4th level of complexity.

It is only possible to explain the organisation and shape of the organisate by taking the internal processes into account. The contacts with their environment require that the chronological rhythm of the processes corresponds to the rhythm of the superior compartment, i.e. the market. This determines the time limits for the production processes.

Due to division of labour, these are firmly linked to one another. As a general rule, the processes are arranged in time and space in such a way that they are particularly effective for the organisate. This means that they were joined up to form an unified process sequence, in which all the departments are integrated. In this way it is possible to fulfil the demand imposed from outside, i.e. by the market. This organisation requires reliability and punctuality on the part of the workers. Internally, the departments are structured like flow equilibrium systems. As part of the organisate however, they must submit to the requirements of the whole, otherwise the division of labour cannot work.

Structure conserving and structure changing processes:

The processes which preserve the structure ("structure conserving processes") are normally operating. This involves an amount of production which assures utilisation of machines with a certain degree of fluctuation. These should be in a state which allows them to provide their normal performance in spite of omnipresent wear and tear. The textile factory employed a number of mechanics whose responsibility this was (work shops, see fig. 64).

The adoption of innovations requires investments. As mentioned above, the textile factory acquired new machines as an investment in the 1950s. This made considerable conversion work necessary in the factory, i.e. a process which altered the factory itself ("structure changing processes").

In every organisate the tendency exists to expand itself or its influence in order to increase its productivity. This takes place primarily to maintain its position on the market as the superior environment with reference to competing organisates. Thus it attempts to minimise the input of energy and material (from the inferior environment) and maximise the output of products (to the superior environment). In this process, organisates also tend to organise themselves in such a way that the flow processes in the departments can be linked together as well as possible. The (spatial) self organisation serves to minimise the consumption of time and energy, i.e. the effective utilisation of the time and energy available to them. The compact shape of the organisate is the result of these tendencies. Because of its integration in the production chain and its drive to secure its own existence, the organisate developes a considerable amount of dynamism.

2.4.1.2. The Model

It goes without saying that this problem cannot be explained or simulated with the causal method, the hermeneutic interpretation, the functional method or even with the traditional methods of system theory and complexity research. On the contrary, a special method is required which focusses on the process sequence itself thereby creating the conditions for simulating the process. It is necessary to take place step by step.

To arrive at an explanation, we must remember that, as with the flow processes (see section 2.3.1.1) there are two shaping tendencies which express themselves in process trains. The first process train is founded in the system itself, while the second process train is stimulated from outside, the environments.

1st process train:

To recapitulate:
In dealing with the complexity levels 1-3, we discussed
1) the solida appear as units. From the point of view of the process theory, it is typical of these that they take physical effect through movements. In our textile mill, the individuals, as employees, transform a definable amount of energy into action motions.
2) The individuals as employees are also carriers of the movement projects. Materially defined tasks are carried out by them systematically in various individual steps, e.g. the weaving of cloth by operating a loom. The individuals are grouped into departments, larger equilibrium systems, in which the sequence of these processes is harmonised chronologically. These are homogeneously structured equilibrium processes.
3) These departments are provided with tasks by the company as their superior environment, and receive material from suppliers in the inferior environment. They are therefore located in the flow of information and energy and strive to meet the demand with their supply. They form a flow process. This applies on the one hand to the individuals who earn their living in this way, but also for

the flow equilibrium system of the department whose existence also depends on it achieving a flow equilibrium. In order to control the flows, the hierarchy of the bonding levels is created internally (see 1st process train: section 2.3.1.1).

Action motions of the individuals, equilibrium processes and flow equilibrium processes in the departments now have to be assembled as a non-equilibrium system in the factory. There must be an effective linking of the processes until the necessary contacts are also made between the elements and with the systems of the environment as source of energy. It is obvious that the more the system closes up and the closer the sources are to the system, the more easily this can take place. This is achieved by another process. This process of spatial concentration now has to be defined.

We have already discussed the long-range effect (see section 2.2.1.1) which can be described fairly well using Newton's Law of Gravity. Everything which seeks contact with a point of attraction tries to move radially towards it. At the centre, the density of the objects seeking contact (the elements) is very high and declines rapidly as we move outwards and then much more slowly towards the periphery.

First of all, let us assume that the attractive power of the centre is increased by new attractive stimuli being created. This also increases the long-range effect and the space requirement. Small non-equilibrium systems generally have a low degree of attractive force and larger ones a higher degree of attractive force and long-range. To describe this, we assume that new attractive elements are taken into the initial place of a given volume of the non-equilibrium system. The density value increases. If the original density value is to be restored, the system has to be enlarged into the environment.

This happens in the 4 spatial process stages. A suggestion of describing this process mathematically:

- 1st process stage: The elements as spatial units are brought into the system as a whole, i.e. intake of additional units N in the given volume K of the system. The density increases. The formula for negative exponential increase can be used:

[17] $$N_n = N_{n-1} + \frac{K - N_{n-1}}{k}$$

(N = number of elements as spatial units; n = number of temporal steps; k = constant, ascend factor; K = upper limit.

- 2nd process stage: It is necessary to calculate how the increased value is dosed and tansformed into an elevated number of steps, with which the elements can be brought into a new space. The formula for a linear development

[18] $$N_n = N_{n-1} + k$$

(*n* = number of steps at the moment n; *k* = constant, ascend factor.

- 3rd process stage (adoption by the elements): The raised value of steps is the basis for the diffusion, i.e. the rise of the elements as spatial units into the system. The formula for a positive exponential development:

[19] $$N_n = N_{n-1} * k$$

(*N* = number of the diffused elements as spatial units; *n* = temporal steps; *k* = constant, ascend factor).

4th process stage (expansion of the elements): The number of elements has increased. The volume of the system now has to be increased. The density of elements depends on the distance from the centre of the system (see section 2.2.1.1). In the immediate vicinity of the centre, the least space is available, and the density is greatest. Further outwards the available space increases, and the density decreases. Proceeding from the centre to the periphery, the exponentially shaped diffusion (with the ascend factor *k*) receives a power growth *a*. This exponent *a* states the (geometrical) dimensionality of the space.

1st step $N_1 = N_0{}^a * k$, 2nd step $N_2 = N_1{}^a * k$, etc.

[20] $$N_n = (N_{n-1})^a * k$$

n = temporal steps, *k* = constant, ascend factor.

For a homogeneous surface *a* = 1. For a (geometrically) three-dimensionally shaped space *a* = 2 (according to Newton's Law of Gravity). See also “Notes on the figures”, fig. 89.

It is, however, also possible to interpret the formula in such a way that exponent *a* reflects the intensity of the long-range effect from a centre to its surroundings, i.e. the intensity of the readiness to adopt. If the value *a* is smaller, i.e. only a little more than 1, the acceptance is small, the long-range effect is small. If the value *a*, however, is distinctly greater than 1, this means that the centre has a greater effect on its surroundings.

In this way the system concentrates itself, takes on a compact shape and builds up its sphere of influence (its area of long-range effect), through which it interacts with the other systems. It is a spatial influence of a general nature. This process coming from inside, from the system, which shapes the spatial environment, is not strictly controlled outside the system itself, because the elements seeking contact around the centre must themselves decide how close to the centre they wish to be.

Transition from the 1st to the 2nd process train:

In our discussion of the 1st process train we explained, how the non-equilibrium system and its environment receives spatial order developed from within. In this way all 4 process levels are involved which describe the hierarchic structure of this type of system. In each process level, the system is ordered in accordance with a system dimension. From the top downwards these are:
- 1st process level (space): The system is spatially concentrated. The other processes are subordinate to this.
- 2nd process level (hierarchy): The hierarchy system/elements develops in the flow equilibrium system through creation of the bonding levels.
- 3rd process level (time): Within the process levels, the chronological sequence is regulated (as in the equilibrium system, see section 2.2.1.2).
- 4th process level (quantity): This is all dependent on the supply of energy at the lowest process level.

In the 2nd process train however, the influence from outside dominates and enters the system through the interactions with its environments. In our discussion of flow processes (see section 2.3.1.1) we saw how the creation of an internal hierarchy (bonding levels) permits the controlled absorption of energy. The system involves a part of the environment (for getting a quantity of energy), and is in turn affected by the environment in form and arrangement.

The spatial concentration which took place in the first process train and gave contours to the non-equilibrium system, now also seems to be essential for time being received from outside, i.e. from the environment, and incorporated into the system. This makes it possible to re-define the chronological order. The chronological sequence was already defined in the equilibrium system (see section 2.2.1.2), but this concerned only the sequence of stages in the process, not their duration.

Here, a new operation is recognisable:
The hierarchy of the processes in the first process train is turned upside down. The processes and movements are now arranged as follows:
- 1st process level: The "main process" controlling the flow of energy and information (i.e. the quantity) of the non-equilibrium

system, with its 4 stages, represents the highest-ranking process. This process guides the flow of energy (into the system or to the demanding superior environment).
- 2^{nd} process level: The time-differentiating "task processes" with their 16 stages are subordinated to it.
- 3^{rd} process level: Subordinate to these, the "control processes" fit the elements into the internal hierarchical structure (64 stages).
- 4^{th} process level: These in turn are shaped in detail by the space-differentiating "elementary processes" (256 stages).

So this transition is related to a reversal of the content of the system-internal hierarchy (which remains in existence as a structure). The entity created in the first process train (from the energy input to spatial concentration and delimitation) is now completed by an inner division, where the system is regarded here as an all-embracing informational and energetic unit to which the elements are subordinate.

In both process trains it is apparent that at every process level, a new characteristic (i.e. a new systemic dimension; see section 2.1.3) is added (see fig. 65):
- quantity (of energy or information),
- time (duration, speed),
- hierarchy (bonding density), and
- space (central-peripheral).
The systems develop in accordance with these in the course of the process. In addition, they show in which direction the processes affect the system, how they pass through it and structure it.

Apparently this reversal is an essential factor permitting the system to be linked to the superior or outer process rhythm (see section 2.5.1.1).

2^{nd} process train:

As mentioned above, the first level is occupied by the "main process". Subordinate to this in the hierarchy are the "task processes" (2^{nd} level). To ensure the process can reach the elements,

	1st Process train		2nd Process train	
1st Process level	Space		Quantity	1st Process level
2nd Process level	Hierarchy		Time	2nd Process level
3rd Process level	Time	→	Hierarchy	3rd Process level
4th Process level	Quantity		Space	4th Process level

Fig. 65: Transition from 1^{st} to 2^{nd} process train.
Hierarchy of process levels. Re-arrangement of the succession in which the system dimensions are treated. This operation is characterised by a reversal of the content of the system-internal hierarchy (which itself remains in existence as a structure).

all 4 bonding levels which distinguish this type of system (as well as the flow equilibrium systems; see section 2.3.1.1) have to be passed through, i.e. the system horizon (with 2 bonding levels) and the element horizon (also with 2 bonding levels). These are the "control processes". They in turn are supplied by the "elementary processes" (4th level).

Main process:

At the 1st bonding level, the flow of information and energy is ordered because the thematically differentiated process sequence is forced into a chronological framework. This "main process" takes place in the form of oscillations in contact with the superior environment e.g. the market (see section 2.3.1.1).

For a system based on the division of labour (i.e. a non-equilibrium system), the time structure is decisive. The flow of information according to the demand and the flow of energy for the supply take place after one another. The conversion of information and energy (from raw material to the finished product) takes time, and when the required product has arrived on the market in the required quantity, the demand may have changed. The oscillations determine the time budget and the internal sequence of procedures in time. They have to arrange the information and energy flow (from and into the environment, into and from the system), i.e. the sequence of the processes in the whole system. We will consider the process first from the point of view of demand development (it can also be treated from the point of view of supply development).

The main process can be presented in a system of coordinates. 4 "main process stages" (or in abbreviated form: "main stages") can be distinguished (see fig. 66):

- "Adoption": The demand from the market as the superior environment is represented in the y-positive half of the coordinate system [f(x)-quadrant]. At the beginning, the demand is taken upon the system and therefore increases. The energy is demanded from the inferior environment. [In the organisate, the demand for a certain quantity of a certain product is received from the superior environment, i.e. the market, and processed in the system. Adoption stimulates the processes within the company.]

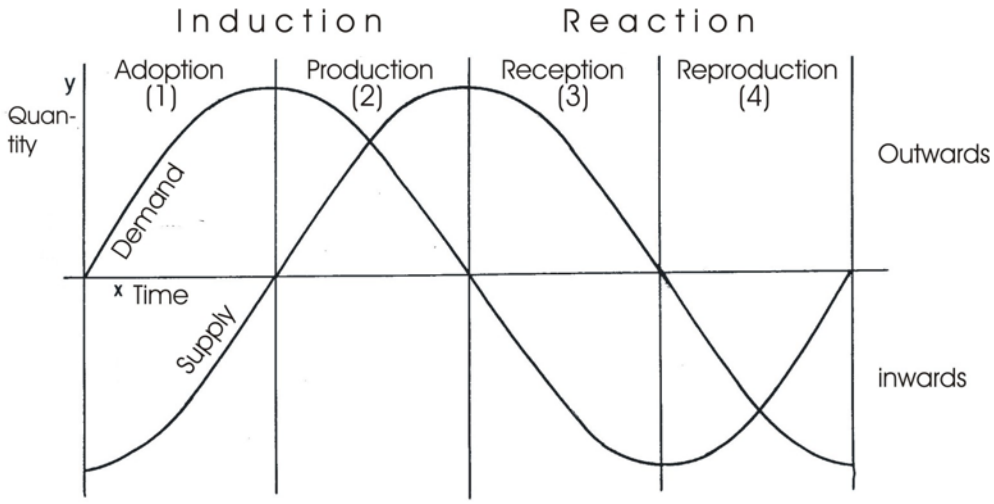


Fig. 66: The main stages (adoption, production, reception, and reproduction) in the interaction of demand and supply.
Both stimulate each other mutually, oscillations occur which impose their rhythm on the internal process sequence. In this way, the non-equilibrium system receives its periodic division. See also fig. 45, section 2.3.1.2.

- "Production": The supply curve is shown in the y-positive half [f(-x) quadrant]. The production for the market increases, while the demand decreases to the same extent. The demand and supply curves intersect one another. [The production of the organisate itself takes place in accordance with the information specified, but also on the basis of the energy etc. contributed by the inferior environment (e.g. its suppliers). This main stage includes processing of the raw materials up to the supply to the market.]

As already mentioned (see section 2.4.1.1), not only the market has to be supplied with energy (in the form of products). The system itself must also receive energy, otherwise it will decay. So we can distinguish between the "induction process" which satisfies the requirements of the market, and the "reaction process" which affects the system itself, i.e. the system adapts itself to the new conditions.

In the induction process, energy is transformed into products for the market. This is the y-positive part of the oscillation curve in the main process. In the course of the process, it may become apparent, that a change in the system structure is necessary. In the reaction process, the structural adaptation takes place, through self-organisation. This is the y-negative part of the oscillation curve in the main process. The system changes the number of its elements and arranges the elements in a way which is most favourable for the next induction process. Here, too, information precedes energy flow, i.e. it must first be established what has to be renewed before the renewal process can begin:

- "Reception": The demand curve leads into the y-negative zone [-f(-x) quadrant], stimulates the system to adapt itself. The supply curve begins to decline. This reflects the same development as for adoption but with a reversed situation. [An organisate must undergo a continuous process of renewal in accordance with the requirements of the market and for the purpose of saving energy. This is registered first of all as information, and planned accordingly.]

- "Reproduction": The demand curve moves within the y-negative zone towards the x-axis again. By contrast, the supply curve declines into the y-negative zone [f(-x) quadrant], i.e. the system itself is supplied with energy and is changed. The elements are increased in number with the result that this stage is comparable to that of production. [In the organisate, this is expressed in the actual maintenance and investment tasks - depending on the circumstances of the market and its own possibilities and intentions.]

Task processes:

In each of the main stages Adoption and Production (induction process) a number of tasks have to be carried out and for each of these tasks a particular stage is available. The "task process

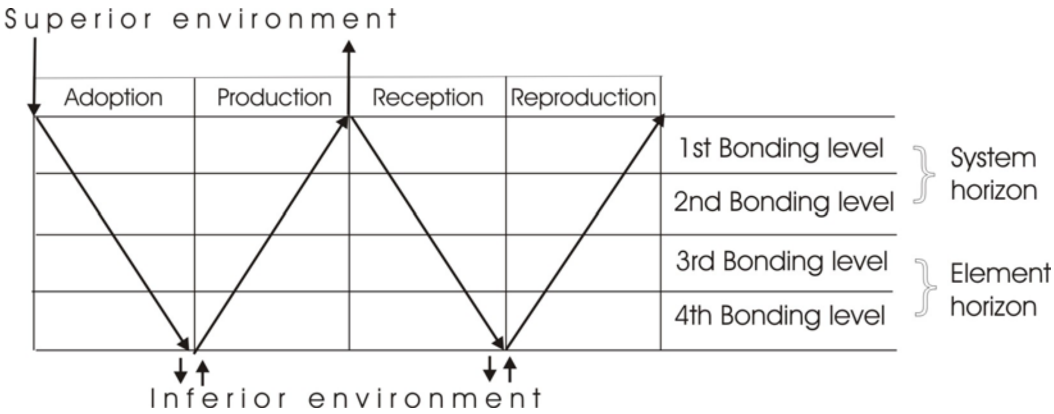


Fig. 67: The course of the 4 main process stages through the 4 bonding levels.

stages" (or "task stages" for short) are located at the 2nd process level. Here, subordinate to the main processes, the processes are ordered according to the time sequence specified by oscillation.

Like the flow equilibrium system, the non-equilibrium system is structured vertically by bonding levels. At the task stages, the process crosses the bonding levels, thereby joining the superior with the inferior environment, i.e. the energy-demanding environment (market) with the energy-supplying market (suppliers etc.). Both in the induction and in the reaction process, the flow of information (demand) leads downwards (adoption, reception) and the flow of energy (supply) upwards (production, reproduction).

The elements are involved in the process in the various ways in which they are integrated in the system (see fig. 67). Structurally, the bonding levels are (subordinate) flow equilibrium systems, i.e. the information and energy are diffused horizontally in them (see section 2.3.1.1, and 2.3.1.2).

Let us take the induction process first:
In the adoption process the stimulation, i.e. the demand for certain products, has to be incorporated into the structure of the system. I.e. the process leads down the bonding levels

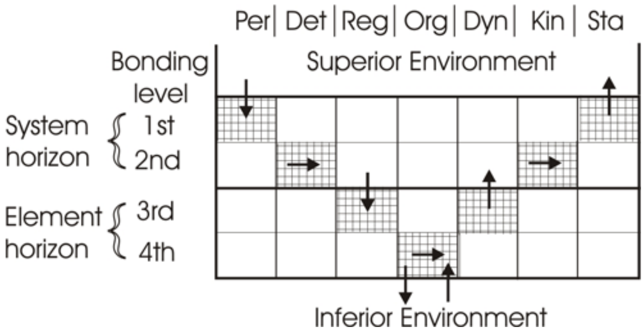


Fig. 68: The course of the process sequence (induction process) in the system horizon and the element horizon of a non-equilibrium system (see also fig. 67).
Vertical arrows: Flow processes (demand or information resp. supply or energy flow), horizontal arrows: Changing and coupling processes.
At the perception stage, the flow of information (demand for products) is received from the superior environment and then processed at the stages of determination, regulation, organisation, and passed to the inferior environment, the energy resource: "adoption". From here, the flow of energy again leads up to the superior environment. At the stages of organisation, dynamisation and kinetisation, the energy is processed to the demanded products: "production". The supply to the demanding superior environment (market) takes place at the stabilisation stage.
Per = perception, Det = determination, Reg = regulation, Org = organisation, Dyn = dynamisation, Kin = kinetisation, Sta = stabilisation.

from the system to the element horizon. The higher the demand, the stronger the stimulus for the process as a whole. Thus, the perceived information has to be transformed and distributed according to the process structure of the system, in a similar way to the energy itself later, during the production stage. Seen vertically, the flow of energy is opposed to the flow of information (see fig. 68).

The formulae describing the task and control stages were already presented in the discussion of flow equilibrium systems (see section 2.3.1.2). The formulae as such have already been listed in section 2.3.4 dealing with the third type of process, but in the order corresponding to the U variant. Here, in association with the remaining processes, the task stages are described by functionals which dictate the types of calculation (see also section 2.2.1.2). Let us attempt to describe these processes at a more general level using the example of the textile mill and its departments (see fig. 64).

"Perception" (1^{st} bonding level): In this task stage, the demand from the superior environment is entered into the system, inasmuch as the size (according to the constellation of elements), permits. The system "perceives". The performance of the system demanded by the superior environment must be transformed into the system according to its size. All elements have to be considered. The greater the demand, the greater the stimulus. In this way, the extent to which the system would be stimulated is reflected. This is described by logarithmic functions. Carrier in the factory: The marketing department.

"Determination" (2^{nd} bonding level): The system, however, cannot be stimulated at will. How much stimulation strength the elements (as the potential adopters) can still accept is determined in this task stage. Here it is evaluated and decided whether the stimulus to production should be accepted, and if so, to what extent (depending on the capacity of the company). The value of the stimulation strength must be reduced, as some elements are already stimulated. The system determines the extent of the accepted stimulation. The result is a reduced value. This is described by rational functions. Carrier in the factory: The board of directors.

"Regulation" (3^{rd} bonding level): At this task stage the stimulation strength of the system has to "regulate" the internal distribution of the limited stimulation among the number of elements. An attempt is made to achieve an internal flow equilibrium between the stimulation which is supplied from the system horizon, and the stimulation which is demanded from the elements. The elements become definite adopters, i.e. the demand for action is accepted by the elements step by step. This is described by exponential functions. Carriers in the factory: the planning department, middle management, employees' representatives.

"Organisation" (as a part of the adoption main stage; 4^{th} bonding level): The demand for energy is communicated to the inferior environment. The transition from the main stage of adoption to the following main stage of production now takes place. As already discerned in fig. 66, the upward slope of the demand curve terminates while the supply curve changes to the y-positive zone. In the production stage, the work is carried out according to the adopted information.

"Organisation" (as part of the production main stage; 4^{th} bonding level) merges with the organisation stage of Adoption (see Fig. 70): The systems in the inferior environment now produce the raw material or energy demanded by the system. The number of adopters which become producers depends on how much energy can be received from the inferior environment. The transition from adopters to producers can therefore only be defined with a certain degree of probability. This is described by probabilistic functions. Carriers in the factory: the purchasing department and stores administration.

"Dynamisation" (3rd bonding level): In the meantime, the systems of the inferior environment have provided the energy for production and supply it to the system. Here, they are distributed to the workers (or work groups) and the action projects. In this way the system is "dynamised". This in turn is described by exponential functions (as for "regulation", see above). Carriers in the factory: the raw material store, coal bunker etc.

"Kinetisation" (2nd bonding level): The elements adopt the assignment and produce accordingly. The different individual energies or materials are combined to form new products. This is the actual production. Rational functions describe this (as with "determination", see above). Carrier in the factory: the production department (machine shop, boiler house).

"Stabilisation" (1st bonding level): The products are offered to the elements of the (demanding) superior environment. (This is described by logarithmic functions.) This decides whether the products (and the system) can maintain their position (feedback). In this way, the system is "stabilised". At the same time, a new induction process can begin (perception). Carriers in the factory: the sales (marketing) department and dispatch store.

Thus, through feedback, it is determined whether the supply corresponds to the demand. In the course of the process the demand may change (see section 2.3.1.1, fig. 38) with the result that oscillations occur. A cyclic process is described, i.e. a chronologically coordinated process with its start and finish in contact with the superior environment (see fig. 69). The control is more complete than with the flow process because not only entry and exit are controlled, but also the individual stages.

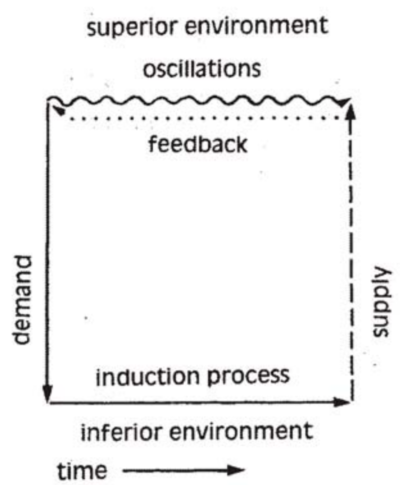


Fig. 69: Circular process and feedback in the non-equilibrium system. Induction process.
The induction process commences with the receipt of the demand and ends with the supply to the market (superior environment). The feedback takes place through comparison of the supply with the demand.

Control processes:

In detail the control is carried out by the control processes. For the organisate, this means that the task in the next stage can only be undertaken when the requirements in the inferior bonding levels have been fulfilled, until when each element has been involved. Here the bonding levels do not appear as flow equilibrium systems as they do above in the task processes, but in their structure within the non-equilibrium system. The relationship of the whole to the elements is controlled here.

The process consists (depending on the succession of bonding levels) of 4 stages:

- 1st bonding level: the stimulus is entered from the superior environment. Here, the system may be regarded as a more or less undifferentiated quantity of elements. The limits of the system have no effect on the organisation of the internal process.
- 2nd bonding level: the stimulus is taken up by the system which is defined by its limited number of elements. This affects the course of the process.
- 3rd bonding level: system horizon and element horizon form a flow equilibrium. Both relate to one another.
- 4th bonding level: through its elements, the system comes into contact with the inferior environment in order to receive energy. The system as a whole and all the elements are now affected by the stimulus.

Thus, the elements are bound progressively more tightly ("control process stages" or "control stages" for short). These 4 levels must be gone through, and the values are transferred in each case. Besides this, in every control stage, the values from the same stage in the previous task stage are taken in.

In the discussion of the flow-equilibrium system (section 2.3.1.2), we explained that the task processes cross the bonding levels between the superior and inferior environment and are thereby ordered. Here, in the second process train in the non-equilibrium system, the bonding levels are in turn ordered by the task processes. At the task stages, the individual control processes lead alternately downwards (order) and upwards (obedience)(see fig. 70).

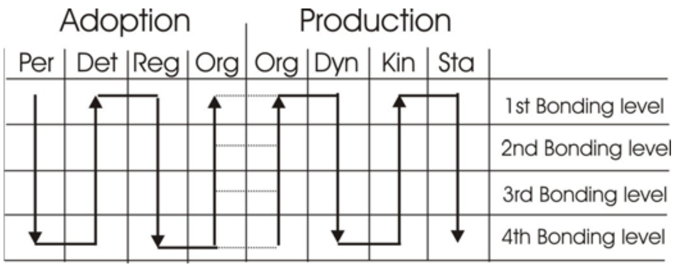


Fig. 70: The course of the control processes at the individual task stages.
The bonding levels are passed through at each stage of the task process, i.e. system and elements are connected. In the diagram, the control processes are indicated by arrows, and the links by horizontal strokes. See also fig. 77. Abbreviations: Per = perception, Det = determination, Reg = regulation, Org = organisation, Dyn = dynamisation, Kin = kinetisation, Sta = stabilisation

In this way, a transition between task processes becomes possible. At the corner stages of perception, organisation and stabilisation of the main process stages (adoption, production, reception, reproduction) the control processes proceed parallel to one another with the result that here too, the transmission of data during the process is facilitated. Precise control of the course of the processes in all main and task stages becomes possible.

Elementary processes:

In addition to this, the question of space requirement also has to be solved at each bonding level. When dealing with the first train of processes in the non-equilibrium system (see above), we saw that the system as a whole is compact in form and affects its environment spatially (long-range effect). There now follows a similar process in the second train of processes at the 4^{th} bonding level. Non-equilibrium systems require space not only externally, but also internally for their processes. These spaces are structured radially (between centre and periphery). The "elementary processes" order the system according to thematic and structural considerations in line with the task and control-process stages. The space requirement therefore has to be fixed for each of the 16 stages of the control process (divided up according to task) in the adoption stage. A spatial value is assigned to each of the resulting values in the different control stages. In this way, the various control stages of the conversion process receive their contours. [This also applies to the other main stages].

The mathematical formulae are given in the section dealing with the first process train (see above, and fig. 77).

Reaction process:

"Adoption" and "production" belong (as mentioned already) to the "main process" which includes a total of 4 stages. Adoption and production serve the market ("induction process"). If the market is satisfied, the company is adapted to the new situation on the basis of experience and according to feedback at the stabilisation stage. This is as the second half of the main process the "reaction process". To adoption and production are added "reception" and "reproduction". It leads to another process line (see below, twin processes). The oscillations around the abscissa described above have an effect on the direction of the process. The fact that the induction process is located above and the reaction process below the abscissa, indicates that the induction process stimulates the production whereas in the reaction process, activities regulate the optimising of the system itself. This is where the actual "self organisation", typical of non-equilibrium systems, takes place. The system "learns".

However, the sequence of tasks from perception to stabilisation remains the same (see fig. 71). The sequence developed for the induction process assumes that (1) the information has to be processed before (2) realisation can take place. To that extent, reproduction follows on reception. However, in these main process stages the task stages too are arranged in this sequence. Stimulation by the preceding process takes place here and first has to be introduced into the system as a whole (perception) while later, energy is procured from the inferior environment for the reconstruction of the system (organisation).

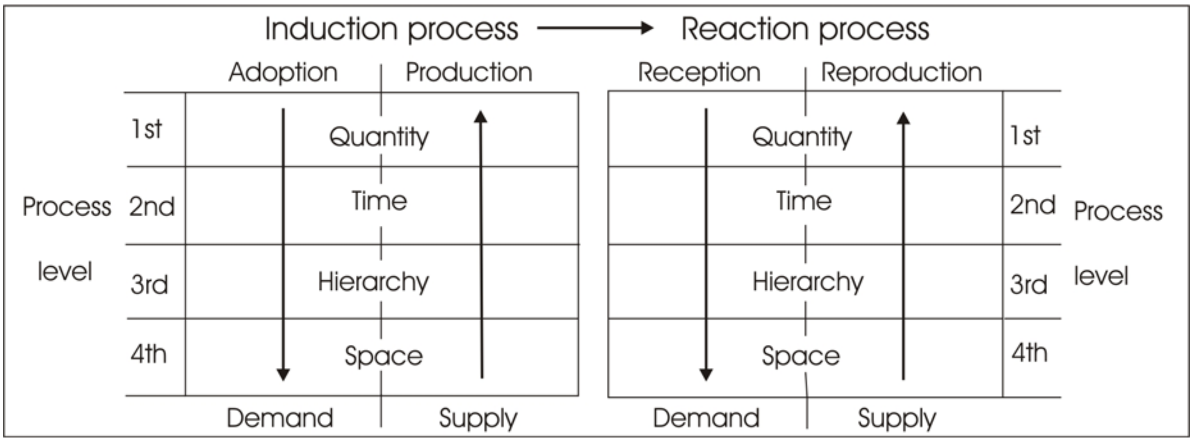


Fig. 71:
Course of the processes between the process levels at the induction and reaction process

Taking the example of the organisate:
The structure and size of the organisate required for the activities of the organisate are dealt with in the main process (1st process level). At the 2nd and 3rd process levels, the chronological sequence (task process) and vertical hierarchy (control process, bonding levels) are ordered. The process leads from task process stage to task process stage. Subordinate to the control process stages the space is arranged (4th process level). The process stages join up with one another in the same way as in the induction process (see above). The result is:

Reception:
- Perception: input of stimulus from the preceding induction process into the system;
- Determination: decision whether the stimulus should be accepted, and if so, to what extent (system);
- Regulation: distribution (ramification) of the information to the elements;
- Organisation (as part of the reception main process): arranging the structure for receiving energy;

Reproduction:
- Organisation (as part of the reproduction main process): reception of energy from the inferior environment;
- Dynamisation: distribution of energy to the elements;
- Kinetisation: execution of the structuring and shaping of the system (i.e. investment);
- Stabilisation: the new system structure is offered to the following induction process.

Course of the processes:

Process sequence as an entirety:

Let us now look at the process sequence in general:
Main process (containing both the induction and the reaction process), task, control and elementary processes consist of 4 stages each. Each stage of the superior processes contains one subordinate process which itself consists of 4 stages (see fig. 72). The number of processes and stages therefore increases exponentially from the 1st to the 4th process level, i.e. (4+16+64+256=) 340 process stages altogether (but only 20 different formulae; see sections 2.3.1.2 and 2.4.1.2).

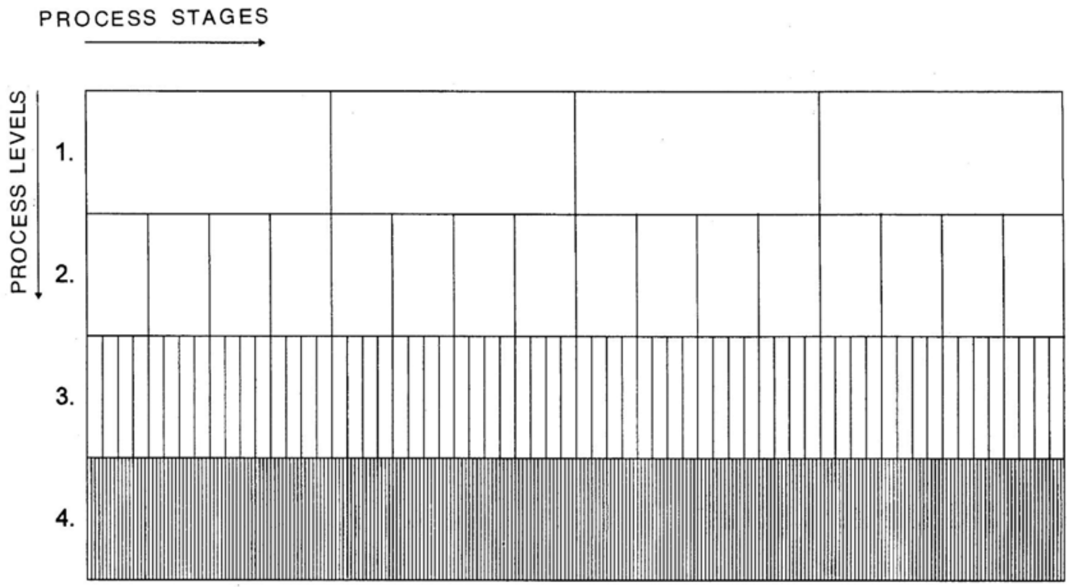


Fig. 72: Hierarchy of the processes in the overall non-equilibrium system. It is apparent that the process sequence is divided into 4 process levels, where the inferior processes in each case, each with four stages, are assigned to one stage of the superior process. Thus, the entire process sequence includes 4 + 16 + 64 + 256 = 340 stages.

Here, all the process stages (including the formulae) have to be assigned codes to avoid confusion. To this end, it is advisable to use a numerical code (see fig. 73). The formulae describing the four stages of the basic processes are each arranged in reverse order (1-2-3-4, 4-3-2-1; see below and section 2.4.3).*)

*) In earlier publications, I used a code based on letters instead of numbers (S-T-U-V now changed to 1-2-3-4). A change in code was necessary to avoid confusion with the system dimensions.

Adoption is followed by production (see above). If the order of the task-process stages in the adoption stage is 1-2-3-4, the task-process stages in the production stage are the other way around 4-3-2-1. Thus the fourth task-process stages (organisation), come into contact with one another (probabilistic functions) and unite, with the result that there are only 7 instead of 8 task stages.

The transition from the reception to the reproduction stage in the reaction process is similar. Here, the stimulus is passed on at the 4^{th} bonding level. Thus, instead of 8 there are only 7 stages at the second process level in the reaction process.

The corner stages also overlap at the transition from the induction to the reaction process, thereby resulting in 13 instead of 14 stages.

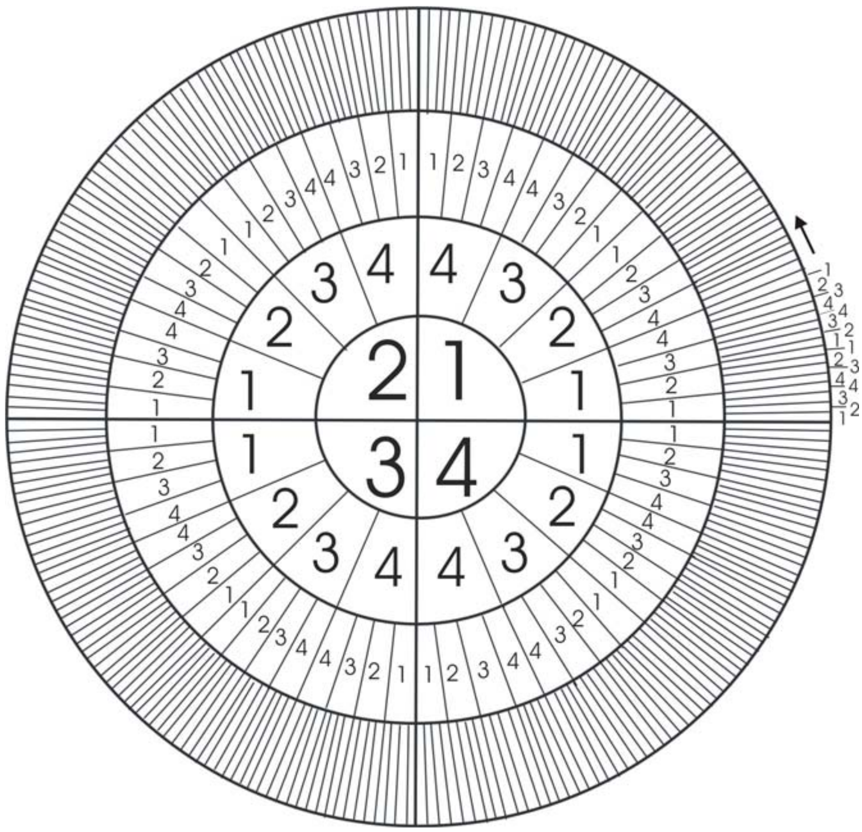


Fig. 73: Hierarchy of the processes in the non-equilibrium system.
Shown on the basis of the numerical codes. The main process is placed on the inside. Moving outwards, the task, control and elementary process follow. The process is aligned to the left (in anti-clockwise direction). The numerical codes (e.g. 1.1.4.4) allow identification of the appropriate functions (see text).

Structure of the process course: demand-supply-relation and twin processes:

The process sequence is not continuous. It has two interior borderlines which make it nearly indeterminable:
1) Between demand and supply at the transitions between adoption and production and between reception and reproduction:
Until now we have concentrated mainly on the demand process without giving much attention to the corresponding supply process. In the induction process, as shown, the system is stimulated via the demand process from the superior environment while it receives energy from the inferior environment through the supply process and then supplies it as a product to the superior environment. In the reaction process, the demand process stimulates the system to change itself. The supply process provides the energy necessary for this so that the system can complete the change. The relation between the two corresponds to the Lotka-Volterra equations (see formula 15, section 2.3.1.2). The supply process is in social

systems delayed by about one quarter of an oscillation period in relation to the demand process and does not start until the demand process has passed through the adoption stage and is entering the production stage. I.e. the adoption stage of the supply process is simultaneous with the production stage of the demand process. Or more precisely: at the organisation stage of the demand process, the demand for energy is introduced into the supply process. This represents a stimulus in the supply process at the perception stage. This applies both for the induction and the reaction process, both of which take fundamentally the same course i.e. have the same sequence of task processes. At the reception stage of the demand process, the demand for change in the system

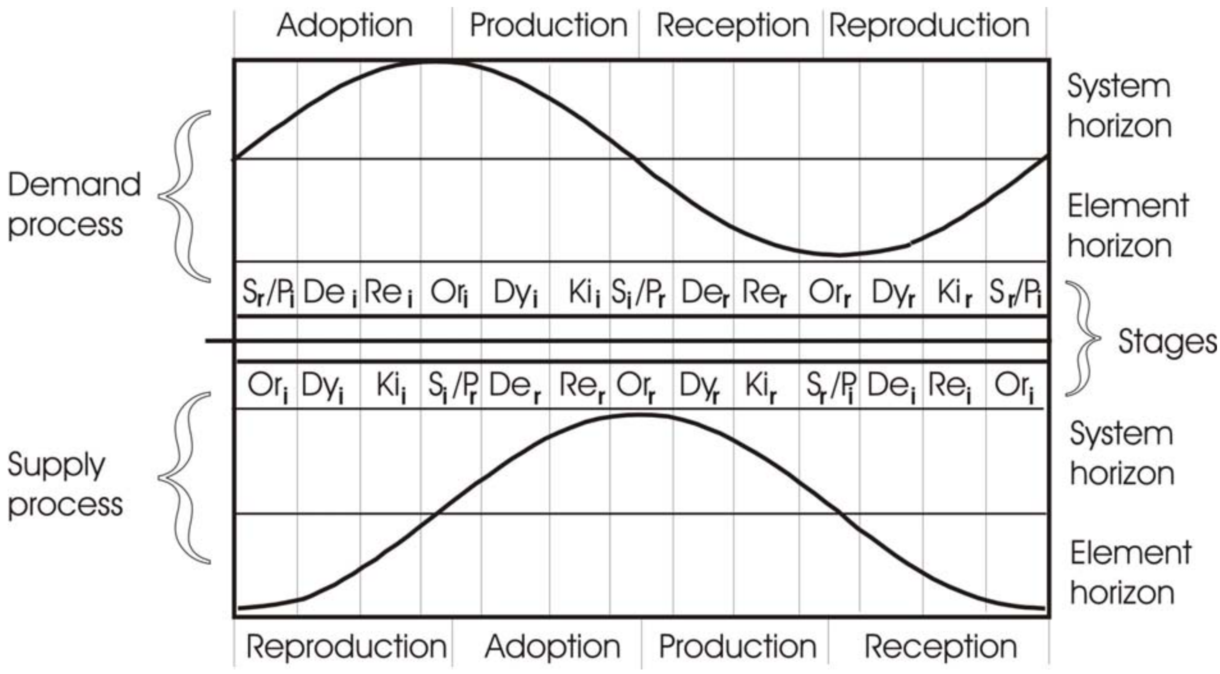


Fig. 74: The supply curve follows the demand curve with a certain delay.
See also fig. 66 above. Abbreviations: P = Perception, De = Determination, Re = Regulation, Or = Organisation, Dy = Dynamisation, Ki = Kinetisation, S = Stabilisation. i = Induction process, r = Reaction process.

is passed to the system itself. At the reception stage of the supply process, the system absorbs this stimulus while the change itself takes place at the reproduction stages of the demand or supply process (see fig. 74). First of all the system as a whole (demand) changes and then the elements (supply) follow, which at the same time are systems of the lower environment (see section 2.5.1.2).

2) Between the induction and reaction processes, i.e. between market orientation and self organisation:
Empirical research shows that (at the base) induction process follows induction process and reaction process reaction process. Examples of this are provided by phases of colonisation and the diffusion of innovations (see sections 2.3.2.2 and 2.6.2.2). This

is a problem inasmuch as the induction process follows the reaction process. This can only mean that two processes A and B, shifted chronologically by half an oscillation phase, proceed

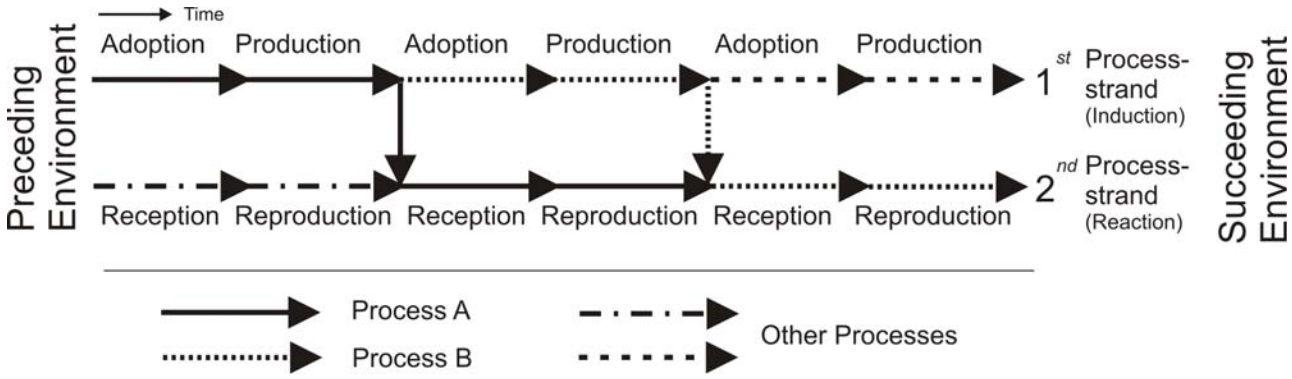


Fig. 75: The course of the induction and reaction process on two different tracks I and II (twin processes)

parallel to one another (see figs. 75 and 76). Demand process A (induction process) reaches its climax when demand process B (reaction process) is at its lower point, and vice versa. The same applies for the supply processes, but with a delay of a quarter phase. Plainly, two processes (A and B) – by using adjacent strands – are interacting with one another with the result that the reaction process B can take place in the second strand at the same time as the induction process A in the 1st process strand. This means that time is put to double use. Are we dealing with a stationary wave?

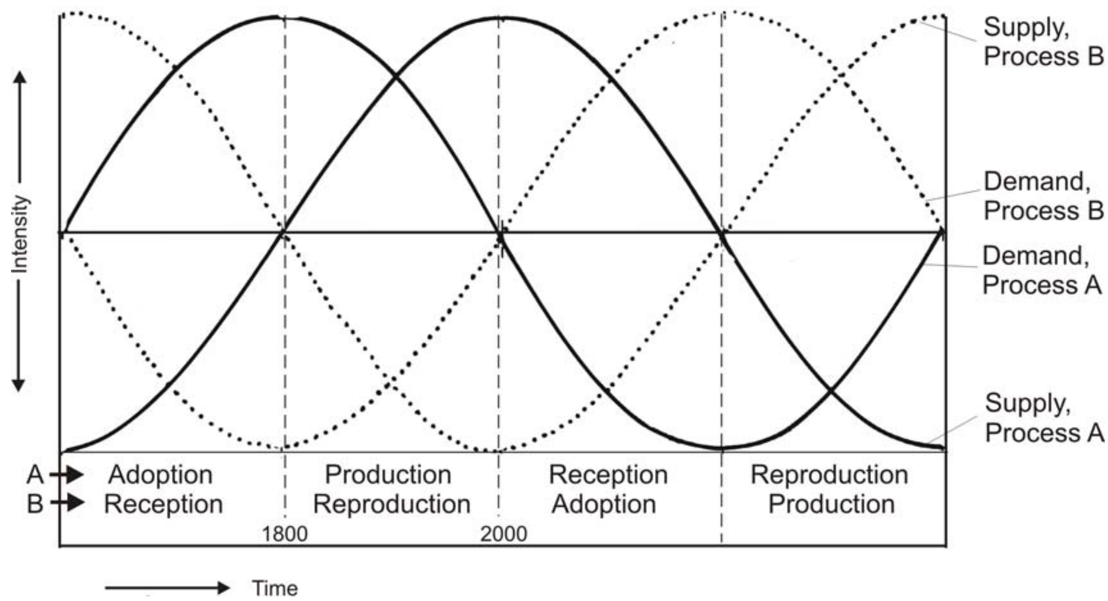


Fig. 76: Course of the demand and supply curves of the twin processes (A and B) which follow one another chronologically offset by half a process length. The upper half is occupied by the induction process, the lower half by the reaction process. For the yearly figures, see Fig. 86. *See also Fig. 66.*

We describe these parallel and interacting processes as "twin processes". Let us look more closely at the twin processes. In the textile factory, the repair (reaction process) of the damage from the preceding production phase (induction process) is carried out. While this work is taking place, the production (i.e. the next induction process) continues. (In addition to its production facilities, every larger company has to maintain workshops to carry out repairs of this kind). Seen geometrically, the corresponding process halves (induction and reaction process) of the two twin processes are interwoven with one another in the manner of a plait, with the result that an induction process can follow an induction process and a reaction process a reaction process. With regard to content however, the reaction process remains connected with the induction process which precedes and causes it. It's tasks are carried out simultaneously with the next induction process.

In reality, there is no clear-cut transition between the individual process halves (induction or reaction process). This smoothness is reflected in the probability transitions (see above). This gives rise to a certain degree of vagueness. The two twin processes A and B for their part are still divided into demand and supply processes. Through them, as described above (see section 2.3.1.1) the (superior and inferior) environments are involved and oscillations released (according to the Lotka-Volterra equations).

The result is a 4-strand process:
1) Demand process in twin process A
2) Supply process in twin process A
3) Demand process in twin process B
4) Supply process in twin process B.

There is a transition between twin A and twin B which depends on the result of the feedback at the end of the induction and reaction processes (see above). Since the induction and reaction processes begin and end at the same time, a transfer of information and energy is possible at the perception or stabilisation stages. This makes coordination possible. In this way, a rather confusing co-existence of individual processes and intertwining at system and element level is produced. One example of an extremely complex twin process is cultural evolution (see section 2.4.2.1).

In detail the sequence of the process is shown in fig. 77.

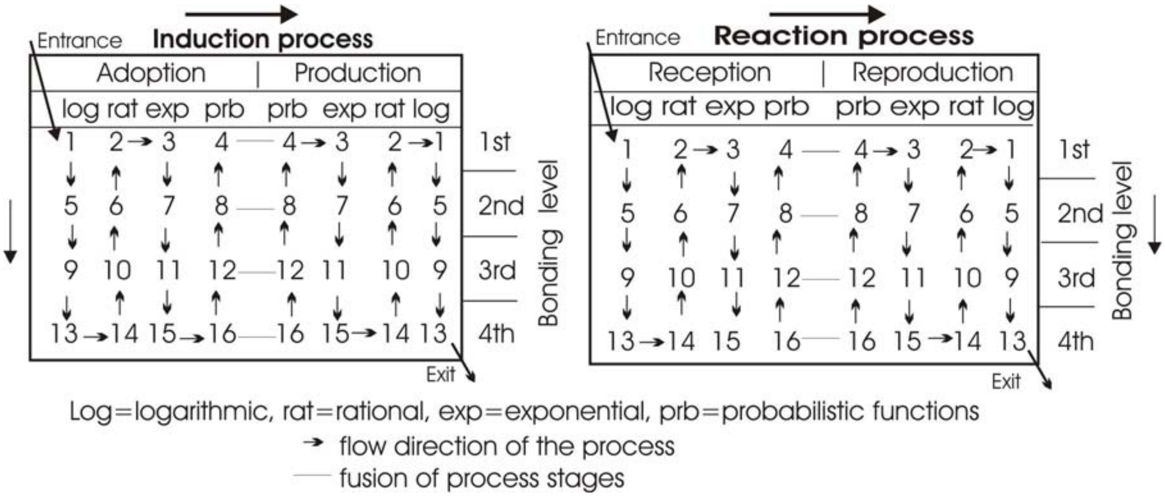


Fig. 77: The course of the processes in the induction and reaction process.
The figures reflect the numbers of the formulae (see section 2.3.1.2).

For guidance:

Mankind as a society consists of many different populations which appear structurally as non-equilibrium systems. This type of system is composed heterogeneously and is distinguished by its division of labour, i.e. various processes are coupled together thereby creating a product. It is demanded by the superior environment (e.g. the market) and is produced in the induction process. The inferior environment (e.g. the suppliers) supplies the required energy (raw materials etc.). In the following reaction process, the system organises itself according to the require-ments.

Two process trains should be distinguished:
1) The system is shaped spatially as a whole from within.
2) The system receives energy from outside, is chronologically determined from outside. Four hierarchic process levels should be distinguished:
a) The main processes organise the flow of information and energy (induction process: adoption and production; reaction process: reception and reproduction).
b) The task processes divide the process according to subject (adoption or reception: perception - determination - regulation - organisation; production or reproduction: organisation – dynami-sation - kinetisation - stabilisation).
c) The control processes organise the flows in the hierarchy system/elements internally.
d) The elementary processes organise the space requirement internally.

The course of the internal process is controlled by the fact that the four process stages are joined hierarchically with one another.

The course of the process can be traced back to
1) the contrast between demand (from the superior environment) and supply (from the inferior environment). Here, the rhythm of the processes is also dictated by oscillations.
2) the contrast between induction process and reaction process. Both oscillate against one another and each consists of a demand-supply "oscillation pair". Thus, four individual oscillations should be distinguished which are woven around one another in the form of a braid.

2.4.2. Other examples

2.4.2.0. Instead of an introduction: Conversion process and non-equilibrium system as seen by an artist

Processes which are based on the division of labour are not often seen in art. This is doubtless due to the difficulty involved in such a project.

Fig. 78: Raoul Dufy, The Orchestra.
Example of a conversion process based on the division of labour.
Source: See "Notes on the figures".

In 1942, Raoul Dufy executed a series of pictures showing the work of a Paris orchestra with whose conductor he was acquainted. His aim was to represent the interplay while emphasising the peculiarity of the individual instruments. He wrote that different colours can be attributed to the instruments – oboes, flutes, violins etc. – depending on their role in the orchestra as a whole, and that geometric patterns have certain associations for him (KLANG DER BILDER 1985, S. 254/5; MALEREI 1986, S. 196).

According to him, every moving body leaves a coloured image on the retina whereas the corresponding outlines rapidly disappear again. Water colours offered him the most suitable medium to convey this. His representation shows on the one hand the movement of the musicians when playing, and on the other their interplay under the conductor (see fig. 78).

Seen economically, the orchestra is a good example of a highly disciplined jointly executed conversion process based on the division of labour. Notes are converted to music and the symphony is the product.

2.4.2.1. Example of a complex conversion process: The cultural evolution in Europe since 1800

About the method of the investigation:

There is little point in scrutinising the structure of a highly complex process by means of a cross-sectional analysis as it can convey only a very rough impression (see section 1, Introduction). We will therefore attempt to gain an insight into the structure by taking the processes as our starting point.

First of all, a few remarks on methodology:
The subject we have chosen for examination is the cultural evolution in Europe since 1800. For European society, the French Revolution opened the way into a new age. The ancient structures of absolutism were broken down, the outmoded social stratification disappeared and new hierarchies came into being. This development led us towards the industrial society. Economic structures altered radically and production in industry and mining increased along with the population. The network of settlements became more closely knit creating the large conurbations of modern times. Traffic was directed into new paths. New forms of human co-existence developed, clearing the way for an intellectual liberation. New vistas opened up in art and science.

This period in time has been examined exhaustively with idiographic objectives. However, we are less concerned with presenting a wide spectrum of facts and processes emphasising the special nature of Europe as a cultural area and the evolution of culture during this period. Instead, the following reflections are intended to throw light upon the changes in human society as a complex structure.

The first question which arises is how to obtain a differentiated picture of the course of this process. Cultural evolution consists of a large number of individual processes which affect one another mutually. They also have quite different durations, beginning and ending in different times which means that the division of the overall process into periods can only be very vague. In my view, it is necessary to start from the detail, i.e. from individual clearly defined processes. Of course it is impossible to analyse all the processes involved, but only those which may serve as indicators. The selection is based on the extent to which they represent and embody the material, structural and spatial position of man as an agent in his environment.

We will now look at those processes which permit conclusions with regard to social and cultural change itself. This means that we are attempting to view the population from inside; it is not the productive side of the process which is of principal interests. This would be equivalent to the induction process. Instead, we are dealing here with the reaction process. The productive side of the cultural evolution will be discussed in a different context (see section 2.5.1.1, and 2.5.2.2).

The question is this: How does man see himself in society, in his world, how does he adjust to it and come to terms with it? We will then discuss whether any common features exist behind the observable phenomena, e.g. structural features which have changed in the course of development and have decisively affected the overall process of cultural evolution.

1. First of all let us take art, and in particular that of painting. On the one hand, the painter exists as subject and on the other, the real or intellectual environment as object. Perhaps the artist attempts to reproduce a landscape or catch the character and thought of a person in a portrait. He may depict his own relationship to his chosen subject and reveal feelings or illusions with the content of the picture serving as a vehicle for these. His view of his environment and space is reflected indirectly in his choice of subject and its artistic interpretation. The artist is incorporated intellectually in his society. In many cases he may foresee certain developments and attempt to draw attention to them.

2. Philosophy concerns itself directly with the position of man in his world as seen from differing angles. The fundamental science is metaphysics, which enquires what is "behind nature", conveys a certain view of the world. Ontology on the other hand analyses being and reality and the possibility of recognising these. Philosophical anthropology sees man in his position in the development of nature and the process by which culture comes into being. Over the course of time, philosophy has given many different answers and has shown itself to be an acute observer of social development and human thought and action. In the theory of perception and science common ground exists between philosophy and the natural sciences. Methods and concepts are developed in which space, time and matter play an important part. In our essay we will refer to the natural sciences only inasmuch as they are of importance to questions on hand.

3. In this context, geography is also of importance. It deals with the earth, its physical phenomena and social structures, analyses and comments on changes in society. It covers a wide material spectrum while maintaining close contact with related sciences such as regional geology, meteorology, ecology, sociology, economic and cultural sciences. Geography has always seen itself as the "science of space" – space being given a number of interpretations. It is precisely this aspect which is of importance for the position of mankind in his universe. This is particularly true of human geography, where one of the central objects of research is the man's relationship to the natural environment on one hand and to society and culture on the other.

Perhaps these different disciplines are most suitable for covering a spectrum which may be regarded as representative with reference to our enquiry mankind-universe. In the following these indicators will be used as a basis for elaborating the development of the European cultural population against the background of the complex structure of society. There are 4 stages recognisable:
1st the material stage,
2nd the functional stage,
3rd the systemic stage, and
4th the process stage (evolving).

The material stage:

Painting in the Romantic period:

Around the year 1800, a fundamental shift in perspective took place in the visual arts, especially in Germany. Until then, there was a certain distance in the artist's relation to his subject. It was the things, persons and landscapes whose essence he tried to grasp, it was the moments whose importance he sought to preserve. The Romantic Movement brought a more dynamic view of the world. A shift in emphasis took place and the artist brought himself into the process. The subjects of the paintings remained material, they were accurately painted and easily understandable to the observer. The paintings were correctly constructed and their overall conception remained within the conventional framework. But now the artist presumed to make a general statement of his own, to show feelings and pursue certain intentions. Painting became a reflection of personal feeling and sensitivity (WARNKE 1988, pp. 35), while retaining an awareness of individual responsibility dedicated to higher purposes.

The objects in the paintings were subjected to this. They were selected in accordance with the purpose in mind, and occasionally altered when it suited this purpose. Material elements such as people, trees, mountains etc. could be removed or added to the subject being painted. In this way the artist became able to convey such things as, for example, religious feeling (Friedrich), happiness and warmth within the family (Richter), identification with the history of a region or

Fig. 79: Caspar David Friedrich: Morning. Example of a romantic painting.
Source: See "Notes on the figures".

of a people and its legends (Schwind), beauty and drama in the landscape (Constable, Turner), ironic criticism of petty bourgeois habits and attitudes (Spitzweg) or appeal to national emotions (e.g. Delacroix). Symbols became more important. Thus, new creative possibilities and fields of experience came to be explored and developed (GEISMEIER 1984, p. 10).

The artist also became more emancipated socially and economically. Where previously he had been a tradesman or servant or employee of the powerful, he now became a free agent who was able to liberate himself from dependence and convention, but also had to forego the relative social security which these offered.

Example (forest painting 1): Caspar David FRIEDRICH: Morning (see fig. 79): Friedrich's romantic landscapes which are so full of symbolic and allegorical meaning are intended to express wistful sensations of transience and eternity. Everything they contain is unutterable longing (BOCOLA 1997, p. 98). Friedrich painted this picture around 1820. The subject is apparently taken directly from

nature, the contours of the mountain in the back-ground, the shore, the poles in the water all indicate that the composition is not contrived. It is interesting that Friedrich did not name the painting by the subject. He was more interested in the message, in speaking to the observer through the beauty of the scene and the religious awe stimulated by it. The scene is divided into three levels:
- First there is the shore of the lake with the fisherman which reminds of the day-to-day toil of human existence. The house symbolises security and warmth.
- The second level: Morning mist lies over the scene. The fisher is unable to see upwards or far into the distance.
- The third level: Spruce trees loom above and behind, dominating this part of the painting. The oversized forest towering above the man symbolises the Christian view of life (BÖRSCH-SUPAN 1973/80, fig. 24).

Philosophy:

Intellectual change began to take place almost simultaneously, and made itself felt most strongly in the fields of philosophy and natural science.

Metaphysical concepts:
Kant's idealistic view of the world was put more and more into perspective. The Schlegel brothers developed a program which gave the new artistic and scientific impulses a philosophical framework. The guiding principles of thought were no longer harmony and universal reason. It was now subjective feeling and thinking which formed the starting point in the search for the divine which eclipses all reality. The emphasis was no longer on being, but on striving.

In this way, the individual also became involved. In the process of perception, the "human" attained much greater importance. Reason and consciousness obtained the status of the "objective" an idea which became fundamental to the development of science – knowledge as accumulated perception (CASSIRER 1922-57/94, III, p. 256/257).

An even more radical step was taken by Schopenhauer. He shared the opinion of Kant that reality, the universe in itself is only available to us as appearance, that it only exists in man's imagination. He wrote that everything which is available to perception, i.e. the entire universe, is only object in relation to subject ..., a conception of the conceiver, or, in a word, imagination ("Vorstellung"; SCHOPENHAUER 1818/o.J., vol. 1 p. 33). The human body can, on the one hand, be experienced through imagination, through the chain of cause and effect with other objects of our conception, but also through the act of will which comes from man himself i.e. from the subject.

According to Schopenhauer, the intellect (and with it, access to space, time and causality) proves to be subordinate to the will, i.e. serves the will. The will is primarily an undirected existential drive, the will to live and to act. It is unconscious and everything is controlled by it. Thus, subject and object relate to one another. An objective being is unconceivable without the subject and vice versa. The continuing process of perception of the universe is also the continuing process of liberation from the universe. Schopenhauer expresses in words the forces which inspired the artists and drove science onward to new progress.

Schopenhauer's thought also had a significant political influence. His philosophy formed an important prerequisite to the social and philosophical reflections of MARX (1867/1962-64) who analysed conditions in capitalistic society and demanded their change. Society is not a more or less static entity, but is subject to change which is stimulated by conflict (manifested in the struggle between the social classes) between the old and the new, the outmoded and the progressive. Marx saw the existing social conditions (the being) and the perception to change them (consciousness) as being in a dialectical relationship to one another.

Positivism and scientific theory:
The opposition between observer (i.e. subject) and object forms an essential precondition for science which is free of preconceptions. This is the fundamental distinction between the scientist on the one hand and the philosopher and artist on the other. However, he can involve himself to the extent that he not only describes what research has learned, but also explains it. This requires consideration with regard to method. A fundamental role in the development of method in the empirical sciences was played by Comte and Mill, who founded positivism. The fundamental principle of positivism is that each sentence which is not strictly limited to a simple statement of fact, can have no real understandable meaning (CASSIRER 1922-57/94, IV, p. 15).

According to Comte (and Newton) time and space are infinite, which means that our knowledge can never be complete. Thus man is central. All research must proceed from him. Humanism is the aim of science.

Mill proposed a general doctrine of scientific method in which he separated the natural sciences from the humanities. He thought of developing the method in such a way that it could also be applied in sociology and politics. Inductive research should be founded on accurate analysis and the results should be capable of generalisation. MILL placed the historical sciences in the same category as the natural sciences.

WINDELBAND (1894, pp. 10) and RICKERT (1902, p. 226) also separated the natural from the humanities. However, they believed that the historical sciences were part of the humanities, for which hermeneutic "understanding" was the appropriate method. With the natural sciences however, it was causal explanation. Moreover, they regarded the humanities as being idiographically oriented, as relating to the special and the individual. The natural sciences however were nomothetic, i.e. directed towards the general and the regular. However, they were also of the opinion that natural-scientific questions could be treated in the humane sciences, and historical in the natural sciences.

The preoccupation with the relationship between man and the universe gave science a strong impulse. From now on, theoretical and empirical enquiries complemented one another and presupposed one another. The emphasis was on classification, the exact designation and explanation of forms and phenomena. Attention was focussed on the environment as an object. The different method of explanation and the growing awareness of the details of reality enforced specialisation and the division of science into a number of single disciplines.

Geography:

In the early stages of its development, geography had to find its own way. It took little part in the economic and cultural development of society, but regarded itself as a pure science whose purpose was to examine the earth scientifically. But first of all, it had to define the subject matter and the method more closely. "Form" was seen as being the most important unit of the terrestrial environment accessible to analysis (see section 2.1.1.1).

On the one hand it was possible to represent the forms in their spatial association, thereby allowing the identification of regions of a specific shape. On the other hand, the forms could be described as types and examined with regard to their origin. Accordingly, geography made a distinction between an idiographic and a nomothetic branch, i.e. between regional and general geography.

Regional geography:
Regional geography saw it as its task to define and classify the various material phenomena of a terrestrial area (i.e. the forms or aggregates of forms) and present these in the unique spatial co-existence to the reader. Presentations of this kind were also required outside scientific geography. There was an enormous requirement for information about the "wide world". However, there was also an interest in one's own country. In the period following the end of the Napoleonic Wars, patriotism and nationalism grew in importance in Europe. People wanted to know about their own states.

The terrestrial area (which was regarded as 3-dimensional) was defined by its material content. The forms made up spatial aggregates or regions. However, the borders of these regions were generally less distinct because the forms of different kinds (e.g. surface forms, settlements, industrial plants) may be differently distributed. It was the task of the geographers to decide how to classify the different aggregates of forms and which criteria to choose for their division and demarcation. This was the work of the researcher.

The decisions were based on an understanding or the hermeneutic method. However, at this early stage in the development of geographical science around 1900 they could not be treated very precisely as it was still not known that only knowledge of the structure permits a more exact statement regarding regional formation. Thus, the works of regional geography at that time were mainly compilatory in character (v. RICHTHOFEN 1903), i.e. they summed up the knowledge available at the time.

General geography:
The actual research was to be found principally in general geography. It was divided into 2 large areas according to their area of interest, i.e. physical and human geography. These in turn could be divided into their fields of research which examined such things as the forms of the earth's surface (geomorphology) or climate (climatology), or patterns of settlement and economy (settlement and economic geography). They had a mutual influence on one another, formed "geofactors" (SÖLCH 1924). There was a desire to understand the effects of the "forces" themselves as well as the interrelationship and its significance for the formation of the settlements, countries or regions. The choice of words makes plain that the forms in each case were subject to causal explanation (BUNGE 1929/87; see also section 2.1.1.1).

Human geography:
In human geography (which we will look at more closely here) the central subject was the relationship between mankind and his terrestrial environment. The activities of mankind are recognisable in his works, settlements, economic forms, traffic courses, defensive structures etc. and open to causal explanation (see section 2.1.1.1). They were described as definable anthropogenic forms and interpreted as effects, men being the cause, or more precisely, "anthropogenic forces". The form of causal explanation assumes that the same phenomena have the same causes. Those forces were regarded as causes which seemed to be most likely taking into account phenomena of a comparable nature. This permitted a scientific discussion, since with the increase in knowledge more progress was possible in identifying causes. And this in turn encouraged research. In this way theories could be tested and if necessary replaced by new ones.

One problem in this approach was represented by man himself, who cannot be interpreted as a force alone. But in view of his wide distribution, demographic peculiarities, religious, cultural, political and economic activities it was impossible to ignore him. That meant that he too became the object of scientific curiosity on the part of geographers wherever this was possible in view of the material available at the time.

Indeed, it was possible to see the relationship between mankind and the terrestrial environment from the point of view of mankind itself. RATZEL (1882-1891) had already assigned this question a central importance to mankind. He associated it with "soil" and emphasised the causal relationship. Space was living space ("Lebensraum") and the state was depicted as an "organism" (1897, pp.5). Ratzel did not yet have the opportunity of comparing the peoples as political units with all their differences. The statistical data was not yet available. His reflections therefore had to be deterministic in nature. That did not however mean monocausal (OVERBECK 1957, pp. 174). Ratzel was interested in the conditions without which peoples and states would be unthinkable, i.e. without 'location', 'space' or 'border' including the physical features of their areas of habitation and influence (THOMALE 1972, pp. 24).

For VIDAL DE LA BLACHE (1911), it was not space with its material content which reflected mankind and his culture (as Ratzel thought), but the other way round. Man adapts to the conditions of the soil, climate etc. but he shapes his mode of living ("genre de vie") himself. Thus, Vidal de la Blache points in a new direction. According to him, man has a certain freedom of decision ("possibilism"). However, one difficulty facing Vidal de la Blache was the fact that he based his theory on simply structured groups only (e.g. nomads). Highly differentiated industrial societies (which were already in existence) are closely bound up with one another spatially, practice division of labour and for this reason alone are less dependent on the properties of the soil than less differentiated groups.

It therefore appears that the causal method can produce results for simple relationships, but not when differentiated human geographical conditions are under consideration.

The functional stage:

Impressionist painting:

In the second half of the 19th century, a new artistic movement made its appearance in France associated with names like Monet, Degas, Renoir, Manet, Pissaro etc. (GOMBRICH 1950/96, pp. 519; BOCOLA 1997, pp. 123). Even more than in the Romantic Movement, objects were removed from their own intrinsic meaning. The artist took his easel and went out of doors to record his own personal impressions directly on canvas. This appears in the pictures. Although he reproduced the objects and persons correctly from the point of view of perspective and structure, but he no longer represented them in their actual context of meaning. Thus, their contours are often indistinct and the objects seem to blend into the background. Their coloured surfaces are reduced to dots, strokes and dabs and appear almost to be dematerialised. Through this technique, the artist was able to include imaginary things not seen directly by the human eye. In this way, the viewer receives the impression of the air between himself and the subject, of heat and light. The colours seem to be altered by the sunlight and the fall of shadow, i.e. the intervening space is also painted, so to speak, and the contours remain only as a framework holding the picture together.

Fig. 80: Max Slevogt: Forest landscape near Neukastel. (1921).
Example of impressionistic painting.
Source: See "Notes on the figures".

In this way the painter "filtered out" what he saw or wanted to see. Everything else was of secondary importance or ignored completely. Thus, the balance of the interaction between the artist and his subject shifted more in favour of the artist than it had been in the Romantic period. The Impressionists took a phenomenological approach (see below): the visible world is depicted as a purely visual one and in a phenomenality whose intrinsic meaning is not recognised (IMDAHL 1981, p. 12). The subject is freed from the previous knowledge of the observer, thereby acquiring a different meaning. In this way, it is easier to convey moods and values to him: the feeling of wellbeing when viewing the landscape, the exhilaration of the colours, the warmth of the sunbeams, identification with the person portrayed, the elegance of the company, the joy of dancing or enthusiasm for national sentiments.

Example (forest painting 2): Max SLEVOGT: Forest landscape near Neukastel (see fig. 80). In 1921, Slevogt painted the landscape close to his home in the Weinstrasse area in the German Pfalz. It sketchy in appearance, offers a fleeting impression of the forest and of the cheerful mood of the painter at work. It is not only the trees which are depicted, but the sensation, the communication between the artist and his subject, the scene of the autumn in sunshine. The trees and branches lend the painting its compositional framework. The foreground appears restless, but the distance conveys tranquility.

Philosophy:

Phenomenological and ontological schemes:
The phenomenological method already used intuitively by the Impressionists, did not receive its scientific justification until the end of the 19th century. HUSSERL (1913 etc./1985-86) called for philosophy to present itself as a strict science with logical structures of perception and consciousness. He was concerned with a knowledge of things free of all preconception. The subjective examiner no longer approaches an object as a material phenomenon (as he does in the first stage) whose cause he wishes to explain.

In the review of essence ("Wesensschau") or the idetic reduction ("eidetische Reduktion") a method is described by which things can be defined by their sense content or their essence. Each individual lives in a special world and is only able to see the phenomena within his special world. In this limited environment, the horizon is restricted and, accordingly, the ability to judge and to act. Consciousness is intentional. The individual enquires about the meaning of phenomena. For example, a house appears different from different angles, but the observer knows that it is one and the same object. The result is the opinion ("Doxa"). According to Husserl, true perception which is free of the preconceptions of the individual "special world" should take the place of opinion ("Episteme"; HELD 1990, p. 79). This means that subjective feelings, preconceived ideas, situatively variable moods, lack of overall view etc. must be removed. This refraining from any personal comment was named by Husserl "Epoché".

Phenomenology is concerned not with the existence of a thing because it may be that the thing at which the consciousness is directed, exists only in the imagination. The phenomenological examination concentrates on the essence of the object "Eidos". This procedure also includes the dissection of the object into its parts and the description of the parts.

The phenomenological method is therefore designed to facilitate intersubjective communication and therefore raises the problem of structure in a universe accessible to general perception (see also STEGMÜLLER 1987/89,I, pp. 56). Thus, the work of the scientist becomes much more complicated than with the causal method. He must obtain the data which permit him to penetrate into the essence of the object under examination in order to make intersubjective communication possible.

Definition of man:
Philosophical anthropology in particular received a powerful stimulus from the phenomenological method. It examines the task or function of man or his position in the universe. For SCHELER (1928/47) for example, man himself was the object of examination, it was not so much the processes of intellectual consciousness which led to understanding, but the participation of the innermost core of a person in the essential being of things (STEGMÜLLER 1987/89, I, p. 97). The emotional has a decisive meaning for life, in particular for ethical understanding. On the scale of nature, man appears as a relative of the animals, but the mind gives him a position of his own, makes him into a person.

HARTMANN (1933/49) believed that the unity of the real world can only be understood when the structure and organisation of the world are understood. This unity does not appear as uniformity but as the fitting together of very differently formed diversities. Hartmann developed a layer model (p. 198) in which areas of being ("Seinsbereiche") are determined which complement one another. The actual being ("das reale Sein"; inorganic, organic, and psychophysical layer) is the unique, individual and chronological. The ideal being ("das ideale Sein") appears as an objective mind (language, science, art, law etc.). He stands above the world of individual experience and manifests himself in historical reality (HARTMANN 1933/49, especially p. 188 f.; STEGMÜLLER 1987/89, I, pp. 268).

GEHLEN (1940/62) rejected the idea of a scale and regarded man (as opposed to the animal) as a being with certain deficiencies. The resulting permanent state of danger caused him to develop well-planned systems of common action (pp. 46). He created institutions which permitted coexistence. The society with its structures and links and division of labour made life easier for the individual (pp. 62). This was how culture crystallised (pp. 80).

These theses, in particular the automatism they contain, are regarded critically from the philosophical (e.g. from the point of view of philosophical anthropology, see LORENZ 1990, pp. 68 and the Frankfurter Schule) and ethnological sides. Here in the transition area to natural science, more modern research results are touched on, which philosophical anthropology is compelled to take notice of.

Leaving aside the question of existence as Husserl had done, is, according to HEIDEGGER (1927/76), not possible for mankind (STEGMÜLLER 1987/89, I, p. 139). Although he worked according to the same phenomenological method, he maintained that the being what ("Was-Sein") of mankind was not limited to existing characteristics but to possible ways of being. His strict approach which emphasises structure and function, is apparent in his definition of certain terms. Thus, the phenomenon and the being ("das Seiende") are separated conceptually (HEIDEGGER 1927/76, p.28/29). According to him, man is not a self-contained being or a subject without interest in relation to the rest of the universe. He is placed in a certain environment or surroundings and is absorbed in it by pursuing his activities (STEGMÜLLER 1987/89, I, p. 142). This environment affects his human behaviour, but also has a hostile and threatening character which causes fear. This means that the universe is also in man, there is no barrier between the interior and exterior universe, no contrast between subject and object as with Schopenhauer. Heidegger calls this being in the world ("In-der-Welt-Sein") (HEIDEGGER 1927/76, pp. 52).

Although the French existentialists took Heidegger as their starting point, they developed an even more radical view of being. Sartres Being ("Sein") does not mean being there ("Dasein") as Heidegger's does, but existence itself (SARTRE 1943/97, pp. 37 f). This term cannot be derived or thought from a distance. It is absolutely and directly capable of being experienced. Man is left to his own devices. At the start, man is nothing. He must create himself. According to Sartre, man is condemned to freedom, the freedom to control his own actions, while introducing himself into the universe out of responsibility towards himself and others.

Science:
The work of the authors quoted above as examples, proves that the phenomenological method and its development open up completely new possibilities for viewing man and the universe in their structure and function. In this way, a hitherto unknown precision was achieved. At the same time, similar methods also led to new insights in the natural sciences.

This was the case, for example in the science of physics. It turned its attention increasingly to researching into the structure of matter, time and space. Perhaps the most important results of this were the development of the atomic model by Rutherford (1911) and Bohr (1913) and in particular the explanation of the fundamental relationships between space, time and energy as formulated in EINSTEIN's theory of relativity (1905, 1916).

Geography:

For geographers the main question was still: what is a geographical area and how is it defined. The outmoded regional geography was unable to free itself from the suspicion of serving principally for compilation purposes. The space-related characteristics are not just interconnected causally. There may be no doubt that relationships exist between the geofactors, the vertical chain of causes, e.g. between the soil and agricultural production, but this explains only partial aspects. It was also known that the horizontal "neighbourhood effects" affect the regions. But how it took place remained obscure.

Regions (see also section 2.2.1.1, and 2.2.2.1):
Thus an attempt was made to approach the varied mosaic of material forms on the surface of the earth from a different side. The knowledge of many concrete facts still did not permit clear regionalisation. A radical change in basic perspectives and methods was required. In the 1920s, the outdated observation of material forms and the causal method gave way to the study of the structure of forms and groups of forms and their functional interconnections. The question was no longer just what a region (or form) looks like, but how is it structured. The examiner maps the individual facts, e.g. the plants in a biotope, the area utilized by individual farms, the arrangement of houses in a village, the occupational or social characteristics of man.

However, this way of looking at things became more difficult when not only the co-existence of these cells but also their functional relations were analysed in detail. This lent itself most immediately to economic geography. In rural areas WAIBEL (1927/69) found regional economic units which he called economic formations ("Wirtschaftsformationen") thereby recalling certain corresponding units in the plant world. He believed he had found the structural components which interweave with one another, thereby shaping the economic landscape. The economic formations also mean forms of life, i.e. they form the basis of certain ways of living.

Social geography:
At this time in human geography there was a distinct shift in fundamental outlook, as in the other social sciences ("functional period"; OVERBECK 1954/78, pp. 218). A social geography took shape, first of all outside Germany, which did not return to the

scientific community in this field until after the end of the Nazi regime.

The stimulus came from sociology. In the Netherlands in 1913, STEINMETZ argued that man should be seen as a link in society – a decisive departure from Ratzels view of man in his living space. The descriptions of different peoples as provided by geographers seemed to him to be too superficial and one-sided. The sociologists on the other hand lost contact with reality. He therefore called for a careful empirical analysis and gave his approach the title of "sociography".

Various groups of characteristics could now be assigned to each individual (depending on his physical size, age, membership of tribe or religious community, professional status, income, place of residence in relation to the distance to place of work etc.). In other words, differently defined groups, the question of place of work and place of residence could now be studied and placed in relation to other factors such as settlement, nature, economy, traffic etc. The information base was becoming broader all the time and detailed statistical data was becoming available to industry, administration and science. Thus, regions and regional relationships could now be identified which had hitherto remained undiscovered because the methods were not yet sufficiently refined. The geographer now began to understand that anthropogenic areas should be studied from the inside starting with man and his various groupings.

BOBEK (1948) took up the concept of groups of life forms in which specific social forces receive expression. These are groups which appear, as he stated, to be affected both by the forces of society and landscape, and whose "functioning" causes their influence to be felt both in the natural (landscape) and the social (society) spheres. Bobek created a system of social geography and became one of the founders of this geographical sub-discipline.

The towns in particular proved to be forms in which the constituent geofactors suggest themselves as objects of research both structurally (i.e. in their construction and co-existence) as well as functionally (i.e. in their relations to one another). In this connection BURGESS (1925/67, p. 54) noticed a concentric structure of cities (see section 2.2.2.3). In these years the Thuenen model was re-discovered (OBST 1926/69; WAIBEL 1933a). Besides this, the relations between the central towns were examined (CHRISTALLER 1933; see also 2.5.2.1).

By studying the material aspect of form it was therefore possible to throw light upon the structure of relationships for one particular moment. Every point, e.g. in a city-umland system, has a relation to the centre which can be repeated at any time. In order to approach reality more closely, the area structure has to be defined in relation to its content. This may be people who are pursuing their own aims and who therefore "behave" and not just function according to the system. In this way, the functional relationship is modified. Deterministic models are no longer permissible and it becomes necessary to work with others, e.g. probability models. This points the way to the following stage.

The system stage:

Classical Modern painting:

Around the beginning of the 19th century, new tendencies appeared in art which ushered in the so-called "classical modern" period (HAFTMANN 1954/76; BOCOLA 1997). It was characterised by a great variety of style including Cubism, Dadaism, Constructivism, Expressionism, Futurism and Surrealism. The paintings of Picasso, Kandinsky, Dali, Severini, Duchamp or Klee seem to the observer to express quite different things, although they all have one thing in common: The artist penetrates more deeply into the matter of the subject.

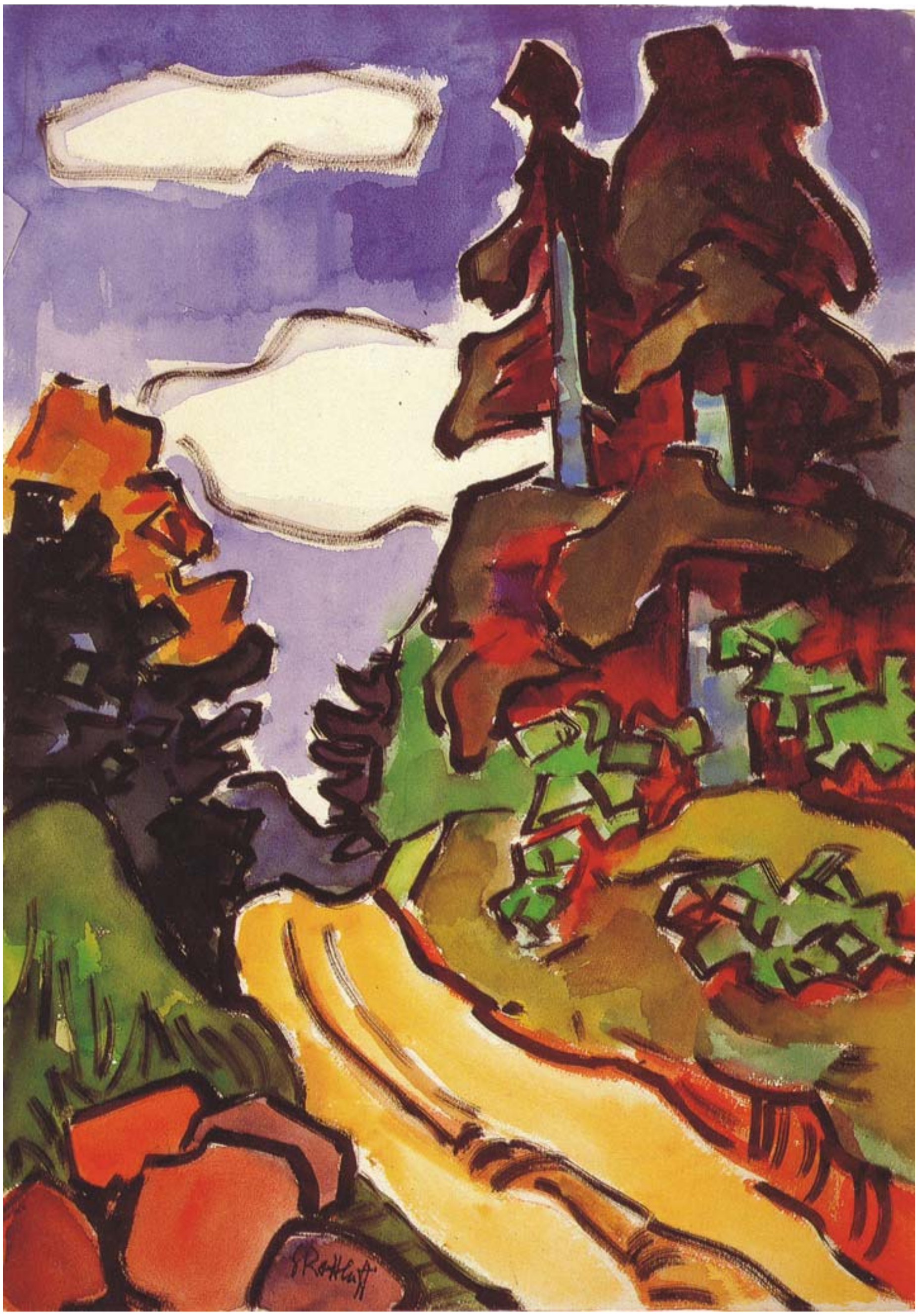


Fig. 81: Karl Schmidt-Rottluff: Bend in the path. (Ca. 1960).
Example of a classic modern painting.
Source: See "Notes on the figures".

The visible world which Impressionism depicted in its geometrical arrangement, is resolved into its components which are re-evaluated and then re-assembled. For example, the proportions of the objects appearing in the painting could be varied, the colours modified, physical elements removed from their structural anchor points, contours blurred and perspective distorted, and all in order to re-express the meaning of painting's subject. In a word, all the aspects and properties which the observer associated with objects in his environment could now be re-arranged and re-emphasised artistically.

With regard to content, the artist's range of expression has indeed become much greater than it was. Because the re-interpretation of a picture in its entirety with all its elements is now up to him alone. He has another tool at his disposal and can prompt certain associations or feelings on the part of the observer which would otherwise remain concealed, e.g. joy, sorrow, helplessness, fear and admiration. The variety of elements from reality becomes a construction kit for a different world, the inner world of the artist (HAFTMANN 1954/76, p. 495). This is how the shape develops and becomes a self-contained painting which has grown organically out of itself.

The emancipation of the artist as the subjective interpreter in relation to his environment, has entered a new phase.

Example (forest painting 3): Karl SCHMIDT-ROTTLUFF (see fig. 81): Bend in the path.
The picture was painted by Schmidt-Rottluff around 1960. It is a watercolour depicting a piece of woodland. The artist chose the watercolour technique in order to transfer his expressive and dynamic sensations to paper as quickly as possible. The path takes us into the picture. The ground rises to the left and right with the bulky forms of large boulders. At the bend on the upper right, rather threatening-looking trees loom, extending to the edge of the picture. To the left, bushes and low trees reveal a bright apparently stormy sky. It is not the wood as such which conveys the dramatic atmosphere. Instead, the forest is the means by which the artist expresses his feelings. Schmidt-Rottluff is one of the founders of the group "Die Brücke", and one of the main representatives of German Expressionism.

Philosophy and interdisciplinary theories:

In the 1930s, philosophical thought also underwent a fundamental change. Man now saw himself as part of a whole which determined his life but which he was also able to use in his own interest as well as to make changes. Thus, the environment and/or society were seen as a fabric of activity in which man must seek his own place. The system plays a central role as a new guiding model.

Critical social philosophy:
Some philosophers took Marx' model of society as their point of departure. According to BLOCH (1954-59/73) history moves in dialectically self-correcting processes towards a future in which the ideal of a classless society, free of any alienation and in accordance with nature, will be fulfilled. According to him, the evolution of history is dictated by Utopias, daydreamers and wishful thinking. The anticipation of the future is an important driving force in human action.

A significant part of the reflections of the "Frankfurt School" (Horkheimer, Adorno, Marcuse, Habermas) followed up the ideas of Bloch (WIGGERSHAUS 1986). Critical theory dealt with problems related to social and scientific theory, in particular with regard to sociological consequences. The interconnections of a world determined by economic and technical forces, the conditions in which it came into being, its administrative coldness were all examined and ways of changing it to create a more humane social order free of estrangement were analysed.

Neopositivism:
Popper criticised these lines of thought, in particular the view that history proceeded according to certain "laws" as proposed by Hegel and Marx (POPPER 1960/87). He warned of the claim to absolute truth made by "false prophets", conceded that the course of history followed certain trends (pp. 90) but that its development was open and might be affected one way or another. Clever planning may be able to correct errors step by step ("Patchwork Social Technology"; pp. 51). The ideas of Popper and the Frankfurt School assume that the course of history proceeds "normally" i.e. a social structure in an equilibrium which is capable of change.

Popper's fundamental position was (neo) positivistic, i.e. he assumed that human knowledge was limited to what could be experienced and perceived (the "positive"). This could be proved, defined and analysed in a systematic manner. In his book "Logic of Research" (1934/89) POPPER argued (p. 29) that everything we know is genetically a priori. A posteriori is only a choice selection of what we have ourselves invented a priori. And further on (p. 36): The task of all thinking beings is to determine the truth. The truth is absolute and objective. Only we do not have it in our pocket. It is something which we seek continuously and which is often hard to find.

In particular, positivism claimed complete freedom from values, i.e. objectivity. Decisions on this basis were allegedly independent of moral or political commitment. However, this was vigorously disputed, especially by Habermas, who argued that judgement which was completely free of values was not possible per se in the sense of objective establishment of the truth. The knowledge was affected by interest and intellectual formation. Thus the positivism dispute ("Positivismusstreit") affected not only fundamental questions of social structure and development, but also scientific methodology.

Modern Empiricism:
Popper had his roots in the "Vienna Circle" which revived to the tradition of empiricism (at a distance from critical social speculation) within the sphere of modern scientific and technical thought. Originally, Empiricism allowed only rough insights. Mankind was regarded in its entirety, not in its characteristics.

This now changed. Progress in knowledge is based on the fact that empirically treated or logically derived statements are verifiable. The steps in the operation are controllable. Metaphysical statements on the other hand cannot be verified (STEGMÜLLER 1987-89, 1, pp. 351). Modern empiricism saw it as its task to encourage science.

In his first work, the Tractatus Logico-Philosophicus, WITTGENSTEIN (1922-53/90) may be seen as a precursor of modern Empiricism, especially that of the Vienna Circle. His intention was to support the natural sciences by developing a precise language and clear terminology. Only then does communication become possible.

The truth of statements must be intersubjectively verifiable. This requires a logical rule which allows statements to be retraced to observational principles ("recording principles"). This "criterion of empiricistic sense" is connected with "verification" (Carnap). STEGMÜLLER (1987-89, 1, p. 382) is more precise: The verifiability of a statement is a necessary and adequate condition for regarding it as empirically reasonable. This means that sentences which contain partial statements which are not accessible to observation, are not regarded as reasonable.

However, this view soon proved to be untenable. Among other things, POPPER (1934/89, pp. 7, pp. 15) pointed out that many scientific principles too are not verifiable. Because these are universal principles (i.e. they claim to be valid in a general way) which can only be proved empirically on individual examples. In verification, we therefore come only to unreliable statements. Popper therefore introduced a new method which he named "falsification". The truth of a theory or hypothesis must be scrutinisable. In general, he postulated that a theory should be constructed in such a way that it can be proven false, i.e. that the reader is able to test its statements and deductions empirically and if necessary reject them. A deductive scrutiny must (a) examine the theory for any inner contradictions, (b) determine whether the theory can be treated empirically and scientifically, that it is not, for example, tautological, (c) determine through comparison with other theories whether its statement can be regarded as scientific progress.

In practice, such an elaborate scrutiny is only partially possible, and always highly complicated. From the critic it demands a degree of open-mindedness to novelty and detachment with regard to his own previously accepted view. This is generally difficult to achieve.

System theory (see also sections 2.3.1.1, and 2.3.2.1):
As early as the development of the atomic model, the question had arisen how the movement of the electrons could be observed. The conclusion was reached that it is only possible to answer this

question by taking an overall view. The Quantum Theory was the result. It operates with probability scenarios. This means that the processes cannot be precisely controlled beforehand and the initial condition can no longer be determined. The laws of physics should be regarded as laws of statistics (indeterminism; see also Outlook, section 2.4.3).

The theory of probability is based on the distinction between the whole and the parts. If we assume that the parts always have a structural function for the whole, we arrive at the System Theory (see section 2.3.2.1). Within a system, the components co-operate with one another in such a way that they stimulate and subdue (i.e. regulate) one another mutually. The foundation of the theory of information (SHANNON and WEAVER 1949/76) and the development of the theory of self-regulating systems (WIENER 1948/68; v.BERTALANFFY 1950) created a formal basis. In this way, closer attention was given to the progress of time.

In ecosystems and social systems, living organisms "behave" according to certain characteristics and properties. Innate abilities and environmental conditions play an important role here. This problem has been discussed particularly in ethology. It examines tribal origins and the reason for certain patterns of behaviour (LORENZ 1965, I, pp. 9). The naturalist is dealing with the forms of processes, which unlike physical features, are not always visible (EIBL-EIBESFELDT 1967/99). These include the perception of form, learning, methods of expression and formation of communities.

Thus the System Theory has become established in many different fields of study, i.e. it has developed into a "General Systems Theory". As SUTHERLAND (1973, p. 19) explains: "In the broadest sense, General Systems Theory is a supradiscipline, including such special system disciplines as mathematical systems theory, systems engineering, cybernetics, control theory, automata theory. In other sense entirely, general systems theory offers a vocabulary of both terms and concepts applicable to systems of all types, with the terms and concepts drawn from many different substantive disciplines (i.e. biology, engineering, economics, quantum physics)".

Geography:

Macrogeography:
Geography now concerned itself much more closely with the actual problems of society than it did previously. Under the impression of differing economic developments on a global and regional scale, numerous detail studies on developing countries, the development of emergency areas and the formation of ghettos. The problems were identified and attempts made to find solutions. The study of reality was now stimulated by the objectives in view. Among other things, these studies raised questions as to the origins of such

imbalances and undesirable socio-economic conditions. And different answers were found, depending on the political and cultural viewpoint. In this way, "radical geography" (and in its train Marxist geography; HARVEY 1973) made its appearance in the English-speaking world against the background of Marxism-dominated European philosophy. Feminist Geography and the gender studies (PEET 1998, pp. 247) also appeared within the context of the international women's liberation movement.

In Germany too, society itself became the central object of research in human geography. Above all, it was realised that the social forces are of a completely different kind than the natural ones. Now, the social groupings are not defined (as in the functional phase) as groups of features, but as behavioural groups (HARTKE 1953; HAHN 1957). They are defined by their activities in space. The human beings which belong to them shape their environment in a similar way and react in similar ways to external influences, i.e. they behave similarly. Their members may have a similar attitude to economic activity, have common standards and moral attitudes etc. Groupings of this kind can be identified by certain criteria or indicators.

As a continuation of the idea behind this approach, Ruppert and Schaffer regarded the landscape as an area in which processes took place. The social groups appear on it not only as fulfillers of functions but as fulfillers of spatial processes (RUPPERT 1968, p. 171). Basic existential functions ("Daseinsgrundfunktionen") can be identified as motivation for the members of these behavioural groups (according to PARTZSCH 1965). Here too, an approach had been found which enabled socio-geographic research to be used for practical spatial planning (SCHAFFER 1968, p. 205).

Spatial approach:
In the 1950s, within the context of empirical social research, reliance was placed initially on statistical methods based primarily on the theory of probabilities. Here too, the deterministic view was no longer adequate, since social scientists deal with humans whose actions follow their own intentions (and emotions).

Probabilistic models were also developed in the field of human geography ("quantitative revolution"; e.g. GARRISON 1959-60). In this field, simulation began to be used increasingly, e.g. in the study of migrations and the diffusion of innovations (HÄGERSTRAND 1952; 1953/67). An extensive data base had been created in the official statistics and elaborate methods were developed to improve interviewing technique.

The methods permit a clear approach, limit regions of different types, reveal spatial structures and allow comparisons.

Microgeography:

The approaches described above attempted to comprehend the entirety of the system from the point of view of the linkages. It is only logical that human geography should turn its attention increasingly to the individual human as the element, because his behaviour determines the processes in the group context. The deterministic models postulate the existence of a "homo oeconomicus" who fully understands his environment with all its realities and possibilities. Of course he does not exist. The insights into his environment possessed by the individual human being are rather limited in nature and his behaviour is in no way perfect. By taking the individuals into account, space was defined "from the bottom" so to speak. In this way the system received a new component. The elements are not only materially definable data quantities, but the people themselves with their ideas and intentions. Thus, man was regarded as a maker of decisions.

In detail, two lines of investigation were pursued:
1) Behaviour is determined substantially by perception and decision. The processes of perception are very complicated. The impressions coming from the external world are filtered, a process in which talent, education, attitudes etc. as well as intentions (e.g. in relation to an action) play an important role. The result is a view of the world ("mental map"; LYNCH 1960/65, pp. 20). The decision based on the knowledge gained is the precondition for the shaping of the individual environment. WOLPERT (1963/70, p. 384) balanced the role of "homo oeconomicus" with the behavioural concept of "satisficer" which is satisfied with what it can achieve in a particular situation.

2) The time factor becomes apparent in the "activity-system" and "time-geographical" approach. CHAPIN (1965) observed that the behaviour of people is strongly dependent on the time available to them. Each person has his sphere of action and activity which allows him to go about his business. Within sphere or space, he has to fulfil all the actions necessary for his living within a certain period of time. Here, significant roles are played by distance, time available, accessibility by means of transport, business hours etc.. On the other hand, the individual movements themselves have been discussed in the field of "time geography" (e.g. HÄGERSTRAND 1973). The spatial decisions are also affected by the time available. Here, each individual has possibilities and limitations. In a three-dimensional model, in which the surface of the earth appears horizontally as a map in which time is entered in the verticals, the changes in location ("paths") of each individual can be marked in a certain period of time. These time periods may be days, years or phases in a person's life. These individual paths represent the material by means of which individuals with the same spatial behaviour can be identified. In this way, time-geographical studies can be carried out in town or country or in different cultures, thereby producing a pattern for the behaviour of people in space.

All these studies indicate that we are limited in our freedom of decision and that we constantly move between possibilities and constraints. We can add our own ideas in order to influence the course of developments, but for this we require specific social structures to point the way. This problem is discussed in the following stage.

The process stage (evolving)

Art in the Present:

During the Second World War, a new period began in the development of art. Painting liberated itself from all the formal constraints of patterns and stereotypes. Whereas in the first half of the 20th century, the painter selected elements of form and structure from the world of visible phenomena and emphasised or suppressed these according to his own ideas, the painter was now quite free in his choice of content, technique and design. In this way he was able to convey his message more effectively and express his feelings more directly. Many different styles and movements came into being.

Perhaps the first of these we should mention is the Informal or Tachism movement which can probably be placed closest the classical modern (de la Motte in: INFORMEL 1983, p. 10/11). It attempts to depict feeling and thought in a way which is free of forms and constraints, almost anti-formalistic. In the 1960s other styles made their appearance, such as Pop Art, Opart, Photo-Realism, Minimal Art, Neo-Expressionism, Neue Wilde, Chromatic Painting, Zero etc.. It is impossible to assign many artists to a this group and others changed their techniques and methods of representation. It is almost as if they were looking for the right way to realise their ideas. New materials were used in addition to the conventional paint – porcelain, glass, plastic, soil, scrap and even transient substances.

The time component received a new importance. Happenings, Fluxus, Vienna Actionism, Performance, Video, Computer Simulation are all completely new types of representation. The rapidly changing information and design techniques are used to depict processes in order to draw attention to particular problems – social problems, environmental problems, political problems – and the artist's attitude to them. So the artist Tino SEHGAL said (2005) that for him, art is a celebration – it celebrates the ability of mankind to transform nature, invent things and derive a subject constitution from these. The aim of the Avant-Gardists is to change the world. The utopias they create not only depart from the traditional categories of visual art, but totally abolish the idea of art by abolishing the line between art and life (GLOZER 1981, p. 235).

The area of artistic expression is society and the world at large. In many respects, the artist and his audience come closer to one another because this art demands direct participation. The viewer is involved. The universe becomes a work of art, society a "social sculpture" (Beuys; see also section 2.5.2.0). The artist (as creator) leaves his studio and approaches his subject, the human habitat, itself.

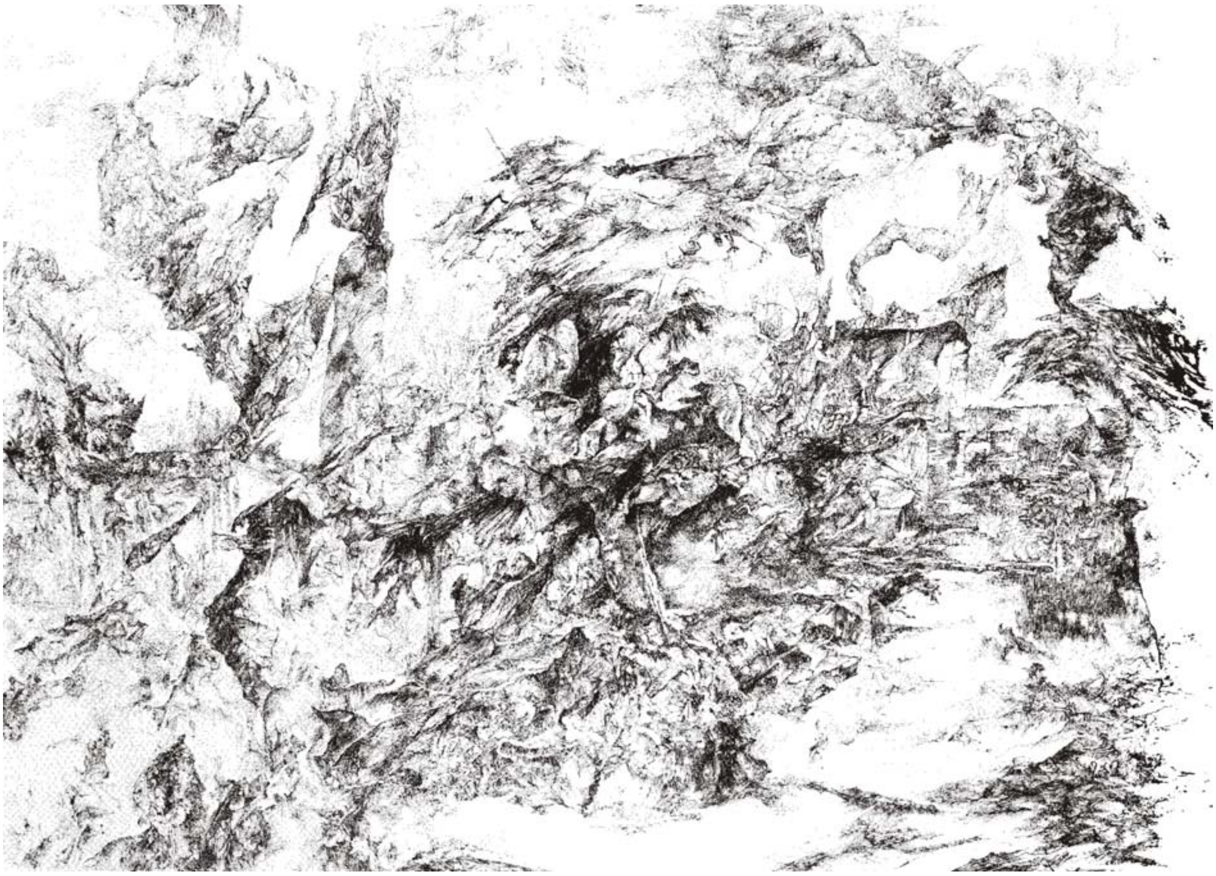


Fig. 82: Bernard Schultze: Deep in the forests.
Example of a picture of the present.
Source: See "Notes on the figures".

Whereas art in the Classical Modern period was still a well-defined institution, the edges now become more blurred with imperceptible transitions to technology, design, politics, events and commerce. Numerous exhibitions give the art scene a platform for self-projection which it never had before. The viewer's interest grows accordingly. And even if the artist seems not yet to have found his place in this confusion, if many of their works are still far from being self-explanatory, it is at least clear that art is a sign of a new fundamental tendency in the development of society.

Example (forest painting 4): BERNARD SCHULTZE: Deep in the Forests. 1978 (see fig. 82): Schultze is one of the founders of the Informal School in Germany. The picture shows a structured chaos, a labyrinth of stripes, shadows and white areas. The gaze travels over doughy, gnarled, swampy, leafy, crumbly structures. Schultze works from the unconscious to the conscious – carries out a medial process of movement from the inside outwards. The hand is guided by the subconscious. The impression is of something organic, of rank growth. The viewer can read anything he likes into the picture, a forest may not occur to him right away. The development of structure from one's own personal feelings is the artist's most important concern. In the last resort it is of no importance what the painting is called (ROTERS 1981, p. 55). The title becomes a metaphor which may assist the acceptance of the viewer.

Philosophy and interdisciplinary theories:

Post modern:
Before the development of modern empiricism, WITTGENSTEIN (1922-53/1990) had subjected language to a logical examination with regard to its expressive capacity and acknowledged its role as a general means of communication. In this way, he provided modern empiricism with important impulses (see above).

In his "Philosophische Studien" he came to completely different conclusions. The play of language ("Sprachspiele") now took the place of depiction ("Abbildung"). The assumption is therefore relinquished that the linguistic statement coincides with the given facts. In order to apply language meaningfully, a general context has to be understood (mode of life; "Lebensform"), a kind of linguistic "creature" from which meaning can be derived (WUCHTERL 1961, p. 50).

Obviously there is a vast number of possible "plays of language". With this concept, Wittgenstein ran contrary to modern empiricism and positivistic thought. Here a certain degree of uncertainty is apparent as to what science can hope to achieve. The idea of truth becomes more blurred, thereby opening the way for the post-modern movement.

The philosophical discussions of the 1960s are characterised by a peculiar degree of confusion ("Unübersichtlichkeit"; HABERMAS 1985). Whereas Popper (see above) and the representatives of the Vienna School were convinced of the existence of a truth and developed methods for finding it out scientifically, everything now appears relative and indefinite. General communication becomes almost impossible. Far-reaching theories which could provide general guidance, are nipped in the bud. Thus, there are many hypotheses which refuse to come together in a single theory. The conviction that the processes shaping the universe can be defined in the context of system structures (as described above for the third stage) is given up and the desire arises to re-define the universe and its modes of life.

The pluralism of the post-modern was assumed by the scientific historian KUHN (1962/67/88) at an early stage. He analysed the character and appearance of several scientific revolutions of the past and gave the term "paradigm" a specific meaning (p. 25). He wrote that important achievements served subsequent generations of scientists for some time indirectly as a means of defining the problems and methods of a field of research. They were able to do this, because they had two important features in common. Their achievement was sufficiently novel to attract a stable group of adherents who had previously conducted their science in a different way, and at the same time was still open enough to set the new group of scientists any amount of unsolved problems. According to Kuhn, changes in paradigm take place in the shape of revolutions. The imminence of such events is indicated by the fact that problems can no longer be solved within the existing scientific framework of the outdated paradigm, until a completely new theory sets a new paradigm. (In 1995 KUHN ceased using the term paradigm – but not the concept itself – because it had become prone to misuse).

Moreover, Kuhn thought (p. 108) that a change in paradigm did not lead to scientific progress. On the contrary, one paradigm was only replaced by another. A younger generation of researchers merely pushed the older one aside. A "falsification" as demanded by Popper (see above) was thought by Kuhn to be impossible. It was mainly psychological, social and in many cases irrational factors which caused a change in paradigm. A cumulative acquisition of unforeseen novelties represented an almost non-existent exception to the rule of scientific development. In principle it was also improbable. We will return to this problem later (see below).

What are the reasons for such delayed acceptance? There are several reasons for this (quite apart from the personal reasons which are generally known). First, it has to be seen that the "old" theory has been widely used and, within certain limitations, has proved successful. Then, the opinion of the scientists itself also has a restraining effect – to which the (necessary) working together within the scientific community, continuously cultivated in discussion groups, symposia, courses, expert committees etc., contributes. It promotes an involuntary convergence of standpoints, especially with regard to fundamental views. Thus, a deceptive feeling of security is conveyed. In addition, generalised descriptions often written by well-informed journalists create a broad basis of acceptance among the public at large. New theories attempting to deal with unsolved and (by conventional methods) unsolvable problems, can only with difficulty develop beyond this solidified network communication.

FEYERABEND (1975/86) even rejected any binding commitment to scientific methods and insisted that much greater importance should be given to imagination and creativity free of all restrictions with regard to methodology i.e. "anything goes".

The post modern is seen as a plurality of ideas, facts and processes which stand alone. They are only anchored "in the social". However, society for its part, is a creation of ideas, facts and processes. LYOTARD et al. (1979/99) places more importance on the "immaterial". News, interaction, language etc. form the "materials", the actual substance. Thus, there are many trends of thought and debate which cannot be compared with one another. Communication is only possible through reflexion. Reason is the "common asset" (see also WELSCH 1987, pp. 307/308).

Using examples from history, a similar conclusion was reached by Foucault with regard to the growing independence of speech and thought, which affect the modern individual in the course of the discussion (WALDENFELS 1991, pp. 191).

However, since the 1980s, remarks can be found in the works of some authors which indicate a certain reserve with regard to relativism which is too naively practised (NIEMANN 1996, pp. 274). KUHN (1995) stresses that he is not a relativist, because he does not believe that all conclusions are of equal value. In his view it is always possible to arrive at a conclusion which is preferable to others. And in 1982 FEYERABEND (1975/86, p.11) wrote in his preface to the new edition that "anything goes" is not his own principle, but a fact to which he wished to draw the attention of his opponents regarding the theory of science.

These extenuations could originate in the realisation of the autors that they have used populistic methods, as Niemann (pp. 274) thought. It could also be argued that they are signs of a change in attitude paving the way for new lines of thought. Moreover, it became apparent (SOCAL and BRICMONT 1999) that some post-modern authors had made over-free use of scientific terminology with the result that some of their statements may be rather doubtful. Without any knowledge of the results of scientific research, philosophy can only arrive at conclusions whose soundness is of a limited nature only.

As in present art (see above), more recent philosophical reflections show an increasing preoccupation with ethics. JONAS (1979) emphasises clearly man's responsibility in a civilisation dominated by technology. Modern technology confronts us with questions, actions and consequences of such magnitude and importance that the former framework of ethics is no longer able to contain them. He therefore calls for a new system of ethics. This however requires a degree of foresight, a prediction of developments in order to obtain an idea of the long-term effects of ones own actions. We have a responsibility towards our descendents and to nature. Man's responsibility for man is primary. To this has now been added his responsibility to nature. The overriding problems with regard to the supply of food, raw materials and energy must be approached with long periods of time in mind. Referring to Kant, Hegel and Marx, Jonas argues that we can no longer trust the inherent "reason of history" and that it is pure negligence to speak of a self-fulfilling "sense" behind events. We must take control in a completely new way of the processes which are striving aimlessly onwards. It would be a fatal error to believe (as Marx did) that the "empire of freedom" begins where necessity stops. On the contrary, there is no "empire of freedom" outside the "empire of necessity".

From chaos research to complexity research:
In system research, a new development (towards self-formation of the environment) is taking place. The self organisation of matter and society is becoming an object of research.

As early as the 1970s, research into non-linear systems, including the emergence of chaos research was established (especially by biologists and physicists). Again new methods of explanation were demanded, and simulation became the most important investigative instrument. The use of computers made a decisive contribution to this. It was recognised that there are phenomena and systems in nature and society whose elements behave unpredictably when they interact, even though, taken alone, they obey certain deterministic laws. For example, slight differences in initial conditions may, unless controlled, lead to completely different developments. In their simulated development, they may be driven to the "edge of chaos", thus causing new patterns to come into being. Against this background, it became apparent that spatial patterns can also develop, so to speak, "from the bottom up".

These fields of research can be summed up in the terms "physics of becoming" (PRIGOGINE 1979), "chaos research", and "synergetics" (HAKEN 1977/83). The phenomena of self-arrangement are indications of a non-linear dynamic process. In the 1960s, Prigogine observed that such systems existed in addition to the equilibrium systems and that they can develop and maintain themselves at a distance from the energetic equilibrium. These systems (he did not yet distinguish between flow and non-equilibrium systems) are able to give themselves a shape. For this purpose they consume energy, of which a part escapes (e.g. as heat), dissipates, with the result that they have been given the name "dissipative systems".

These systems always have a tendency to move from a higher-order state to a lower-order state. Thus, the processes are directed according to the course of time. On the one hand there is the objectively measurable external time which is generally valid. On the other hand, we also have to deal with a second time which is internal to the system (PRIGOGINE and STENGERS 1981, pp. 259) and which finds expression in the changes to which the dissipative systems are constantly subject. This time flows parallel to the external universal time, although their speeds are different.

During the 1980s and 90s, parts of the natural sciences and social sciences were moving towards one another on a more abstract level. Chaos research developed into complexity research (see section 2.3.2.2). With considerably more ambitious objectives than chaos research, it opened up the prospect of unfolding not only more complicated spatial patterns, but life itself and human society, in other words highly complex structures. It was recognised that self-organising systems occupy a key position in our understanding of complex structures such as the living world or human society. Using the method of "cellular automata", attempts are being made to simulate "artificial life" (LANGTON 1989) and "artificial society" (EPSTEIN & AXTELL 1996; see section 2.3.2.2). The time seemed to be ripe to understand the greater interrelationships, but the methods available were still inadequate.

Although obviously it is not possible to create differentiated, permanent systems based on division of labour, e.g. self-organising populations in this way, the observations and hypotheses already made demonstrate the desire to understand more not only about self-regulation but also about self-organisation and emergence. However, to date, the research into dissipative systems has not ventured to take the step to research into processes. Only this offers a way out of the currently unsatisfactory situation.

Geography and related disciplines:

The present discussion in scientific geography is characterised by a number of approaches (PEET 1998, p.10), which, as many geographers believe, are not compatible with one another. They deal with a number of important and much-discussed topics. Most of these have their origin in the preceding period (e.g. radical geography). The post-modern approach is new.

"Post-modern geography" notes that (as Wittgenstein would observe) different languages are being spoken and that different images of mankind co-exist with one another. This does not permit any comparison (REICHERT 1987). These spaces are constantly assigned new values (SOJA 1989). DEAR (1988, p. 271/272) believed "that society is best characterized as a time-space fabric upon which the details of political, social, and economic life are inscribed. There are many theoretical approaches available to describe the creation and evolution of this fabric. A post-modern social theory deliberately maintains the creative tensions between all theories in its search of better interpretations of human behaviour. At the core of the wonderful 'geographical puzzle' lies the dialectic between space and society".

Many individual observations are made without arriving at a common theoretical concept. RELPH (1991, p. 104 f.) states that: "If I were to choose a single word to describe post-modern geography as it is manifest in actual places and landscapes it would be 'heterotopia'... Heterotopia is the geography that bears the stamp of our age and our thought - that is to say it is pluralistic, chaotic, designed in detail yet lacking universal foundations or principles, continually changing, linked by centreless flows of information; it is artificial, and marked by deep social inequalities..".

The tendency towards relativism is unmistakable. This view has its roots in post-modern philosophy (see above; see also PEET 1998, pp. 194). For a discipline that regards itself as the scientific companion of a world in need of improvement, such a relativistic view is not sufficient. The confusion should be understood rather as a problem whose solution can only be achieved by intensifying research.

A first step would be a more precise examination of the systems at microlevel.

Microlevel:
At the 3rd stage behaviour was interpreted as a characteristic of individuals and social groups with methods which, allegedly, produce exact results. This point was much criticised in the 1980s. Indeed, it is difficult to interpret behaviour correctly. Can the cause be determined from the results of surveys and can reliable conclusions be drawn from mental maps (WIRTH 1981, pp. 174)? Although the empirical data are well handled, a certain unease remains, and many a geographer wonders if the reduction of reality to spatial connections, probabilities and systemic involvement is really the purpose of scientific research.

The content and its meaning must be given greater consideration, because this is what moves people to action in the last resort. What does the individual aim to achieve? Are his motives personal or does he feel himself forced to act by the system or society? With this in mind, a Humanistic geography has become established. JOHNSTON (1983/86, p. 55) writes: "The basic feature of humanistic approaches is their focus on the individual as a thinking being, as a human, rather than as a dehumanized responder to stimuli in some mechanical way, which is how some feel people are presented in the positivist and structuralist social sciences. There is a variety of such approaches, for which there is no agreed collective noun. Their common element is a stress on the study of people as they are, by a researcher who has a few presuppositions as possible. The aim is to identify the true nature of human action...".

In the last resort however, it is not the individuals themselves who structure society. It is their actions. These reflections took place at the time of the cultural turnaround of the 1980s and 90s. Individuals expressed their ideas. However, to become accepted, like-minded people had to be found. Only in this way can ideas give way to innovation. Through actions, the individuals express themselves, make contact with other individuals. Interaction is made possible and social structures created. Actions on the other hand, are controlled by intentions and constraints in the widest sense (action projects; see section 2.2.1.1). The most general aim of this view of research consists in decoding the complexity of social circumstances and problem situations on the basis of the actions of the members of the society, or, more accurately, to understand and explain and, in problem situation, make reasonable proposals for changing problematic behaviour (WERLEN 1988, p. 22; about the term action see section 2.1.1.1). The situation in social-geographic research was characterised by a multitude of different approaches (WEICHHART 2008, pp. 338). In my view, this indicates that we are currently in a phase of transition. Aims and methods also have to be re-defined and re-aligned in social-geographic research.

Micro and macrolevel:

To avoid losing our general view, it seems imperative to return to the macro level. But how can individual actions be transposed to a higher magnitude? This has to be examined if we wish to understand how actions can shape society. Seen on their own, actions do not create socially relevant structures. Can we find a link with our earlier reflections?

The sociologist GIDDENS (1984/88) believed that the actions are subject to conditions, which themselves are seen as the consequence of information in space and time (within the context of economic, legal and moral systems), which are specified by overriding social structures. In this way, patterns of action are created at the level of the individual. On the other hand, it is these time and spatial structures which are stabilised by feedback mechanisms. Giddens perceives no "dualism" between individual and structure, but a "duality".

Reflections on the subject have not yet become definite enough. The assumption that the microlevel (i.e. the actions) can be joined to society by means of a three-stage hierarchy (individual – structure – society) points at least in the right direction. However, the difficulty with this theory consists in the vague definition of the term "structure". Are the structures equilibrium systems, flow-equilibrium systems or non-equilibrium systems?

In a similar way, the sociologist LUHMANN (1984 and 1998; see also section 2.3.2.1) is unclear as to what is to be understood by a system. According to him, communication forms the basis of social systems. Three levels of integration may be identified (LUHMANN 1970/75, II, pp. 9):
1) Simple interactions between the actors present. They exist for a short time only (microlevel).

2) Organisations which are made up of members and communicate via media. They have a past, decide in the present, and plan for the future (mesolevel).
3) Society, which contains all interactions and organisations and develops over long periods of time (macrolevel).

Two statements are of importance here: 1. A three-stage hierarchy is assumed (as with Giddens). Thus, the actions are effective in superior systems. 2. Time is involved in the hierarchy. However, essential factors still remain unclear. Here too, it is uncertain how the systems are structured.

Thus, it is not possible to test the theories in real society. However, they still have a heuristic value.

From action to process:
On surveying the development of human geography over the last decades, it can be seen that we have moved forward with increasingly accurate methods from the undifferentiated human groupings via the "social groups", "institutions", "behaviour" and individual "roles" to individual "actions". Now that we have arrived at the microlevel, we cannot find our way back to the macrolevel of wholes and processes. So, here too, it has not been possible to distinguish plausible constant and limited human populations with structures intrinsically based on a division of labour. Apparently, many social geographers still believe they can arrive at a definition of social reality without the assistance of the knowledge possessed by the natural sciences - only by humane-scientific methods of explanation. Thus, empirical research remains confined to disciplines concerned with human society in its many forms, but without a satisfactory theoretical basis.

Actions are fixed in time. They are parts of processes (see section 2.2.1.1). Every individual case, every type of behaviour, every action (project) at the microlevel fits into superior processes. This is reflected already in the above-mentioned approaches. In the sense intended here, process means an entity within a period of time, in which various stages develop logically in succession. This already applies for the actions themselves. The main focus of consideration shifts from individual behaviour and action to the conversion process and the non-equilibrium system. Thus, geography has arrived at the 4th level of complexity.

Summary and interpretation:

From the brief review of the last 200 years of intellectual development and cultural evolution in Europe, certain principles become apparent. In view of the complexity of developments, we have had to select certain processes, which may be used as indicators. Art, philosophy and geography are particularly suitable because they describe the social change from inside, from the point of view of those concerned, the individuals. Thus, we obtain not only a quantitative but also a qualitative insight into the process.

Process development:

For the past two centuries, four stages are apparent, all of which covered several (approximately five) decades. The processes overlap one another. There are transition phases covering from one to three decades in which the developments can affect one another mutually. The principal reason for these overlaps is that the individual processes (here the indicators) are shifted in time in relation to one another. The innovative ideas (if they have proved suitable) move the disciplines of the individual processes in the new direction only with a certain delay.

Thus, two process levels with different degrees of complexity can be made out in decennial cycles (see section 2.5.1.1):
1. The single processes which are defined thematically as indicators and which can be elaborated by inductive examination. These processes form sequences of single processes which are distinguished by their qualitative characteristics. Thus, in painting for example, a number of different styles follow on from one another (Romantic, Impressionism, Classical Modern, and art of the present).
2. The complex processes which these single processes serve as indicators, are what constitute social change. To define these as processes, we must proceed to a more abstract level and ask what the main theme of this change was from a system point of view.

Interpretation of content:

For this, we should firstly summarise the most important conclusions of the above discussion (see fig. 83):

1. Material stage:
- In the painting of the Romantic period, the artist incorporated his own feelings and views in the depiction of a certain subject.
- Philosophy argued that man was no longer a remote observer of the universe but that he is involved through his desires and emotions.
- The geographer observed the phenomena on the surface of the earth and identified certain forms as the subject of his research. He described and explained them. Geography saw itself as a science of space.

2. Functional stage:
- In Impressionist painting, the eye of the painter penetrated the subject, laying its structure free. In this way, the artist could interpret it in his own way.

- Philosophy saw the development of the phenomenological method, with the help of which things could be observed and analysed free of all preconception in order to understand correctly their meaning and position in the superior structure.

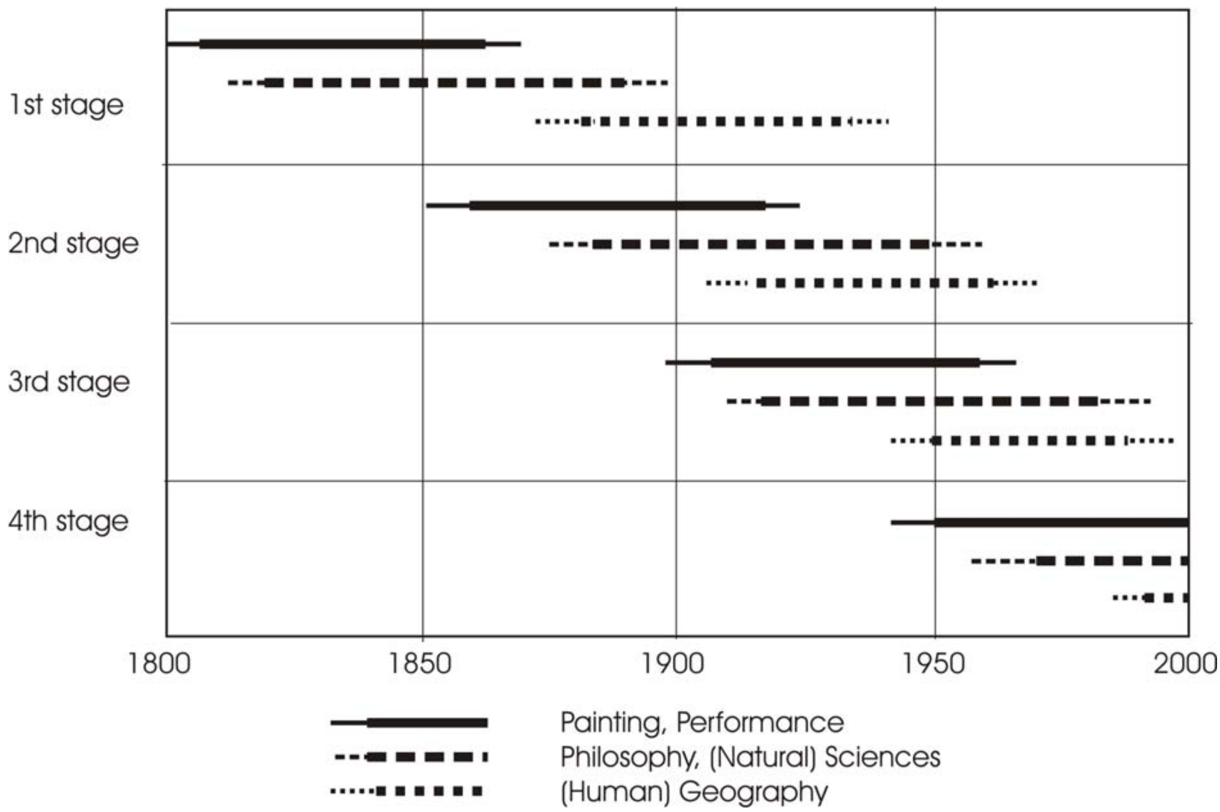


Fig. 83: Classification of the stages of cultural evolution over the past two centuries.

- The geographer studied the structure of forms. In human geography, humans appear as defined groups whose members display certain characteristics. They have a certain function for the forms. The objective was to define the structure of relationships in subdivided space and to gain knowledge of the parts in their functional context.

3. System stage:
- The painters of the Classical Modern period took elements of reality and re-composed them according to their own ideas. In this way, they were able to create new entities and elucidate their own message.
- Philosophy concerned itself with the involvement of man in society. The deviations from the desired and expected were studied and analysed.
- The geographer examined the cooperation between materially defined components in different areas. Man appeared against the background of his dependencies. Developments take place within a structure which is oriented according to standards.

4. Process stage (evolving):
- A new stage is in the process of emerging in the context of the "post modern" and the "cultural turnaround". In the art of the present, the painters free themselves completely from a subject. The picture is re-shaped according to the intentions of the painter. At the same time, other artists attempt to approach society's problems directly through their own actions in order to change society (overlapping of two corner stages of centennial periods? See section 2.5.1.1).
- In philosophy the individual is the agent in his environment. Many different units of communication co-exist with one another. At the same time, research into chaos and complexity takes place in order to understand the formation of patterns and processes of spatial self organisation.
- The object of geographical research is man himself in his environment. He has gained influence as a member of society and with regard to his environment and attempts to shape these to his will. The process theory described in this book attempts to show how this takes place.

Behind this development, we see that the fundamental perspective of man has changed successively. This was expressed in the changes in the way in which man sees himself within his surrounding environment:
- At stage 1 he perceives a material environment (consisting of solida) which, (with his own intentions) he shares spatially with others;
- at stage 2 he takes his determined place as an element in a structured whole which consists of functioning elements (equilibrium system);
- at stage 3 he is part of a self regulating whole whose elements are interconnected by the flow of information and energy (flow-equilibrium system). He can affect their course;
- at evolving stage 4 he is part of a self organising whole as an element in association with other elements (non-equilibrium systems). System und process blend together to form a unit.

Thus, translated into the terms of the process-sequence model (see section 2.4.1.2), these 4 stages could be perhaps equalised as perception, determination, regulation and organisation. Seen vertically, the process of change penetrates more deeply into the specified object, i.e. society, at each stage. This can be represented in a simple diagram (see fig. 84). The 4 bonding levels are included one after the other (see section 2.4.1.2, fig. 67; main stage “reception”; section 2.4.1.2). At each stage, people gain more influence on changes in their society and become more emancipated. Put in a general way, this means that, as complexity increases, the elements in the processes shaping the systems gain an increasing importance.

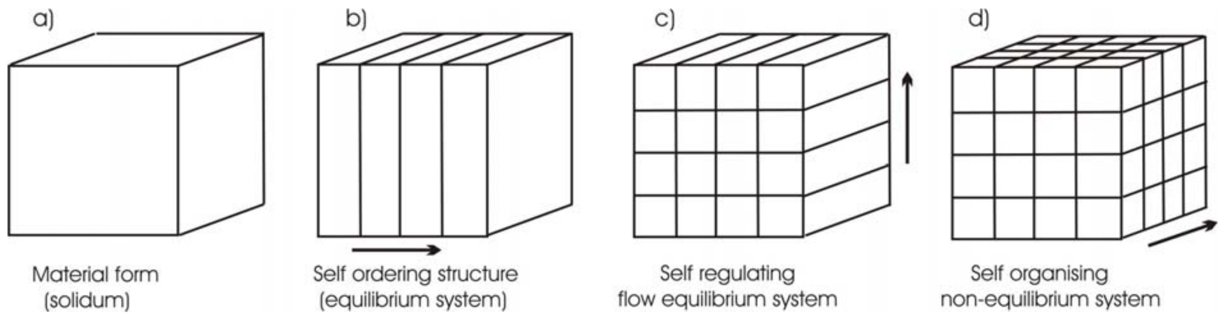


Fig. 84: Geometric diagram illustrating the increasing complexity in the development of cultural evolution since 1800 (stages 1..4).
Arrow: Direction of differentiation.

Kuhn's theory:
These considerations bring us back to the study by KUHN (1962/67/88) quoted above. On the one hand, his assumption that the history of science does not progress continuously but in stages in the form of revolutions, is confirmed. These revolutions give rise to new theories and new perspectives.

On the other hand, contrary to Kuhn's assumption a certain progress can be made out in the sciences, at the metalevel. In this review over the last 200 years, scientific development has not been treated in isolation, but as a part of social development. The progress of knowledge is anchored in this.

Even if Kuhn has now (as mentioned already) modified this assertion, this contribution perhaps provides additional arguments through its new way of looking at things.

The processes in the frame of the twin processes; an approach:

How can we fit these stages into the overall process of cultural evolution? In another context (see section 2.5.2.2) we have investigated the process which shaped the modern European age from the Renaissance to the present day and focussed our attention on the development of communications and industry in the period following 1800. We identified four stages, in which, among other things, traffic and industry underwent renewal and allocated them to the tasks of organisation, dynamisation, kinetisation and stabilisation. This is a process initiated by the superior environment and which serves production ("induction process"). In the process now presented, it is the population, which provides the energy for production through its labour, which itself is changed. We interpreted that process as a “reaction process”.

The question with which we are now confronted is:
How can we fit these stages into the centennial rhythm (see section 2.5.2.2) of the overall process of cultural evolution? Induction and reaction processes could perhaps be seen as parts of

twin processes which in turn consist of two process trains (A and B; see figs. 85 and

Year	1800	1900	2000
Supply A (Production) Supply B (Reproduction)	- Per (4) - Det (5) - Reg (6) - Org (7) - Per (8) - Det (9) - Reg (10) - Org (11)		

Fig. 85: Stages in the development of communications and industry (induction process) in chronological relation to the development of thought (reaction process) in the European cultural population since approximately 1800. The numbers (4)…(11) are identical to those in fig. 86.
Per = Perception; Det = Determination; Reg = Regulation; Org = Organisation; Dyn = Dynamisation; Kin = Kinetisation; Sta = Stabilisation.

86). In another context (see section 2.4.1.2) we noted that process trains taking place simultaneously are typical of the process sequence. Thus, induction process may follow induction process and reaction process reaction process.

The treatment of the task processes within the framework of the four process levels of the non-equilibrium systems shows that, in each case, the first four stages (Perception, Determination, Regulation and Organisation) receive their uniqueness through the vertical integration of the demand process in the flow of information. The first stage (Perception) signifies the transfer of the stimulus, i.e. the demand in this process. The second stage (Determination) is characterised by the decision to receive the demand, the third stage (Regulation) by the distribution to the elements and the fourth stage (Organisation) by the passage to the inferior environment as the source of energy.

However, this scenario can also be used for tying the supply process into the flow of information. Through the demand, the stimulus is transferred to the inferior environment, i.e. the supply process where it is processed with the result that, here too, the sequence Perception - Organisation can be seen.

This option may also be present in the cultural evolution taking place in the period 1800 – 2000 (Fig. 86) with the result that the supply process at the production stage (i.e. in induction process A) has to be described by the sequence Perception ... Organisation indicating an increase in complexity as well as at the stage of Reproduction (i.e. in reaction process B). The stages of the reaction process seem to be somewhat delayed with reference to those of the induction process (Fig. 85), i.e. the change in society is slower than the activities of production. This is typical of the conversion process as a process involving a division of labour.

In the period under consideration, the European cultural population was the most important centre of innovation of mankind as a society. Some of the impulses were passed on in a modified form to other cultural populations. This process continued, although the centres of innovation moved to other parts of the globe. This also means that the process discussed here will continue in the phase of production or reproduction, but now spreads to the whole of mankind as a society. It remains to be seen how culture with its prominently European bias will be changed in the process.

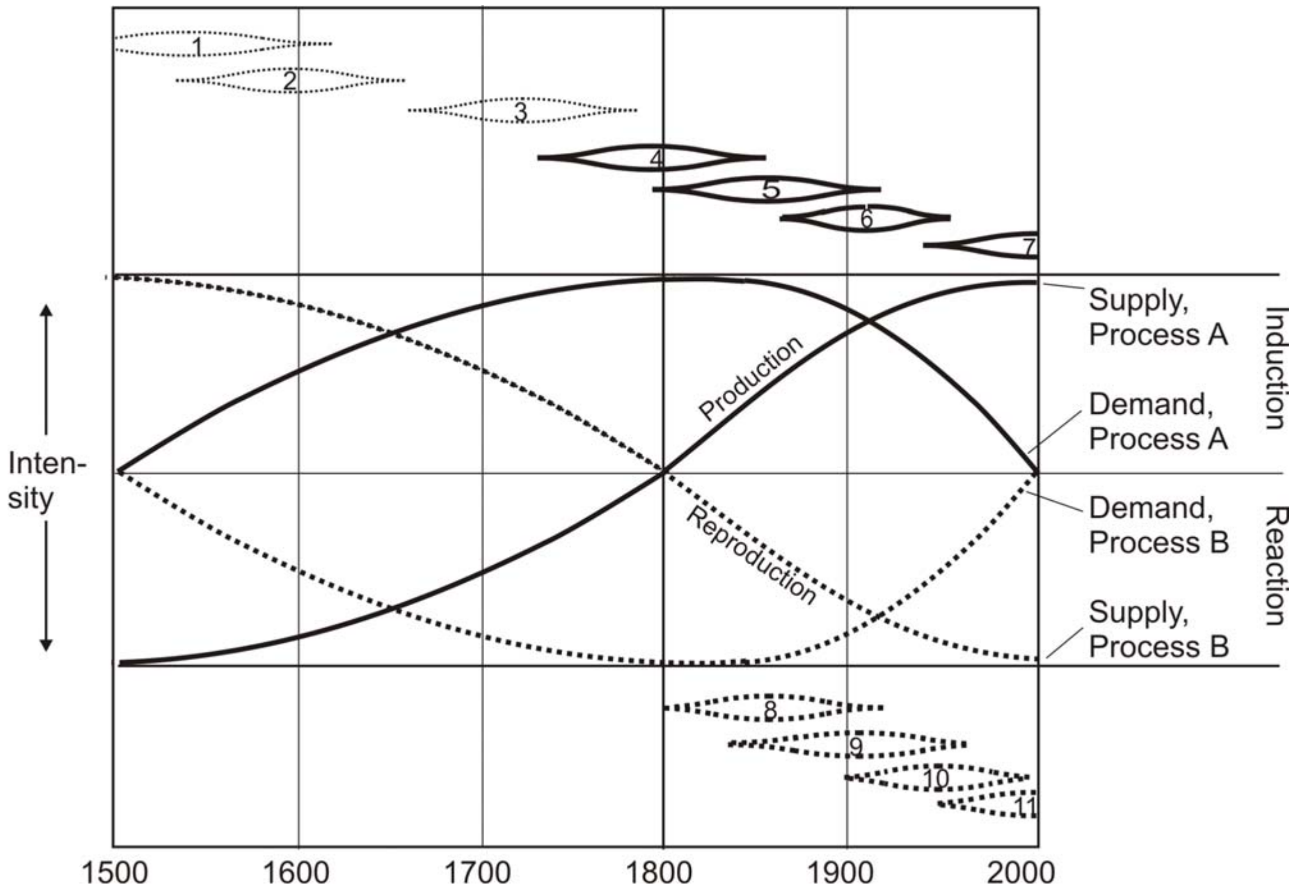


Fig. 86: The hypothetical development (in diagrammatic form) of the European cultural population in the past two centuries (lower section), showing how it fits into the rhythms of population development in modern times (see also Fig. 76, section 2.4.1.2).
For information: In the top section (process train A): 1) Renaissance; 2) Reformation and Counter Reformation; 3) Absolutism; 4) Improvement in communications in the 18th and early 19th centuries; 5) first phase of industrialisation (old industry); 6) second phase of industrialisation (mass production); 7) high technology of the present.
In the bottom section (process train B): development of art, philosophy and science: 8) Material Stage; 9) Functional Stage; 10) Systemic Stage; 11) Evolving Process Stage.

Whether all these events and processes justify our division into periods is a matter for history sciences to decide. To a certain degree the choice of institutions used as indicators plays an important role. The processes are of varying importance for cultural development. Here, the researcher has to make a decision of his own. In our theoretical discussion, it is only possible to give a superficial impression. The development of better defined criteria for decisions of this kind is without doubt one of the most important tasks for research.

2.4.2.2. Examples of other non-equilibrium systems

We will now turn to examples of non-equilibrium systems from quite different areas of existence in order to illustrate the many different forms in which these may appear.

A technical system:

In many technical systems, energy and/or information is transformed. These systems are also non-equilibrium systems which carry out their work continuously. Technical non-equilibrium systems are tools in the hands of human beings. They function in accordance with the process sequence.

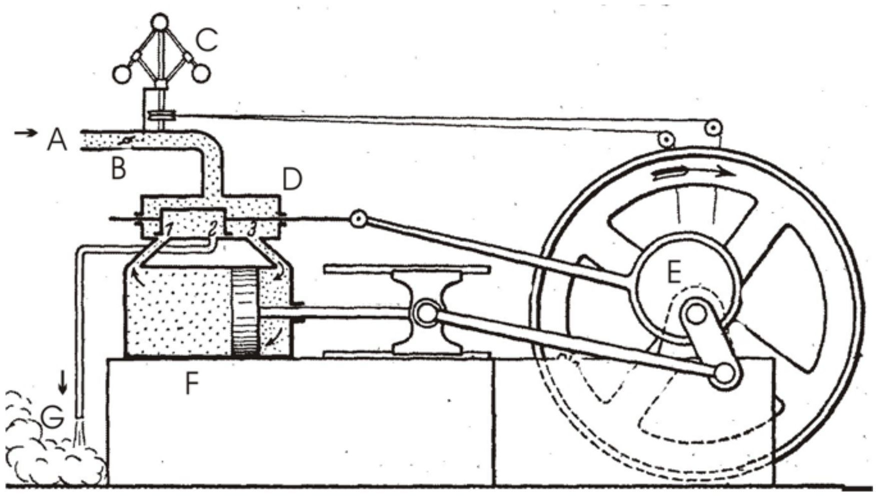


Fig. 87: Diagram of a steam engine.
Abbreviations: A = steam from the boiler, B = pressure valve, C = speed regulator, D = slide-shaft box, E = flywheel with eccentric cam, F = cylinder, G = exhaust pipe.
Source: See notes on the figures.

The adoptive and reactive tasks are mostly specified by man or are controlled or taken over by him. It is mainly the productive stages, i.e. the actual transformation of energy which is left to

machines. One example of this is the steam engine, in which thermal energy is converted to kinetic energy (see fig. 87). The parts have certain tasks:
- Perception: the running of the machine is stimulated by man. He needs the power in the machine shop of the factory (as the superior environment).
- Determination: the machine is set to a certain power. This must be supervised by man.
- Regulation: Control of the machine is exercised by the steam-pressure valve (B), the speed controller (C, set in motion by the flywheel) and other devices. Lubrication is also carried out to a certain extent automatically.
- Organisation: The steam is generated from the boiler (the inferior environment) through pipe A.
- Dynamisation: steam is fed to the slide-shaft box D. In the slide-shaft box, the steam is fed into the cylinder (F) or the exhaust-steam pipe (G).
- Kinetisation: The piston drives the flywheel (E) via the piston rod and the connecting rod. The flywheel in turn drives the slide-shaft box.
- Stabilisation: the power is transmitted to the looms via rods and drive belts.

Thanks to the development of control technology, machines now exist which are able to carry out several tasks on their own. Also the computer is a man-made machine. Its designers created it to process information and to provide useful data (as products) which enable other machines to process material products in accordance with the given information.

Organic and inorganic non-equilibrium systems:

The biotic non-equilibrium systems form the second large group in this type of system. It includes the cells and organs, but also the biotic populations such as the area systems, species and kingdoms. Living organisms play a particularly important part here. They transform energy, i.e. they produce. They are also programmed in such a way that they can organise themselves, i.e. that they can structure their elements and processes in such a way that they can fulfil this task while consuming as little energy as possible. Besides this, living organisms are also autopoietic systems, i.e. systems which organise themselves not only structurally like the non-equilibrium systems, but can also reproduce themselves materially and are therefore integrated in the general energy cycle through their own corporeality. They therefore also belong to the 6th stage of complexity (see section 2.6).

Systems in the micro and macrocosmos (e.g. atoms, molecules, star systems and galaxies) also occupy a double position. On the one hand, they constantly convert energy as non-equilibrium systems. On the other hand, they also create themselves materially. In our order of magnitude, i.e. in the mesocosmos (see section 1) inorganic non-equilibrium systems as enduring self-maintaining structures characterised by division of labour and task processes do not seem to exist. However, many flexible constantly changing non-equilibrium systems emerge in the large compartments of the earth's crust (litho-, hydro-, and atmosphere). For example, they may take the form of swirls. Atmospheric examples of these are tornados, tropical hurricanes or the depressions in the temperate zones. Various bodies of air are moved structurally and dynamically and joined together to form new dynamic entities. These non-equilibrium systems are on the move and exist only for a few hours or days before breaking up again.

An impressive example is offered by the tropical cyclone (BLÜTHGEN and WEISCHET 1980, p. 415 f). The weather chart (fig. 88) shows a hurricane with its centre to the west of Cuba. It is a centrally and peripherally organised system of about 500 – 800 km in diameter which is characterised by a difference in air pressure of 1016 bars at the periphery and 968 bars at the centre with winds circulating at up to 45 knots (approx. 80 km/h). Areas of precipitation with lengths of up to 800 km can be seen running parallel to the isobar lines.

An essential precondition for the formation of a tropical cyclone is a layer of warm moist air lying over warm sea water (minimum temperature 26°C) as well as low air pressure provided by a depression originating from outside the tropics. This fringe depression sucks up the warm humid air in its vicinity. However, this air does not reach the centre directly but is deflected by the Coriolis force (already perceptible at 10° latitude north and south) and pulled into the system in a spiral path. In this area of converging air currents the warm humid air is forced to rise, resulting in cloud formation and extremely high amounts of precipitation (up to 1000 mm and over). The condensation releases warmth which in turn considerably accelerates the convection. This then increases the flow of air from outside producing wind velocities of over 100 km/h and locally over 200 km/h. Due to the vertical convection currents, an area of high pressure is created in the cooler layers of air around the top of the troposphere (approx. 12 km high) from which air is withdrawn to enter the general atmospheric circulation. At the centre of the cyclone, the so-called "eye", which has a diameter of approximately 10-30 km, there is a compensating downward flow of air which dissipates the cloud and causes the wind to drop.

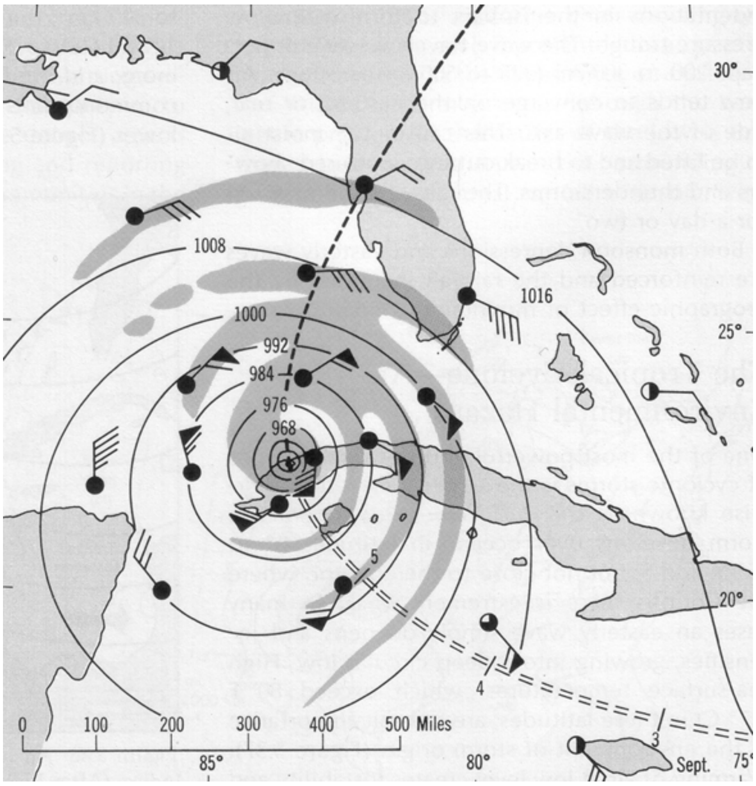


Fig. 88: A hurrican in the West Indias as an example of an inorganic non-equilibrium system (weather map).
The centre of the storm ("eye") is over West-Cuba. The shaded areas are the precipitation areas. The dashed line is the storm track.
After Strahler and Strahler. Source: See "Notes on the figures".

Thus, the tropical hurricane can be seen as a gigantic heat engine in which the thermal energy is converted to kinetic energy. The processes of conversion from the gaseous to the liquid state of the water also play an important role. By far the greater part of the energy is expended in the processes of elevation and only a smaller part in the horizontal movements i.e. the winds close to the surface of the earth and export movement in the upper layers of the atmosphere.

On the mainland, the tropical cyclone quickly loses its energy since the source of its energy, the warm humid air above the surface of the ocean is cut off, and forces of friction (including the damage to entire regions) slows down the movement of air.

Individuals as elements and as non-equilibrium systems:

In all the types of system reviewed, the elements were regarded as units and their internal features (structure, processes) not discussed. However, in doing so, we assumed that the elements have an existence of their own, that they strive to maintain their existence. We attributed to them certain interests and abilities of their own which make it possible for them to react individually. This is especially apparent in the example of the individuals. They play a decisive part in understanding the populations.

These elements should be interpreted differently from the "agents" of the "artificial society" (see section 2.3.2.2). These have no existence of their own and are controlled from outside. For these, either fixed characteristics (e.g. sex) are prescribed or such characteristics as change through interaction with other agents or the peculiarities of the “landscapes”. These agents are not the image of a living being which aims to satisfy its own requirements, which depends on carrying out certain actions which are essential for its existence (action projects, see section 2.2.1.1).

However, the agents too may be regarded as individuals in their specific roles, as elements of which it is possible to describe using the model of non-equilibrium systems. We have to take two basic facts into account, i.e. 1) that humans are incorporated in a society and contribute to changing it (this is their role), and 2) that humans are beings which have to satisfy their own (cultural, biotic) requirements. This must also be considered in the case of the agents.

Firstly in the tasks of the humans inasmuch as they belong to mankind as a society (see section 2.5.1.1):
1. Perception: this is necessary for orientation in the environment. It is used for exploration, the formation of new communication links, the channelling of information and therefore the expansion of knowledge and experience.
2. Determination: individuals decide how to use their knowledge. In this way they exercise self-determination, give their actions, along with others, a direction and a purpose (e.g. "cultural functions" according to BOBEK 1948).
3. Regulation: humans adjust themselves to the hierarchy, e.g. of the state community ("political functions" according to BOBEK 1948). This allows them continuity of actions within regulated channels and the provision of protection from external influences ("Basic requirement of security" according to MALINOWSKI 1944/75, pp. 123). Communication is essential to this (PARTZSCH 1965).
4. Organisation: the individuals and their actions require space. The demand for space obliges them to co-exist on the surface of the earth. This raises the question of competition and the problem of the optimum location (Bobek's "toposocial functions"). This includes movement and transport ("overcoming of space")(PARTZSCH 1965: participation in traffic as a basic function of existence; Bobek's "migrosocial functions" are included here).
5. Dynamisation: individuals require the infrastructure of a community which allows them to utilise the environment to the best effect ("oikosocial" and partly "toposocial" functions according to BOBEK 1948).
6. Kinetisation: the actual action then follows. It is expressed in many ways. It includes for example, work in an organisate

through which energy from the environment becomes usable. It is here that the tasks mentioned in the above categories are completed.
7. Stabilisation: the extent of this supply has to be adjusted to the requirements of the demand and this is determined by consumption. The harmonisation of supply and demand produces stability.

Secondly: Whereas the people here are seen as producers procuring the materials they require by acting as part of the superior populations, the consumption starts at the 7th stage, i.e. the individuals as living organisms (as members of the mankind as species, see section 2.5.1.1) absorb the materials they require. The induction process therefore leads into the reaction process.

This process in turn includes perception (finding out), decision, incorporation in a group, the overcoming of distance, as well as the intake of food, enjoyment of rest periods, reproduction etc. Unlike the populations, the individuals as non-equilibrium systems order the sequence of these action projects themselves in accordance with their own requirements and the requirements of the populations in which they are integrated as elements. It is important to remember that each individual can only carry out the projects one after the other and that he therefore has to adhere to a time allocation, e.g. day or week or year.

Thus, we take into account the multifarious links in a society due to the flow of information and energy, in which individuals through their private and professional lives and intentions are integrated.

City-umland system:

The city-umland-population is of special importance for the mankind as society (see section 2.5.1.1). This is reflected in the assignment of the concrete utilisation activities involved in the tasks of the process sequence. A clear ring structure is recognisable (the city of Saarbrücken as an example; see figs. 89 and 90; see also section 2.2.2.4):

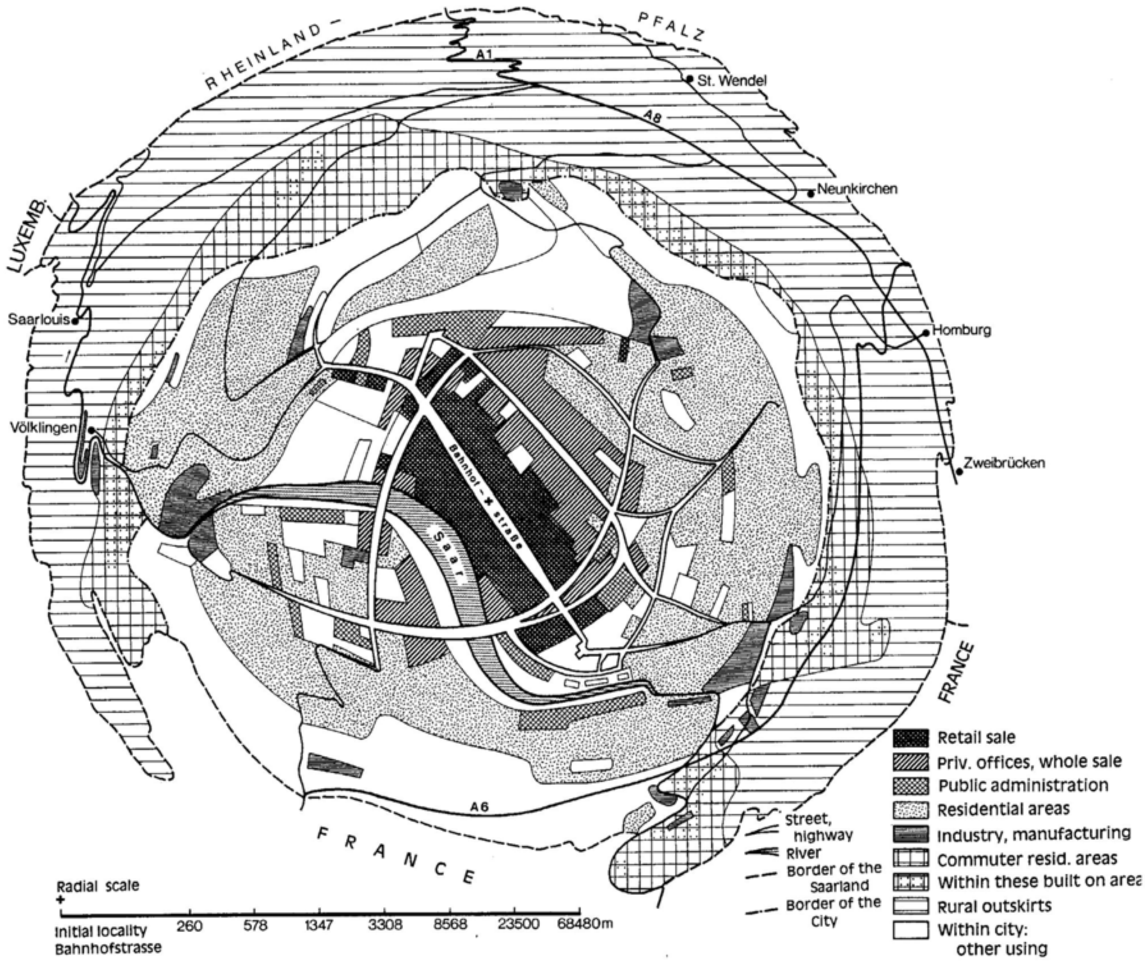


Fig. 89: City-umland system Saarbrücken/Saarland, zoning of socio-economic activities (A). Result of mapping in the 1970s. The distance from the centre to the periphery was entered according to the potential scale. Source: See "Notes on the figures".

- Perception: The centre of the town is (from a geometrical point of view) the most accessible point, i.e. among other things because it is here that producers and consumers can come into contact with one another most easily. The retail trade forms a link between the two groups.
- Determination: This centre also attracts the organisates which are most important for making decisions in the economy, i.e. representative offices of companies, banks etc.
- Regulation: the public administration adjoins towards the outside. It supervises the good order and legality of activities, thereby forming a link between the system as a whole and its inhabitants.
- Organisation: The actual elements of the city-umland-system are the inhabitants. They consume. The workers also produce and live either from their work in the central business district or in the industrial areas around its periphery.

It is here that those districts of the town and country population begin, which are engaged in the actual production.

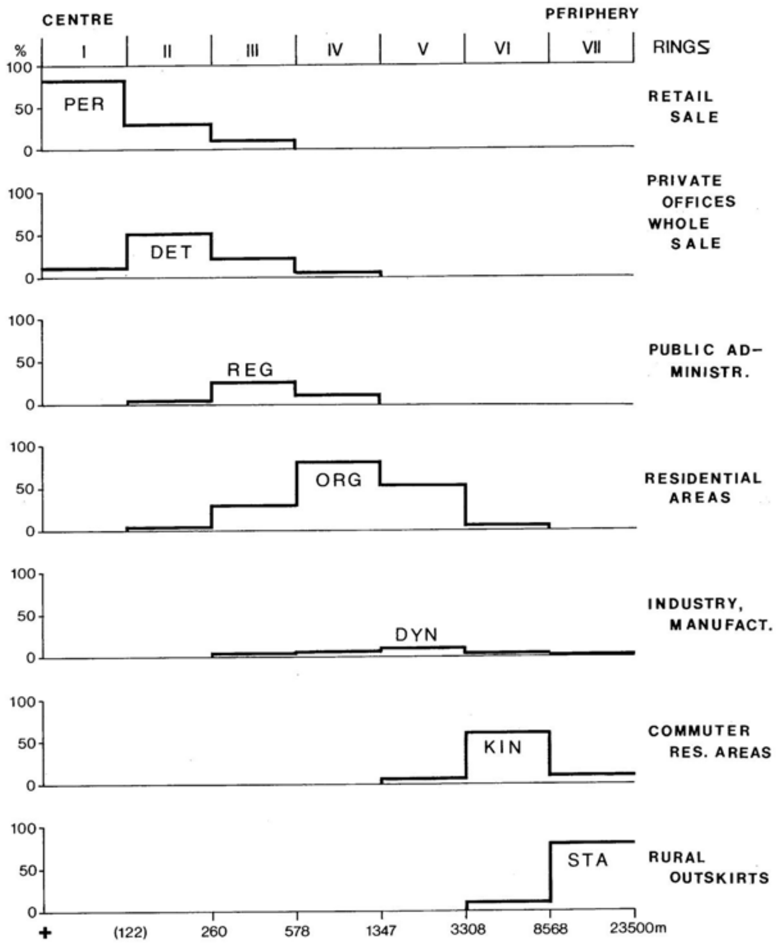


Fig. 90: *City-umland system Saarbrücken/Saarland, zoning of socio-economic activities (B). Result of mapping in the 1970s.*
In the arrangement of the rings, the scale of tasks can be seen in accordance with the process sequence perception ... stabilisation.
Abbreviations: Per = perception, Det = determination, Reg = regulation, Org = organisation, Dyn = dynamisation, Kin = kinetisation, Sta = stabilisation (Source: See "Notes on the figures").

- Dynamisation: Moving outward, places of high productivity and high energy consumption become more common, industrial plants, intensive agricultural units, market gardens etc..
- Kinetisation: Then come the large traffic facilities (railway shunting yards, airports, highway junctions, canal ports etc.). Here the communities are concentrated in which the commuters live, i.e. those population groups which are dependent on effective communications systems with the city.
- Stabilisation: The extensive outlying districts are occupied by agriculture and central places of lower rank (see section 2.5.2.1). It is in the area of transition to the field of

influence of the neighbouring city-umland-population, that the system stabilises.

As the process goes on, the tasks change in radial direction (see fig. 91) from the centre of the system (in this case the central business district of the town) outwards towards the periphery of the umland. The task stages of the system are passed through gradually, as is typical for conversion processes in non-equilibrium systems.

Since the 1970s, the picture has changed slightly. The private car has become the favoured means of transport of the commuting population at the expense of the previously predominating public forms of transport. Many of the inhabitants have moved into the country, thereby attaching these areas more closely to the centre, i.e. the town as employer and shopping centre. On the other hand, new shopping centres with large car parks have appeared close to the residential areas. These too have loosened the economic relations between the retail business, the trades and agriculture, because the cost of transport no longerrepresents the same proportion of the final sales price as before. Thus, in certain sectors, the markets are dominated by extensive trans-regional and trans-national fields of influence. All this promotes change in the structure of production and population of the city-umland-populations.

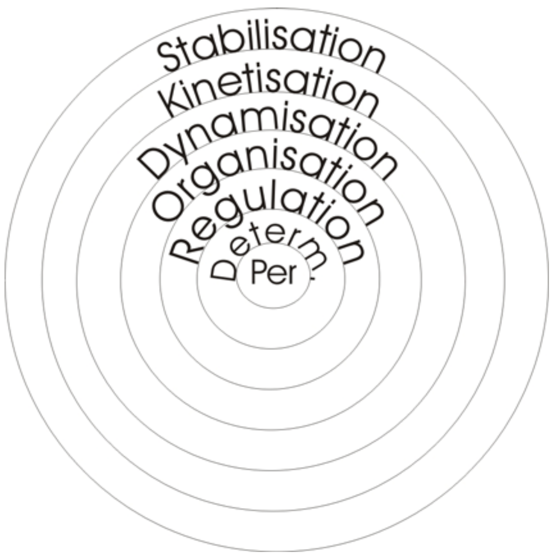


Fig. 91: The process pattern in a spatial central-peripherally shaped non-equilibrium system (city-umland population).
Scheme. The process leads from ring to ring, from the inside outwards (induction process). Per = perception; Determ. = determination.

Nontheless, the central-peripheral organisation of the population itself, i.e. of the actual system, is clearly recognisable. It will be interesting to observe how this development continues in future.

In each case the city-umland population is limited by the accessibility of the city. The commuters and the inhabitants of the surrounding area making use of the services provided by the town must be able to reach it, carry out their work or other business and return to their homes in the course of a single day, as is the case with the city-umland population of Saarbrücken in the Saarland. Very high-ranking centres have other functions (e.g. Frankfurt am Main which possesses a big airport and is a centre of finance) which go well beyond those of the city-umland population.

Time maps:

In section 2.2.2.4, we looked at an isochronal map in which the times taken for journeys were shown. With time charts, the procedure is reversed. The maps take the time duration as its basis. They depict "time space". These maps display features such as borders, rivers, towns, coastlines etc. on the surface in such a way that the distances between two points on the map are not shown in proportion to their spatial distance, but to the time taken to travel between them. I.e. with shorter travel times, the towns move closer together, whereas with longer ones they appear to be further apart. This leads to a geometrical distortion of the map.

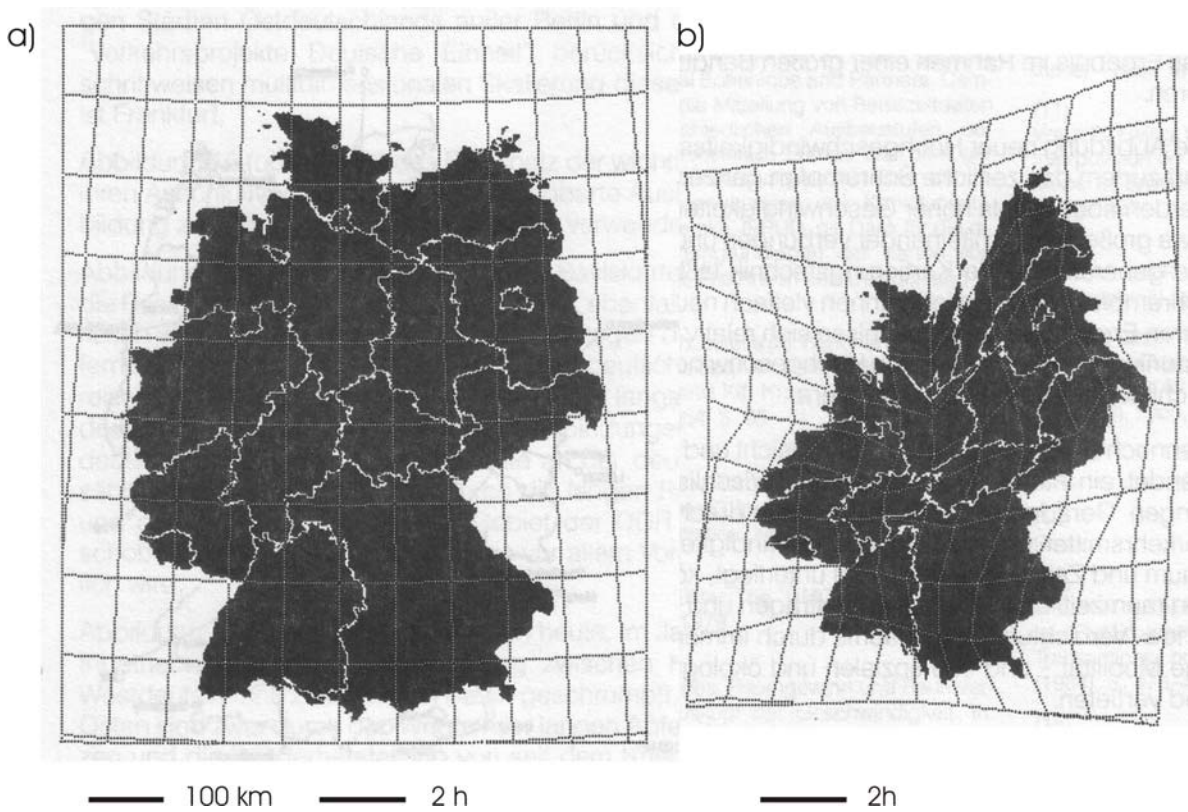


Fig. 92: Time map using the example of rail travel in Germany.
a) Basic map (60 k.p.h),
b) Railway travel times 1993. The scale is not the spatial distance as in a) but the time taken to cover it.
After Spiekermann und Wegener. Source: See "Notes on the figures".

If it is assumed that journeys everywhere in the region displayed on the map are undertaken at the same speed, the maps are similar to the conventional topographical maps (see fig. 92a). SPIEKERMANN and WEGENER (1993) called these basis maps. They are necessary for reasons of comparison. The example quoted here uses travel time by rail in Germany. It is assumed that all the distances are covered at an average speed of 60 k.p.h. The strong distortions (im fig. 92b) indicate that on most of the railways the speed of travel is greater than 60 km. per hour. The period has contracted, although to a different extent. Regions with a highly developed network are specially privileged. Time-space is especially reduced by high-speed railway systems. In West Germany, space seems to be condensed, whereas the territory of the former GDR to the east seems disproportionately large.

2.4.3. Process sequences and dominant systemic dimensions

Numerical sequence:

The conversion process is specified and arranged in a hierarchy of 4 process levels. The main process consists of 4 states – adoption, production, reception and reproduction. The differentiation of the process dominates with a total of 16 task process stages (the fact that, in reality, only 13 and not 16 task process stages are defined is not taken into account here; see section 2.4.1.2), and at the inferior process levels there are 64 control and 256 elementary process stages.

The non-equilibrium system is also anchored horizontally (temporally) in the environment, or, seen from a different angle, the nonequilibrium system has annexed a part of the preceding and succeeding environments, i.e. taken over control of it (see twin processes, section 2.4.1.2).

The coordinate system is again passed through in horizontal direction (anti-clockwise, variant C of the basic process; see fig. 93). As a result of the interlacement (see section 2.2.3) appears the new structure:
f(x), adoption: The demand (information) is entered as a stimulus from the previous environment.
f(-x), production: The energy is absorbed from the inferior environment according to the capacity available, and in so doing is processed into the products demanded.
Now, the market-related flow of information and energy turns into the system itself:
-f(-x), reception. The succeeding environment is involved.
-f(x), reproduction: The system re-shapes itself as specified by reception and emerges in a new shape (self organisation).

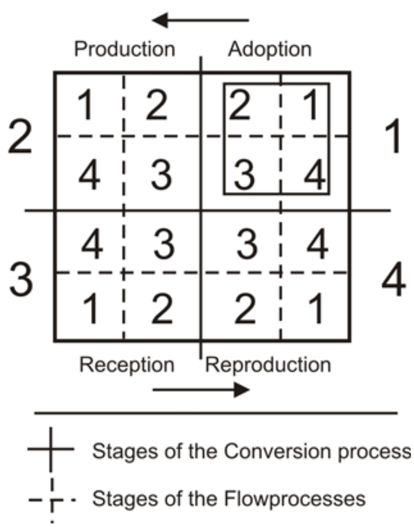


Fig. 93: Scheme of the conversion process. Numerical sequence.
1st rank process (C variant, see arrows); Induction process: Front side (Adoption) upper right, Development from right to left. The reaction process (see section 2.4.1.2), i.e. the opposing part, is symbolised in the y-negative area (from left to right). 2nd rank process: The main processes are sub-divided chronologically by the task processes. Within Adoption: 1 (perception), 2 (determination), 3 (regulation) and 4 (organisation 1st part). Within Production: 1 (organisation 2nd part), 2 (dynamisation), 3 (kinetisation) and 4 (stabilisation). The same order (exists) at the stages of Reception and Reproduction.

Through folding the coordinate system is broken up and the process sequences are linked up. The task processes are horizontally ordered in the sequence. Here, the basic processes are doubly opposed. This corresponds to the sequence perception ... stabilisation in the induction resp. reaction process (see section 2.4.1.2). The production stage and the process of reaction (reception and reproduction) are folded behind the induction process ("emergence code"; see section 2.2.3).

Route diagram:

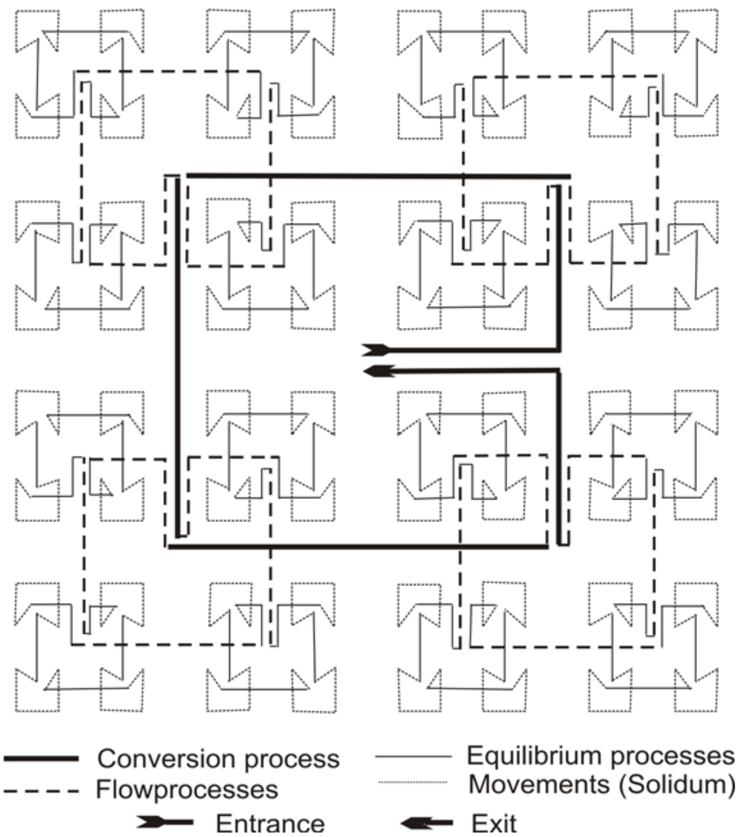


Fig. 94: Route diagram of the Conversion process (Non-equilibrium system), assigned the processes and systems of the lower complexity levels.
The stages of the 1st rank basic processes can be assigned to the systems structured according to the C variant. Each of the lower basic processes shown in the diagram represents a large number of individual basic processes.

The course of the entire process is shown in fig. 94. To achieve clarity concerning the flows themselves, it is necessary to unfold the numerical sequences of the systems. We are dealing with variant C of the basic process, i.e. the process course tends to the left. The entrance from the previous environment and the exit to the succeeding one are shown at the centre of this diagram. In particular, it should be noted that two different halves of the overall process must be distinguished. In the upper half, the induction process (stages 1 and 2, adoption and production) is located. The lower half is taken up by the reaction process (stages 3 and 4, reception and reproduction). Here, the order in which the processes take place is reversed. In the main stages of adoption and reception, the task stages of perception ... organisation can be seen, and in the main stages of production and reproduction, the task stages organisation ... stabilisation. These sub-processes are structured as flow processes (see section 2.4.1.2).

The dominant systemic dimensions (see fig. 95):

Time (T): In the conversion process, not only are the beginning, sequence and end determined, but also the chronological rhythm fixed (2nd process train). The chronological rhythm from the environment (oscillations) is brought into harmony with the internal processes of the system. The environment is seen as being chronologically preceding and succeeding and can therefore be linked with the process in the system. Inside and outside (e.g. market) the sequences can be coordinated with one another, i.e. the process rhythms can be harmonised. In this way time is established as an independent system dimension. The planning of time and the shaping of space can be undertaken independently of one another. For the structuring of this type of system, the time dimension is predominant.

Space (S): This requires an internal spatial order and an external border. This core space can now be organised to suit the process sequence. The processes in the different internal departments can be linked with a minimum of space between them. System, departments and elements form a unified organisation. The self-organisation represents the internal predominance of the system dimension of the space. Process fluctuations peculiar to flow-equilibrium systems are reduced by stricter control.

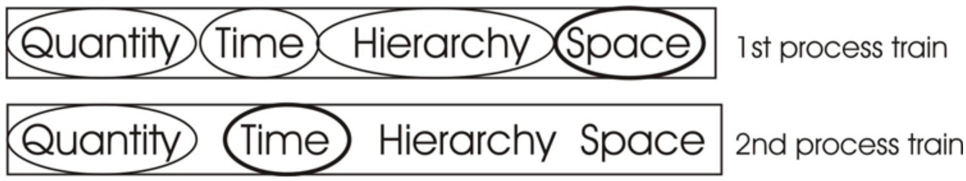


Fig. 95: Space appears as the predominant system dimension in the 1st process train and time as the predominant system dimension in the 2nd process train.

Moreover, this requires an external space of influence which allows contacts with other systems. The superior and inferior environments are realised spatially as areas of influence. These areas also consist of non-equilibrium systems which stimulate or are stimulated. The superior environment (as part of the superior hierarchic system; see section 2.5) is formed by those systems which demand and receive products through the market (marketing area), the inferior environment of the energy and material suppliers (supply area). Thus the flow process rhythms can be harmonised and the process sequence co-ordinated. The environments are not subject to the same control as the internal departments. Here, it is self-regulation which takes place, as with the flow-equilibrium systems.

Outlook:

Products generally consist of different parts which have to be processed and assembled. This takes place in processes of conversion. These require a division of labour and accurate coordination of the various operations. They have to be organised in such a way that the products are available when the market (i.e. the superior environment) requires them.

This type of process is therefore very different from a flow process. However, the objects of study as such are the same. They are either non-equilibrium systems, which construct the flow equilibrium systems (= compartments) and are stimulated to activity by these through the diffusion of innovations (e.g. factories in the operations of the market), or flow equilibrium systems, which are involved as compartments in the flow of energy of a non-equilibrium system (e.g. a factory). There are a number of possible results depending on the question asked and the method of examination. Unless the right approach is adopted, this border zone between the third and fourth level of complexity is elusive, and it is easy to understand why the different nature of the two types of system remained concealed for so long.

The internal flows of information and energy in the non-equilibrium system are optimised in the conversion process. But the contact with the superior and inferior environments is achieved only through feedback, i.e. only after completion of the conversion process is it certain whether the products meet the requirements. It may therefore be advisable to incorporate a more precise control here in order to moderate the fluctuations associated with feedback. The non-equilibrium system must receive a task for the overall proceedings at a higher level. This can only be achieved in a superior hierarchic system in which every non-equilibrium system is allocated an exact position and has to maintain itself there. The hierarchy becomes the predominant systemic dimension at the next higher level of complexity.

2.5. Hierarchy processes and hierarchy systems

2.5.0. Instead of an introduction: The textile factory as a member of mankind as society

The factory was bound up in a web of economic and social relationships. It had to sell the fabrics (cloth and blankets) it produced, but on the other hand, it had to purchase the raw materials and a multitude of other goods, machines and services. It also required workers, which, as independent individuals, had to be able to lead their own lives culturally and economically in the community in which they lived.

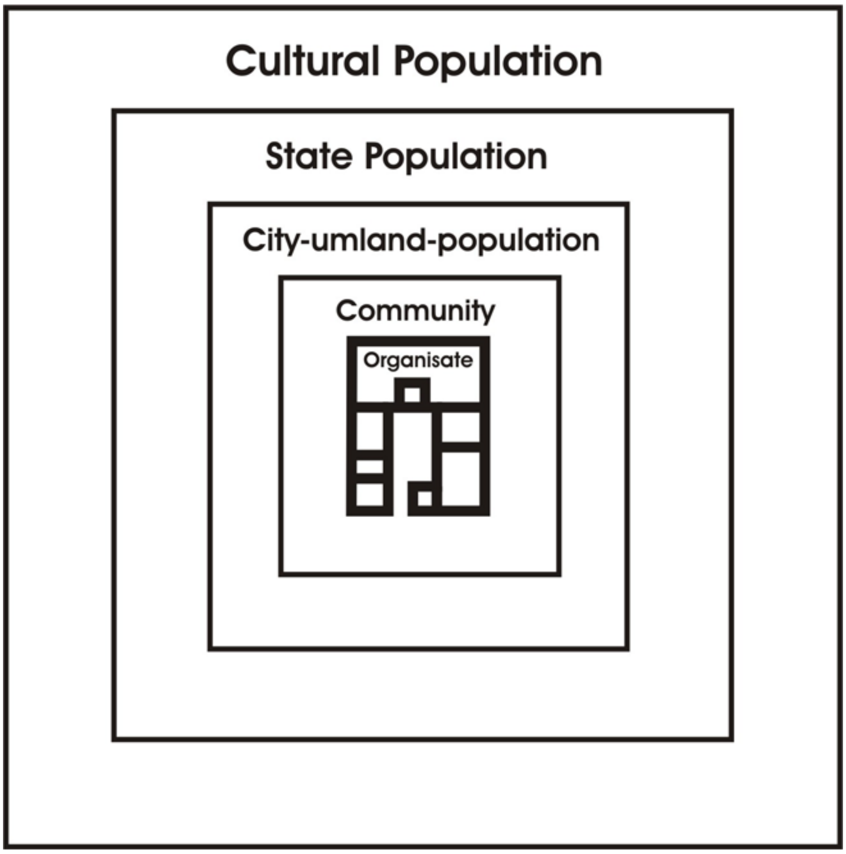


Fig. 96: The textile company in the hierarchy of populations.

The factory was situated in a small town and was therefore part of that community (see fig. 96). It paid taxes and other duties to it, but also benefited from the services it provided. The community is traditionally responsible for the local infrastructure, i.e. for the way in which land is used, for the construction and maintenance of roads, bridges, schools, sports facilities, cultural institutions etc. On the other hand, the community must ensure the protection of the environment, conservation of the landscape, disposal of waste and sewage. It is the infra-structure which makes it possible for the organisates to function. Besides these, there are private central institutions (organisates) such as shops, cinemas, doctors' surgeries, chemists, banks etc. which are generally grouped around the centre of the community where they are easily accessible for the inhabitants. All the places of importance for day-to-day business can be reached in a relatively short space of time (in smaller communities in less than an hour) either on foot or by transport. The community offers the organisates not only the environment they require, it is also the living space of its inhabitants. These inhabitants live with one another and develop their own forms of social communication. Common festivities, clubs and social institutions, assistance among neighbours bind the people together, are the expression of a strong social coherence which also includes social control.

The smaller communities are linked with the nearest large city by public-transport systems and private vehicles. It is the economic and cultural centre of the region, with vast range of shopping facilities, banks, insurances, medical specialists, hospitals, theatres, institutions of advanced education and many other services. As a large industrial centre, it also offers employment to those who find no suitable work closer to their homes and have to commute daily. The country surrounding the city provides it with the greater part of its foodstuffs and provides recreation and living space to many of those who work in the city. Thus, besides the rural and small-town communities, a population has become established which is based on the city and its surrounding district: the city-umland population. Its function is to permit a balance between the commercial/industrial and the land-based agricultural activities in space (see section 2.4.2.2).

This population is in turn subject to the state which guarantees safety and the protection of the law. For this purpose too, taxes have to be paid. Certain restrictions on individual freedom have to be accepted, although every citizen requires a clearly established legal framework for self-fulfilment. The police departments are present in the community, but it is principally the legislative and executive functions exercised by the state which make it possible for the organisates to develop economically and benefit from the markets and finance industries. Some of these state functions are fulfilled by local government institutions.

The inhabitants of the communities, city-umland populations and states are generally also members of religious communities. For instance, the church as an institution conveys religious and philosophical, i.e. "eternal" values, and sets ethical standards. They are a constituent part of the culture, whose carriers are the entire cultural population, e.g. of Europe, the Orient, Eastern Asia.

2.5.1. General considerations

2.5.1.0. Introduction:

The "hierarchical system" and the "hierarchical processes" constitute the 5th level of complexity.

Every working person is on the one hand part of the socio-economic hierarchical system which we will term "mankind as society" and, on the other, as a living creature, part of the biotic hierarchical system which we will term "mankind as species" (see section 2.5.1.1). Here, we are primarily concerned with membership of mankind as society.

The society appears as a hierarchically structured formation composed of populations. As an organisate, the textile mill occupied a certain position - as a socio-economic population in which individuals worked and produced. The organisate provided the economic basis for the individuals working in it and enabled them to resolve their personal cultural, physical and biotic problems (as expressed in nourishment, reproduction, rearing of children, provision for old age etc.).

In order to cope with their working lives, individuals have a multiplicity of different problems to solve. This is only possible because they are embedded in this hierarchy which relieves them from certain specific qualitatively (thematically) definable tasks which they are unable to fulfil themselves. Each individual (who himself appears both as worker and consumer) belongs to these populations. Their characteristic features and their integration in the hierarchy with regard to process and structure will be described in more detail below.

2.5.1.1. System and process

First of all a brief preview:
1. The population types have - as mentioned already - certain tasks for society. These tasks are given thematic form within the framework provided by the institutions of work, consumption, traffic etc.
2. At the hierarchical levels, the populations fulfil their tasks through processes (see section 2.4.1.2). These too are in a hierarchical relationship to one another. The populations provide work for the hierarchically superior populations. This should be reflected in the duration of the processes.
3. The populations are arranged hierarchically in such a way that the more general institutions include the more specialised ones, and that the larger populations are in a system-subsystem relationship to the smaller ones. Two hierarchies can therefore be distinguished.
4. The hierarchy also takes effect in the spatial arrangement of populations since the superior populations encompass the inferior

populations spatially. Moreover, the populations as non-equilibrium systems have fields of influence through which spatial interlinking is possible.

The catalogue of tasks and institutions, the populations as carriers:

Originally, mankind was a species like many others, i.e. a population, a non-equilibrium system, which fulfilled all the tasks fulfilled by any population intent on survival. In the course of mankind's history, individuals have delegated more and more of the tasks necessary (or useful) for life, by coming together to form superior entities, i.e. new populations, and dividing up their activities or work. There are no completely self-sufficient individuals who can carry out all the tasks necessary for living themselves. Becoming human is causally bound up with the process of specialisation. This process of division and subdivision into specific tasks is part of cultural evolution and experienced a dramatic acceleration around 30 - 20.000 years ago with the result that mankind is now a highly complex structure.

In the last resort, it was most probably economic reasons (effectiveness) which were decisive for specialisation.
As basic requirements, the biotic necessities (health, recuperation, nourishment, security, reproduction etc.) explain an ever-increasing differentiation, for example in economy, technology, transportation etc. continued to sub-divide rapidly. Thus, mankind divided (as already mentioned above) structurally into two parts, which developed differently:

Mankind as species, within which individuals satisfy their biotic requirements, and mankind as society, responsible for the optimum utilisation of environmental resources, for energetic supply and for comfortable conditions of living (see also section 2.5.2.1). Each individual belongs to both types of mankind. In order to understand and categorise the multitude of tasks and activities of humans from their structural side, we must proceed step by step.

The single action projects resp. processes are concretised, i.e. thematically institutionalised. This includes a division of human activities according to the tasks, i.e. the thematic or qualitative aspects. In institutions, this thematic division through different norms and organisational forms (as well as through feedback, see section 2.3.1.1) is given permanent form with the result that they represent components of order which are generally accepted by society.

In some comprehensive institutions, the basic socio-economic activities and processes are easily recognisable. Mankind as society must - like any population (see section 2.4.1.2) - fulfil the tasks listed above (perception ... stabilisation) in order to exist. One might now enquire which of the institutions may be assigned to a specific task. These institutions which are, so to speak, of the highest rank are described as "basic institutions". Each of these institutions is embodied in a certain type of populations. They are the carriers:

- In order to have a foundation for vital decisions, it is first necessary to obtain information. "Perception" appears as a task. It is the essential pre-condition for all (non-spontaneous) action. By nature, humans possess an organism which is identically equipped with senses which permits them to perceive the advantages and disadvantages of nature as a vital resource. "Knowledge" and "science" as well as "art" are the basic institutions. They are founded on perception, and this is, in a general sense, essential for allowing mankind to cope with its environment and adapt its behaviour to it. The carrier is the mankind as population.
- How humans act depends (in the last resort) on their basic attitude to life and their environment. It is a decision. In the catalogue of tasks, "determination" now appears. "Religion" (as a basic institution) as well as the "conveying of values" in general, give mankind its fundamental orientation, its sense. They establish the desired, if not always achievable, ethical ideal. This forms the units, which are distinguished by a certain view of life and by the technical approach taken to the utilisation of the environment ("culture"), a definable position in the cultural evolution, i.e. by the degree of division of work. The carrier is the cultural population.
- "Authority", "power" and "rule" form the basic institutions connected with the task of "regulation". They ensure that the actions and processes are carried out in accordance with law and order. They form the framework, within which the process steps can be co-ordinated, in which the passage of information can be controlled. Without control, no coordination is possible, and work is dissipated without effect. The carrier is the state population.
- "Transportation" and "interchange" (as basic institutions) permit spatial "organisation". The resources of the inferior environment can only be utilised to the best effect by linking the differing advantages of the various localities with one another. So the services and the trades and the dwellings at the centre are linked with the agriculture and the recreational facilities in the surrounding country. The carrier is the city-umland-population. At this level, the population types in the hierarchy are divided between those which serve the processing of information and those which serve the processing of energy. Whereas the populations situated higher up the hierarchy process more abstract information (science and art, religion and control), those lower down the hierarchy are concerned with the activities devoted directly to the processing and distribution of energy.
- The utilisation of the energy resources of the inferior environment, i.e. the task of "dynamisation" is made possible by the creation of the "infrastructure" (as a basic institution),

among other things of the earthbound artefacts (see section 2.1.1.1). The carrier is the community.
- The "processing" of the products themselves (as a basic institution) is defined by the task of "kinetisation". It is linked with the division and organisation of work. This may involve completely different things and the product may be of material or immaterial type. At this level, the immense variety of intellectual and material products, typical of a society based on the division of labour, is manufactured. The carrier is the organisate (see sections 2.4.1.1, and 2.4.1.2).
- Planned physical and intellectual activity may be defined as work. The remuneration for work allows man to satisfy his requirements. "Work" and "consumption" are the basic institutions located at the end of the scale, thereby fulfilling the task of "stabilisation". Here, the elements in the hierarchical system are formed. They receive their income from the services they provide, and must also provide services for the superior populations. The carrier is the individual (in his role).

In Tab. 1, the results of this section are summarised.

Tab. 1: The population types of mankind as society, basic tasks and basic institutions:

Population types	Basic tasks	Basic institutions
Mankind as population	Perception	Science, art
Cultural population	Determination	Religion, culture
State population	Regulation	Rule, power
City-umland-population	Organisation	Transportation
Community	Dynamisation	Infrastructure
Organisate	Kinetisation	Processing
Individual	Stabilisation	Work & consumption

The hierarchy of processes:

All these institutionalised tasks are constituent parts of human existence. They must be realised in temporal succession, i.e. in processes. We must take this into account in two respects:
1. Mankind as a society is in general undergoing change. A constant change can be detected, renewal against the background of social change. The renewal does not take place continuously, but in the shape of innovations (about the diffusion of innovations see sections 2.3.1.1, and 2.3.2.2). These arise at the individual hierarchic levels which join up to form flow-equilibrium systems. Their elements are the populations as subsystems (see below and section 2.5.1.2). The basic institutions are come into being in the flow-equilibrium systems. In reality, the above-mentioned list of tasks is worked through step by step in the form of a process

sequence, it begins with perception, determination then follows, then regulation etc.

2. At the various hierarchical levels, the processes (in the populations) take place at different speeds. The validity of established views, technical standards, fashions etc. lasts for different lengths of time. There are "eternal values", i.e. those which are unshakeable, in particular the accumulated knowledge of the world and the basic ethical standards. Besides, the term "longue durée" (BRAUDEL 1958/92) can be applied to large-scale technical installations (e.g. the railways), artistic periods which may involve many decades or even centuries. The local infrastructure of economic activity has to be changed more frequently, every few years. Finally, the yearly, monthly, weekly and daily periods should be mentioned, which strongly influence the conditions of life and work in their details.

If one establishes that the inferior processes provide work for the superior processes, one can come to the conclusion that the processes differ by the factor 7, because each process sequence (induction process) comprises 7 stages (perception ... stabilisation). Actually, - and this is suggested by the inductive results of earlier studies (FLIEDNER 1981) - the average number is 10. Why this should be so is not well understood. In particular, this factor 10 becomes apparent in the processes higher up the hierarchy. With the shorter processes, there are variations primarily because nature imposes a different rhythm (yearly rhythm, daily rhythm).

The cyclic structure of processes observable in the "rhythms" is due to the feedback at the end of each induction and reaction process (oscillations; see sections 2.3.1.1, and 2.4.1.2). If we carry out a classification, we define the duration on the basis of the individual process stages (perception, determination etc.) and not on that of the overall process sequence of the induction process.

The principal process of the mankind as society is that of "cultural evolution" (see also section 2.4.2.1). In the earlier palaeolithic era, humans were hunters and gatherers. They spread over the earth little by little and so created their living space, the ecumene. In the later palaeolithic era, a new chapter in the history of mankind began. The humanity grew rapidly; it was accompanied by the invention and spread of innovations, in particular of technical equipment for economic purposes, which indicates increasing knowledge of the (energetic) environment and the possibility of its utilisation. The hunters and gatherers became more differentiated. In the course of the evolution, mankind as a society developed structurally out of mankind as a species. Thus, the energy in the ecumene could be obtained much more efficiently. Indeed, not only the extraordinary growth of the population, but also the increase in life expectancy and living standards proved that mankind was learning to exploit the resources of the inferior environment much better. The differentiation of the flow of energy and the differentiation in hierarchically arranged populations are essential for this.

The tasks of society incorporated in the basic institutions gradually became more specific and a hierarchy came into being. In this way, mankind took the form of a hierarchical system, mankind as society. Mankind perceives the possibilities in its environment, accumulates knowledge and with this knowledge, creates the basis for its own existence. The state of knowledge is reflected in the processes. It is possible to distinguish 7 process levels (see table 2; examples see section 2.5.2.2):

1) The cultural evolution as a whole is divided into different stages which are initiated by "revolutions" (see in particular CHILDE 1936/51). They show (provided we are correct) that mankind as society develops in a process, each of whose stages take several thousand years, i.e. in "millennium rhythm". The carrier is the mankind as a population.
2) Hierarchically, the next lower level is formed by processes whose stages cover several hundred years ("centennial rhythm"). At this second level, religion is created, the fundamental decision in the shaping of one's own culture. This is the basic task of "determination" in the hierarchy of processes. The carriers are the cultural populations.
3) The "decennial rhythm" covers several decades with an average of 50 years. It is apparent in a large number of ways e.g. in the so-called Kondratief Cycle (KONDRATIEF 1928; see section 2.3.2.1), in historical periods. The carriers are the state populations.
4) Also the "several-year rhythm" whose stages last for an average of 5 years has not yet been sufficiently studied. At this level, society is ordered spatially (in the hierarchy of processes, the basic task of "organisation"). The carriers are the city-umland-populations.
5) The "yearly rhythm" can be observed particularly easily in infrastructural measures, e.g. in settlement activity (in the hierarchy of processes, the basic task of "dynamisation"). The carriers are the communities.
6) The execution of the processes in detail (in the hierarchy of processes, the basic task of "kinetisation") is carried out in the "monthly" or "weekly" rhythm, with the result that the work is completed within one year. The carriers are the organisates.
7) Finally, individuals plan, work, eat and recuperate on a "daily rhythm" (in the hierarchy of processes, the basic task of "stabilisation") according to the possibilities at their disposal and the constraints to which they are subjected. Here, there is little or no process sequence involved. The carriers are the individuals (in their roles).

Table 2: The population types and basic tasks of mankind as society and the duration of the processes:

Population types	Basic tasks	Duration of processes (stages)
Mankind as population	Perception	Millennial rhythm (approx. 5000 years)
Cultural population	Determination	Centennial rhythm (approx. 500 years)
State population	Regulation	Decennial rhythm (approx. 50 years)
City-umland-population	Organisation	Several-years rhythm (approx. 5 years)
Community	Dynamisation	Yearly rhythm
Organisate	Kinetisation	Monthly - weekly rhythm
Individual	Stabilisation	Daily rhythm

Through the established process sequence, i.e. its fixed program (teleonomic processes; see section 1), the overall process of cultural evolution appears as an oriented process which continuously shapes human society with many variants, at every level and in every stage, thereby leading to ever-increasing complexity. The course of the process is determined by legitimacy and individuality, necessity and chance. It is within this framework that the reaction processes take place, i.e. in the populations of the mankind as species and its various hierarchical levels (see below). This either preserves or changes the structure of the entire hierarchical system.

In this treatise, it has only been possible to describe the ideal model. In reality, populations are linked to one another in a much more varied way, chronologically, hierarchically and spatially. This fact has to be taken into account, when the model is regarded as a module.

The hierarchy of subsystems:

Introduction:

Through hierarchies, the production of the non-equilibrium systems can be co-ordinated, the processes, i.e. the flows of energy can be controlled and the energetic resources of the environment to a great extent optimally exploited.

As shown above, 7 levels can be identified in the hierarchy of mankind as a society. These differ from one another in their tasks and institutions. The institutions are arranged in flow-equilibrium systems. The processes in these various hierarchical levels are carried out by populations (non-equilibrium systems). These are - as mentioned already - the carriers of the processes. The processes differ from one another in their duration. The question now arises as to how cooperation is possible in these various types of system. The processes can only take place within an organised framework which offers them the necessary security.

We distinguish two types of hierarchy (SALTHE 2001):

1) The "specification hierarchy" arises through division by content and typology. Thus, according to Salthe the "physical realm" is an essential precondition for the "material realm" which in turn is necessary for the "biological realm" etc. Our own example: With mankind as a society, a qualitative or thematic hierarchy appears, a scale which demonstrates the degree of dependency. It is a hierarchy of flow equilibrium systems.
2) The "scalar hierarchy" is created by the sub-division of structure and space. AHL and ALLEN (1996, pp. 107; they use the term "nested hierarchy") use an army as an example. It consists "of a collection of soldiers" and "is made up of them". Our own example, mankind as a society, is divided into populations which have a hierarchic relation to one another. It is a hierarchy of non-equilibrium systems.

Specification hierarchy:

Seen in this way, mankind as society proves to be an example of a specification hierarchy because the division of the levels into tasks and institutions also possesses a sectorally based hierarchic structure (see above). Knowledge (1^{st} level) is essential for living, for dealing with the environment. The form of living (culture, 2^{nd} level) must adapt itself to this. Power (3^{rd} level) on the other hand is conceivable within a cultural framework. And the control which it creates is essential for functioning transportation and interchange (4^{th} level). In this way, the communities (5^{th} level) can organise their infrastructure according to the overriding economic and traffic networks in such a way that the organisates (6th level) can fulfil their task with the employees (7th level) operating them. In the course of cultural evolution, the division into tasks may indeed have been of prime importance and it was increasingly stabilised through division into different population types.

If we assume that mankind as a society developed from mankind as a species primarily as a result of economic requirements, mankind as a species (as part of the biosphere, see section 2.6.2.1) can be regarded both as the superior and the inferior environment. The individual hierarchic levels (institutions) are formed by groups of populations (non-equilibrium systems). Seen structurally, these groups are flow-equilibrium systems which define the basic tasks (perception ... stabilisation). In their context they are (flow equilibrium) subsystems (see above and table 4, section 2.5.1.2).

These flow equilibrium systems (as institutions) in the hierarchy are divided between those which serve the processing of information (like the adoption) and those which serve the processing of energy (like the production). Whereas the systems situated higher up the hierarchy process more abstract information (science and art, fundamental outlook and religion, and control), those lower down the hierarchy are concerned with the activities devoted directly to the processing and distribution of energy (see below). Between these two part hierarchies, the flow-equilibrium system formed by the city-umland population has the task of taking the energy from the natural environment (ecumene) and of passing it on to the hierarchically inferior populations (communities, organisates) and individuals to allow them to make the required products within the context of the flow of energy.

The process from above to below is the information flow, the reaction process leads from below to above. The levels are connected to one another through links of demand and supply. As outlined above (see formula 15, section 2.3.1.2), these can be described in the form of Lotka-Volterra equations. So the information and energy products of the populations on the levels can be transmitted between the demanding consumers and the supplying producers in the form required.

In detail (the example of 3 levels): The information, i.e. the demand from flow equilibrium system A is fed into flow equilibrium subsystem B (see fig. 97). The appropriate non-equilibrium systems absorb it and they then demand energy from the inferior flow equilibrium subsystem C, which is then supplied by the non-equilibrium systems. However, they on their part demand energy from their own inferior environment. Thus, the flow equilibrium subsystems B and C are both suppliers and demanders.

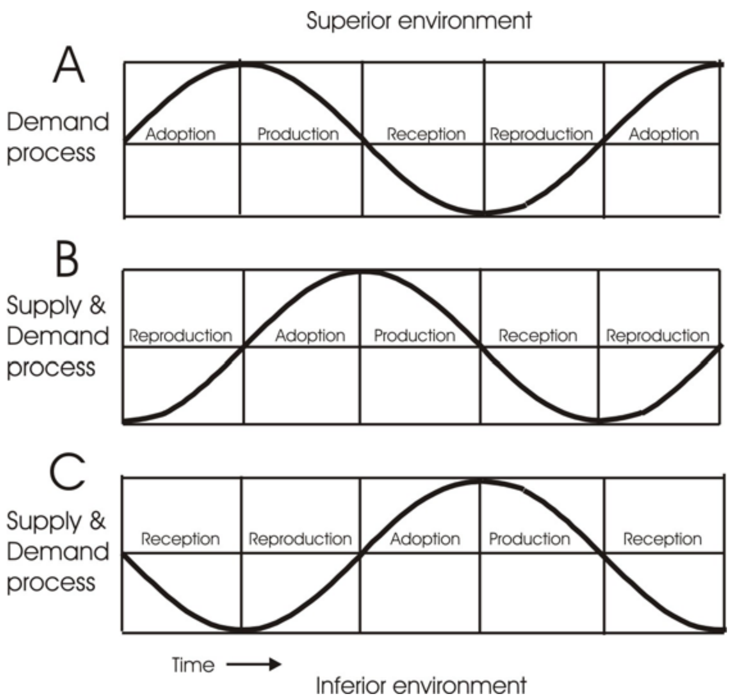


Fig. 97: Three hierarchically adjacent levels as flow equilibrium systems.
(See also fig. 66, section 2.4.1.2).

This vertical flow of information and energy is made possible by the fact that the flow equilibrium systems at the different levels oscillate at ca. the same rhythm (see fig. 98). The rhythms are dictated by the flow-equilibrium systems defining the tasks (basic institutions) in the hierarchic systems responsible (see above). As all seven hierarchic levels are involved,

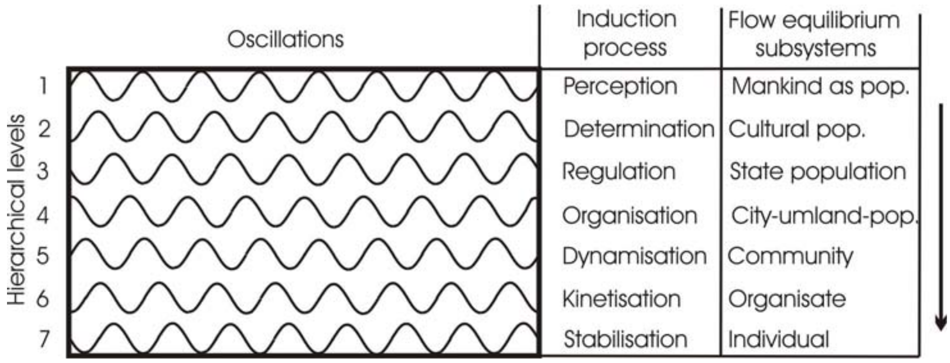


Fig. 98: Induction process in the mankind as society.
Diagram of the delay in the course of the oscillation of the hierarchic levels according to the Lotka-Volterra relationship. Delay approx. 1/4 cycle.

they oscillate in all seven rhythms. For example, the organisate also has to adjust to the day-to-day rhythm of the employees, but on the other hand is also affected by economic cycles and other overriding rhythms.

The information is absorbed during the adoption phase and the energy is supplied in the production phase (induction process). The reaction process follows at the reception and the reproduction phase. Thus delays occur which last for about one quarter phase (see section 2.3.1.1).

At the lower end are the individuals as elements in the hierarchic system. In the last resort, they are responsible for the existence of the hierarchic system of mankind as a society. On the one hand, they carry out the work, and on the other, they are the consumers, who receive the energy they require in order to carry out the work. This is the transition from the mankind as society to the mankind as species. This is the source of energy of the hierarchic system of mankind as a society and to this extent they form the inferior environment. Mankind as species forms the hierarchic system which can be placed beside the other species.

Energy should be understood here in the broadest sense. The individual has his biological basis and is shaped culturally into a personality enabling him to carry out his work in mankind as society. The induction process leads into mankind as species, "feeding in" to socio-economic goals ("demand"). The reaction process leads in the opposite direction, from mankind as species into the hierarchic system of mankind as society and organises these accordingly from the bottom up ("supply").

Mankind as species (from a systematic point of view, part of the biosphere and therefore the autopoietic systems - see section 2.6.1.1 - 2.6.1.3) is also organised hierarchically. The populations are human societies: families (or corresponding partnerships of different types), communities, ethnic groups, peoples and cultural populations. The individuals as human beings (not only in their roles) are the elements.

Tab. 3: Primary und secondary populations in mankind

Primary population	Secondary population
Mankind as population	
Small cultural population	Large cultural population
Tribe, people	State population
Ethnic group	City-umland-population
Local group, community	Community
Family	Organisate
Individual	

Thus, we distinguish between "primary populations", in which mankind's biotic concerns (i.e. those affecting its existence) are regulated, and "secondary populations", with their socio-economical tasks within the context of mankind as a society. Everyone (as working being) is directly or indirectly involved in mankind as a society, and as a biotic being in mankind as a species (see tab.3).

Scalar hierarchy:

Such a complex network of processes necessitates strict control. This is provided by the scalar hierarchy. We have shown (see section 2.5.1.1) that for the entirety of mankind as a society each task corresponds to a population type.

Structurally and spatially, the populations are normally (not always) enclosed by the population which has the higher position in the hierarchy (see above). The number of populations belonging to a population-type varies widely in mankind as a society. (It may be a few or many thousands). On the other hand, the duration of the process is fixed in the example of mankind as society, the rhythms differ approximately by a factor of 10 (see above and fig. 99).

The hierarchy of the populations of the mankind as society is held together and controlled by the context of order and obedience (control scalar hierarchy). The inquiry after the performance of work (order) passes vertically downwards to the individual via the control hierarchy, and the provision of the work (obedience) vertically upwards. Mankind as a species as a whole appears as a superior environment. On the other hand, the inferior environment is located "beneath" the individuals (in their capacity as elements of mankind as a society) and regarded from a

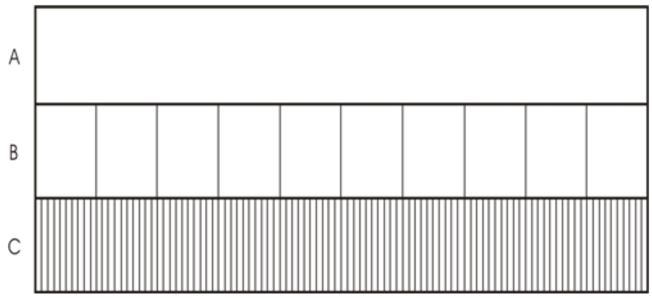


Fig. 99: Diagrammatic ratio of the process duration of systems in three hierarchically adjacent hierarchic levels A, B and C.
The duration of the processes differs by a factor of about 10.

systemic point of view also belongs to mankind as a species. At the transition points to the superior environment or inferior environment, the hierarchic process merges perhaps into the all-embracing flow of order and obedience of the universal system.

Between the system (mankind as population) and the elements (individuals) come the subsystems (cultural populations ... organisates). To distinguish them from the subsystems formed by the flow-equilibrium systems (flow equilibrium subsystems, see above) we will call them "non-equilibrium subsystems" (see table 4, section 2.5.1.2). The populations and individuals of all the 7 hierarchical levels of mankind as society are involved. They are required to fulfil their task and they do this by working through the process sequence in their own rhythm. On the other hand, the populations are independent structures which are concerned with maintaining their existence, as are all non-equilibrium systems. This means that besides the task for the hierarchical system of mankind, the populations also have tasks to fulfil which concern only themselves. Thus, they obey the orders from above, because their existence depends on their integration in the system.

This dual aspect, i.e. the fulfilment of the task on the part of the superior population, and the necessity for the population (as subsystem) to maintain itself, causes the process structure to split up:
1) the processes follow the sequence of task stages described above (see section 2.4.1.2) through the system and the element horizon, i.e. through all four bonding levels. Thus, the populations are able to produce and maintain themselves in the flow of information and energy (demand and supply).
2) in the context of the hierarchy, the elements of the populations at the next lower level are independent non-equilibrium systems, i.e. subsystems. The fact that the elements (individuals) are non-equilibrium systems on their own, has already been discussed (see section 2.4.2.2).

This also means:
The order and obedience relationship between the hierarchically adjacent system levels takes place directly between the system horizons. To illustrate the processes, we will examine three hierarchic levels A, B and C more closely. The hierarchic levels differ as explained above (see section 2.5.1.1), by the duration of the process (the rhythm). Due to this system/element (subsystem) relation, transfer of order and obedience can take place. The element horizons oscillate with the same rhythm as the corresponding system horizons. This results in the model of all the hierarchic control processes shown in fig. 100. At each level a task is solved and for this purpose the inferior system levels are used in a controlled fashion. Each level receives instructions from above. The inferior systems receive instructions from the systems directly superior to them (relation system/element), but also from those positioned much higher. For example, a community receives directives from the city-umland population (e.g. concerning traffic), has to offer the state services, has to provide a place for religious services in the form of a church etc. With the individual, this order-obedience relationship is particularly marked. The individual participates directly in the functions of the hierarchy by payment of taxes and by his right to certain services in return.

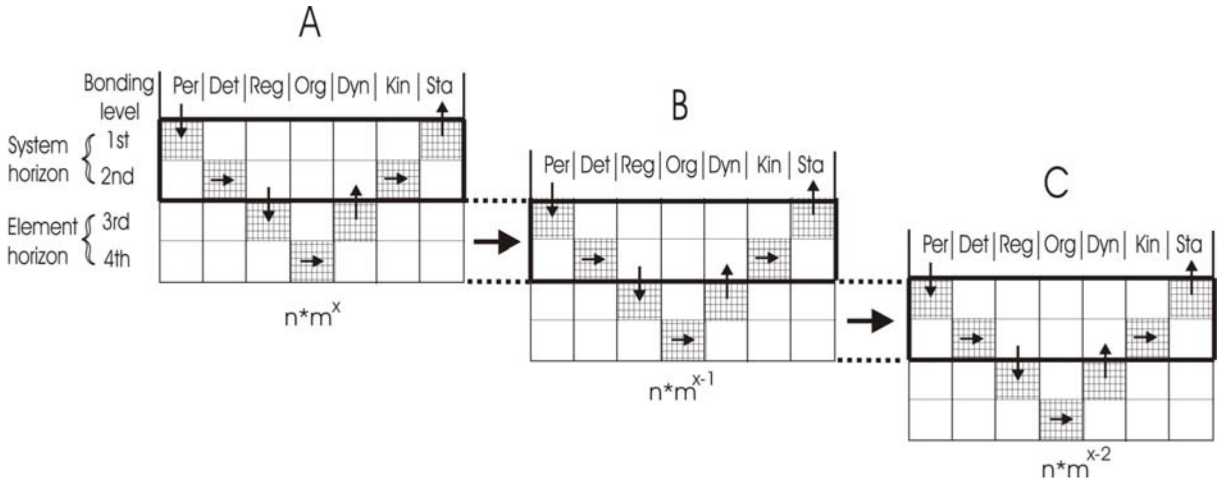


Fig. 100: The elements of the systems of hierarchic level A become independent subsystems at the next-lower hierarchic level B and the elements of the systems of hierarchic level B become independent subsystems of level C.
The arrows show the path taken by the processes.
Task stages: Per = Perception, Det = Determination, Reg = Regulation, Org = Organisation, Dyn = Dynamisation, Kin = Kinetisation, Sta = Stabilisation. The duration of the processes: n = constant (with mankind as society approx. 5) m = constant (with mankind as society approx. 10).

The deeper into the hierarchy, the more instructions have to be taken into account and the more varied is the actual execution of the orders. At the lowest level (i.e. the individual in human society) all the orders and conditions come together as they are specified in the catalogue of basic institutions (see above).

Thus the order descends from the top level downwards step by step, to the individuals who receive the orders and, as such, are obliged to provide obedience (see above). The obedience proceeds from here upwards. That means that the individuals - after having received the energy - have to execute the work which is expected of them.

Secondary order-obedience relationship, upper and lower levels:

To this should be added:
The hierarchy of the populations and processes is differentiated by division into two parts (see fig. 101). Just as the first process half in the non-equilibrium system serves the purpose of adoption (i.e. processing of information), and the second the purpose of production (i.e. processing of energy), the same is the case in the vertical course of the hierarchic system. The populations and processes in the subsystems are not only in direct contact with the hierarchically adjacent populations and processes. Instead, the group of the upper half forms the correlative to the lower half, as is seen in the tasks (see above).
- In the city-umland population, the population types processing information are brought together with those which process the energy. The hierarchic level devoted to the task of "organisation" has a double aspect: Seen energetically, the inferior environment (the ecumene) is contacted. Seen spatially, the populations which are compactly organised, come together with those populations which are more widely distributed. The city is joined with the umland.
- The population of the state is the next higher stage. This is the part of the hierarchic system assuring order and administration. It protects the people and the territory. In the hierarchically inferior subsystems, the community assumes some of the sovereign tasks of the state. Legislative activities are the duty of the state, whereas executive duties are mostly carried out locally, e.g. the police ensure law and order in the community, inhabitants are registered, elections supervised and infrastructure organised there. Thus, "regulation" (state) and "dynamisation" (community) are correlated with one another.
- At the third stage (from the point of view of the city-umland population) the cultural population determines the values around which life is structured and the principles according to which communicate with one another ("determination"). These rules are implemented in the smallest populations, in the family the stable and orderly conduct of life, "genre de vie", mutual respect shown by individuals. In the organisate, this is reflected in the division of labour ("kinetisation").
- Finally, mankind as a population encompasses the whole being of man as an entity fitted for survival by his equipment and his

knowledge ("perception"). The individuals carry on their lives on this basis. Through the judicious use of the natural environment they create "value" for themselves and consume it. To do this, they organise and shape the space which makes this possible ("stabilisation").

The subsystems of the 4 lower levels become subsystems of the second order in an element-like dependence on the corresponding subsystems of the 4 upper levels.

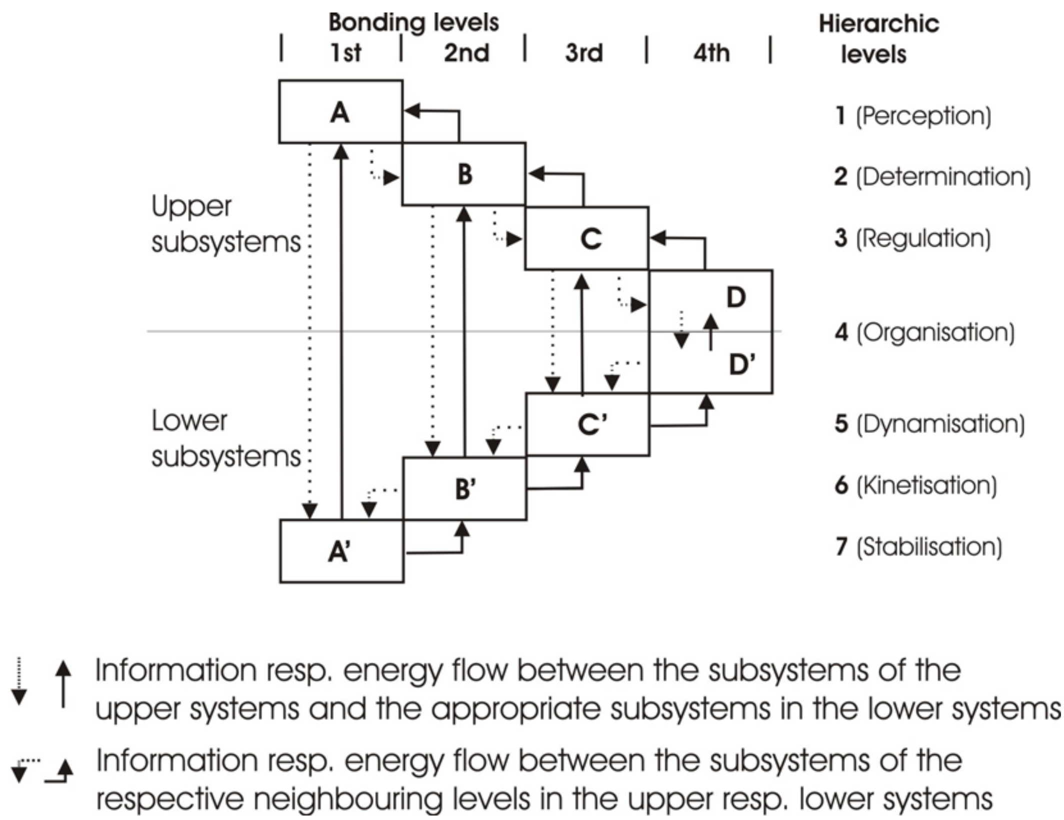


Fig. 101: The subsystems of mankind as a society in their relation to one another. Upper and lower subsystems.
A = Mankind as population, A' = Individual; B = Cultural population, B' = Organisate; C = State population, C' = Community; D = City-Umland-Population as subsystem of the upper systems; D' as subsystem of the lower systems.

The hierarchy of spaces:

The hierarchy of the basic institutions, processes and populations corresponds to the hierarchy of anthropogenic spaces. The spaces occupied by the populations are mostly filled by the inferior populations. Thus, the space occupied by the population of a state generally contains several spaces which are occupied by city-umland populations (see section 2.4.2.2), and these in turn contain several which are occupied by communities. Thus, at each hierarchical stage, a mosaic of spaces of the same population type forms.

As already shown, the populations of the various types ideally adjoin one another in the ecumene without gaps or intervals, i.e. community adjoining community (apart from unsettled land and land now belonging of any owner), state adjoining state etc. Thus, they form continuously the hierarchical levels of mankind as society. Structurally, these hierarchical levels are flow-equilibrium systems, in which the populations (i.e. non-equilibrium systems) as elements can compete.

The spaces shaped by the hierarchical system are derived from those of the non-equilibrium systems. We must distinguish between the spaces which are shaped by the populations themselves, i.e. non-equilibrium systems ("core spaces"), and the spaces which characterise the spheres of influence ("environments") of the populations, i.e. such spaces as are created by interlinking of the population.

Spaces occupied by the populations themselves:

The spaces which are occupied by the populations themselves are also controlled by these. The individual populations exercise their internal control in various forms depending on their tasks. Thus, the spaces are shaped differently.

Populations which are hierarchically located beneath the city-umland populations, are generally compact in shape and serve directly to process energy. The individuals can make direct contact with one another within one day. With organisates, this is easily seen. As already established using the example of the organisate weaving mill (see section 2.4.0), the individual stages of the induction process are implemented in subsystems (departments), which give spatial organisation in a specific arrangement of population. This should be as favourable as possible for the production of the populations, i.e. when the circumstances permit, the elements are brought together in such a way that internal contact between the various work groups is facilitated. In rural communities, assorting takes place between the central institutions at the centre, the residential area and out in the agriculturally used field area. As already outlined (see section 2.4.2.2) this type of assorting can be seen in the city-umland populations in an extreme form. The city-umland population is made up of a compact core, the city, and a more thinly populated surrounding area, the "umland". Thus, the city-umland population occupies the position of intermediary.

The populations at the hierarchical level above the city-umland populations - states and cultural populations - are loosely structured. Here the individuals cannot make any contact involving personal appearance within one day (unless modern means of transport are used). On the contrary, the populations are concerned principally with disseminating information, as is shown in our discussion of institutions and tasks (see above). Each stage in the hierarchic process is connected with the spread of an innovation (see section 2.3.1.1). As mentioned above, in a hierarchical system, the groups of populations of the same kind should be imagined as a flow-equilibrium system.

Areas of influence of populations*:*

All populations are – depending on their structurally defined environments - surrounded by areas of influence which affect the levels formed structurally by populations of the same type, each of which together forms a flow-equilibrium system. They try to maintain and extend their influence, because their own existence depends on this.

As already mentioned, the area influenced by mankind as a society is marked by the ecumene. The ecumene is exploited most intensively in the densely populated highly industrialised areas of the world and declines progressively moving outwards towards the anecumene. In the past few decades, primarily because of pollution, it is no longer possible to identify areas of the earth which are not influenced by man. The sphere of influence goes beyond this, takes in oceans, the Arctic and Antarctic regions and out into space.

The areas of influence of the cultural populations are extended mainly by mission or migration. States secure their military, economic or cultural spheres of influence by means of policy (or war), treaties, trade relations, special cultural institutions etc. This is frequently legitimised by treaties. In the last century the USA and the Soviet Union secured their spheres of influence in this way. But smaller states also have an interest in extending their influence culturally and economically by means of radio, cultural institutions or trade relations. By definition, city-umland populations already possess areas of influence. Organisates too, as mentioned above, also have their supplier and market areas. Thus, the areas of influence are not only spatially but also thematically different.

2.5.1.2. The Model

In conclusion, the above processes can be summarised as follows. Certain differences exist between the demand process and supply process on the one hand and the flows of order and obedience on the other hand. The demand process and supply process affect the flow equilibrium systems (specification hierarchy) whereas the flows of order and obedience affect the non-equilibrium systems (populations) of the various hierarchic types (scalar hierarchy). Both hierarchies interlock with one another (see table 4).

Tab. 4: The arrangement of hierarchies of the non-equilibrium (Ne) systems and flow-equilibrium (Fe) systems.

Hierarchy of populations	Type of systems	Hierarchical Position
Mankind as population	Non equilibrium system	System
Group of cultural populations	Flow equilibrium system	Fe-Subsystem
Specific cultural population	Non equilibrium system	Ne-Subsystem
Group of state populations	Flow equilibrium system	Fe-Subsystem
Specific state population	Non equilibrium system	Ne-Subsystem
Group of city-umland-populations	Flow equilibrium system	Fe-Subsystem
Specific city-umland-population	Non equilibrium system	Ne-Subsystem
Group of communities	Flow equilibrium system	Fe-Subsystem
Specific community	Non equilibrium system	Ne-Subsystem
Group of organisates	Flow equilibrium system	Fe-Subsystem
Specific organisate	Non equilibrium system	Ne-Subsystem
Group of individuals	Flow equilibrium system	Fe-Subsystem
Specific individual	Non equilibrium system	Element

When we joint both aspects of the hierarchy (demand-supply and order-obedience) together, this can be shown in a model (see fig. 102). The various population types with their obligatory tasks follow from top to bottom (demand process resp. from the bottom up (supply process). In the inferior populations, the processes take only one tenth of the time of the next superior ones (in the logarithmic representation in the figure). The orders come from above and are passed on downwards. Compliance with the orders is from the bottom upwards. The processes in the hierarchic levels take place from left to right, the feedback from right to left. The circular process model serves as a basis (see fig. 69, section 2.4.1.2).

We must also remember that the hierarchic system also receives information and energy from outside (in this case from the ecosystem; see above, fig. 101). Both have to pass through the 4 bonding levels (like in the other non-equilibrium systems). We already noted above that the systems of the hierarchic levels above the city-umland population serve adoption (perception ... organisation, bonding levels 1 ... 4) and those of the levels below, production (organisation ...stabilisation, bonding levels 4 ... 1). At the level of organisation (bonding level 4) the energy is taken to the hierarchic system. Fig. 103 attempts to illustrate the different connections.

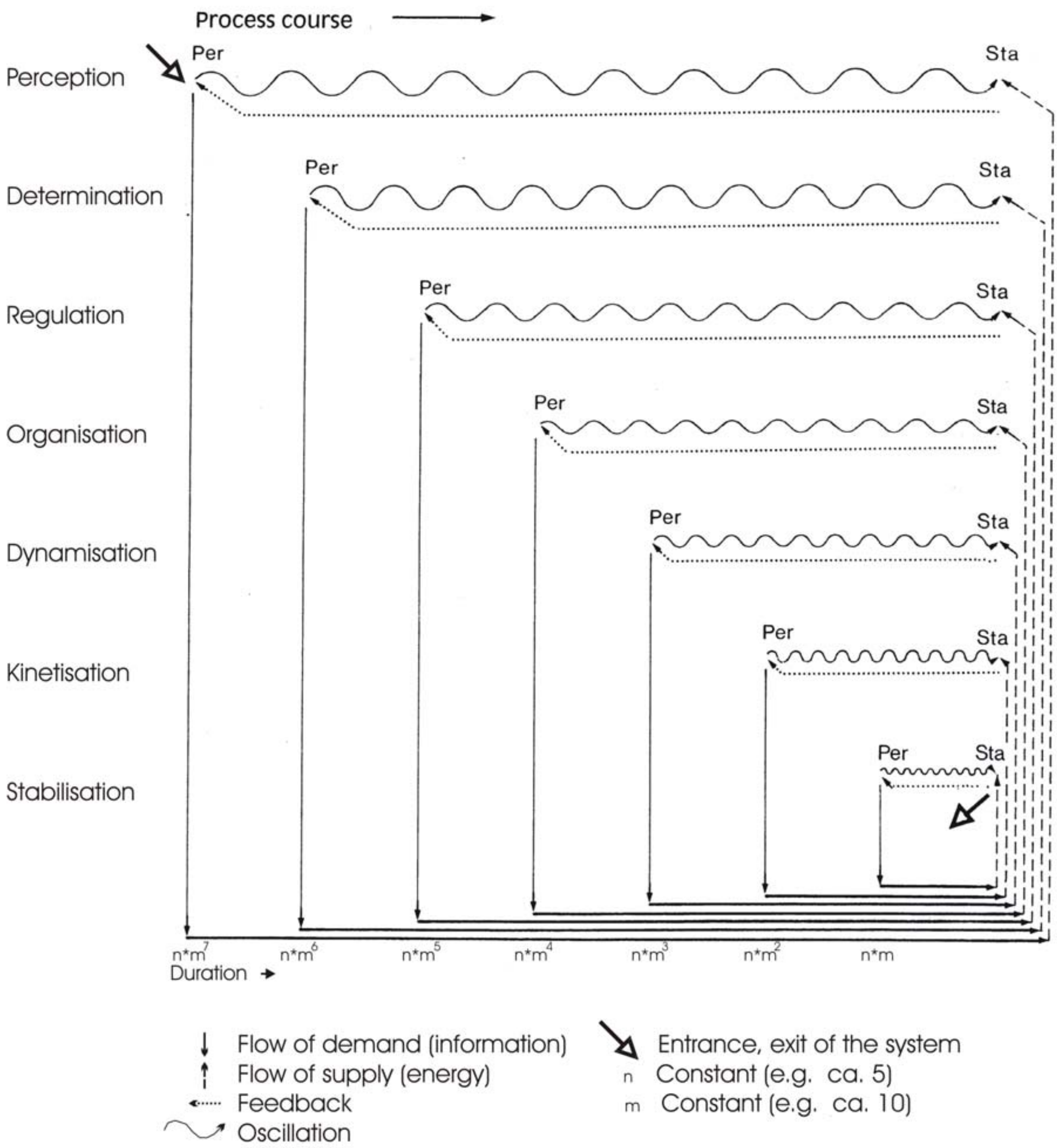


Fig. 102: Structural model of mankind as a society. Hierarchy of populations.
It shows the hierarchy of the populations and the circular course of the processes (see also fig. 69, section 2.4.1.2). Specification hierarchy: In each case, the flow of demand is from top to bottom, the flow of supply from bottom to top, while the course of the processes is shown horizontally from left to right and the feedback from right to left. Scalar hierarchy: The process duration is shown downwards from population type to population type to the individual on a logarithmic scale. Per = perception; Sta = stabilisation.

If we wish to describe the processes mathematically, it is important to arrange the internal sequences:
1) The hierarchic system is divided into two parts, the upper and the lower parts. Both are divided into four levels each, in which the tasks of perception .. organisation and organisation ..

stabilisation are carried out one after the other in vertical succession.
2) These 8 (7) levels are formed by populations, which on their part have to carry out the process sequences horizontally. At the middle level (organisation) the upper and lower parts of the hierarchy are brought together.

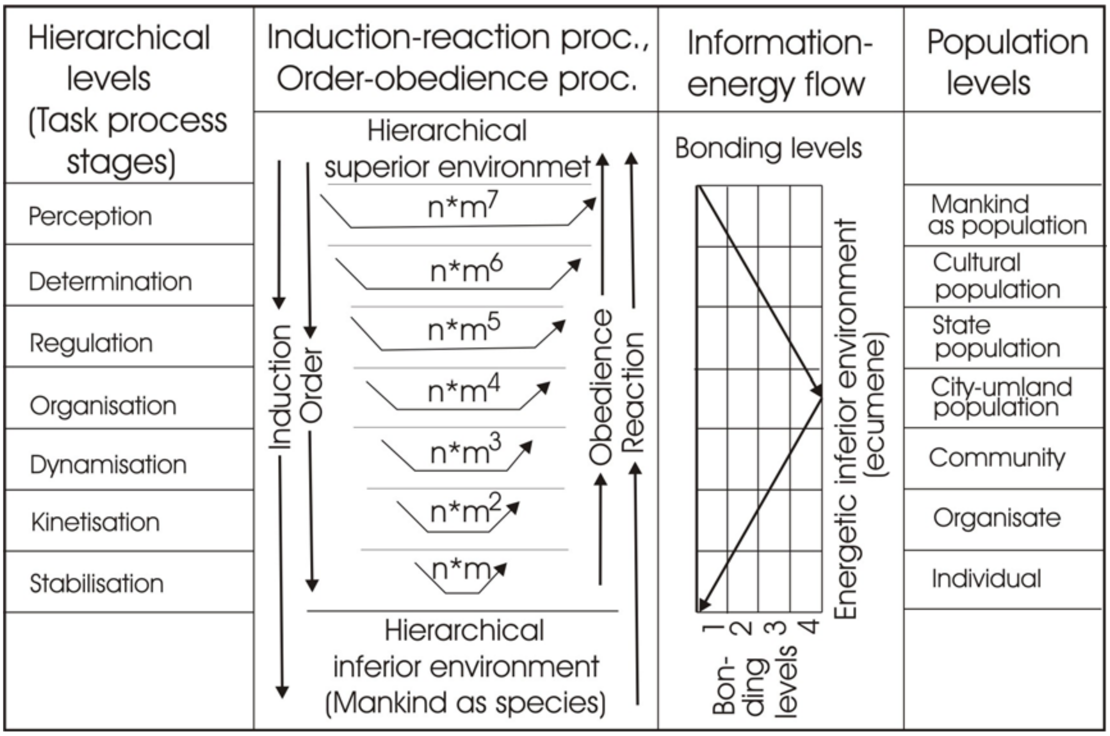


Fig. 103: The hierarchical processes of the mankind as society (information and energy flow resp. order and obedience).
There are 3 hierarchical processes:
1) Induction-reaction process (specification hierarchy) from the uppermost level (mankind as population) to the lowest level (individuals); the hierachically inferior environment is the mankind as species. n and m see fig. 102.
2) Order-obedience process (scalar hierarchy)
3) Information-energy flow through the 4 bonding levels; the energetically inferior environment is the ecumene.

This can be represented in a table (see fig. 104). But additional factors also have to be considered:
1. These process sequences are embedded in a hierarchy, i.e. the superior populations include a large number of the inferior populations. It must also be remembered that the speed at which the processes are carried out in the populations also have to be differentiated in the same way.
2. With the populations, the spatial dimension is localised and does not appear in the table either.

For guidance:

From the example of mankind as a society, it therefore emerges that the hierarchy has two aspects:

1) it appears as a specification hierarchy, i.e. the superior units encompass the inferior with regard to the thematical content (task);
2) it appears as a scalar hierarchy, i.e. the superior units encompass the inferior structurally and spatially.
Behind these, there are various types of system and process – flow-equilibrium systems (flow processes) and non-equilibrium systems (conversion processes), i.e. the hierarchic levels appear as a flow equilibrium structure on the one hand and as a non-equilibrium structure on

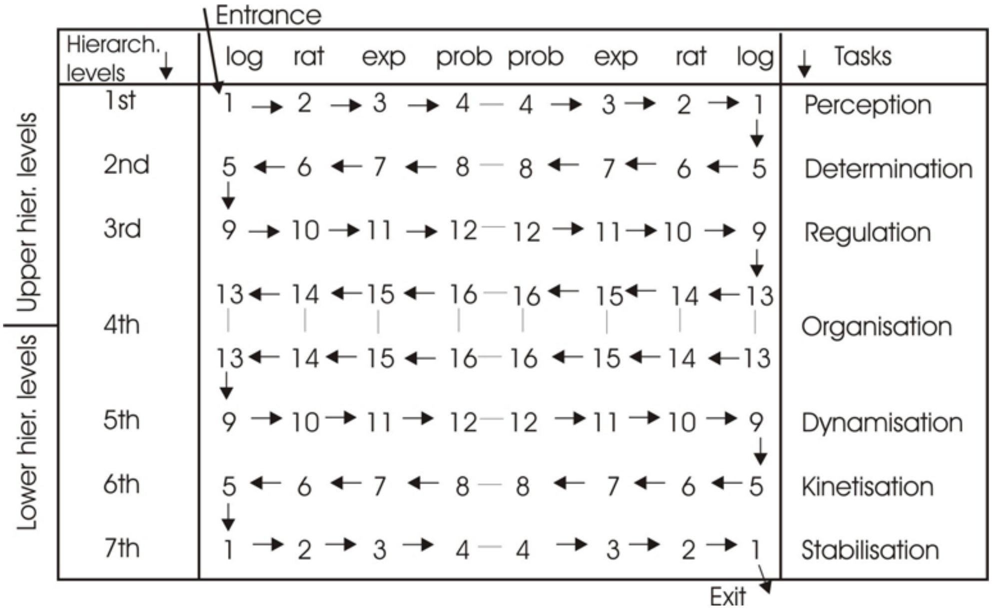


Fig. 104: Linking of the induction process of a hierarchic system.
The figures contain the numbers of the formulae of the task and control processes in the hierarchical levels (see section 2.3.1.2).

the other. The control of the hierarchic system takes place accordingly, both by a demand/supply relationship linked to oscillations, and by an order-obedience relationship.

In all, 7 hierarchic levels can be identified: mankind as population (task: perception) – cultural population (determination) – state population (regulation) – city-umland population (organisation) - community (dynamisation) - organisate (kinetisation) - individual (stabilisation). The processes of the inferior hierarchic levels supply those at the higher levels.

The various aspects are grouped together in a comprehensive model.

2.5.2. Other Examples

2.5.2.0. Instead of an introduction: hierarchy as seen by an artist:

In past centuries, the visual arts were concerned with hierarchy in a religious context. The representation of the divine order with God the father at the top surrounded by a host of angels and saints with humanity at the bottom (e.g. in the "Last Judgement" or the "Creation"; see fig. 128, section 2.6.1.0) is a frequent subject. In the Catholic church, ecclesiastical hierarchy (pope, cardinals, bishops, priests and laymen) is of greater importance than in other faiths and religions. Indeed, this is the origin of the term "hierarchy".

The state order can be seen as the epitome of temporal hierarchy. Joseph BEUYS was concerned with state order in Germany as shaped by the political parties and presented a new concept. He regarded himself as an artist, but extended the idea of art to cover the level of politics. To him, society was a "social sculpture" which it was possible to alter. TISDALL (1979, pp. 268) wrote:
"Beuys founded the 'Organization for .... Direct Democracy through Referendum (Free People's Initiative)'. ... In the political programme, nine essential characteristics of democracy were outlined:
1. Politics structured from below to above;
2. The absolute sovereignity of the people at all levels of administration;
3. A constitution made by the people;
4. Men and women without party membership to have equal rights with party members in legislative bodies;
5. No privileges for single representatives of the people or for civil servants;
6. People's veto in individual cases (where for instance no equality before the law for all is ensured);
7. Respect for the will of the electors on the part of the elected;
8. Referendum on important issues and questions of basic law;
9. Possible removal from office of unworthy or incompetent representatives of the people or civil servants.

....Beuys' political thinking is considerably influenced by the theories of Rudolf Steiner. The aim is not to mimic the dry, abstract and short-sighted formulations of offical party politics, but to bring into political activity the humane and sometimes unexpected dynamism of culture."

In a diagram he compared his ideas of a democracy controlled from below directly with the existing hierarchic structure in a democracy ruled by the political parties (fig. 105).

With regard to process theory, the old question is again raised as to whether the processes are controlled from the top down (order-oriented) or from the bottom up (obedience-oriented). From the discussion up to now (regarding information and energy flow, and system and element horizon), it will be apparent that there has to be a balance between both directions. The following examples of hierarchy quoted are taken from the organic and the social world. It is mainly systems which are presented. In a second section, the principal emphasis is on processes (i.e. those which illustrate the remarks contained in the section 2.5.1.1).

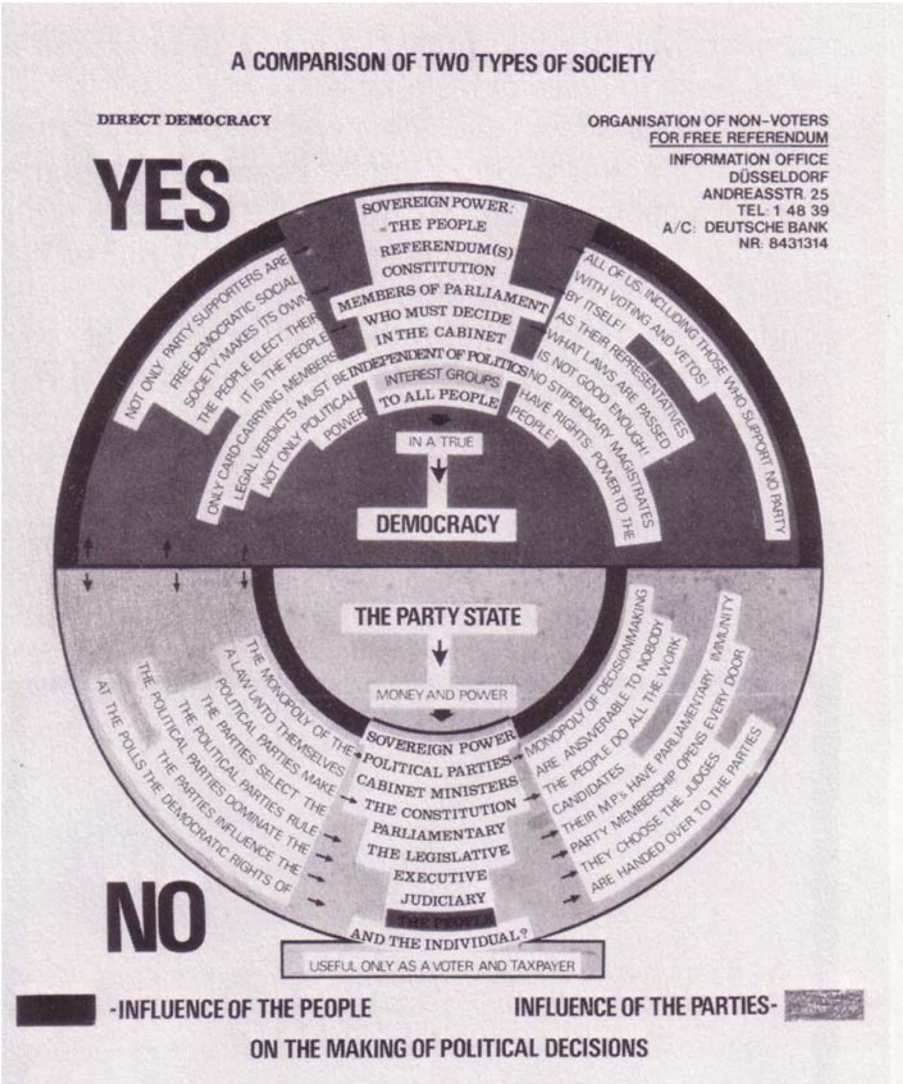


Fig. 105: Joseph Beuys: Hierarchy in a “party state” and in a “true democracy”.
Scheme in which the artist sets out his ideas for the changes necessary in the hierarchic structure of Germany.
Source: See "Notes on the figures".

2.5.2.1. Hierarchy of the systems

In reality hierarchies are ubiquitous. Only a few examples taken from mankind as a society and the biotic processes are given here.

Inorganic hierarchic systems are dealt with in the next section (see section 2.6.1.2).

Hierarchy of the living world:

Biologists have created detailed systems for classifying living organisms. These taxonomic systems represent hierarchies which are based on relationships but which are intended mainly as a basis for accurate terminology in order to facilitate scientific communication. One example of this is the botanic system (see fig. 106). It is an example as well of the "scalar hierarchy" as of the "specification hierarchy" (SALTHE 2001; see section 2.5.1.2).

The individual stages have quite different degrees of importance. Thus, the “species” has a disproportionately greater significance for the life process than, for example, the "section" or the "tribus".

Mankind as a species is itself part of the global ecosystem and as such embedded in a vertical flow of information and energy. Taxonomically, mankind is one species among many. Hierarchical structures have also formed among other species, but they are admittedly much less differentiated than in the case of mankind (WILSON 1975).

Perhaps the global ecosystem also structured itself as a hierarchical system for reasons of control. After all, mankind as a species is part of this system and as such, embedded in its vertical flow of information and energy. Then it would be possible to assign the non-equilibrium systems in the hierarchical levels to the tasks in the same way as the populations to mankind as a society. The following is an attempt to do so:

1st level: Perception of the environment. The living beings perceive the advantages and disadvantages of the environment to their own advantage. Carrier: the living world as a whole, task: perception.
2nd level: Decision on the type of exploitation of the environment. The plant and animal kingdoms define themselves as antagonists through their position in the flow of energy (see section 2.6.2.1). Their independent existence is dictated by this. Carrier: the kingdoms, task: determination.
3rd level: Control of the flows of information and energy. The absorption of nutrients and reproduction are specified by the fact that living beings belong to certain species. This permits a control of the vital processes of life. Carrier: the species, task: regulation.

Botanik

Abteilung *(phylum, divisio)*: *-phyta*, bei den Pilzen *-mycota*
Unterabteilung *(subphylum, subdivisio)*: *-phytina* bzw. *-mycotina*
Klassic *(classis)*: bei den Algen *-phyceae*
bei den Pilzen *-mycetes*
bei den Flechten *-lichenes*
bei den Gefäßpflanzen *-opsida* oder *-atae*
Unterklasse *(subclassis)*: *-idae*
bei den Algen *-phycidae*
bei den Pilzen *-mycetidae*
Überordnung *(superordo, cohors)*: *-iidae*
Ordnung, Reihe *(ordo)*: *-ales*
Unterordnung *(subordo)*: *ineae*
(Familiengruppe: *-ineales*)
Familie *(familia)*: *-aceae*
Unterfamilie *(subfamilia)*: *-oideae*
Tribus *(tribus)*: *-eae*
Subtribus *(subtribus)*: *-inae*
Gattung *(genus)*
Untergattung *(subgenus)*
Sektion *(sectio)*
Untersektion *(subsectio)*
Serie *(series)*
Art *(species)*
Unterart *(subspecies)*
Varietät *(varietas)*
Untervarietät *(subvarietas)*
Form *(forma)*

Fig. 106: The taxonomic classification of plants according to the „International Code of the Botanic Nomenclature“.
After Weberling und Stützel. Source: See „Notes on the figures“.

4th level: Contact with the inorganic inferior environment, transition of flow of information to flow of energy. The living beings define themselves as independent objects in their environment and give the vital processes spatial order internally. Carrier: the organism, task: organisation.
5th level: Division of energy from the inferior environment in the system. The internal flow of information and energy involved in the metabolism is carried out by the organs. Carrier: the organs, task: dynamisation.
6th level: Transformation of energy into useful substances or products. The various (metabolic) products are manufactured for the body in chemical working units by a process based on division of labour. Carrier: the cells, task: kinetisation.
7th level: Organic substance preserves life. The construction of organic substance and its release from the inorganic environment are controlled at molecular level. Carrier: the organic molecules, task: stabilisation.

In the hierarchy, the non-equilibrium systems are loosely distributed at the levels 1-3, but concentrated more compactly at the levels 5-7. The organism (level 4) divides both partial areas of the hierarchy. There is a similarity with mankind as a society recognisable.

Each non-equilibrium system is securely bound into a hierarchy and possesses a defined task for this hierarchy. In the hierarchical systems, non-equilibrium systems are created structurally. One has to assume that hierarchical structures have also formed in the inorganic world, e.g. in the creation of the macro- and microcosmos (see section 2.6.1.2). However, the hierarchies are normally much less differentiated, i.e. at the various levels several tasks have to be resolved in the vertical process sequence.

Central place hierarchies:

In the socio-economic context, the city-umland populations are of special importance. These structures are composed of the central places and their fields of influence (CHRISTALLER 1933; see fig. 107). Here the hierarchy finds its spatial expression. By way of exception, the core space here also includes the area of influence (the umland or the environment).

The term "central place" is a structural term. As a rule, central places are towns, i.e. inhabited settlements, which may also be termed central towns or cities. As a rule, the people meet their day-to-day needs (e.g. grocery, physician, townhall, parish school, church etc.) directly within the community. The supply organs, i.e. the organisates, must be easily accessible. Conversely, it is the consumers who secure their existence. Organisates which are visited frequently but not daily (e.g. textile shops, hardware shops, dentists, lawyers, highschool, restaurants etc.) are generally located in small market towns and villages. These are dominated by medium-sized towns in which periodically recurring requirements are satisfied (e.g. shopping street, city hall, banks, hospital etc). And then there are the large towns with more specialised organisates which tend to be visited in episodes (e.g. central business districts, airport, state government, university, zoo).

We therefore have a hierarchy of central towns, villages etc. where the requirements of the consumers and the profitability of the producing institutions determine the location. Or conversely, the producing and distributing organisates have umlands which differ in size

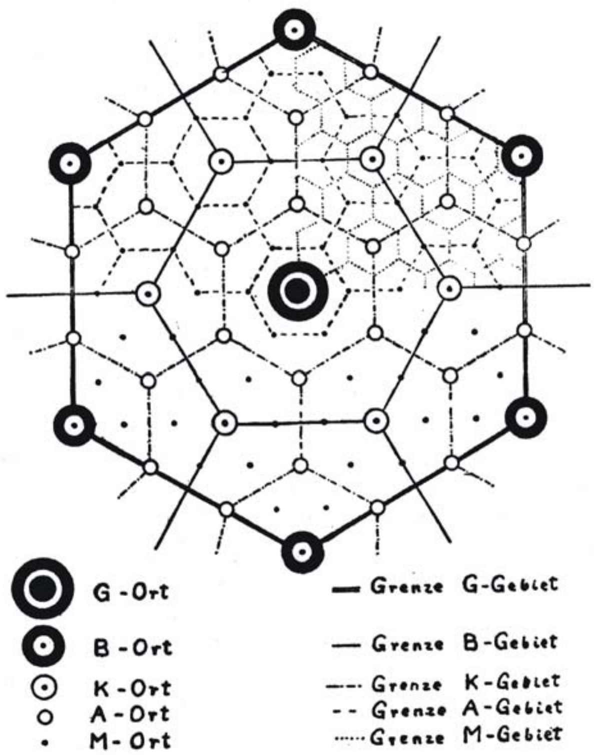


Fig. 107: Diagram of the hierarchy and peripheral areas around a central town.
(5 types of central towns).
After Christaller. Source: See "Notes on the figures".

which they supply and from which they live. The decisive factor is accessibility for as many customers as possible (this includes the establishment of large shopping centres on the periphery of towns; see section 2.4.2.2). The areas of influence of the central towns overlap in many places forming multi-level spaces.

Rank-size-rule:

If we assume that the number of inhabitants of the central towns is proportional to the inhabitants of the entire area supplying them, we can enter the central towns of a country on a dial scale. As we see in fig. 107, the largest central town has to supply about 6 times as many inhabitants as the six next smaller towns, which in their turn have six times as many as the next 36 etc. The catchment areas of the larger central towns with its inhabitants embrace the catchment areas of the smaller central towns with the same inhabitants. The number of inhabitants of the larger towns on the scale is almost inversely proportional to the position in rank.

There are a number of intermediate figures because it is not only the supply principle which determines the number of inhabitants. On the contrary, additional special functions have to be taken into account such as administrative functions, ports, tourism, industry etc.

However, the validity of this relationship between rank and size depends on the following circumstances: 1) that all the central towns concerned are located in a country which has had the same frontiers for a long period of time (centuries) in order to allow the system of central towns to develop undisturbed; 2) that the country in question has nearly no conurbation whose size is not due to their centrality, but to other factors, especially mineral resources (such as the Ruhr area). Germany and Britain do not fulfil these conditions, but the USA (see fig. 108), France and Spain do. Thus, we arrive at the following general equation:

$$y = 1/F,$$

where y is the position of the town in the ranking and F the diameter of the area of the central town, or approximately the number of inhabitants of the central town. This is an application of Zipf's law (ZIPF 1949). This is a deterministic equation. We can also select the version based on the calculus of probability:

$$P(y) = c/F,$$

where c is the number of inhabitants of the largest town. Or the more developed version (Zipf-Mandelbrot law; MANDELBROT 1977/87, pp. 361)

$$P(y) = c/(F+b)^a,$$

where a and b are constants. (In Zipf's law, a = 1 and b = 0).

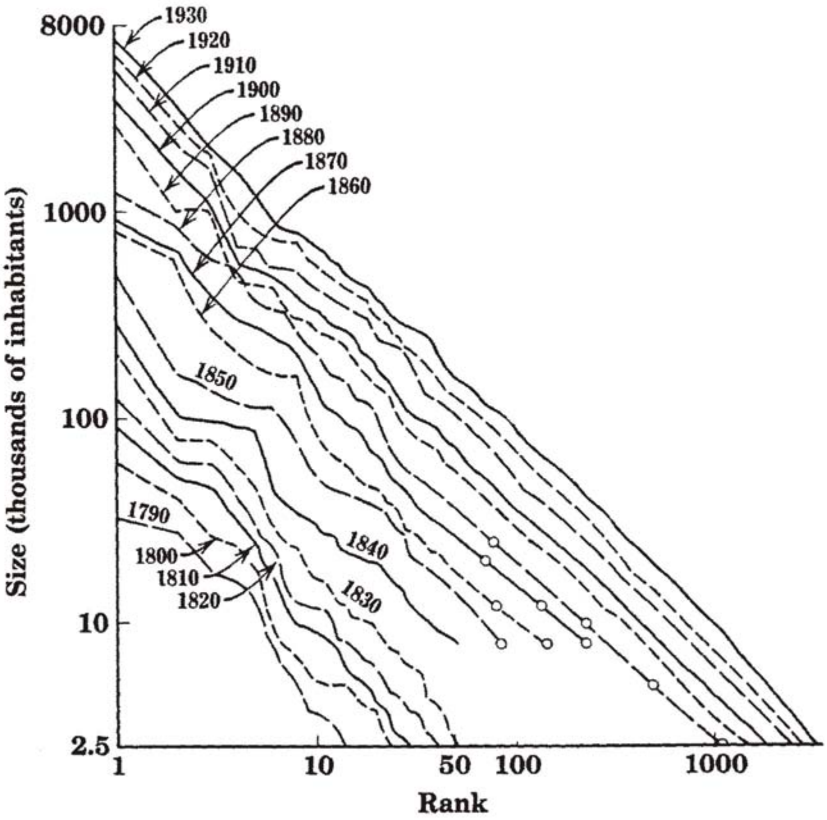


Fig.108: Rank-size rule.
Communities of 2500 or more inhabitants in the United States, ranked in decreasing order of population size. Development over the period 1790-1930. Logarithmic scales.
After Zipf. Source: See "Notes on the figures".

2.5.2.2. Hierarchy of processes: The cultural evolution.

In section 2.5.1.1 we discussed the hierarchy of the processes. A few examples will be given with reference to the cultural evolution in Europe (see also section 2.4.2.1).

Millennium rhythm:

The millennium rhythm lends structure to cultural evolution as a whole. The following is a brief summary of this process (see fig. 109):

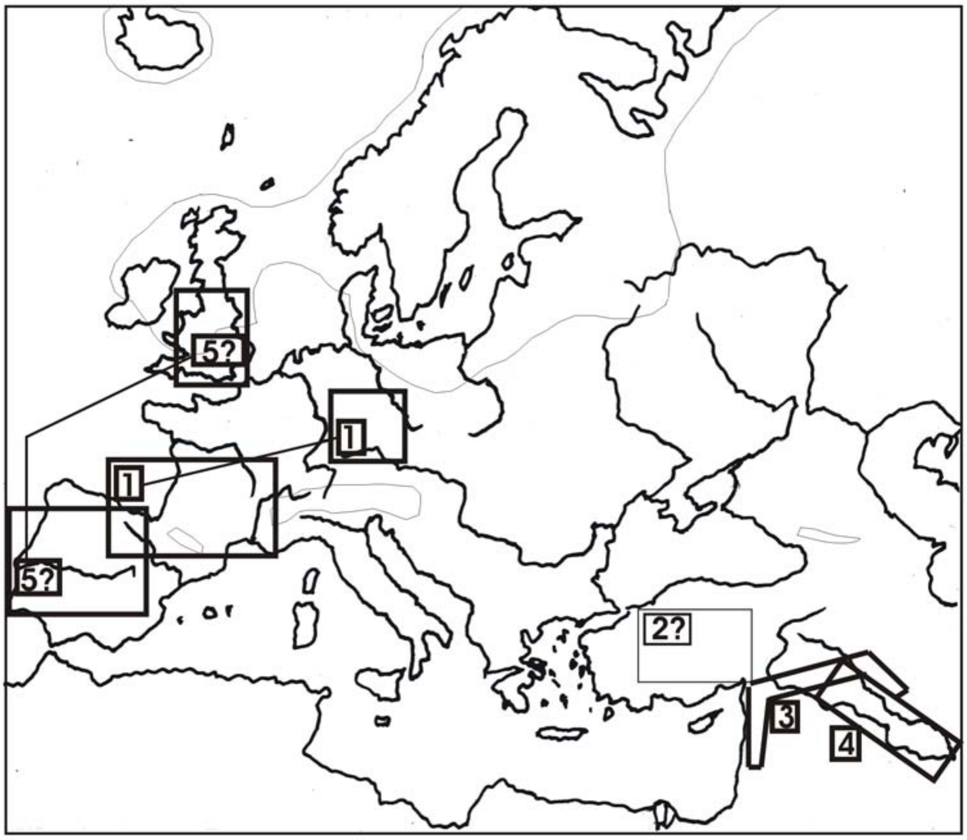


Fig. 109: Innovation centres in millennium rhythm.
An example of an irregular rotation. Abbreviations: 1: Neo-paleolithic revolution, 2: Perhaps begin of the mesolithic (or late neo-paleolithic?) period, 3: Neolithic revolution, 4: Urban revolution, 5 (?): Beginning of the Europeanisation of the globe and industrial revolution. The thin line marks the limit of the Würm (Wisconsin) ice cap.
Source: See "Notes on the figures".

1. "Neo-palaeolithic revolution" (approx. 30.000/15.000 B.C.): fine arts (basic institution of perception) experienced their first heyday, especially in the upper area of the Danube and franco-cantabrian region.
2. "Later neo-palaeolithic era" (beginning around 12.000 B.C. ?): No precise knowledge available. Perhaps, the first solid houses began to be built in the southern Anatolian and neighbouring regions, even though the economy was still based on hunting and gathering. Possibly these were religious sites. (The jump in space and time from the central European and franco-cantabrian area to the Orient is perhaps attributable to the increasingly difficult living conditions during the last or Würm ice age in Europe).
3. "Neolithic revolution" (approx. 9000/7000 B.C.): Introduction of cultivation in the "fertile semicircle" (i.e. in the wide strip of territory to the west, north and north-east of the Syrian and Mesopotamian desert), accompanied by a sedentary mode of life. Structures of domination or rule may also have come into being (basic institution of regulation ?);
4. "Urban revolution" (approx. 3000 B.C.): urban cultures appear for the first time in Mesopotamia, accompanied by a re-orientation

in transportation. Writing and philosophy spread westwards from Mesopotamia and Persia via the Mediterranean to Europe as well as to India and China (HOLENSTEIN 2004, S. 84) (basic institution of organisation).
5. CHILDE (1936/51) maintained that the "Industrial revolution" (approx. 19th century A.D.) could be regarded as equal in quality to the preceding revolutions. The industrial revolution was preceded by the period of colonisation which opened up new sources of raw material. Portugal and Spain initiated this phase at the end of the 15th century. The actual industrialisation began in England. It made possible the utilisation of energy of non-human and non-animal origin to an extent previously unimagined (basic institution of dynamisation).

Centennial rhythm:

In a centennial rhythm too, the centres of innovation shifted repeatedly ("irregular rotation"; see section 2.3.1.1). This is shown in the development of culture. In each case, the initial centre is formed by the population of a state. Innovation (or social change) then spreads outward from this centre to the remaining population.

As an example of the centennial rhythm we try to interprete the creation of European culture (on the basis of the known historical periods; see figs. 110 and 111):
1. Classical antiquity (approx. 500 B.C. up to approx. the birth of Christ): formation of art, philosophy, science in Greece and the Roman Empire (perception);
2. Late antiquity (birth of Christ up to approx. 500 A.D.): diffusion of Christianity in the Roman Empire, Palestine and Rome were the centres from which it spread (determination);
3. Early middle ages (approx. 500 up to approx. 900 A.D.): creation of state systems and administration, especially within the Frankish Empire. Paris was capital of the Merovingians, the Carolingians moved the centre of their activities towards central Europe (Aachen) (regulation);

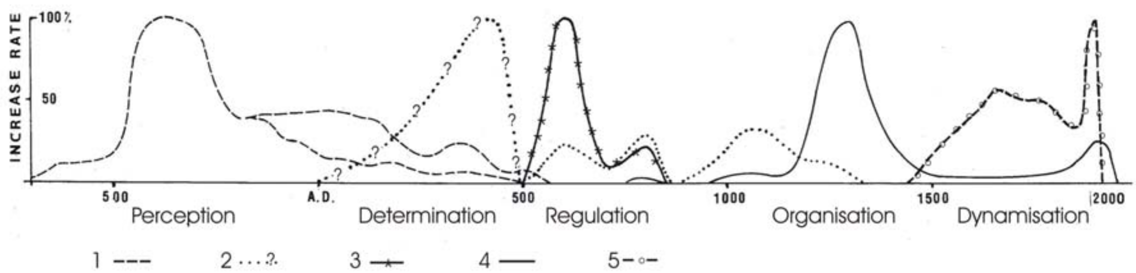


Fig. 110: Process in centennial rhythm.
The diffusion of a number of innovations essential to the formation of culture is shown:

1: Greek and Roman authors; 2: Spread of Christianity in Europe (before 500 A.D. uncertain); 3: Spatial expansion of the Frankish empire; 4: Foundation of towns in Germany; 5: Spatial expansion of European colonial empires.
Source: See "Notes on the figures".

4. High and late middle ages (approx. 900 until approx. 1500 A.D.): formation of central places (city-umland-systems) and improved transportation. Germany (Ottonians, Salians, Hohenstaufens) formed the central region (organisation);
5. Modern period (begin approx. 1500 A.D.): Opening of Europe to the sea (starting with Portugal and Spain, and proceeding through France, the Netherlands, England) acquisition of colonies, exploitation of raw material and energy resources (precious metal, tropical fruits and spices, textile fibres, etc.) of the globe ("Europeanisation of the globe"; dynamisation);

The closer to the present the more difficult a clear classification becomes because the course of development is still uncertain. It seems that we have entered a new stage of the centennial rhythm, of "kinetisation". Industrialisation came in the late phase of the expansion of the colonial empires. The development first took place in England but then soon spread to Europe and the USA. This area was the centre of innovation in the multiplication of productivity. This was further affected by the political changes of the present, especially the formation of "superstates".

Decennial rhythm:

The decennial rhythm can be demonstrated in many different forms. As an example, we may take the early industrial development in Germany (see fig. 112).

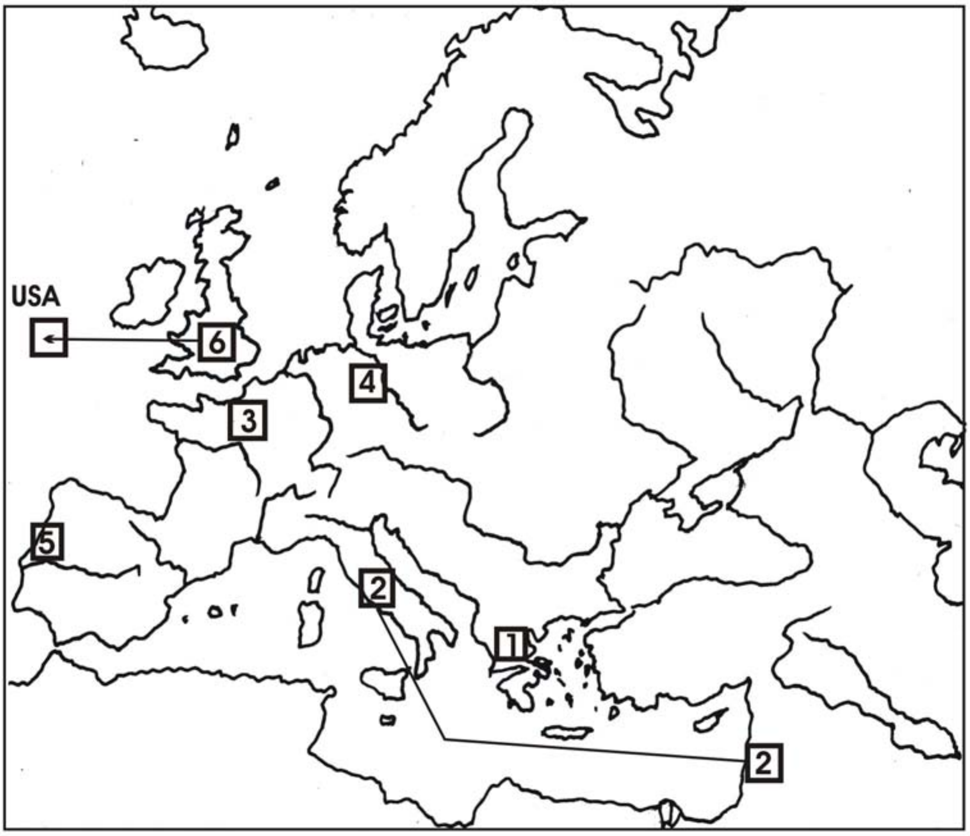


Fig. 111: Centres of European innovation in centennial rhythm.
An example of an irregular rotation. 1: Art and science in classical antiquity, 2: Christianity in late antiquity, 3: Formation of states in the early middle ages (Francia); 4: City-umland formation in the high middle ages, 5: Europeanisation (colonisation) of the globe in early modern times, 6: Industrialisation in early modern times. Formation of superpower states in the present (USA).
Source: See "Notes on the figures".

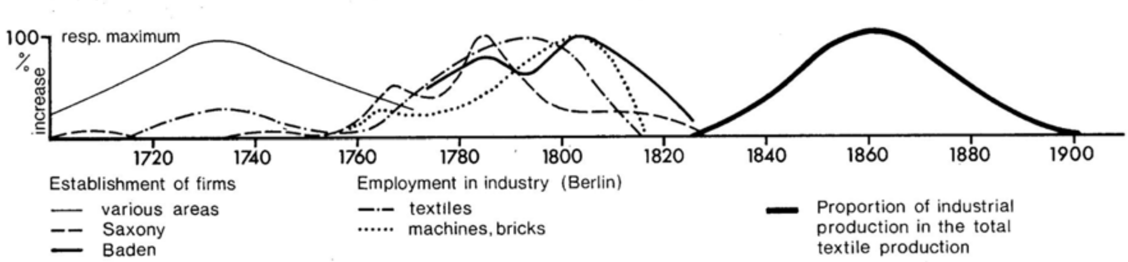
In our context, it is important to recognise not only the oscillations themselves, but also the stages to understand the reasons behind the development. The following general remarks may be made in order to outline the development of Europe in modern times (see also section 2.4.2.1):

1. With the Renaissance in Italy began the intellectual emancipation from the medieval view of the world. Art and science opened up new perspectives. In the course of the 15th century, the new ideas spread to Europe north of the Alps.
This development reached its climax in the 16th century and gradually came to an end in the 17th century (e.g. in the field of architecture). These ideas formed the basis for new modes of thought and action which are characteristic of the modern age. For this reason, we may classify this phase as "perception".
2. In the first half of the 16th century (i.e. slightly later) the Reformation in Germany initiated a religious renewal of the Church with the Counter Reformation following from the mid 16th century (especially in Spain). These religious differences were then instrumental in the outbreak of the 30 Years' War in the first

half of the 17th century. This period would therefore fall under "determination".

3. In the meantime, absolutism had become established as the new political system. The state was placed on an entirely new basis. The ideas originated in Italy, but they were implemented primarily in France (17th century). It was then adopted by other European states, especially in the form of enlightened absolutism. Absolutism also promoted the "regulation" of human intercourse including its economic aspects (mercantilism). In the mid-19th century, this political system gradually disappeared.

a)



b)

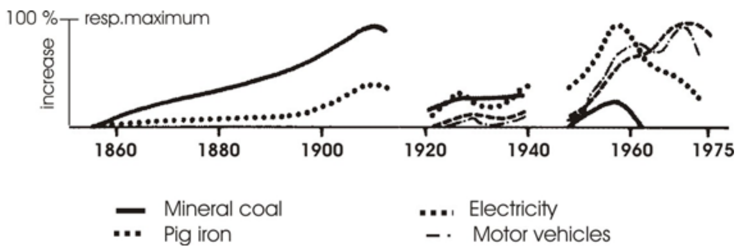


Fig. 112: Processes in decennial rhythm: Development of mining and other industries in Germany.
a) Early industrialisation (1700 - 1900) in Germany, shown according to various criteria (manufacturing industry in several areas of Germany, beginning of the textile industry).
b) Mining and industrial production in Germany (1860 – 1975), shown according to the production of mineral coal, pig iron, electricity and motor vehicles.
Source: see "Notes on the figures".

4. As early as the 18th century, greater attention began to be paid to road building with a view to improving communications and promoting the economic development in towns, and in 19th century Britain, the first railways created a fast and reliable means of transport. The towns grew in importance as centres of development. This stage could be interpreted as "Organisation".

5. In 18th century Britain, textile processing commenced on a large scale powered by water, and the smelting of iron powered by large reserves of coal. In the second half of the 19th century, heavy industry also became established on the continent in addition to the textile industry. It was founded on the mining of coal and iron ore. Large conurbations came into being, e.g. the Ruhr, upper Silesia, the Saarland etc. The result was a "dynamisation" of the economy.

From about here, it becomes difficult to say with certainty which institution should be assigned to which task in which process. The closer to the present, the more difficult it becomes to make a definite statement in view of the multiplicity of processes taking place simultaneously in cultural evolution:
6. At the beginning of the 20th century, Germany was one of the principal industrial countries with important secondary industries such as engineering, vehicle construction, electrical and armaments industries. Mass production became predominant, assisted by assembly-line technology. And increasing specialisation led to the growth of industrial networks. This period may be seen as a phase of "kinetisation".
7. This phase ended with the Second World War. And Germany became economically and politically integrated in the European community – a development which may be called "stabilisation".
The present phase of industrialisation began which is characterised by the use of highly complex technologies (atomic energy, computer technology, automation, biotechnology, nanotechnology etc.). The USA has become the leading industrial nation. Since the 1950s, it has provided the strongest impulses in the fields of science, technology and art. This indicates a departure for a new age beginning with a phase of "perception".

Several years' rhythm:

The "several years' rhythm" is difficult to prove. No studies exist which take account of the process sequence. Although certain economic cycles have been known for some time (Kitchin and Juglar cycle; see section 2.3.2.2) there are very few documents capable of substantiating the course of a process at a rhythm of several years, unlike the decennial rhythm.

Perhaps the city-umland population provides an indication. It is conspicuous that building activity following the Second World War had a number of different points of emphasis. Taking Saarbrücken as an example (see section 2.4.2.2):
- Development of the state administration in the 1950s;
- Appearance of large densely constructed residential complexes (1960s);
- Restructuring of industry: mining, textile industry, heavy industry etc. declined to be replaced by new industries (among others automobile and its supplier industries (1960s and 1970s);
- Construction of highways and canals (lower Saar) in the early 1970s. Disproportionate growth of commuter suburbs (early 80s);
- Re-organisation of retail trade: building of large shopping centres around city peripheries and establishment of pedestrian areas in shopping areas of inner cities (1970s and 1980s).
New investigations are necessary.

Yearly rhythm:

The yearly rhythms are also reflected for example in the activities resp. unemployment. The fact that the individual stages are so easily apparent depends on the weather conditions in the different seasons.

A good example of the yearly rhythm is the foundation of the settlement of Wörpedorf during the Hanovarian colonisation of moorland near Bremen in the 18th century (LILIENTHAL 1931):
- Before 1747: general deliberations on the possibility of taking the moor into cultivation, preliminary surveys (perception);
- August 1747: decision to survey the moorland (determination);
- 1749/50: process of colonisation established, quarrels with neighbouring communities settled (regulation);
- July 1751: instructions to colonise the moorland, thorough planning of land allocation (organisation);
- July/August 1751: recruitment of peasants for cultivation work (dynamisation);
- Autumn 1751 - 1753: execution of work (purchase of building material, erection of huts, excavation of ditches, channels, locks, planting of trees etc.) (kinetisation);
- October 1753 - 1755: inspection by government commission, all posts are occupied, officials of self-government are nominated (stabilisation).

Monthly or weekly rhythm:

On the farm, the following sequence of task stages applies (see also section 2.3.2.1):
- Perception: it is perceived that a requirement for certain products exists on the part of the market.
- Determination: a decision is taken to grow these products on the basis of division of labour.
- Regulation: planning is carried out, i.e. it is laid down how, when, and by which persons the work should be carried out.
- Organisation, part 1: the fields on which the products are to be grown are prepared (fertilising, ploughing, sowing the seed in the fields etc.).

This is the processing of demand (flow of information), i.e. the adoption. Then follows the production, i.e. the work itself, always in contact with the inferior environment. Production takes place, i.e. the supply is created (flow of energy):
- Organisation, part 2: the soil is tended by the workers, weeds are removed.
- Dynamisation: The seed germinates, the plants begin to grow.
- Kinetisation: the crop is brought in and prepared for sale.
- Stabilisation: the products are supplied to the market for sale.

In the "daily rhythm" the action projects are carried out by the individuals according to their own capabilities or overriding constraints. The whole process sequences (lasting about a week or longer) are not yet sufficiently investigated.

2.5.3. Process sequences and dominant systemic dimensions

Numerical sequence:

At the 5th level of complexity, another vertical alignment takes place. The hierarchical order serves the purposes of control (see section 2.5.1.2). Here the hierarchically inferior environment is involved. Mankind as society is a good example. We have a vertically oriented process (U variant; see fig. 113). This involves clockwise passage through the coordinate system.

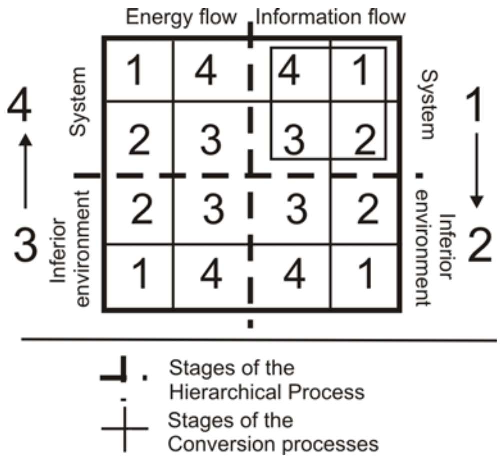


Fig. 113: Scheme of the hierarchical process. Numerical sequence.
1st rank process (U variant, see arrows) before folding: Development of the information from above to below (1 > 2) and development of energy from below to above (3 > 4). The front side (mankind as society) is located at the upper right.

As a consequence of interlacement (3rd operation of the emergence code; see section 2.2.3), the newly organised process structure appears.
The induction process (flow of information):
f(x), Input: The stimulus (order) enters the system from the hierarchical superior environment (front side).
-f(x), Acceptance: The stimulus moves downwards in the inferior environment (in our example the mankind as species).
The reaction process (flow of energy):
-f(-x), Redirection: The inferior environment is involved, the reaction process leads upward.
-f(x), Output: it is here that the energy supplying process arrives at the hierarchical system (in our example the mankind as society).

The 2nd rank process (see fig. 113) contains the process sequences of the conversion process: in the process of the first order information flow, stage
- 1: Perception (1), Determination (2), Regulation (3), Organisation (4);
- 2: Organisation (1), Dynamisation (2), Kinetisation (3), Stabilisation (4).

The same applies for the flow of energy (stage 1st order, no. 3 and 4).

Route diagram:

Clarity concerning the course of the flows of information and energy in the hierarchic system and the involved inferior environment is obtained when the numeric sequence is unfolded (see

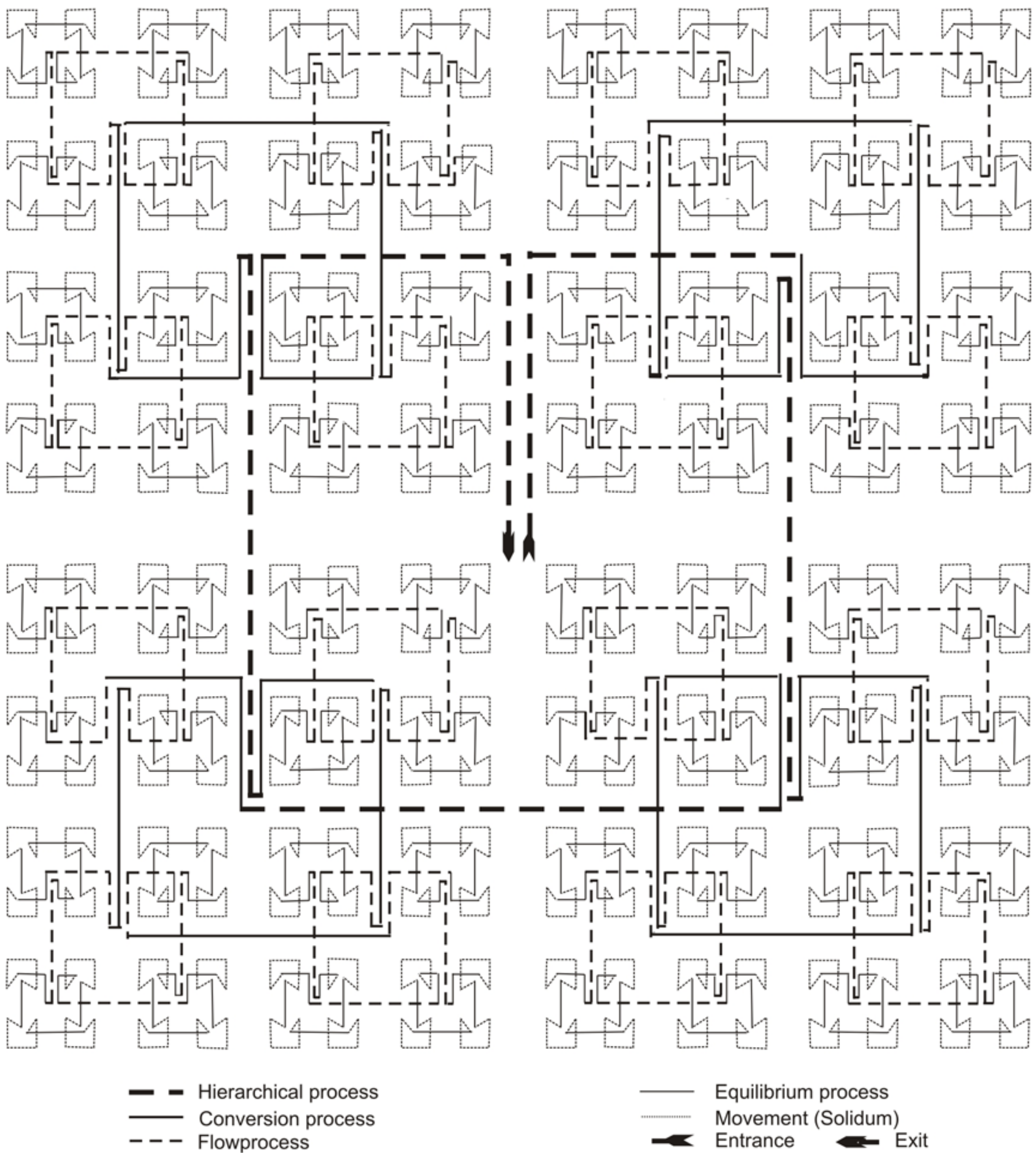


Fig. 114: Route diagram of the hierarchical process with the processes and systems of the lower complexity levels shown.
The first rank basic process stages are assigned to the systems structured according to variant U.
To each of the four stages of the basic processes of a level of complexity is assigned a basic process of the next-deeper level of complexity. Each of the basic processes shown in this drawing represents a large number of individual basic processes.

fig. 114). The upper part represents the system (e.g. mankind as society) and the lower part the involved inferior hierarchical environment (e.g. mankind as species). The development of the process sequence takes place according to the U variant of the basic process, i.e. on the right side downwards (information flow), and on the left side upwards (energy flow).

The dominant systemic dimension (see fig. 115):

At this level of complexity, hierarchy (H) becomes the independent and dominant dimension. The superior environment (demanding mankind as species) is located above hierarchically and the hierarchic system (mankind as society) itself is integrated in the superior hierarchic structure. The conversion processes or non-equilibrium systems are grouped at (8, by overlapping:) 7 hierarchic levels.

Fig. 115: The hierarchy as the dominant system dimension.

The information flow and the energy flow are enabled by the demand/supply-relation (Lotka-Volterra-relation) between the hierarchic levels (specification hierarchy). Each hierarchic level is represented by a flow equilibrium system which has a task for the whole. The result is a sequence of tasks which corresponds to that of the task sequence in the conversion processes (perception ... stabilisation). Each non-equilibrium system must assure its own existence and is involved in the general flow of energy. Information flow comes from the hierarchic system (e.g. with mankind as society), energy flow comes from the involved inferior environment (e.g. with mankind, the supplier of workers, as species). The energy for the work required in the economy of the system "mankind as society" is supplied by the ecumene as part of the ecosystem (see section 2.6.2.1).

Within the system "mankind as society" the populations lower in the hierarchy (compared to local populations) function as elements in each of the superior systems (scalar hierarchy, section 2.5.1.1).

Outlook:

The hierarchic system is not a structure which can be interpreted deterministically, but one which is divided internally and in which many non-equilibrium systems compete with one another at the corresponding hierarchic level. In this way, a selection takes place. However, this also means that there is a permanent stimulus for internal improvement. Moreover, the control of the relationship demand-supply is decisively improved by means of order- obedience. Thus, noise in the flow of information and dissipation in the flow of energy are kept within limits.

However, hierarchies are not spatial and material structures in themselves but only structures which control themselves. A framework running through the systems materially and spatially is necessary which might lend them strength and durability. This can only be made possible by a specific process. Autopoiesis is the essential task of the highest level of complexity within the universal system.

2.6. Autopoietic processes and universal system

2.6.0. Introduction

2.6.0.1. Foreword

Our above remarks are based substantially on the examination of historical processes and social systems. The flows of information and energy can be particularly effectively analysed in these. They are accessible to our daily experience (mesocosmos) and relatively recognisable with regard to content. Besides this, sources are also available to us which permit a more precise analysis. We have, however, also been able to demonstrate that the laws derived therefrom apply not only to the systems and processes in human society. Instead, it has been shown that the same types of process and system of this order of magnitude can also be detected in nature.

However, if we leave the level of the mesocosmos and wish to extend our knowledge of the complex constitution of our reality in pursuit of the process of emergence, we must leave human society as an object of study behind us and add natural systems and processes to the empirical base. We then arrive at the 6th level of complexity, in which we have to deal with a further type, i.e. the autopoietic systems. These have the ability to reproduce themselves materially, i.e. they do not only organised themselves structurally like the non-equilibrium systems, but also fabricate their own material substance.*)

*) The term "Autopoiesis" is made up of the Greek "Autos" (=self) and "poiesis" (= creation, generation). Luhmann's autopoietic systems (1984, u.a. S. 43, 60 f., 296 f.) correspond more closely to our non-equilibrium systems).

MATURANA and VARELA (1984/87), the originators of our insight into autopoiesis, based their theories principally on living organisms. In fact (as is shown here) the inorganic systems such as molecules, atoms, stars and galaxies, should also be included. As we see it, these systems generate not only matter, but space (S_e) is introduced as a new systemic dimension (section 3.2.1 of the main text). In other words, the process theory regards space as order shaped by matter.

We must also take account of the fact that a large proportion of the object of study is located outside the sphere of our direct contemplation. In many areas of quantum physics we are confronted with paradoxes which show that through experimentation, results are obtained which may seem strange to the observer because they do not appear to have any equivalent in our order of magnitude i.e. the mesocosmos. Einstein was also puzzled by such phenomena and regarded the so-called entanglement as a "ghostly" occurrence (ZEILINGER 2005). To date, no approach seems to have been found with which the problems created by it may be tackled with any prospect of success. It sounds like resignation when, for example, ALBERT and GALCHEN (2009, 9 p. 37) say with reference to the applicability of Schrödinger's wave function to specific physical objects: "... we must accept the notion that world history takes place neither in the three-dimensional space of our everyday experience nor in the four-dimensional space-time of the theory of relativity, but in this gigantic vague configuration space from which the illusion of three-dimensional everyday space somehow proceeds".

The question now arises as to whether the methods of dealing with the problems which have been known for several decades were not simply unsuitable. It might occur to an outside observer that in astrophysics or quantum physics, objects are regarded as specific phenomena and that the causal method is still the most important basis for study. The system-theoretical approach however, which has been the standard one in biology since the 1950s and which is now widely used in other fields, has had little or no influence. System research and the methods derived from it lay open the flows of information and energy, i.e. they examine the links between the elementary energy carriers, thereby revealing entireties which are known as systems (see section 2.3.2.1).

An anthropo-geographer, who constantly has to deal with complex structures may not necessarily see the results of studies, which in quantum physics are paradoxical or absurd, as being illogical or contrary to experience. In the process theory, which like complexity research, has its roots in the system theory, channels are opened up which lead to new solutions. Thus, the following article attempts to treat the phenomena of the macro and microcosmos using the methods of the process theory and to integrate them in the process of emergence.

As a geographer, experience has taught me to expect resistance from various quarters because I am attempting to go beyond the limits of geography using the previously developed methods and previously achieved results. The object of study is now the universe. However, for transdisciplinarity to have any meaning, such a "violation" of the borders between the disciplines must be permissible. I can see no other way forward. Our essential objective is to increase our understanding and consequently we do not ask about the "causa". The causal method refers to individual objects. The questions involved are answered by physicists and chemists (and explained to the layman in secondary literature produced by specialists in these fields) (see bibliography). With reference to the process theory, we are much more interested in the "finis" and the way in which we may achieve it. Only in this way is it possible for us to obtain a general view allowing us to draw broader conclusions on the structure of complex reality and come closer to answering the question set in the foreword.

2.6.0.2. The employees of the textile factory in their life spheres

To date, we have regarded the textile mill as a place of production. We now propose to examine it from a purely material point of view. Seen in this way, it was also part of the natural systems of the earth – in three different respects (see fig. 116):

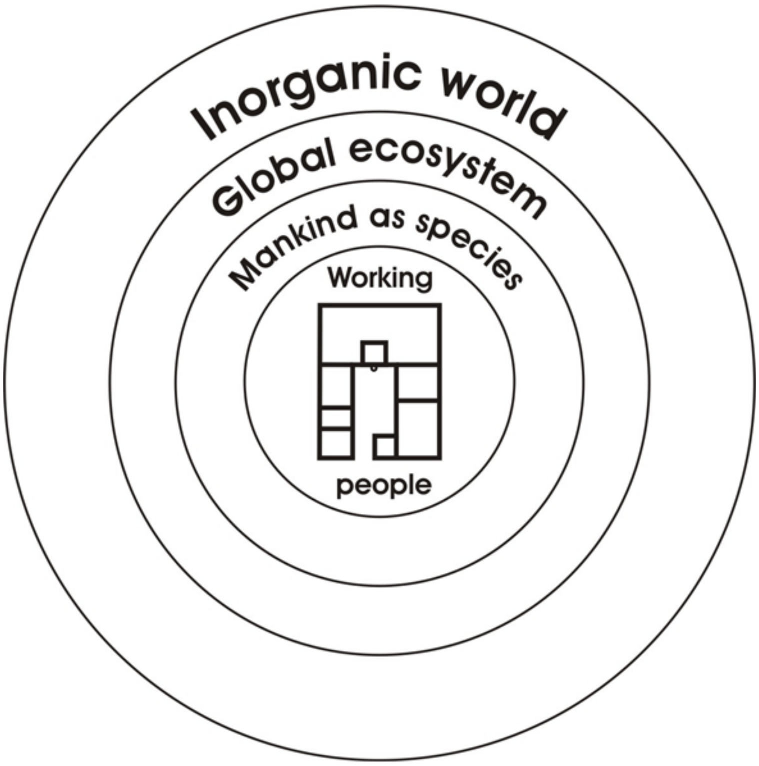


Fig. 116: The employees of the textile factory as members of mankind as species.
This is in turn part of the global ecosystem, and the ecosystem, for its part, is rooted in the inorganic world.

1) The people who worked in the factory had their own specific biographies, their own living space and their own special requirements. They needed food and clothing, founded families and raised children. They were members of mankind as a species (see section 2.5.1.1). They were free to lead their lives independently and to find the place in society and in the environment best suited to their requirements. But they were unable to change the fact that they were born, that they had to take in energy in the form of nourishment and warmth, and that they had to age and die. As living organisms, they had to fit into the cycle of nature.

2) This also applies for the company itself. It processed organic materials, especially the natural fibre cotton. The textile products were consumer articles with a limited period of use. They then became waste and entered a number of different cycles in the

form of detritus. In the production process, coal was burned to provide energy. On the other hand, the factory sent smoke through the chimney and produced liquid and solid waste which had to be removed, thereby polluting the natural environment. Here the ecosystem is affected.

3) In the last resort, the biotic substance has been formed from inorganic substance, and is mineralised again at the end of the food chain. The buildings, as earthbound artefacts, and the machines were constructed of natural materials, bricks, concrete, mortar, lime, iron etc. The formation of these materials is controlled by exogenous and endogenous forces such as tectonics, volcanic activity, sedimentation, reef formation etc. Man may influence these processes here and there, but he cannot control or prevent the forces behind them. The buildings of the factory have now been demolished and the material used for new purposes or "returned to nature" as waste where it may (in a new geological era) find some further use.

Thus, the people working in the factory as an earthbound artefact were, from a material point of view, part of the surrounding ecosystem and the inorganic world. This brings us to a new field of study.

2.6.1. General considerations

2.6.1.0. Instead of an introduction: The Universe as seen by an artist.

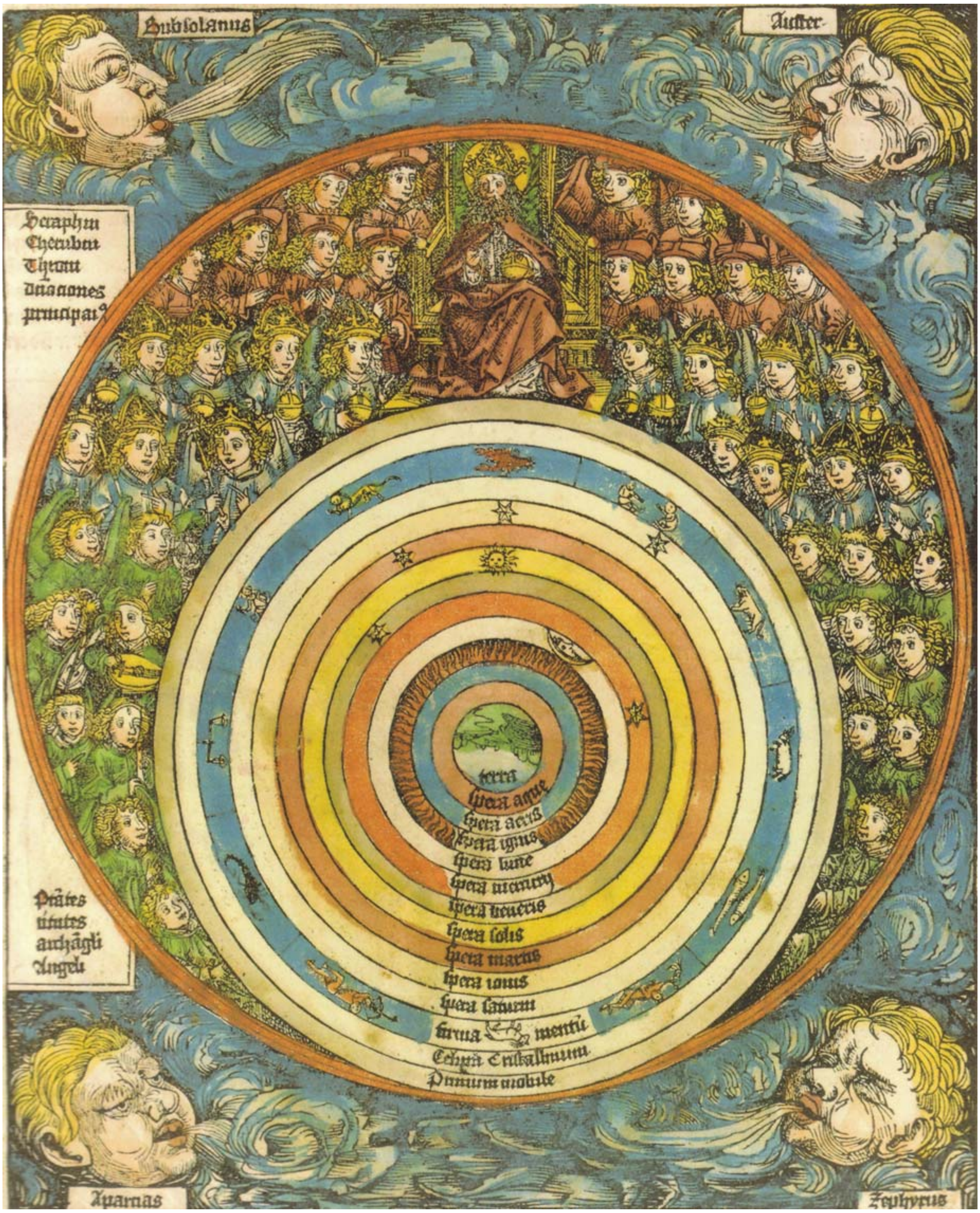


Fig. 117: The Creation as described in Genesis. Hartmann Schedel (1493).
Source: See "Notes on the figures".

The creation is the symbol for autopoiesis, whether it is anchored in the Bible, Buddhist myths, Hindu or naturist religion. In Christianity there are many representations of this event, especially in the late middle ages. On the verge of modern times (1493), Hartmann SCHEDEL published his famous Chronicle of the World. Schedel was a prominent humanist with an extensive education. On the other hand, his view of the world was still medieval in the sense that it was based nearly entirely on the Bible. The image described below originates from his Chronicle (see fig. 117). God the Father is enthroned at the centre above the orb of the world and surrounded by the angels in heaven and, in the four spandrels, the wind divinities. According to the Ptolemaic system, the earth is at the centre (upside down in the picture) surrounded by the spheres of water, air and fire. These are followed, moving outwards, by the orbits of the moon, and the planets from Mercury to Saturn. The outer canopy, where it was possible to see it from the earth, is formed by the firmament with the signs of the zodiac. Schedel numbered Moses among the reliable writers of history, calling him "a father of the historians of God". On the other hand, he also referred to the writers of antiquity and argued, for example, that the primitive matter "hylae" preceded the creation. When Schedel's Chronicle of the World appeared, Copernicus began his studies on astronomy on which he based his modern heliocentric system.

The example shows how, according to the notions of the time, the universe had a spherical structure and how, according to the knowledge available, the mesocosmos occupied the central space.

2.6.1.1. Systems and elements

In our time too, we attribute a spherical structure to the universe, albeit in a different respect:

In this section the central theme is the universal process as a structure-preserving process. The rules and terms developed in the previous sections for the objects of mankind as a society must be imagined as applying mutatis mutandis to the objects present in organic and inorganic nature.

The purpose of the 6th level of complexity is the additional involvement of the systemic dimension of space (S) in the process of emergence. In order to represent the processes and links as simply as possible, we have developed a scissor-type diagram (as in our discussion of the hierarchic system in section 2.5.1.1, Fig. 101) to demonstrate the linking of the autopoietic systems (Fig. 118). Two different processes should be distinguished:
1) The individual spheres (each designated by one type of system) form a continuously ordered system depending on the size of the autopoietic system, from the sphere of the universe (A) through the biosphere (G/G') to the sphere of the photons (A'). Each type

of system has a task and is linked with the adjacent system types by a supply-demand relationship. The type of hierarchy is therefore a specification hierarchy. The larger systems in each case represent the superior environment.
2) Each type of system in the spheres of the macrocosmos (A ... G) has a corresponding type of system in the spheres of the microcosmos (A' ... G'). From this and from the related tasks of the system types concerned, it may be concluded that the systems of the microcosmos represent the elements of the corresponding systems of the macrocosmos, i.e. both are linked to one another through a scalar hierarchy. Thus, the organisms as systems of the biosphere produce the cells which themselves, as elements, construct the organisms. The chemical systems create the molecules which they use as elements etc. (section 2.6.1.3).
3) It is assumed that the autopoietic systems also have the characteristics of the non-equilibrium systems in a structural sense (section 2.4.1), in particular the ability to create, by division of "labour", complex products in the flow of information and energy, to use the inferior environment and to organise itself spatially i.e. centrally and in the peripheral zones.

2.6.1.2. The tasks of the systems in the universal process; an approach

The central question is whether, in the course of the interaction between the autopoietic systems, a way of understanding the creation of matter and space is revealed. We attempt to suggest a new point of view based on the facts and premises of the process theory developed above.

The first task is to define the individual spheres and their importance for the universal process. The following points must be established one after another:
a) Identification and brief description of the system types in the macrocosmos with their systems (interpreted as elements, section 2.6.1.1) in the microcosmos. As with the hierarchic process, we will proceed according to the size of the systems – here in the macrocosmos (Fig. 118);
b) determination of task according to the position in the sequence of the universal process;
c) definition of the system type.

A/A’) Sphere of the universe and sphere of the photons:
a) The "universe" of course embraces everything and has the highest conceivable complexity. However, our aim is to determine the specific share of the universe as its own type of system in the universal process (in the scale of all system types). We are therefore withdrawing all inferior system types which means that only the shell remains. When seen thus, the universe has to be interpreted as a uniform undifferentiated electromagnetic field, whose elements or components in the visible range are the

"photons". These are massless particles which can transmit electromagnetic energy and which travel through the cosmos at the speed of light.
b) This is the start of the universal process, the "input" (as in the basic process, section 2.1.1.2). For the conversion process in the context of mankind as society, this corresponds to the 5th level of complexity or "perception".
c) As mentioned above, the universe (seen as a sphere) appears in the universal process as an undifferentiated unit. For this reason, it is still not a system. However, the photons are part of it. It cannot be ascertained whether any spatial limits of the universe have any effect on their motion (in contrast to the shape of the space within the systems containing the mass in the spheres located lower in the hierarchy; see below). The photons too, appear as undifferentiated units. According to this model, the universe and the individual photons are therefore "solida".

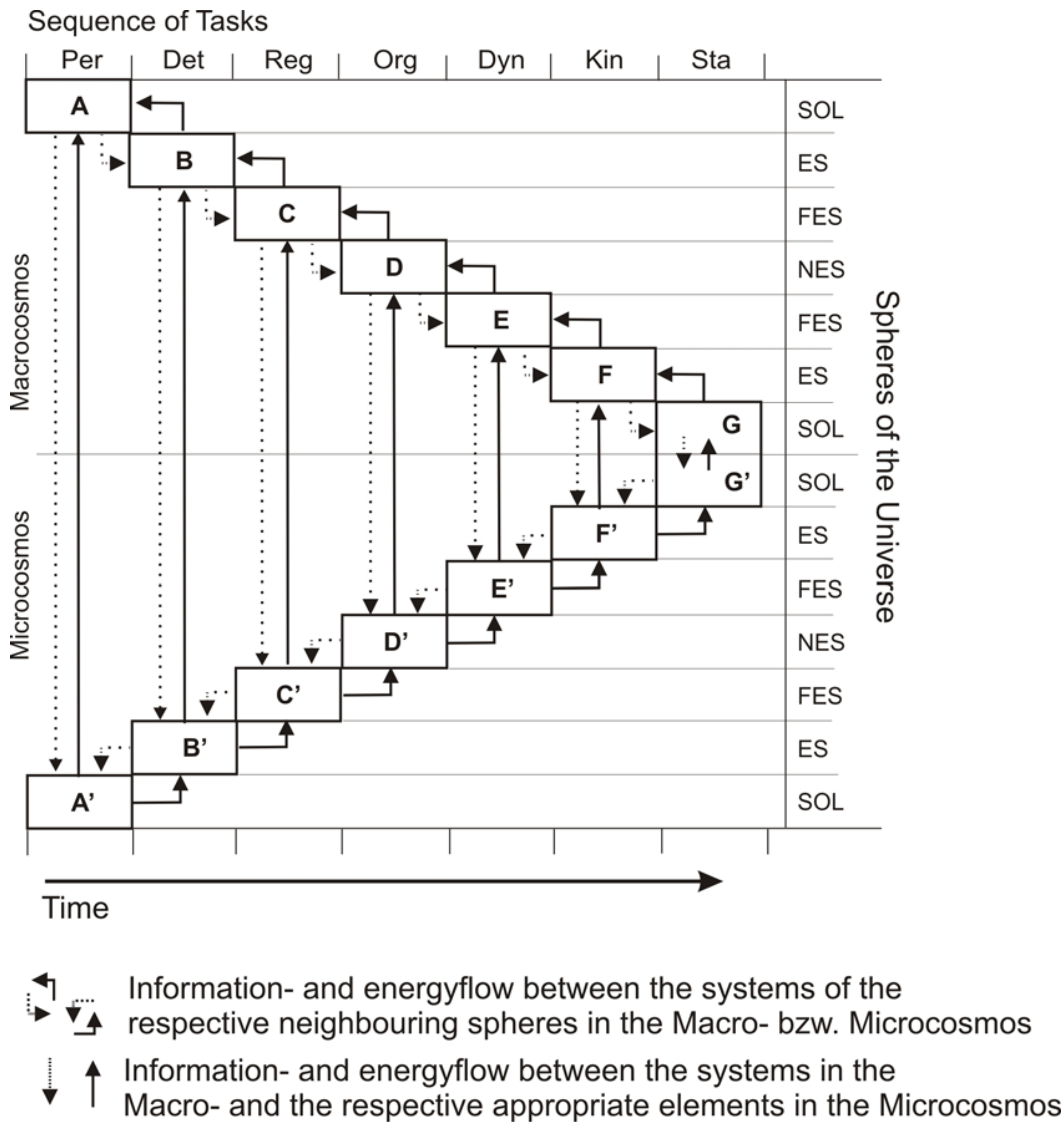


Fig. 118: The spheres of the macro and microcosmos (scissor diagram).
A = sphere of the universe; A′ sphere of the photons;
B = sphere of the galaxy clusters; B′ sphere of the electrons;
C = sphere of the galaxies; C′ sphere of the hadrons;
D = *sphere of the solar systems;* D′ = *sphere of the atoms;*
E = *sphere of the planets;* E′ = *sphere of the atomic and ionic bonds;*
F = *sphere of the chemical systems;* F′ = *sphere of the molecules;*
G = *sphere of the organisms;* G′ = *sphere of the cells.*
G/G′ = biosphere.
Tasks: Per = perception, Det = determination, Reg = regulation, Org = organisation, Dyn = dynamisation, Kin = kinetisation, Sta = stabilisation.
Structural types: SOL = solidum, GS = equilibrium system; FGS = flow-equilibrium system, NGS = non-equilibrium system.

B/B′) sphere of the galaxy clusters and sphere of the electrons:
a) The "galaxy clusters" appear as coherent areas and filaments. If we follow the scale of the spheres in the universal process in the microcosmos, the elements in these structures are assumed by us to be the "electrons" (belonging to the group of the leptons). These are negatively charged particles which possess mass and which may travel at various speeds below the speed of light. Their obvious limitation distinguishes the galaxy clusters from the universe (as a sphere) and the variability of their speed of motion distinguishes the electrons from the photons.
b) Perhaps we could describe the galactic clusters as systems which mark those parts of the universe assigned to take part in the universal process, i.e. which are integrated in it. The remaining part of the universe outside the clusters is an environment which cannot be defined more closely ("dark matter", "dark energy" etc.). At a general level, i.e. that of the basic process, "acceptance" in the system corresponds to it. In which case, the galaxy clusters then assume the task of "determination" in the universal process.
c) The galaxy clusters with the uniformly structured electrons as their elements are identifiable as spatially limited groups of features which could perhaps be described as "equilibrium systems".

C/C′) Sphere of the galaxies and sphere of the hadrons:
a) Because of their position on the scale of the spheres, we believe that the massive particles of the "protons" and "neutrons" can be assigned as elements to the "galaxies". The protons and neutrons belong to the "hadron" group. The protons are positively charged and (along with the electrically neutral neutrons) form the atomic core. These in turn are composed of quarks and are bound together by the "strong inter-reaction".

b) The galaxies receive shape and structure through a strong centripetal pull and rotation of the masses around a common centre with the result that clearly identifiable large structures become apparent. This would suggest that the elements as vehicles of mass

are brought under the control of the system structurally. The task of this type of system in the universal process is "regulation".
c) Here the most important objective is to establish mass (represented as elements in the protons and neutrons) in the universal process. Presumably, galaxies are energetically open. They absorb energy and this is effective in the structure. Seen from this angle, it assumes the characteristic of a spatially formed "flow equilibrium system".

D/D’) Sphere of the solar systems and sphere of the atoms:
a) The "sun" is the star at the centre of our solar system. It is a gas sphere with a shell-like structure. Density and temperature are highest at its centre, where hydrogen nuclei merge to form helium nucleii, thereby releasing energy. Among other things, it causes "atoms" to form which are the elements in this system. It also generates radiation. The effects of the reactions in the sun extend far into interstellar space diminishing with increasing distance. Among other things, the radiation emitted by the sun supplies the planets and other bodies orbiting it with light and thermal energy.
b) In this type of system, mass is organised spatially and the greater part of it concentrated in the sun itself. Space, seen as order, is defined here by a mass constituting it in some way or another, in which the atoms as elements are also involved. Space includes not only the sun, but also its surroundings which are shaped according to the influence exercised by the sun. A central and peripheral arrangement into tasks is also associated with the formation of space, i.e. spatial organisation. By means of this process, mass becomes a spatially shapeable matter.
- This applies equally for the atoms. Here however, the energy is provided by electromagnetism. Like the sun, the atomic nucleus contains by far the greater part of the masse. It consists on the one hand of positively charged protons and, on the other hand, of electromagnetically neutral neutrons. The nucleus is surrounded by a shell of negatively charged electrons distributed in various orbits which represent energy levels. The number of electrons depends on the number of protons. In this way, the electrons are subjected to the control of the nucleus. Thus, the atom as a whole is electromagnetically neutral.
c) The arrangement of the solar system is reminiscent of that of the town-umland population in the mesocosmos (section 2.4.2.2), i.e. of a non-equilibrium system. In the universal process discussed here, the centre (i.e. the central star) exercises a force of attraction on its surroundings, thereby giving rise to a "division of labour". The division of tasks (not discussed here) is seen for example in the shell-like structure of the sun. Space is differentiated and mass arranges itself in encompassing shells, each of which performs a different task for the whole.

The shaping of space with the aid of mass (where it originates from the macrocosmos) is completed here. The atom itself has a complex structure which may be described as "task-sharing". The number of hadrons and electrons varies and this defines its characteristics. The periodic system of the chemical elements arranges the various types of atom (about 100 in all) systematically according to mass and other criteria. Besides this, the atom is the basic element involved in chemical processes which is the reason why, in the further course of the universal process, the impulses leading to the shaping of materially defined space, pass over to the microcosmos.

E/E’) Sphere of the planets and sphere of the atomic and ionic bonds:
a) As far as we know, the earth and the other "planets" have a shell-like structure similar to the sun. The crust of the earth for example is made up of matter which has cooled (rock). Beneath it, in the mantle, masses of molten rock are mixed and distributed by convection and other currents. The earth's core on the other hand consists principally of iron and nickel.
b) Electricity and magnetism are generated by rotation like a self-energising dynamo. This causes polarisation of the matter in space and the atoms are charged ("dynamisation"). In this way the planets make it possible to engage the neutral atoms in the electromagnetic flow of energy. The charging of the matter is the essential precondition allowing molecules to form because chemical bonding takes place mainly due to electro-magnetic forces. The (negatively charged) electrons in the outer "orbits" of the atoms play an important part in this process. This position makes them relatively instable which means that they can interact with the electrons of other atoms, thereby allowing the atoms to alter their charge.
c) In this way the atom becomes the basic unit for a multitude of different possibilities of shaping space in the microcosmos. It is located continuously in the flow of energy. The earth has its own energetic system which is open to the influence of the solar system. In this respect, we are dealing with "flow-equilibrium systems".
F/F’) Sphere of the chemical systems and sphere of the molecules:
a) As indicated above, the hot semi-liquid substances in the interior of the earth are intermingled with one another both on a small scale and on a large through convection, the formation of eddies etc. The movements shift the plates forming the earth's crust, thereby causing them to overlap, fold and fracture, thereby forming mountain ranges and ocean trenches. On the surface of the earth, the three-dimensional "relief" created by these endogenous forces is re-shaped by exogenous forces, i.e. by wind, water, ice, chemical erosion etc. as well as a host of smaller organisms which tend to level it out. This is the sphere of the "chemical systems" of which the "molecules" are the elements.
b) In the chemical systems, the electromagnetically charged atoms are forced to encounter one another and combine. In this way, multiplicity of "docking" variants is created with the result that the superior flow of energy can be fanned out materially and divided into stages. The molecules thereby created may assume

widely differing geometric forms and highly specific chemical characteristics. Within the context of the universal process, what is taking place here is "kinetisation".
c) All this takes place in a gaseous and fluid state of aggregation. Substances of widely differing natures are created, some of which "freeze" to form solid bodies, e.g. rock strata. The molecules too arrange themselves in order (by Brownian motion). The energy required for these changes is obtained from outside (solar radiation, wind, gravity, falling water, magma from the earth's interior etc.). These systems are feature groups or "equilibrium systems".

G/G’) Sphere of the organisms, and sphere of the cells (biosphere):
a) Humanity as a species (section 2.5.1.1) is integrated in the natural environment which is its "habitat", the oikoumene. It forms the energetic foundation, its ecological niche. Other living organisms are also grouped taxonomically into species as well as structurally in ecological niches. The organisms form the systems in the macrocosmos with the cells as their elements and part of the microcosmos. These are spatially limited functionally complex units which embody all the principal characteristics of life.
As the "producer", the flora absorbs the necessary inorganic substances from the inferior environment, the molecular sphere. The fauna live on the flora, fulfilling the role of "consumer". Spatially, this is the biosphere, in which the organisms have created their habitats.
b) In the pursuit of optimum adaptation to the environment i.e. the flows of information and energy, many different species have developed in the course of time. For this, it is important that the cells are able to synthesise protein, i.e. molecules, and to reproduce themselves autonomously, i.e. cells can originate only from other cells.
Individual organisms adapt extremely sensitively to the possibilities of absorbing energy from inorganic nature, thereby ensuring maximum efficiency in the utilisation of energy. With the death of the organisms and cells, the flow of energy reverses and leads back into the microcosmos (decomposition of biotic material). The organisms of the biosphere represent the final link in the universal process leading to the spatial arrangement of the macrocosmos. The task in the process sequence in the macrocosmos is "stabilisation".
c) As individuals, self-supporting organisms in the macrocosmos (their cells are part of the microcosmos) are units of awareness, i.e. "solida", although their internal structure is extremely complex. They mark the last stage in the universal process. To preserve the species (i.e. to preserve the ecological niches on the one hand and pass on individual peculiarities on the other) special mechanisms are necessary at the cellular level. In the nucleii of the cells of the organisms, the DNS molecule contains the genetic information necessary for this. But the protozoa (part of the microcosm) are also "solida" which reproduce themselves by

cell division. This is the stage at which the most subtle type of spatial shaping and differentiation is reached.

- In the general diagram (Fig. 118) we can see that the structures become more complex from sphere to sphere, both on the scale of the spheres in macrocosmos (A – G) and the macrocosmos (A' – G'). However, we should enquire what exactly "complexity" means here. In the first half of the universal process, (A/A' – D/D') both the systems of the macrocosmos and the microcosmos belong to a higher level of complexity with every step in the universal process, i.e. the autopoietic systems build themselves up structurally from stage to stage. The stations are: solidum – equilibrium system – flow-equilibrium system – non-equilibrium system. In the second half however (D/D′ – G/G′) the structural complexity between the systems and the elements decreases again and the way leads back from non-equilibrium system via the flow-equilibrium system and the equilibrium system to the solidum. In return, the number of systems in each case increases enormously.

The successive importation of mass into the universal process proves to be the key to understanding this phenomenon. In the first half of the universal process, mass is imported into the microcosmos and in the fourth stage it is merged with space (in the sense of expansion). In the second half, mass becomes matter, i.e. it can be shaped spatially in any way and differentiated with regard to content. The diversity of content increases from stage to stage beginning with the approximately 100 different kinds of atom via the countless types of chemical substances and molecules to the individualisation of the flows of energy in the sphere of the plants and animals. We must therefore distinguish between complexity with regard to structure and complexity with regard to content. On the other hand, shape and content jointly define space. The conceptual distinction between the two is a matter of scale and point of view.

It is especially in the biosphere that the flow of energy is utilised in every detail. Mankind as a species is also part of this sphere. Mankind as a society which derives from it divides the flows of energy even further by means of the technology it creates. On the one hand, this means that the complexity is further increased. On the other hand, the question remains as to whether mankind is not destroying the finely spun network of natural flows and cycles of energy it receives, thereby releasing an unreasonable amount of energy uselessly.

Remarkable: The biosphere forms the core of the mesocosmos. In it macro and microcosmos unite. Whereas multicellular organisms are part of the macrocosmos, the cells which compose the organisms belong to the microcosmos. This division is justified not only from an anthropocentric point of view, but it is also inherent in reality, as survey of the inorganic environments of the biosphere shows.

2.6.1.3. The processes between macro- and microcosmos

The universal process serves either to renew the system and counteract its disintegration (i.e. to preserve its structure) or to increase or diminish the systems (i.e. to alter the structure). With other alternatives, the same basic mechanisms are in effect.

We will now try to describe the process of renewal more closely. The systems must reproduce themselves constantly by autopoiesis in such a way as to fulfil their function of keeping the flow of energy joining the systems as efficient as possible. This general flow of energy between the spheres takes place in such a way that the demand from the superior systems in the macrocosmos is passed to the systems belonging to the next lowest sphere, whose elements in the microcosmos supply the necessary components for the necessary renewal. The systems in the macro and microcosmos collaborate in this process. This is demonstrated taking the example of the chemical sphere F (with the sphere of the molecule F') (Fig. 119). The following process stages should be distinguished:
1) in the macrocosmos the information with the demand for self-reproduction is passed from the sphere of the planets E to the hierarchically inferior systems (with regard to specification) of the chemical sphere F (perception).
2) The affected systems F accept the demand (determination).
3) They pass the orders to the hierarchically inferior elements (with regard to scale) (molecule F') to provide the required additional materials (regulation).
4a) The elements F' demand the electrically charged atoms E' necessary for the construction of the molecules from their inferior environment (with regard to specification). This takes place at the element level, i.e. in the microcosmos (organisation in the flow of energy).

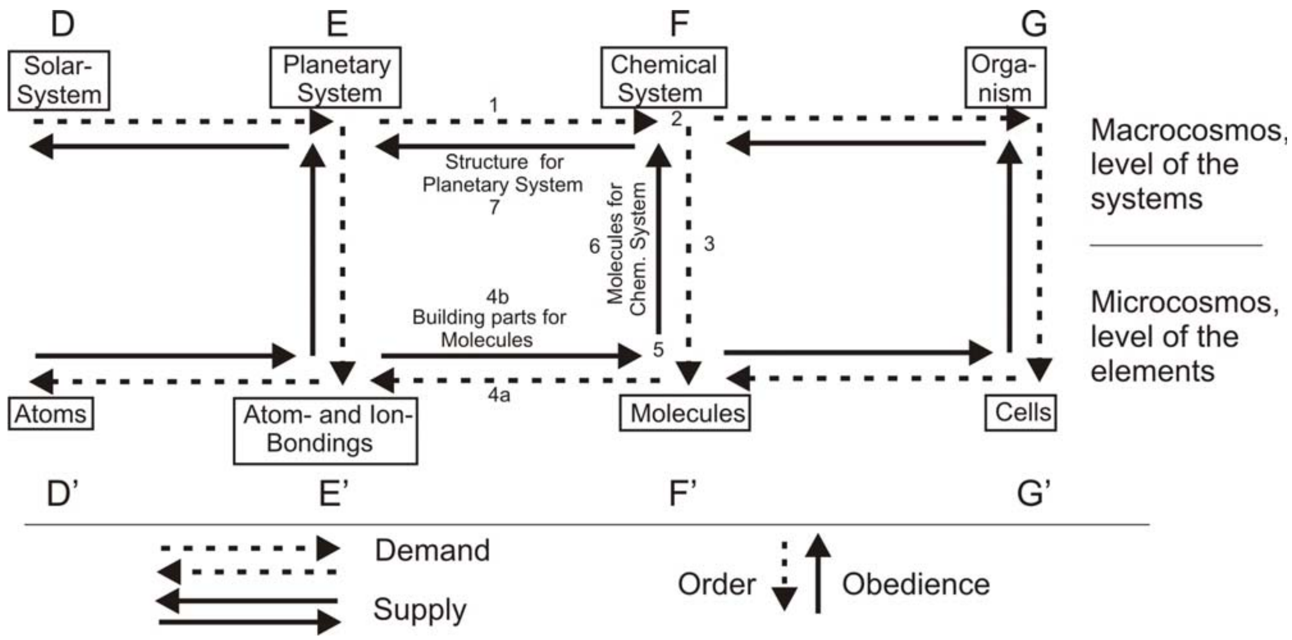


Fig. 119: Diagram showing the flows of information and energy in autopoietic systems based on the transition from the sphere of the planets (E) to the chemical sphere (F). The numbers in this part of the diagram indicate the direction of order and compliance (scalar hierarchy) and of demand and supply (specification hierarchy).

4b) The desired material E' is supplied and offered to the molecules F' as the superior systems in the specification hierarchy from the inferior environment (organisation in the flow of energy).
5) The matter is then accepted by the molecules F' (dynamisation).
6) As the elements of system F, the molecules construct the desired molecules from the electrically charged atoms, in such a way that the affected chemical systems F can renew their space as expansion (kinetisation).
7) System F offers itself in a new shape, i.e. with renewed space to the superior environment (the system of the planets E) (stabilisation).

Many cycles of this type result, which cooperate with one another from sphere to sphere (hierarchically with regard to specification). The disintegration products of the ageing systems are caught up in the spheres of the microcosmos and returned once again to the cycles. We can imagine the universal process as a kind of conveyor belt on which new autopoietic systems are constantly formed or renewed. In this way, an all-embracing cycle is created which, in the induction process, leads from sphere A (i.e. the universe) down the macrocosmos to sphere F (perhaps also via biosphere G/G' if this is present) into the microcosmos to sphere F' and from there to sphere A'. The reaction process takes place in the opposite direction.

Through the relationship of system to elements, the macro and microcosmos are coupled with one another and the macrocosmos has the task of producing space as expansion and the microcosmos space as matter. This too takes place in the manner of cycles. As already mentioned, specification and scalar hierarchies together operate the differentiation process with the aim of preserving the efficiency of energy utilisation or altering it in a controlled manner. Helmholt's "principle of economics in nature" may be reflected here. Is this the driving force of organic and inorganic evolution? However, it is still unknown where the energy and the mass for this process ultimately come from.

The emergence process ends at the sixth level of complexity. Autopoiesis, the creation of matter and expansion, produces space. Its multifaceted constitution shows us (almost as a side-effect) what makes our world so colourful. It is here that the natural and social sciences approach one another closely.

2.6.2. Individual Examples

2.6.2.0. Introduction: About the shaping of materially defined spaces

Structures cannot exist on their own. They require material definition. This is related to the consolidation of the spaces, because material definition gives structures the framework within which the processing and exchange of energy becomes possible. No activity can take place without protective space in which it can take place. Intervening spaces are necesary to create clearance between the processes. Process also means movement, with the consequence that systems take up more space than structures at rest.

Matter is therefore required to stabilise complex structures. In addition, energy can be stored and transported in matter (in the form of products). Matter can assist the processes, as our example of tools as a medium and earthbound artefacts in the service of humanity show (see section 2.1.1.1).

But matter is also transient. It decays. Growth and decay are the two sides of material existence. Specific mechanisms are needed to prevent a system type from disappearing (because it is required in the concert of energy processing). The materially defined systems (i.e. the kind of systems we are discussing here) must be in a position to maintain their form, substance and structure and to pass it on to a new generation.

These problems can be illustrated best in the organic sphere. In the following, we will proceed from the inside outwards, starting with the individual, examining generative behaviour as it applies to man, as well as the use of his (ecological) "niche".

2.6.2.1. Living organisms:

Autopoietic systems:

In the introducing remarks (see section 2.6.0), two levels of being were mentioned: 1) living organisms as such and as part of the global ecosystem, and 2) the systems of the inorganic world. Matter and space are not only structured in them, but also created. The processes shaping them are linked with the term autopoiesis. As part of "mankind as species" man is an "autopoietic system" (MATURANA and VARELA 1984/89; MINGERS 1995; WHITAKER approx. 1995). Man as part of a society, may influence these processes here and there, but he cannot control them or prevent them according to his own laws.

Using the living organisms, we will examine the terms autopoiesis more closely. Organisms are autopoietic products.

They maintain their existence through constant renewal of their cells. Within the cells, the substances supplied to the creature are chemically transformed. MATURANA and VARELA (1984/89) had this process of renewal in mind when they formulated the concept of the autopoietic systems at a time when the traditional system research had actually developed a different perspective (see section 2.4.2.1). While this attempted to identify the flows of energy and the principles of systems by more and more refined methods, the authors attributed more importance to the process of self-renewal. Seen from this point of view, autopoietic systems are distinguished by the fact that they create themselves, that they represent their own product. In other words: Living creatures are the "equifinal" (DRIESCH 1908/28, see section 1) result of the autopoietic processes and possess a fixed structure which applies for the duration of their existence.

In our context, it should be regarded as particularly significant that two levels are concerned here - the level of the organisms and that of the cells. In the case of more highly developed creatures, the level of the organs intervenes. One may take the view that the organisms are the systems, the organs the sub-systems and the cells the elements (see section 2.5.2.1). The cells create the substance, thereby allowing the organisms to supply themselves internally with energy. The organisms have a shape which makes it possible for them to procure the required energy externally. Their form allows them to adapt themselves in such a way to the energetic environment in the ecosystem that the flow of energy is optimised.

At the same time, they form the raw materials for other living creatures. The ecosystem consists of a large number of populations, each of which occupies its own ecological niche. The living creatures maintain their species by means of specific reproductive mechanisms, in addition to which they create nourishment (energy) for other organisms in their ecological niches. In this way, the energy stored in the organisms is distributed throughout the ecosystem. Some of the food chains which have formed are very extensive and linked with one another by cycles. This means that it is difficult to trace the flows of energy in detail. But it is this complexity of the ecosystem which demonstrates the effort made by living creatures to use the energy available to them as fully as possible.

Living creatures only have a limited life span. However, they have the ability to pass the essential data necessary for self organisation from one generation to another. This cannot take place through a simple re-arrangement of the elements, i.e. the cells, in the same way as it does with the non-equilibrium systems. Organisms have a strictly prescribed internal order. The information is stored in the cell nuclei (DNA) and passed from one generation to another through the reproductive mechanisms.

Genetic expression, some considerations:

As the above remarks suggest, the spheres of the autopoietic systems adjacent to one another permit a transfer of information and energy. We assume that this also applies for the transition from the chemical to the molecular sphere on the one hand and the sphere of the organisms and the cells on the other. Does that mean that life (when favoured by environmental conditions) originated from the inorganic world? Closer study of the genetic expression would seem to suggest this. It may be of interest in synthetic biology.

The controlling commands of the formation processes on which the growth of organisms is based are encoded in the DNA which is present in every cell (LEWIN 2002, pp. 59). Of particular interest to us is the process which provides the information for the structuring and shaping, and of the transfer of this information from the DNA into the process shaping a new cell. In this "genetic expression" information is transmitted in sequential form.

The result of the genetic expression is a protein, i.e. a macromolecule, whose structure controls the specific positioning of the structural features in the cell being created. It is formed by a sequence of amino acids which are joined together by peptide links. The amino acids bear the actual information. They are extracted one after another according to the plan of the specific cell being formed.

The incorporation of the amino acids in the protein is governed by a code which is transcribed from the DNA to an mRNA in the cell core and is then available in the cytoplasm for the construction of the new cell. This code is composed of "bases" (integrated in "nucleotides"), each of which are arranged in groups of three (the "codons" or "triplets"). These are hierarchically ordered. The highest in the hierarchy occupies the first position, the second the middle and the third the lowest rank. This can be illustrated using a circular diagram ("calculating wheel") as shown in fig. 120a. As a total of 4 bases are used in the mRNA (see below) there are 4^3 = 64 possible combinations of bases in the codons. Each codon codes an amino acid. However, there are only 20 amino acids (and not 64).

A comparison with the conversion process gives rise to further considerations. The "adoption" process (see sections 2.4.1.2) involves the entry and processing of information. Here too, three hierarchic levels can be identified, as is illustrated by the circle diagram (fig. 120b):

- The inner ring (hierarchic top level): In the "task process" the tasks of the stages are determined in chronological sequence.
- The centre ring (middle level): The "control processes" execute the tasks in detail. They can be described by 16 functions.

- The outer ring (lower level): The requirement for space is determined in the elementary processes, which are described by 4 functions.
In all, 20 different functions (and not 64) describe the conversion process (see sections 2.3.1.2, and 2.4.1.2).

a) b)

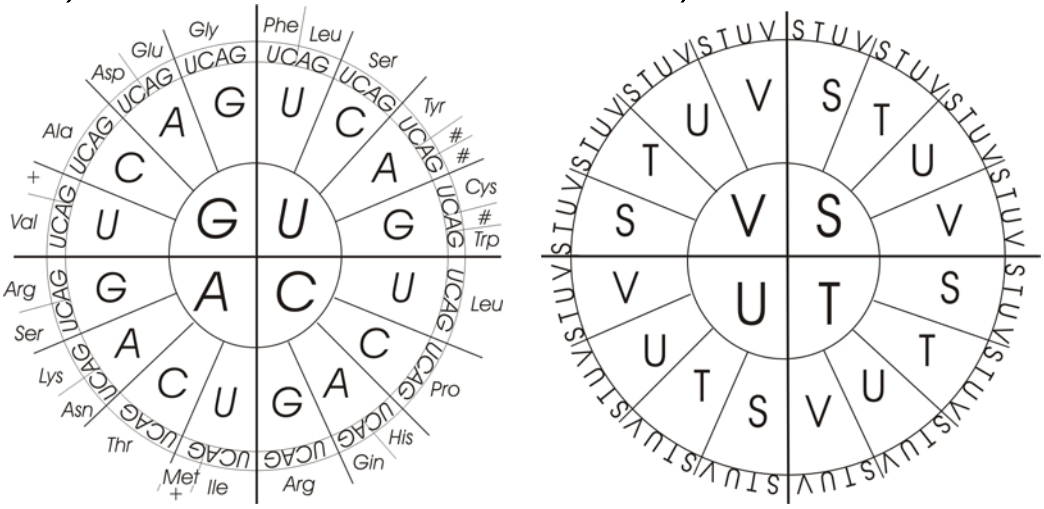


Fig. 120: Genetic expression and self organisation.
The hierarchic arrangement of the bases in relation to the stages of the conversion process.
a) Circle diagram with the assistance of which the amino acids belonging to each of the 64 possible codons can be determined. The bases are shown in the 3 inner rings, and the amino acids on the outside. Abbreviations: Phe=Phenylalanin, Leu=Leucin, Ser=Serin, Tyr=Tyrosin, Cys=Cystein, Trp=Tryptophan, Pro=Prolin, His=Histidin, Gln=Glutamin, Arg=Arginin, Ile=Isoleucin, Met=Methionin, Thr=Threonin, Asn=Asparagin, Lys=Lysin, Val=Valin, Ala=Alanin, Asp=Asparaginacid, Glu=Glutaminacid, Gly=Glycin.
+=start codon, #=stop codon. (See: Chaos Quarks etc. 1995, S. 79).
To distinguish the code letters b, the letters are shown here in italics.
b) Circle diagram: Stages of the conversion process (adoption only, i.e. entry and processing of information), arranged by task process (inner ring), control processes (middle ring) and elementary processes (outer ring). (For the course of the process, see section 2.4.1.2). The letters S, T, U and V are used. They are equivalent to the figures 1,2,3 and 4 of the basic process. The sequence of letters proceeds in clockwise direction round the centre, similar to the calculation wheel a.
Source: See “Notes on the figures”.

Each of the 4 functions of the 3 different conversion process levels cause one systemic dimension to be realised in the flow of information and energy (depending on the specific situation in each case):
1. the quantity of flow, or the involved elements,
2. the time, i.e. the duration or the speed of the throughput,
3. the (hierarchic) structure, i.e. the number of ramifications in the flow or the bond density,
4. the space, i.e. the volume demanded or granted.

As already indicated, the mRNA is composed of the four "bases" as chemical structural units. These are
1. Uramin (*U*; in the DNA Thymine), 2. Cytosin (*C*), 3. Adenin and
4. Guanine(*G*).

A more exact comparison gives rise to the supposition that *U* is parallel to the first dimension (quantity), *C* with the second (time), *A* with the third (hierarchy) and *G* with the fourth (space). If this is so, the bases are the chemical representatives of the systemic dimensions and the 16 formulae of the control processes (and the 4 formulae of the elementary processes) can be assigned to the codons ("transscription").

Tab. 5: Possible assignment of the non-equilibrium system formulae to the amino acids (see fig. 120). As these are only the stages within the main stage of adoption, the letter (S) indicating this stage is not shown. The formulae are given in sections 2.2.1.2, 2.3.1.2 and 2.4.1.2. Abbreviations see fig. 117 (above). The letters in the column "Conversion proc.stages (Adoption only)" are identical with the numbers of the basic process: S=1, T=2, U=3 and V=4. (Example 1st line: SSS .. SST = 1.1.1 .. 1.1.2).

Amino acids Start and stop		Conversion proc. stages (Adoption only)	Formulae	
Abbrev.	Codons		Control process	Elementary processes
Phe	UUU .. UUC	SSS .. SST	1	17 .. 18
Leu	UUA .. UUG	SSU .. SSV	1	19 .. 20
Ser	UCU .. UCG	STS .. STV	5	17 .. 20
Tyr	UAU .. UAC	SUS .. SUT	9	17 .. 18
Stop	UAA	SUU	9	19
Stop	UAG	SUV	9	20
Cys	UGU ..UGC	SVS .. SVT	13	17 .. 18
Stop	UGA	SVU	13	19
Trp	UGG	SVV	13	20
Leu	CUU . .CUG	TSS .. TSV	2	17 .. 20
Pro	CCU..CCG	TTS .. TTV	6	17 .. 20
His	CAU ..CAC	TUS .. TUT	10	17 .. 18
Gln	CAA ..CAG	TUU .. TUV	10	19 .. 20
Arg	CGU..CGG	TVS .. TVV	14	17 .. 20
Ile	AUU .. AUA	USS .. USU	3	17 .. 19
Met, Start	AUG	USV	3	20
Thr	ACU ..ACG	UTS .. UTV	7	17 . .20
Asn	AAU .. AAC	UUS .. UUT	11	17 .. 18
Lys	AAA .. AAG	UUU .. UUV	11	19 .. 20
Ser	AGU .. AGC	UVS .. UVT	15	17 .. 18
Arg	AGA . AGG	UVU .. UVV	15	19 .. 20
Val	GUU .. GUA	VSS .. VSU	4	17 .. 19
Start	GUG	VSV	4	20
Ala	GCU.. GCG	VTS .. VTV	8	17 .. 20
Asp	GAU .. GAC	VUS .. VUT	12	17 .. 18
Glu	GAA ..GAG	VUU .. VUV	12	19 .. 20
Gly	GGU.. GGG	VVS .. VVV	16	17 .. 20

In the second step, the information has to be translated from the language of the codons and bases to that of the amino acids ("translation"). Each codon encodes a certain amino acid. The fact that some amino acids (e.g. serin and leucin) occupy two different positions at the second process level (see fig. 117a), may be due to the fact that these positions were not taken into account in the translation in the conversion process.

But why does the anticodon of most tRNAs accept different codons? The bases in the third positions may be also important, since they either hinder or strengthen the flows of information or energy. Furthermore, in the conversion process algorithm, these positions are described by the 4 functions which define the elementary process stages. They organise the requirement for space (not for the structure). The spatial context is important both for the protein being formed and for the cell being shaped.

The result of the considerations (here shown in outline only) between the stages of the conversion process is summarised in table 5. It is a suggestion only, which remains to be verified by empirical work. Should it prove to be acceptable, it should be of interest in genetic research and genetic technology since it offers a means of simulating the complex processes of cell formation and of understanding them better.

The ecosystem:

The living organisms are embedded in the global ecosystem, or seen spatially, in the biosphere.

In the 3 preceding levels of complexity, the systems (flow equilibrium, non-equilibrium and hierarchical systems) and their elements appear as structures which maintain themselves through the processes (flows of information and energy) but also represent the framework for these processes. The ecosystems too maintain themselves through flows of information and energy, through processes between demand and supply. However here, as mentioned above, the living creatures are themselves drawn into the process as the elements of the systems, are transformed in the course of the process and lateron destroyed to form the substance needed to build up new life. In this way it becomes possible for food chains to form.

The plants form the basis for these processes. The autotrophic plants are perfectly "designed" for their purpose. They have extensive root systems by means of which they obtain nutrients and water from the soil. In fig. 121 it can be seen how the roots of different plants form so that they reach the substances optimally and accelerate the process of weathering. Through tubular cells, these substances are conveyed upwards through the equally extensive system of stem, shoots and leaves (cormophytes). The water is sucked upwards by capillary action caused by the evaporation deficit in the leaves. Through small valves or pits, the leaves extract carbon dioxide from the atmosphere and release oxygen. In the leaves, sometimes even in the shoots, the nutrients are converted chemically into organic nutrients. In the individual cells, the pigment chlorophyl absorbs light from the sun and transforms it into chemical energy. Thus, the plants have adapted perfectly to their inorganic environment.

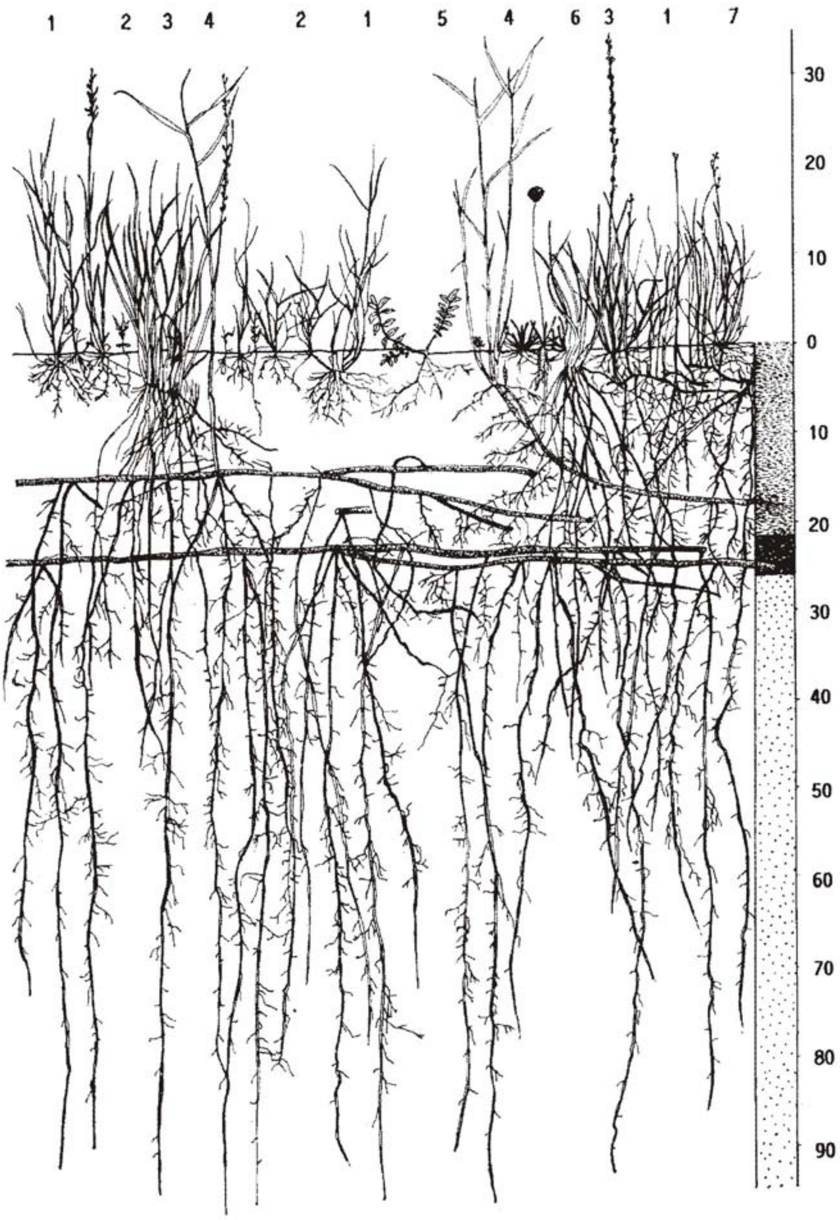


Fig. 121: Shoot and root shape occurring in coastal grassland ("Bottensimsen-Salzrasen") in the western Baltic region. These effectively demonstrate the ability of plants to adapt to their environment.
1) Agrostis stolonifera maritima, 2) Centaurium vulgare, 3) Triglochin maritimum, 4) Phragmites australis
5) Potentilla anserina, 6) Armeria maritima elongata.
Additional: Horizon sequence of soil profile.
After Dierßen. Source: See "Notes on the figures".

The plants spread through reproduction mechanisms (e.g. airborne pollen, pollination by insects) and the transport of seeds by wind, water and animals. They form populations to assure their survival (see fig. 122). They create their habitat and their place in the food chain i.e. their ecological niche (REMMERT 1984; BEGON, HARPER, and TOWNSEND 1991/98; WHITTAKER 1970/75).

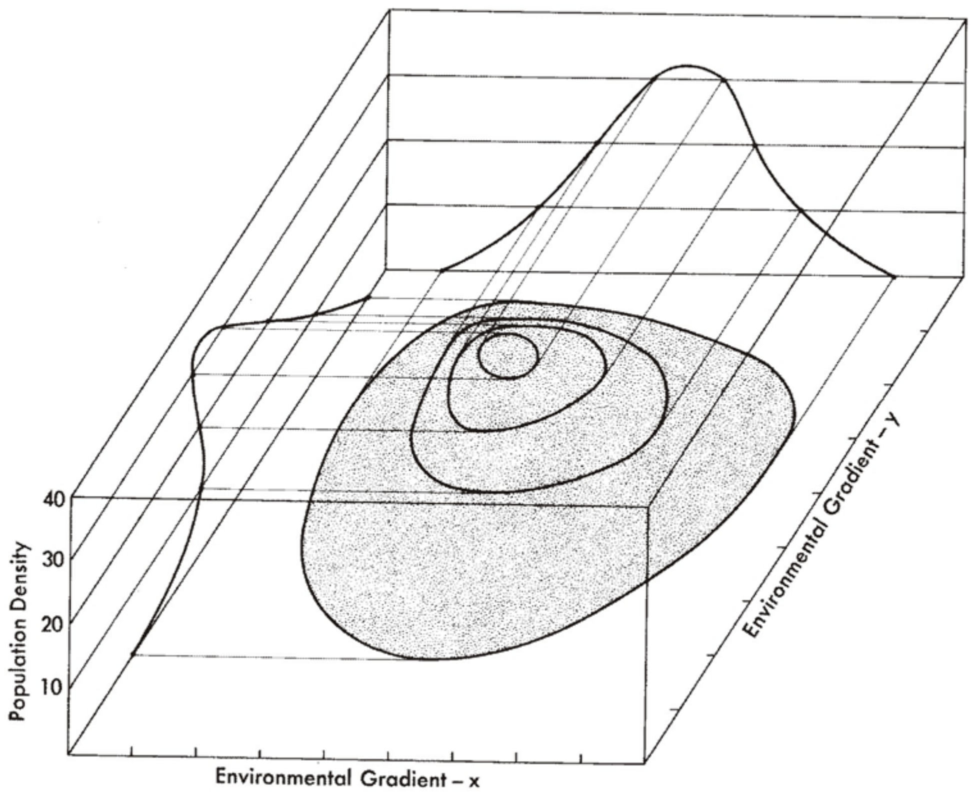


Fig. 122: Ecological niche, population response to two environmental gradients.
The distribution forms a bell-shaped figure, with population density decreasing in all directions away from the population center or peak.
After Whittaker. Source: See "Notes on the figures".

In the course of evolution, the plants have become increasingly differentiated by adapting to environmental conditions. A multiplicity of different species arose. Besides the autotrophic plants, there are also heterotrophic plants which exist as parasites and obtain their nutrients from the host plant. Some plants exist in a symbiosis with others.

In the ecosystem as a whole (see fig. 123) the plants serve as nourishment for the animals. The plants are the "producers", the animals the "consumers". When the animals feed, the cell structure, i.e. the shape of the plants, is destroyed. The organic substance is absorbed by the body, digested, i.e. prepared mechanically and then decomposed chemically by the body and, as far as possible reabsorbed materially and energetically. The process of digestion involves a number of different organs. The oxygen present in the atmosphere or water is required by the metabolism and is absorbed by other organs such as lungs or gills. Once inside the body, the substances are conveyed to the organs which require them and transform them by the circulation system. The gases which are not required for the metabolic process and the creation of organic substance (e.g. carbon dioxide) are returned to the atmosphere, while the remaining substances are excreted and decomposed by micro-organisms in the soil or water along with dead vegetable and animal matter and made available again in this way to the ecological cycle.

Unlike the plants, animals normally have the ability to move, can orient themselves in space by means of sensory organs and create their living space and habitat along with others. Thus, they are able to find the plants they require for nourishment and as well as the necessary sources of water. Man has proved to be particularly skilled at these activities. Mankind as a species has created mankind as a society which has become extremely skilful at exploiting the ecosystem as a source of energy.

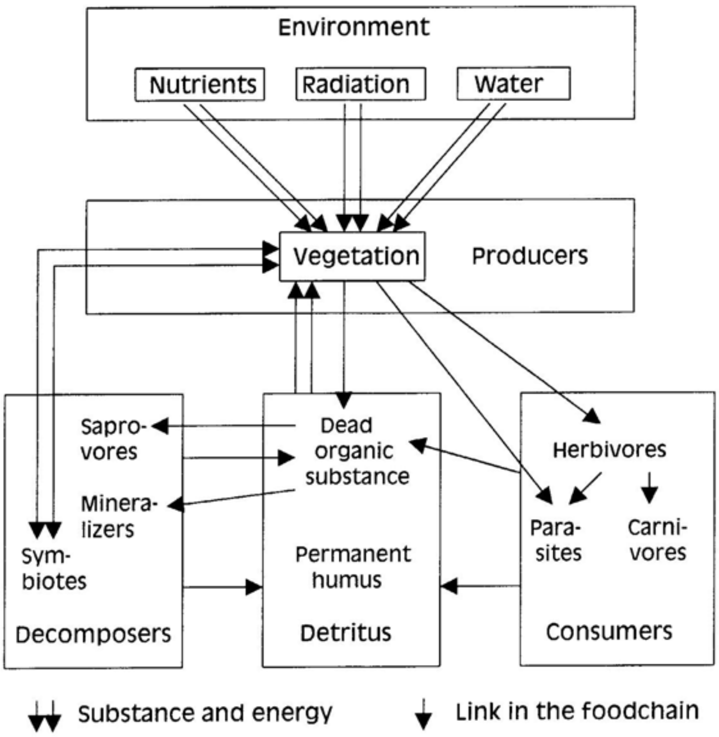


Fig. 123: The basic structure of the food chain in the ecosystem.
The autotrophic organisms (in particular the plants) thrive on mineral nutrients, through radiation energy and water. They are the producers in the ecosystem. These in turn are a source of food for herbivores, and the herbivores in their turn for the carnivores and parasites as consumers.
Some animals and plants live in a symbiosis, i.e. they benefit from one another (e.g. lichens). Living organisms disintegrate to form detritus which serves as humus or a source of nourishment for saprophytes, which contribute to its further disintegration. The mineralisers (e.g. bacteria) then reduce these substances to their inorganic constituents, some of which return to the food chain as nutrients for plants.
Source: See "Notes on the figures".

2.6.2.2. The behaviour of human populations:

Autopoiesis is also controlled by the environments of the systems. The organisms as autopoietic systems are embedded in populations. The species (or at least regional populations) have to secure the survival over time. This is the best way possible to occupy the ecological niches and to ensure an efficient flow of energy. In the course of evolution, improvements in self-organisation can take place (e.g. via mutation) in response to environmental conditions. But how does the population behave within its own "niche"? There are a number of factors which affect reproductive behaviour. This is particularly recognizable in the case of mankind as a species, because numerous demographic studies are available. On the other hand, certain special circumstances have to be taken into account which means that the results can only be applied to animal populations with certain reservations. Through the formation of mankind as a society in the course of cultural evolution, the energy throughput in the ecological "niche" was considerably improved. Internally however, the development also generated considerable tensions.

On the one hand we have the less differentiated populations in the developing countries and the highly differentiated populations of the industrialised countries on the other. A number of examples will be used to show how populations come to terms with their environments. Let us look first of all at the example of an undifferentiated population of Indians in its habitat to return later to the starting point of our examination of the shaping of the mankind as species as a population in the ecumene.

Oscillations and rotation: An Indian population in its habitat:

An example is provided by the use of the agricultural land of the former Pueblo Pecos in New Mexico (see fig. 124). New Mexico is a dry country. Before the Spaniards conquered this region, the Indians did not irrigate the land, but used it for rain farming. In the former economic territory of the Pueblo, a number of ruins of small individual houses were used as shelters by a small family unit responsible for the cultivation of a small plot of land (see section 2.2.2.3). Examinations of the distribution of the datable ruins of field houses around the Pueblo allow us to draw conclusions concerning the extent of the arable land and its changes in the course of time. It appears that the terrain expanded and contracted at different periods. These fluctuations took place on average at 60-year intervals, as an analysis of the ceramics found in the field houses shows. Fluctuations in the population of the pueblo also appear to have followed this pattern. However, population counts were only started after the arrival of the Spaniards. It has been estimated that approximately 2000 persons lived in Pecos around this time (1620). The arable land covered an area of between 2 and 4 sq. kilometres. In addition, there was scrub country used by the population for hunting and gathering.

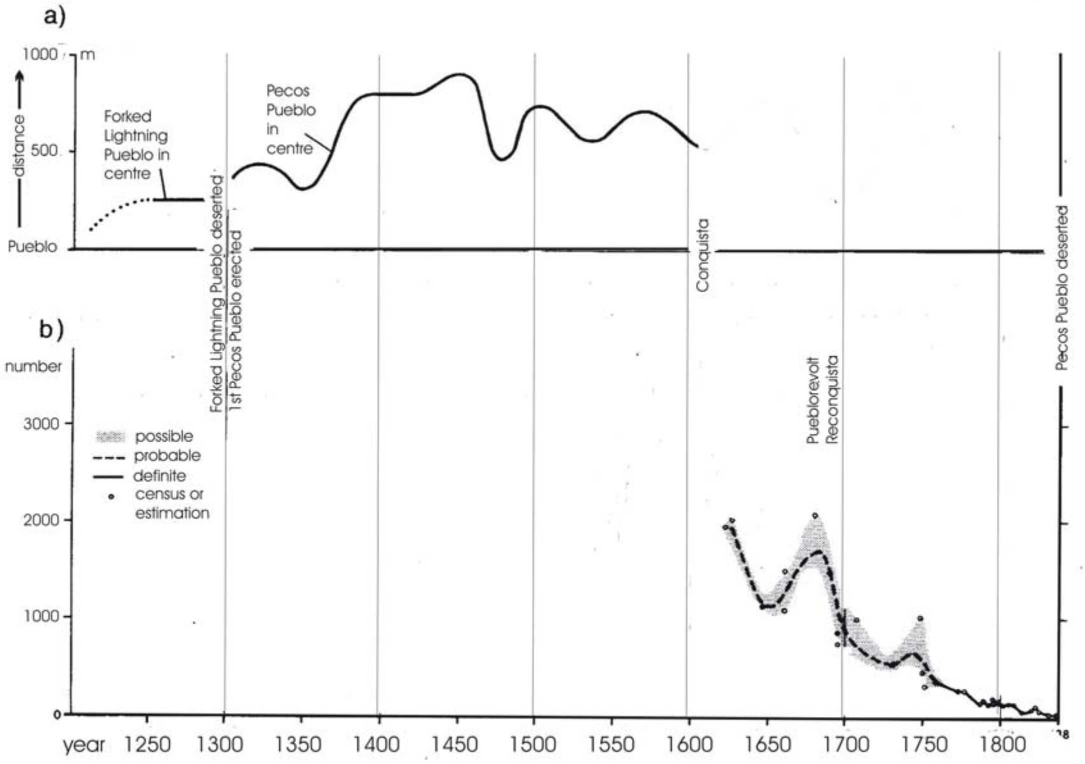


Fig. 124: The (deserted) Pueblo Pecos (New Mexico), oscillations in field exploitation.
Example of a population attempting to achieve a flow equilibrium between intensive cultivation and the self-preservation of the natural environment.
a) Single houses at a medium distance from the pueblo during different periods. Dating based on finds of sherds.
b) Population numbers.
For the time before 1620 (Conquista), the sources for the utilisation of the land are reliable. Thereafter, the documents are less clear. By contrast, the population figures are only certain for the period after 1620. Before this, only unreliable estimates exist.
Source: See "Notes on the figures".

The arrival of the Spaniards seriously disrupted the life of the Indians. The population declined sharply, a development which was also due to the increasing attacks by other non-sedentary tribes of Indians. At this time, the existing area of arable land became fragmented into a series of small islands with the result that it is no longer possible to estimate the amount of arable land.

Rotation:

The Indian population obviously existed at the limit of the carrying capacity of the soil. This can also be seen in the way in which the land was worked. The rhythmic expansion and contraction of arable land in Pecos was associated with a tangential rotation (see fig. 125; see also section 2.3.1.2). In each of the expansion resp. contraction phases, the arable land was shifted slightly away from the previously used area which was now damaged by erosion, with the result that with each expansion of the area under cultivation, new terrain was developed. This was repeated several times while the main area of cultivation moved around the pueblo in a tangent.

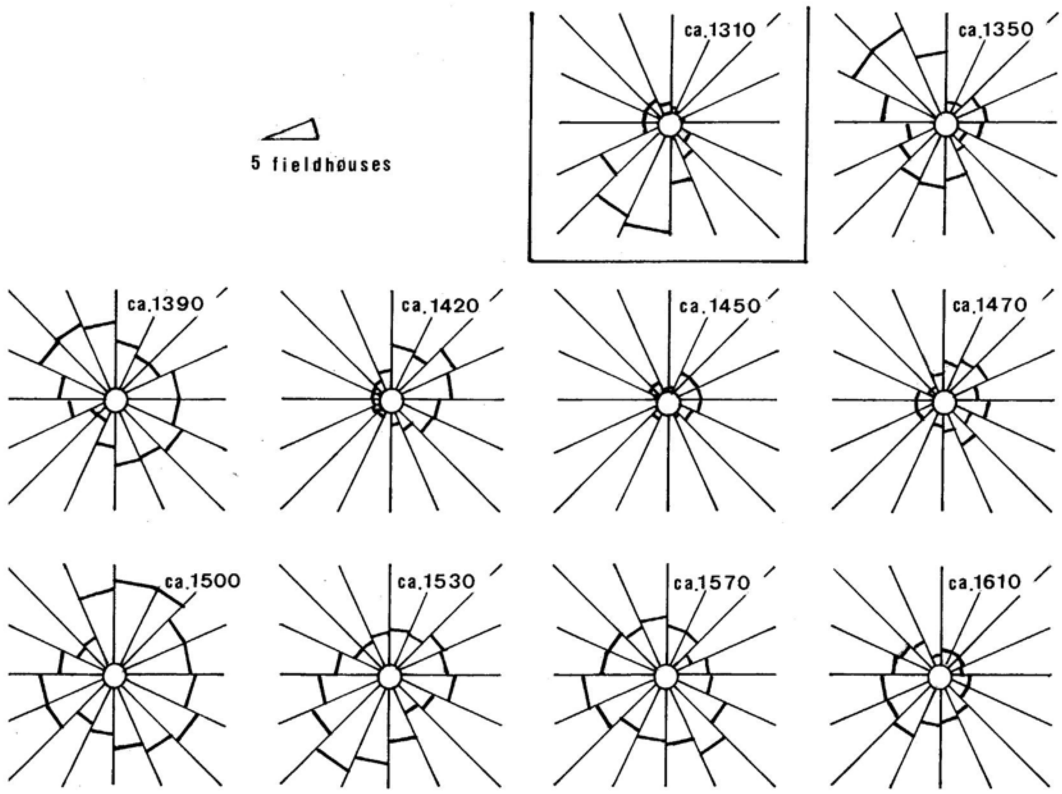


Fig. 125: Tangential rotation in agricultural land of the (abandoned) Pueblo Pecos (New Mexico) before the arrival of the Spaniards (Conquista). Using the number of datable field houses it is possible to determine (using statistical evaluation) in which sector (16-part rose with the pueblo at the centre) the land was used more or less intensively in which years. It can be seen that in the period between 1310 and 1610 A.D., the main area covered by fields shifted in a tangential direction (on average to the right) in a series of oscillations lasting on average 60 years.
Source: See "Notes on the figures".

Processes of spreading: The spanisch colonisation of New Mexico

The agriculture practiced by this population of Indians is only one example. It was an undifferentiated population relying on the yield of its own land.

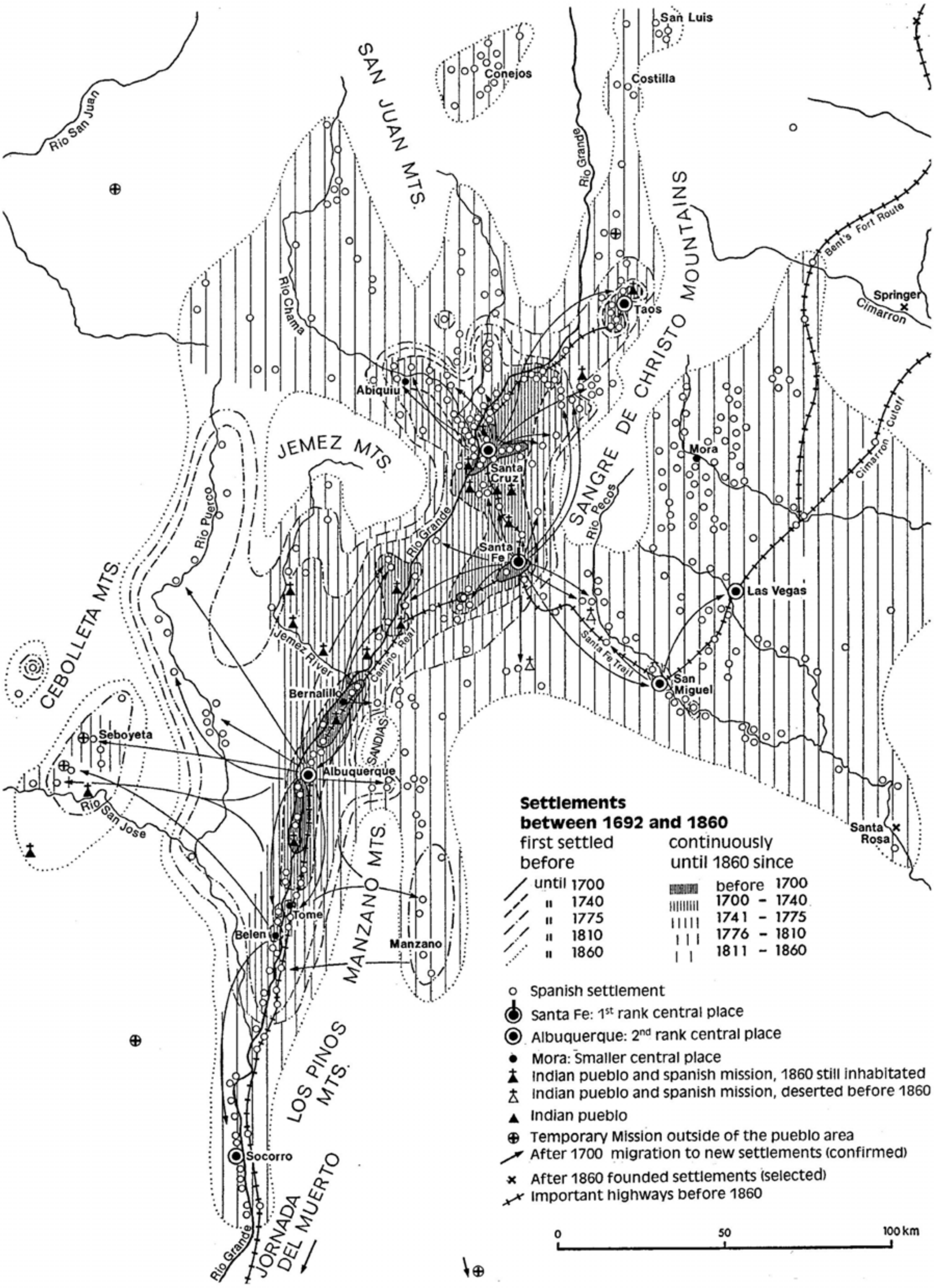


Fig. 126: The Spanish colonisation of New Mexico 1692 - 1860.
Example of the spread of a population.
Source: See "Notes on the figures".

Land occupation and colonisation:

If the population continues to increase or if other factors adversely affect the quality of life (e.g. soil erosion or expulsion through warfare), a process of migration may result. This may involve the entire population or only a part of it.

The taking possession of another area for the purpose of agricultural utilisation may be described as land occupation ("Landnahme") in the case of populations with a low degree of differentiation (e.g. migrations of the Germanic tribes) or as colonisation in the case of more highly differentiated populations (e.g. of America by the Europeans). From the point of view of the process theory, both variants are spreading processes (about spreading processes see also sections 2.3.1.1, and 2.3.2.2). In this way, anthropogenic space was created. The elements, i.e. the farms, are situated in flow of energy and they have to ensure that they maintain a flow equilibrium between demand for and supply of foodstuffs.

We would like to look more closely at a process of colonisation, i.e. that by the Spanish in New Mexico. As mentioned already, about 1600, Spanish soldiers, priests and settlers arrived from Mexico at the dry regions on the upper Rio Grande (see fig. 126). There they found Indian settlements, Pueblos, concentrated mainly in the few river basins. As mentioned above, they practised rain farming. The Spaniard, however, looked for land which could be easily irrigated.

The process took place in waves (each of which lasted about 50 years) from the population centre of Santa Fe (see fig. 127). The reason: as the number of inhabitants increased exponentially, the supply of foodstuffs declined. The requirement for additional land increased, which produced an increase in colonisation. As the crop yields rose, the pressure to acquire new land ebbed, but as the population increased, another phase of expansion became necessary and so on. (The phases are almost contemporary with the colonisation waves in central Europe, see section 2.3.2.1, fig. 55. This shows that also the world economy plays an important role).

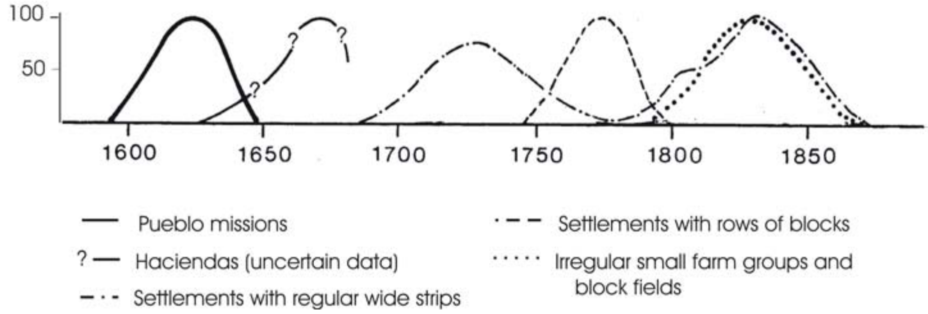


Fig. 127: The phases in the colonisation of New Mexico by the Spaniards 1598 - 1860.
The rhythmic pattern reflects the oscillations or the striving for flow equilibrium between the population and its food supply.
Source: See "Notes on the figures".

The social and economic conditions changed with every oscillation phase which meant that new forms of settlement came into being. Thus, the oscillations are - like the economic cycles (see section 2.3.2.1) - associated with innovations. The Conquista began around 1600 with the foundation of mission stations in or near the pueblos. Following this, the haciendas were established. A period of resistance by the Indians led to the withdrawal of the Spaniards in 1680. Following the Reconquista (1692) in the period up to around 1750, the process of diffusion was generally carefully planned. The settlements were accurately surveyed (wide strips and blocks with strips). Then, up to approximately 1800, the colonisation became much simpler in form, i.e. more irregular (rows of blocks). The last wave of colonisation in the 19th century shows signs of increasing disorder. Apparently, the governing hand of the administration (as manifestation of the system) was no longer able to resist the pressure of the increasing population and control it in well ordered channels. Many settlements (small farm clusters and block fields), show nearly no trace of centralised planning. Finally, it seems that the settlements sprang up where space was available and where it was most suitable for the settlers, i.e. where water for irrigation was available. The population of New Mexico underwent an explosion between 1800 and 1850 (the territory was annexed by the USA in 1846), increasing from 20.000 to 60.000 in this period.

Migration:

The importance of socio-economic differentiation:

Another way to absorb increasing pressure of population is by differentiation. Separation of content i.e. division of labour takes place. Since Adam Smith, the division of labour has been recognised as an essential precondition for the efficiency of economic activity. The use of technical apparatus is simplified. In section 2.4.1.1, it was shown how the stages in work can be coordinated with one another in an organisate. In this way, capacity can be significantly increased.

The people working in the secondary and tertiary sector are not directly connected with the land used for agriculture. Spatial concentration takes place in areas suitable for work, e.g. within the road network. The foodstuffs required have to be imported. On the other hand, the conditions under which the rural population live and work have been improved, e.g. by the development of fertilisers, machines etc.

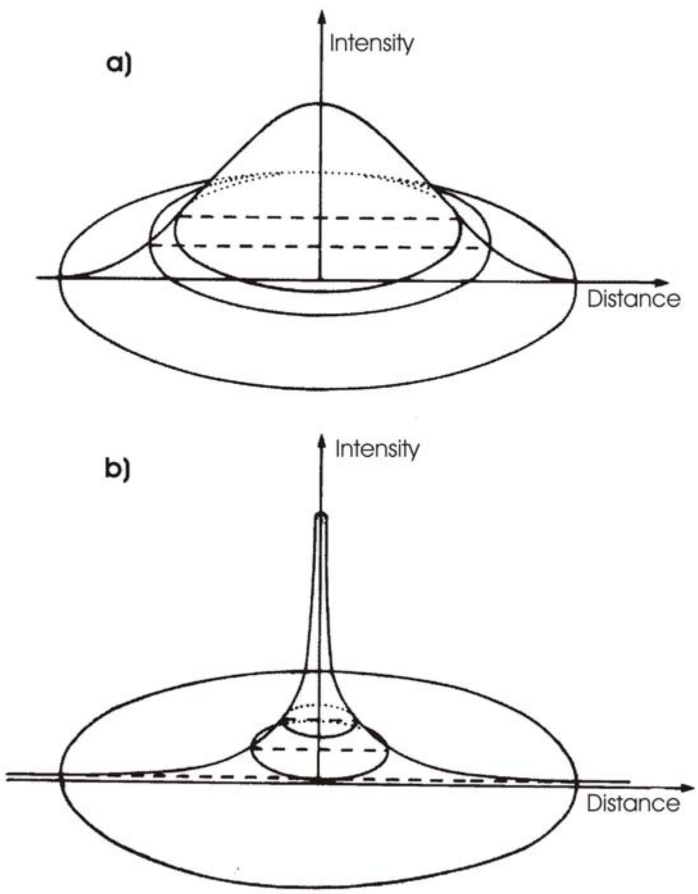


Fig. 128: Spatial distribution of a group of people (Scheme), a)interacting with one another, example: undifferentiated population.
Density values (intensity) correspond to the statistical standard distribution.
b)oriented towards a centre (initial location), example: city-umland population.
The non-agricultural population have been grouped together around the centre.

The formation of urban communities – unthinkable without a degree of differentiation – leads to migration of parts of the population from the country to the town, from agricultural to non-agricultural occupations. This is also reflected in the spatial structuring and interlinking of the population.

Two kinds of communication networks are created:

1. In an undifferentiated country agriculture dominates. The inhabitants or small populations are equal in importance. No central places have yet developed here. Seen mathematically, the distribution is of a random nature ("random networks" to use the terminology of the network theory; BARABÁSI 2003, pp. 69). If the number of contacts, i.e. the intensity of communication, is entered in a diagram, we obtain a curve which decreases on average from the centre towards the edges, i.e. is bell-shaped (conforming to binomial distribution; see section 2.3.1.2, formula no. 12) i.e. the majority of elements (populations or individuals) have

approximately the same number of contacts. Exchange and trade take place between individuals or small populations (see fig. 128a).
2. However, with increasing division of labour trade and industry grow, a process of selection takes place. During this process, some populations (e.g. communities) prove to be better suited for competition and assert themselves accordingly. Here the non-agricultural organisates concentrate. These communities grow larger and dominate others which supply raw materials or purchase products. The principle of long-range effect applies (see fig. 128b; see also section 2.2.1.2, and section 2.4.1.2, formula no.20).

A good example of this is the city-umland-population. Here, the spatial effects of the process sequence can be observed particularly well. The town, with a certain central position concentrates specific functions within itself and engages in exchange with the mainly rural areas surrounding it. These dominant cities can increase their influence by a kind of self-strengthening effect. This type of communication network has another form ("scale-free network", to use the terminology of the network theory). A few outstanding hubs have many links with others and predominate in relation to many smaller hubs.

Country-to-town migration in New Mexico:

The development of population distribution in New Mexico serves as an example, following on from the above description of the colonisation of New Mexico by the Spaniards. In 1776, New Mexico had a population of around 18 000. In the past 150 years, since the occupation of the region by the USA, the region has undergone dramatic social and economic change. In the 17th, 18th and early 19th centuries, the economy was predominantly agricultural although smaller central locations existed with non-agricultural populations. In the middle of the 19th century, this relatively homogeneous regional structure changed into a field structure which was dominated by the central town Albuquerque (see fig. 129).

Through the construction of roads and railways, communications with the rest of the USA are excellent. New population groups have settled there and industry and trade have prospered. A highly differentiated society has come into being. New trends in population development have become apparent, and colonisation (see above) has been replaced by interior migration. The trend continues. Today New Mexico has about 1.800.000 inhabitants, Albuquerque more than 500.000.

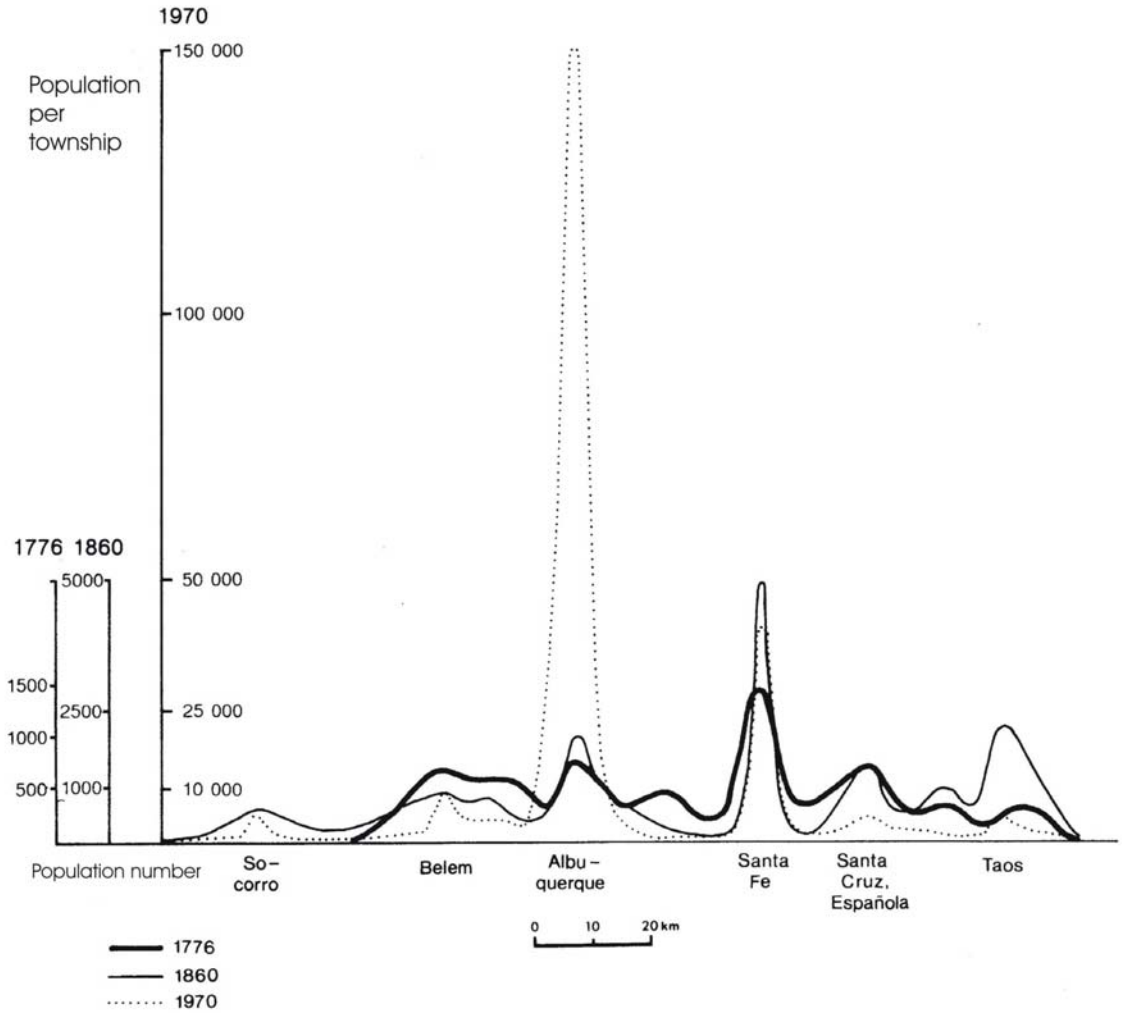


Fig. 129: Population-density profile along the main settlement axis in New Mexico 1776, 1860 and 1970.
The example demonstrates the development from a rural to an industrial city-umland population.
Source: See „Notes on the figures".

2.6.2.3. The mankind as a primary population

Through increasing differentiation in the course of cultural evolution, also new tendencies made themselves felt in the development of the global population. The industrialised countries increasingly became the goal of international migration. Europe and the USA are currently experiencing waves of immigration from underdeveloped countries of Africa, Eastern Europe and Latin America. The principal reasons for this are the very different economic conditions prevailing in the developing and industrialised countries, and related thereto, their different carrying cpacity.

On the one hand, the carrying capacity is dependent on the fertility of the soil. This applies in particular to populations whose existence depends on agriculture especially in developing countries with a low degree of differentiation. On the other hand, the degree of industrialisation and the tertiary sector are also crucial to the carrying capacity of a region, as in the industrialised countries. There are transitions between the two extremes.

The age structure of the population:

Demographic behaviour is closely associated with the degree of socio-economic differentiation. If the age scale is depicted vertically in a diagram, and the number of people (classified by sex) in the age groups horizontally, a clear picture of the age structure of the population is obtained. It varies from country to country. A large number of children gives the diagram the form of a pyramid (see fig. 130a). This is most striking in the case of the developing countries with less differentiation. In the highly developed industrialised countries on the other hand (see fig. 130b) the number of children is much lower. On average, people live to a greater age, but younger people are scarce.

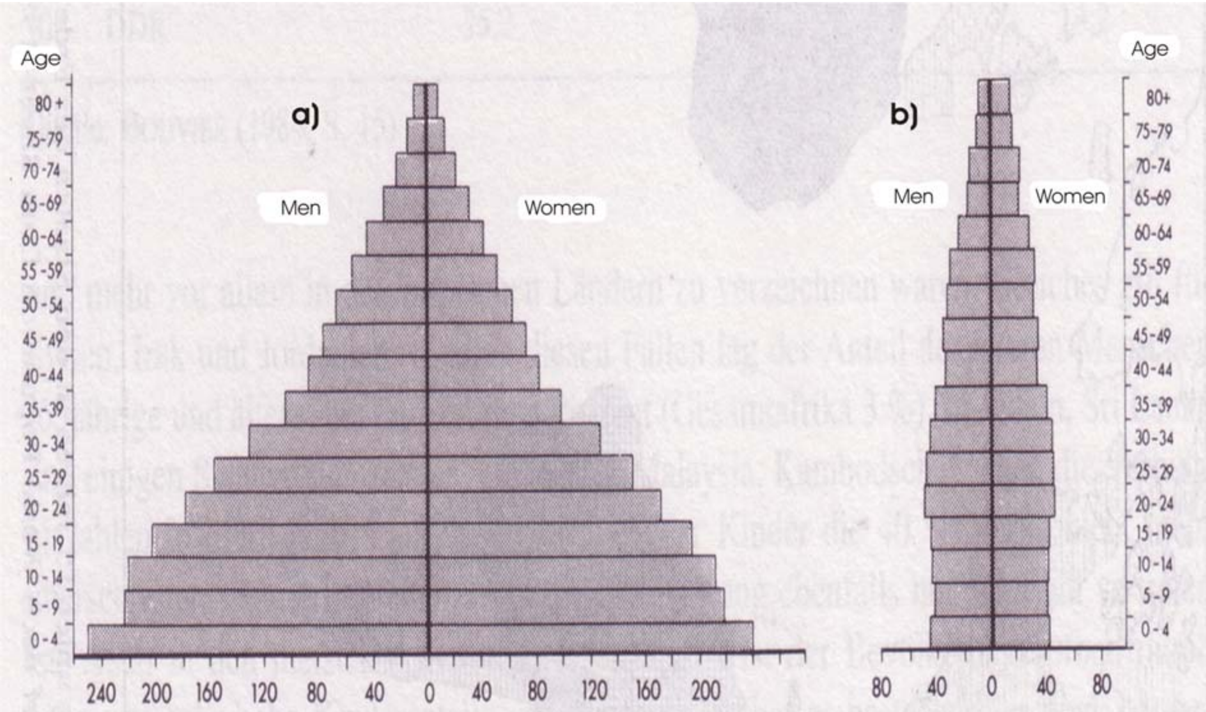


Fig. 130: The age structure of the population in the developing and industrialised countries around 1985.
According to Bouvier. Source: See "Notes on the figures".

Thus, the diagram shows that the generative behaviour of the population depends to a great extent on the socio-economic conditions. The degree of differentiation within the context of cultural evolution is also of critical importance for the adaptation of the population to its habitat and its own organisation in its niche.

These differences can be understood by a development diagram showing the birth and death rates. The "demographic transition" is related to socio-economic status and prosperity. In originally undifferentiated social structures, birth and mortality rates are high (see fig. 131, Phase 1). The population maintains itself at roughly the same level. With increasing prosperity, hygienic conditions improve, resulting in a decline in mortality, especially among children (phase 2). Since the birth rate remains high for a while, the population increases dramatically, until it achieves its zenith in phase 3. The birth rate now begins to decline while mortality stabilises at a low level (phase 4). In phase 5, birth and death rates converge again, causing the

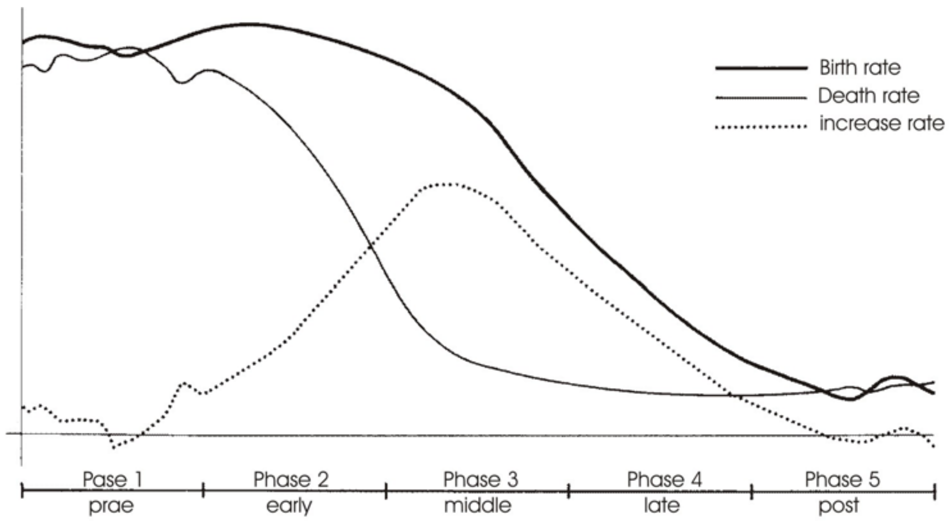


Fig. 131: Diagram of the phases of demographic transition.
Source: See "Notes on the figures".

population level to stabilise again. Projected to the population of the world: In phase 1, very few really isolated populations exist today. A number of West and Central African states have entered phase 2. Most developing countries are passing through phase 3. Phase 4 is typical of emerging economies, while industrial countries are in phase 5.

These are primarily countries which are in phases 2-4 of their development, whose conditions of life are rapidly deteriorating and whose inhabitants are seeking new sources of income, if necessary outside their native countries.

Distribution of the global population

In one sense, the human population of the earth forms a substantially definable space. Its shape is defined by the density of the population. A glance at the map shows that the space is substantially determined by the configuration of the ecumene. This can be best illustrated by taking an "ideal continent" which is obtained by drawing the continental masses together according to the parallels of latitude (see fig. 132). The main mass of this continent lies to the north of the Equator. The southern continents are smaller in size, becoming narrower towards the higher southern latitudes, thereby forming an approximately triangular land mass.

As we see, the greater part of the population lives closer to the coast (Europe, USA, China, India), with the density of the population decreasing inwards. There are a number of reasons for this. Climatic conditions produce a highly differentiated picture. Not only the regions close to the poles are hostile unpopulated, but also the dry regions in the interior of Africa, Asia and North America. This indicates that it is mainly the availability of water, mild temperatures and fertile soil which are important for the distribution of population, i.e. factors which affect agricultural carrying capacity. The history of development, especially in America, is also important for the accessibility of the settlement areas from outside, i.e. the opening up for trade and industry, as well as the general development in coastal areas with regard to international communications.

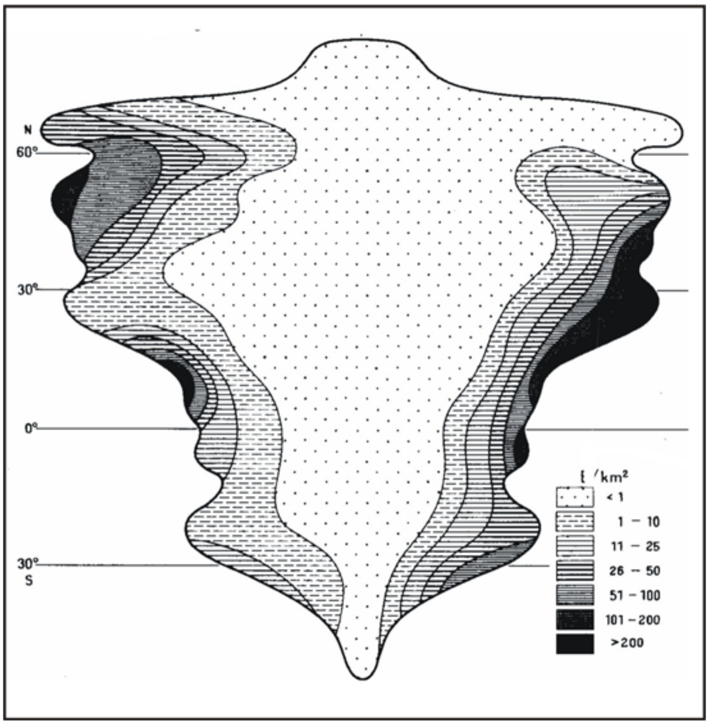


Fig. 132: Model of population distribution according to coastal distance and degree of latitude on the ideal continent.
From Staszewski. Source: See "Notes on the figures".

Here the degree of socio-economic differentiation comes into play. Less differentiated populations of the developing countries still live primarily by agriculture and require large areas of good soil for their livelihood. There is therefore a tendency for settlements to develop with some distance between them. At the other end of the scale, we have the socially and economically highly developed industrial countries which are dependent on mineral resources as well as geographic positions which favour trade and communications. Such areas favour the growth of cities and large conurbations with the consequent tendency towards concentration. This is a tendency only, but is striking in its global effects. There are numerous intermediate stages between these two extremes.

Adjustment of the population to its living space:

The integration of the earth's population as a whole in the ecumene - before the background of the global carrying capacity - is a problem which is particularly topical in view of the dramatic increase in the population of developing and emerging countries (see above) currently taking place. The subject goes back to the 18th century when Malthus (1798) realised that the population increases in geometrical progression, but the area available for foodstuff production can be extended in arithmetical progression only. From the geographical side, PENCK (1924/69) compiled a global review and compared the size of the populations in the various climatic zones. However, the results remained unsatisfactory because he assessed the fertility of the soil wrongly and failed to take account of the potential for development. In the 1970s, a

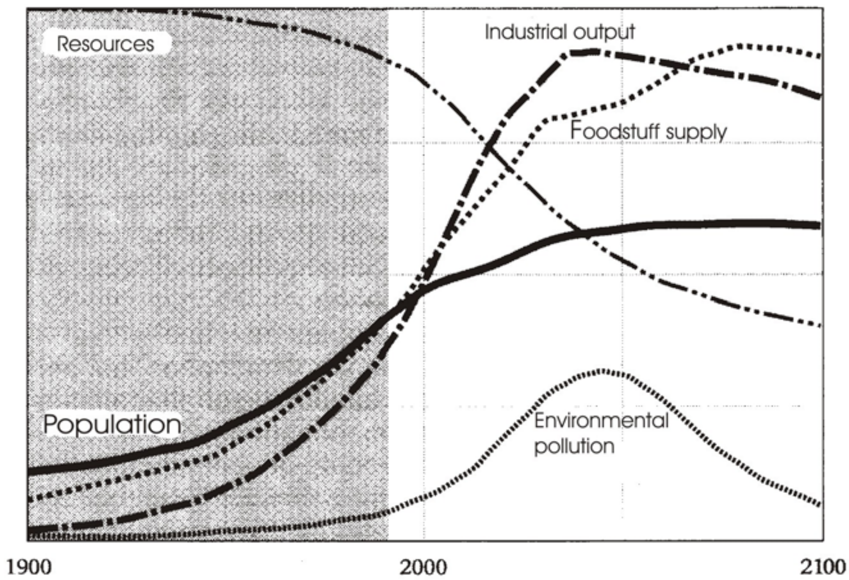


Fig. 133: Carrying capacity (population size) of the earth taking into consideration the development of foodstuff availability, mineral resources, industrial output and environmental pollution.
According to "Club of Rome". Source: See "Notes on the figures".

number of researchers (Club of Rome: MEADOWS, MEADOWS, ZAHN and MILLING 1972) designed a systematic model based on the Forrester Method (see section 2.3.2.1) which takes numerous parameters into account, e.g. development of population size, foodstuff production, availability of mineral resources, industrial output, environmental pollution etc.. This enabled them to compile an overall picture of present-day mankind - even if it soon emerged that these global calculations were rather inaccurate because they saw only the (albeit important) overall interrelationships but failed to take account of the fact that many populations evolve their own means and strategies of dealing with difficult situations. This applies in particular to man's ability to invent new methods of recycling and foodstuff production (MEADOWS, MEADOWS and RANDERS 1992; ERBRICH 2004).

In spite of this, it yields an impressive picture which is capable of refinement, enabling us to come closer to the situation as it actually exists. Fig. 133 shows that a dangerous situation arises if laisser faire development is not consistently opposed by controls which make it sustainable.

For guidance:

Mankind as a species is treated as an example of an autopoietic system:

1) The level of individuals: Autopoietic systems create themselves not only structurally, but also materially. This means that it is essential for these systems "pass themselves on" if the task position in the context of the superior system is not to become vacant with the decease of the individuals. In the case of the living organisms, this takes place by genetic expression.

2) The level of population: Socio-economically less differentiated populations have adapted themselves to their agricultural environment over a certain period of time by means of certain mechanisms (oscillation, rotation). With increasing differentiation, the population increases until a new equilibrium is achieved between it and the capacity of the living space. The living space can be expanded by colonisation. In highly differentiated populations, favourable means of existence come into being which are spatially differentiated, i.e. supply and demand are brought into balance by individuals through migration.

Seen globally, an important aspect of the autopoiesis is apparent in the age structure of the populations, because it provides information on the reproductive behaviour, i.e. the modalities of reproduction. These change over the course of cultural evolution, i.e. with increasing differentiation. More favoured living spaces have come into being for mankind. As a rule, coastal regions have proved more favourable than continental ones. The present rapid growth in population must be countered by systemic controls because the carrying capacity of the ecumene is limited.

These brief comments are intended to show how a space, which is materially definable by mankind as a species, develops and how, as an autopoietic system, it creates a special "habitat" for itself among the totality of spaces which make up our universe. Other autopoietic systems have other mechanisms by which they create themselves.

2.6.3. Process sequences and dominant systemic dimension

Preliminarey considerations

The first step is the division and scaling of the system and process types in the macro and microcosmos in order to gain a picture of the fundamental relationships and configurations. The above reflections will serve as a background. Similar types of autopoietic systems are gathered into groups which we have called "spheres". We are now dealing with three levels of systems and processes:
1) the universe as a whole is maintained or altered by the "universal process";
2) the "sphere processes" are the hierarchical processes in the universe; the levels (spheres) arranged vertically above one another should be seen structurally as flow-equilibrium systems;
3) the "autopoietic systems" form the elements of the spheres and may be compared structurally with the non-equilibrium systems; the "autopoietic processes" (similar to the conversion processes) form them internally.

Numerical sequence and route diagram

Initially we continue the way along the complexity scale with the assistance of the emergence code (section 3.2.4). The numerical sequences are shown in Fig 134.

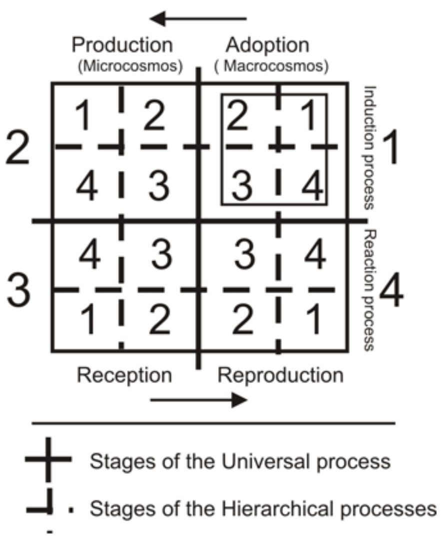


Fig. 134*: Scheme of the universal process. Numerical sequence. Before folding, the macrocosmos appears on the front side, whereas the microcosmos and the reaction process are concealed.*

Whereas the process of the first order of the hierarchic system is vertically aligned according to the "U" variant, the first-order process in this case moves horizontally in an anticlockwise direction, horizontally above from right to left (induction process) and below from left to right (reaction process). This

means that we now have the "C" variant, which is similar to the non-equilibrium systems and conversion processes at the fourth level of complexity (section 4.1.1.2).
In the induction process, the first-order process (i.e. the universal process) joins the spheres of the macrocosmos (adoption) with those of the microcosmos (production). The macrocosmos forms the entrance and therefore appears on the front side (section 3.2.1). The microcosmos is incorporated in the subordinate environment. It and the reaction process remain concealed.

The (hierarchically structured) second-order processes are divided into the spheres offering themselves as hierarchic levels, and arranged according to their various tasks (perception ... stabilisation). Their elements are the autopoietic systems which are organised internally by the processes of the third order.

In this way (according to the theory) the parts of the universe, i.e. the autopoietic systems appear to be linked with one another in the spheres. The chronological and hierarchic structure of the whole is created. As explained above (section 2.6.1) this is the essential precondition for the production of the matter as such (i.e. its basic components), and, related thereto, for the shaping of space itself (as extension).

Route diagram:

Everything is subordinate to the space dimension – the amount of information and energy, the divided process and the hierarchic structure. Space embraces and limits all the components and disciplines them. The route diagram (Fig. 135) conveys an impression of the sequence of the processes shown as cycles. The concealed process surfaces are "unfolded".

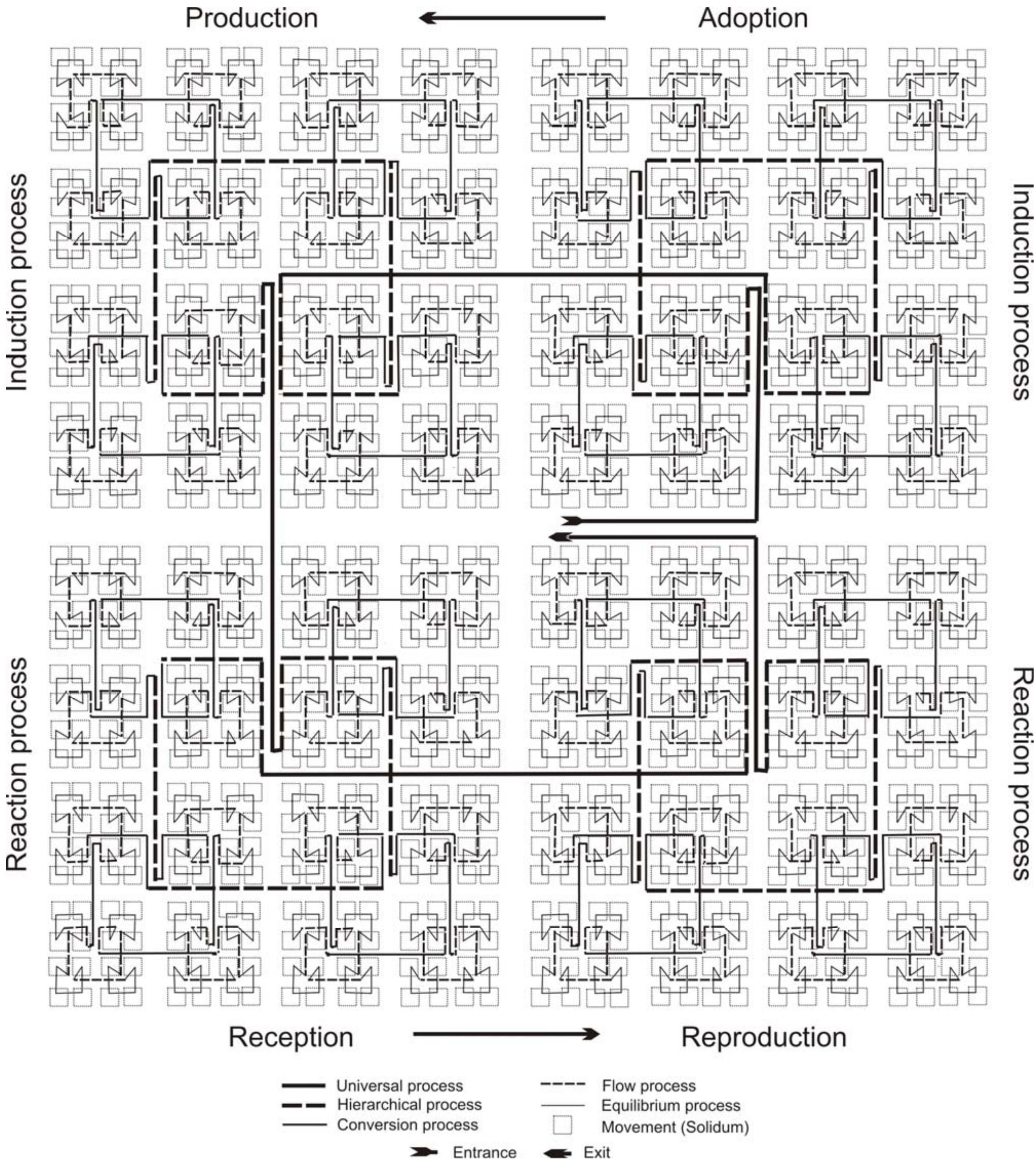


Fig. 135: Route diagram of the universal process. The process of the first order is taken in by the macrocosmos (right) and the microcosmos (left) at the top (induction process, front side) and by the reaction process at the bottom (concealed). The macro and microcosmos are both structured as hierarchic processes (second order). The autopoietic processes (offering themselves as conversion processes) form the processes of the third order.

The dominant systemic dimension (see fig. 136):

The flows of information and energy are fixed at the 5 deeper levels of complexity. Perhaps we are beginning to understand how processes are controlled and products created, how the system organises itself and takes on tasks for the superior systems. However, the formation of material itself had not yet been covered. At the 6th level of complexity autopoiesis predominates. This type of process can only be understood if the mesocosmos is regarded as part of the universe. The most comprehensive autopoietic process is the universal process, the most comprehensive autopoietic system is the universe.

Here it is space (S) which is the dominant systemic dimension. The limits and distances of the processes or systems are determined. Everything is subordinated to this dimension – the quantity of energy (Q), the divided process (T) and the hierarchic structure (H). Everything is embraced, spatially disciplined. According to the theory outlined here, reality is divided into spheres which enclose one another like the skins of an onion. At the core of this structure we find the smallest systems of the microcosmos and at the periphery the largest ones of the macrocosmos. The biosphere is located in the region of the mesocosmos. They form the transitional space from which the scale of spheres leads to the macrocosmos in one direction and to the microcosmos in the other.

Fig. 136: The space dimension becomes dominant at this level of complexity.

3. Emergence

3.1. About the term "emergence"

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

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

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

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

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

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

In the following, we will present the six levels of complexity as a consequence of the emergence process, divided up according to the important indicators:

- emergence and system dimensions,
- course of the processes,
- hierarchy of the processes and systems, and
- folding of the processes and systems.

The code leads from one level of complexity to the next (see section 2.2.3).

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

3.2. Six levels of complexity

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

Tab. 6: Complexity levels, processes and systems:

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

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

Six levels of complexity can be distinguished due to the internal structure of the processes resp. the systems and their control (see tab. 6).

1st level of complexity (see section 2.1):

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

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

2nd level of complexity (see section 2.2):

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

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

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

3rd level of complexity (see section 2.3):

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

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

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

4th level of complexity (see section 2.4):

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

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

Tab. 7: Conversion process and non-equilibrium system. Process stages.

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

Four internal process levels can be distinguished (see table 7). The inferior processes work for the superior ones. Each of these processes consists of four stages. In this way, the transfer becomes more controllable than in the flow processes. In this way, it becomes possible to manufacture products which are assembled precisely in accordance with demand (induction process) and supply them to the demanding environment.

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

5th level of complexity (see section 2.5):

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

6th level of complexity, an approach (see section 2.6):

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

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

3.3. The emergence code

The individual quadruples of an order of magnitude, which originate from the basic process (section 2.1.1.2), alternate with one another in their direction. In the arrangement within the coordinate system, the "U" groups (i.e. aligned to the right) border on the "C" groups (i.e. aligned to the left) and vice versa. In the linear arrangement, the sequence 4-3-2-1 leading downwards follows the sequence 1-2-3-4 tending upwards. In this way, the stimulus or the energy pulse can be passed from one group to the next. This is manifested in the route diagram (section 1.2.3, 2.2.3, 2.3.3, etc.).

However, the route diagrams also show that the alignments of the "U" and "C" groups alternate with one another vertically i.e. in the course of the emergence process, when crossing from one level of complexity to the next. In this way the system maintains its balance.

The emergence code shows how the transition from one level of complexity to the other takes place. It describes 4 operations (example: see section 2.2.3):

1) Bundling: the joining of the initial locations in the first and in each front side at the second to the sixth level of complexity.
2) Alignment: arrangement in the f(x) quadrants and from there into the three remaining quadrants of a new superior coordinate system.
3) Interlacement: reversal of the course of the process, either from left to right-hand alignment ("U" variant) or from the right to the left-hand alignment ("C" variant).
4) Folding: behind the front side (+x, +y) the remaining three quadrants are folded. They are concealed. In this way these environments, which are involved in every transition, are able to utilise the material frame of the system.

3.4. Emergence and systemic dimensions

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

Increasing complexity is associated with an increasing involvement of the environment in its various forms ("environments"). As the analysis of various process sequences of the conversion processes and the non-equilibrium systems has already shown, we are dealing with two different process trains (see section 2.4.1.2). Each of it is divided into 4 stages in the same way as the basic processes, which on their part are dedicated to one system dimension each – quantity (of flow of qualitatively defined information or energy), time (in the sense of the course of the process), hierarchy (in the sense of vertical structural links) and space (understood as geometrical extension). We also assume that 4 process or system types are assigned to each process train, and two of these types belong to both trains (see fig. 137).

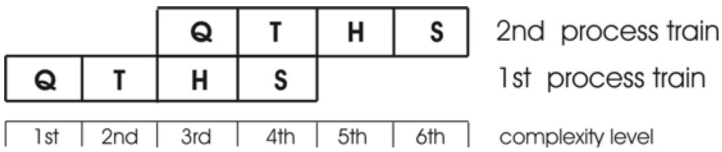


Fig. 137: Assignment of process types to the process trains and the system dimensions.

In detail:
- 1st level of complexity: The simple movement and the solidum are represented only in the first process train. The stimulus is determined from outside. The path of the stimulus is followed internally. The quantity of the stimulus is the dominant system dimension.
- 2nd level of complexity: the equilibrium process and the system are represented only in the first process train. The stimulus again comes from the environment, the process differentiates the transmission of energy internally. The equilibrium process differentiates the course of time. The flow of energy is divided into 4 steps, i.e. the sequence in the equilibrium process (or movement project) is controlled according to the basic process. In this case, time is the dominant system dimension.
- 3rd level of complexity: The flow equilibrium processes and systems are represented in both trains. In the first process train the process differentiates the internal hierarchy. 4 bonding levels are created. Energy from the environment is stimulated in the second process train so that the system is fitted into the

superior flow of energy. The flow of information and energy can be portioned at the four bonding levels. The hierarchy represents the dominant system dimension in the first process train, the quantity of the energy flow in the second.
- 4th level of complexity: In the same way, the conversion process and the non-equilibrium system are present in both process trains. In the first process train the system as a whole shapes its spatial construction and limits. In this process train, the process is dedicated to ordering space, space is the dominant dimension. At the same time, the chronological environment is involved in the second process train. The chronological sequence is ordered by adopting the rhythm from outside. In this way, it is possible to control the passage of information and energy precisely. Time is the predominant dimension here.
- 5th level of complexity: The hierarchic system is represented only in the second process train. The hierarchic levels consist of flow equilibrium systems (specification hierarchy) and non-equilibrium systems (scalar hierarchy). The hierarchy is shaped, it is the dominant system dimension.
- 6th level of complexity: The universal process and system are also represented in the second process train only. Space and matter are shaped. The hierarchical system and non-equilibrium systems etc. are joined spatially in spheres which shape the macro and microcosmos. Space is the dominant dimension.

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

With the increasing complexity of the systems, certain characteristics or resources of the environment (according to the systemic dimensions) become involved (see fig. 138). In this way, control over the processes increases. The systems gain independence, i.e. they increasingly dictate the effect on the environment. By contrast, the effect of the environment on the structure and the events in the system declines. The higher up the scale of complexity levels, the more completely this takes place, the more the unregulated environment declines in importance, and the control along the system dimensions of quantity, time, hierarchy and space shifts into the systems. With the aid of space, control is complete at the 6th complexity level. System and elements are enclosed and integrated materially in the cycle of nature.

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

Fig. 138: The system dimensions at the six levels of complexity, divided according to the two process trains. Predominant dimensions bold script.

Epilogue

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

The emergence process demonstrates how the development from the disordered quantity of solida to the highly complex universal system is organised, during which the frame receives its inner alignment and its structure through the four systemic dimensions. Besides, this, every process receives its counterpart which controls it. Every process gives rise to a counter process at all six levels of complexity. This is one of the preconditions for the creation of the ordered structures and spaces characteristic of our reality. It also means that all the simulation processes attempting to make complexity understandable, have to take account not only of the tendency “from the bottom up” (i.e. competition and struggle for life), but also the counter tendency “from the top down” (i.e. rules and order). This on the other hand requires an analysis of the processes at the individual complexity levels.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Decision 4: The mesocosmos forms the framework for investigation:

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

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

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

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

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

References

ABLER, Ronald, John S. ADAMS, and Peter GOULD (1971): Spatial Organisation, the Geographer`s View of the World. Englewood Cliffs, N.J. (Prentice Hall).

AHL, Valerie and Timothy F. ALLEN (1996): Hierarchy Theory. A Vision, Vocabulary and Epistemology. New York (Columbia University Press).

ALLEN, Timothy F. (between 1996 and 2004): A Summary of the Principles of Hierarchy Theory. http://www.isss.org/hierarchy.htm.

APEL, Karl-Otto (1990): Diskurs und Verantwortung. Das Problem des Übergangs zur postkonventionellen Moral. Frankfurt am Main (Suhrkamp). StW 893.

APEL, Karl-Otto (1992): Diskursethik vor der Problematik von Recht und Politik: Können die Rationa-litätsdifferenzen zwischen Moralität, Recht und Politik selbst noch durch die Diskursethik normativ-rational gerechtfertigt werden? In: Apel, Karl-Otto und Matthias Kettner (editors, 1992): Zur Anwendung der Diskursethik in Politik, Recht und Wissenschaft, pp. 29-61. Frankfurt am Main (Suhrkamp). StW 999.

BÄHR, Jürgen, Christoph JENTSCH and Wolfgang KULS (1992): Bevölkerungsgeographie. = Lehrbuch der Allgemeinen Geographie. Berlin/New York (De Gruyter).

BALL, Philip (2004): Critical Mass. How one thing leads to another. London (Heinemann).

BARABÁSI, Albert-László (2003): Linked. How everything is connected to everything else and what it means for business, science, and everyday life. New York (Plume Book).

BARROW, John D. (1990/92): Theorien für Alles. Die philosophischen Ansätze der modernen Physik. Zuerst 1990 publiziert. Aus dem Englischen. Heidelberg (Spektrum).

BARTELS, Dietrich (1968): Zur wissenschaftlichen Grundlegung einer Geographie des Menschen. = Erdkund-liches Wissen 19. Wiesbaden (Steiner).

BAR-YAM, Yaneer (2003): Dynamics of Complex Systems. = The Advanced Book "Studies in Nonlinear Series". Westview press. http://necsi.org/publications/dcs/

- (2004): A mathematical Theory of Strong Emergence using Multiscale Variety. http://www.necsi.org/projects/recentpublications.html.

BEATS BIBLIONETZ (2005): Begriffe: „Konstruktivismus“: http://beat.doebe.li/bibliothek/w00101.html

BEGON, M.E., C.R. TOWNSEND and J.L. HARPER (1991/98): Ökologie. 3rd Edition. Editor: K.P. Saur. (Transl. from Americ.). Oxford (Blackwell). Heidelberg, Berlin (Spektrum).

BELL, Daniel (1973): The Coming of the Post-Industrial Society. A Venture in Social Forecasting. New York (Basic Books).

BENNETT, R.J. and R.J. CHORLEY (1978): Environmental Systems. Philosophy, Analysis and Control. London (Methuen).

BERCKHEMER, Hans (1990/97): Grundlagen der Geophysik. 2nd ed. Darmstadt (Wissenschaftliche Buchgesellschaft).

von BERTALANFFY, Ludwig (1950): The Theory of open Systems in Physics and Biology. In: Science, Vol.111, pp. 23-29.

- , W. BEIER und R. LAUER (1952/77): Biophysik des Fließgleichgewichts. 2nd ed. Braunschweig (Vieweg).

Bibel und Geschichte (1997): Atlas. Bibel und Geschichte des Christentums. Editor: Tim Dowley. Wuppertal (Brockhaus).

BLOCH, Ernst (1954-59/1973): Das Prinzip Hoffnung. 3 Bände (1st ed. 1954-59). Frankfurt am Main.

BLUETHGEN, Joachim and Wolfgang WEISCHET (1980): Allgemeine Klimageographie. 3rd ed. Berlin, New York (de Gruyter).

BOBEK, Hans (1928): Innsbruck. Eine Gebirgsstadt, ihr Lebensraum und ihre Erscheinung. = Forschungen zur Deutschen Landeskunde 25,3. Stuttgart.

- (1948): Stellung und Bedeutung der Sozialgeographie. In: Erdkunde II, pp. 118-125.

BOCOLA, Sandro (1997): Die Kunst der Moderne. Zur Struktur und Dynamik der Entwicklung. Von Goya bis Beuys. Darmstadt (Wissenschaftliche Buchgesellschaft).

BÖRSCH-SUPAN, Helmut (1975/80): Caspar David Friedrich. München (Prestel).

BOSL, Karl (1970/75): Europa im Mittelalter. Weltgeschichte eines Jahrtausends. Bayreuth (Gondrom).

BRAUDEL, Fernand (1958/92): Geschichte der Sozialwissenschaften. Die lange Dauer. In: Braudel, F.: Schriften zur Geschichte, vol. 1. (Transl. from French: Histoire et sciences sociales. La longue durée). Stuttgart (Klett-Cotta), pp. 49-87.

BUNGE, Mario (1959/87): Kausalität. Geschichte und Probleme. (Transl. from Americ.: Causality: The Place of the Causal Principle in Modern Science, 1st ed. 1959). Tübingen (Mohr).

BURGESS, E.W. (1925/67): The Growth of the City. In: PARK, R.E., E.W.Burgess and R.D.MCKENZIE (Eds.): The City. Chicago (1. ed. 1925), pp. 47 - 62.

CAMEJO, Silvia Arroyo (2006): Skurrile Quantenwelt. Berlin, Heidelberg (Springer).

CAPRA, Fritjof (1996/99): Lebensnetz. Ein neues Verständnis der lebendigen Welt. Aus dem Englischen. München (Droemer, Knauer).

CASSIRER, Ernst (1922-57/94): Dass Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit. Reprint. Darmstadt (Wissenschaftliche Buchgesellschaft).

CHABAUD, Auguste: Gemälde, Aquarelle, Zeichnungen, Skulpturen 1882-1955. Katalog. (1993). Editor: Ernst-Gerhard Güse, 1993. Düsseldorf (Richter Verlag).

Chaos, Quarks und schwarze Löcher. Das ABC der neuen Wissenschaften. (1995). Editor: Ib Ravn. Transl. from Danish. München (Antje Kunstmann Verlag).

CHAPIN, F.St.jr.(1965): The Study of Urban Activity Systems. Urban Land Use Planning. 2nd ed. Urbana, Ill.

CHILDE, V.Gordon (1936/51): Man makes himself. (1. ed. 1936). New York (Signet, Mentor Books).

CHRISTALLER, Walter (1933): Die zentralen Orte in Süddeutschland. Jena (Fischer).

COHEN, Jack and Ian STEWART (1994): Chaos - Antichaos. Ein Ausblick auf die Wissenschaft des 21. Jahrhunderts. Berlin (Byblos). Transl. from Americ.: The Collaps of chaos. 1994. New York (Penguin).

COOLS, R.H.A. (1950): Die Entwicklung und der Stand der Sozialgeographie in den Niederlanden. In: Erdkunde IV, pp. 1-5.

DAVIES, Paul (1987/88): Das Prinzip Chaos. Die neue Ordnung des Kosmos. Zuerst publiziert 1987. Aus dem Englischen. München (Bertelsmann).

-, Paul und John Gribbin (1992/97): Auf dem Weg zur Weltformel. Superstrings, Chaos, Complexity – und was dann? Zuerst 1992 publiziert). Berlin (Byblos).

DEAR, M.J. (1988): The Postmodern Challenge: Reconstructing human Geography. Transactions, Institute of British Geographers 13, pp. 262-274.

DIERSSEN, Klaus (1990): Einführung in die Pflanzensoziologie/Vegetationskunde. Darmstadt (Wissenschaft-liche Buchgesellschaft).

DIKAU, Richard (2005): Geomorphologische Perspektiven integrativer Forschungsansätze in Physisch-geographischer Sicht. In: Möglichkeiten und Grenzen integrativer Forschungsansätze in Physischer Geographie und Humangeographie (Editors D. Müller-Mahn und U. Wardenga). = Forum IFL, Heft 2. Leipzig (Leibniz-Institut für Länderkunde), pp. 91-108.

DILTHEY, Wilhelm (1910/70): Der Aufbau der geschichtlichen Welt in den Geisteswissenschaften. Frankfurt am Main (Suhrkamp). StW 354.

DRECHSLER, Wolfgang (1985): Marcel Duchamp und die Zeit. In: Zeit. Die vierte Dimension in der Kunst. Katalog. Editor: Michel Baudsen. Weinheim (Acta Humaniora).

DRIESCH, H. (1908/28): Philosophie des Organischen. 4th ed. Leipzig.

Dumont Weltatlas der Kunst (2004). Editor: J.Onins. Köln (Dumont).

EIBEL-EIBESFELDT, Irenäus (1967/99): Grundriß der vergleichenden Verhaltensforschung. Ethologie. 8th edition. München/Zürich (Piper).

EIGEN, Manfred und Ruthild WINKLER (1975): Das Spiel. Naturgesetze steuern den Zufall. München/Zürich (Piper).

EINSTEIN, Albert (1905/74): Zur Elektrodynamik bewegter Körper. In: Lorentz, H.A., A.Einstein, H. Minkowski: Das Relativitätsprinzip. Eine Sammlung von Abhandlungen. 7th edition. Darmstadt (Wissen-schaftliche Buchgesellschaft). pp. 26-50.

- (1916/74): Die Grundlage der allgemeinen Relativitätstheorie. In: Lorentz, H.A., A. Einstein, H., Minkowski : Das Relativitätsprinzip. Eine Sammlung von Abhandlungen. 7th edition. Darmstadt (Wissenschaftliche Buch-gesellschaft), pp. 81-124.

Eiszeitkunst (2001): Eiszeitkunst im süddeutsch-schweizerischen Jura. Anfänge der Kunst. Ed. Müller-Beck, H.-J., N.J. Conrad, and W. Schürle. Stuttgart (Theiss).

ELLENBERG, Hans (1973): Ziele und Stand der Ökosystemforschung. In: ELLENBERG, Hans (editor): Ökosystemforschung. Berlin/Heidelberg/New York (Springer), pp.1-31.

EPSTEIN, Joshua M. and Robert AXTELL (1996): Growing Artificial Societies. Social Science from the Bottom up. Washington (Brookings Instition Press) and Cambridge, Mass.(MIT Press).

ERBRICH, Paul (2004): Grenzen des Wachstums im Widerstreit der Meinungen. Stuttgart (Kohlhammer).

Erfindung der Natur (1994): Die Erfindung der Natur. Max Ernst, Paul Klee, Wols und das surreale Universum. Badischer Kunstverein Karlsruhe. Freiburg (Rombach).

FEYERABEND, Paul Karl (1975/86): Wider den Methodenzwang. Skizze einer anarchischen Erkenntnistheorie. (1st ed. 1975, transl. from Americ.). Frankfurt a.M. (Suhrkamp). StW 597.

FISZ, Marek (1976): Wahrscheinlichkeitsrechnung und mathematische Statistik. Berlin (VEB Deutscher Verlag der Wissenschaften).

FLIEDNER, Dietrich (1962a): Zyklonale Tendenzen bei Bevölkerungs- und Verkehrsbewegungen in städtischen Bereichen, untersucht am Beispiel der Städte Göttingen, München und Osnabrück. In: Neues Archiv für Niedersachsen 10(15), pp. 277-294.

- (1962b): Zu- und Abwanderung im Bereich einer deutschen Mittelstadt, dargestellt am Beispiel der Stadt Göttingen. In: Neues Archiv für Niedersachsen 11(16), pp. 14-31.

- (1969): Formungstendenzen und Formungsphasen in der Entwicklung der ländlichen Kulturlandschaft seit dem hohen Mittelalter, besonders in Nordwestdeutschland. In: Erdkunde XXIII, pp. 102-116.

- (1974): Räumliche Wirkungsprizipien als Regulative strukturverändernder und landschaftsgestaltender Prozesse. In: Geographische Zeitschrift 62, pp.12-28.

- (1975): Die Kolonisierung New Mexicos durch die Spanier. Ein Beitrag zum Problem der Entstehung von anthropogenen Räumen. = Arbeiten aus dem Geographischen Institut der Universität des Saarlandes 21. Saarbrücken.

- (1981): Society in Space and Time. = Arbeiten aus dem Geographischen Institut der Universität des Saarlandes 31. Saarbrücken.

- (1987): Prozeßsequenzen und Musterbildung. Ein anthropogeographischer Forschungsansatz, dargestellt am Beispiel des Stadt-Umland-Systems. In: Erdkunde 41, pp. 106-117.

- (1993): Sozialgeographie. = Lehrbuch der Allgemeinen Geographie, vol. 13. Berlin/New York (de Gruyter).

- (1997): Die komplexe Natur der Gesellschaft. Systeme, Prozesse, Hierarchien. Frankfurt a.M., Berlin etc. (Peter Lang).

- (1999): Komplexität und Emergenz in Gesellschaft und Natur. Frankfurt a.M., Berlin etc. (Peter Lang).

- (2001a): Six Levels of Complexity; A Typology of Processes and Systems. In: Journal of Artificial Societies and Social Simulation (JASSS), vol.4, No.1. http://www.soc.surrey.ac.uk/JASSS/4/1/4.html

- (2001b): Processes constitute our complex reality. A theoretical investigation.

http://sova.sulb.uni-saarland.de/sova/volltexte/2001/61

- (2003): Decoding emergence and self-organisation; an alternative approach to understanding our complex reality. In: Complexity International http://journal-ci.csse.monash.edu.au/edit/uploads/dietr01/code2e.doc

- (2005): Processes constitute our complex reality. A theoretical investigation. 2nd edition. http://scidok.sulb.uni-saarland.de/volltexte/2005/482/

-(2005): Processes Constitute Our Complex Reality. A Theoretical Investigation. 2nd edition. http://scidok.sulb.uni-saarland.de/volltexte/2005/482/. Druckversion (mit einem Vorwort) = Saarbrücker Geographische Arbeiten, Band 51. Saarbrücken 2006.

FORRESTER, Jay W. (1968/72): Grundzüge einer Systemtheorie. (Transl. from Americ.: Principles of Systems, 1st ed. 1968. Wiesbaden (Gabler).

- (1969): Urban Dynamics. Cambridge, Mass. (MIT Press).

FOUCAULT, Michel (1973/97): Archäologie des Wissens. (1st edition 1973. Transl. from French). Frankfurt am Main (Suhrkamp) StW.356.

GADAMER, Hans-Georg (1960/90): Wahrheit und Methode. Grundzüge einer philosophischen Hermeneutik. 2 Bände. (1st edition 1960). Tübingen (Mohr).

GARRISON, W.L. (1959-60): Spatial Structure of the Economy. In: Annals of the Association of American Geographers, vol. 49, pp. 232-239, 471-482; vol. 50, pp. 357-373.

GEHLEN, Arnold (1940/62): Der Mensch. Seine Natur und seine Stellung in der Welt. 7th edition. Frankfurt/Bonn.

GEISMEIER, W. (1984): Die Malerei der deutschen Romantik. Stuttgart.

GELL-MANN, Murray (1994): Das Quark und der Jaguar. (Transl. from Americ.). München (Piper).

GIDDENS, Anthony (1984/88): Die Konstitution der Gesellschaft. (Transl. from Engl.: The Constitution of Society. Outline of the Theory of Structuration. 1st ed. 1984). Frankfurt a.M. (Campus).

GLATZMAIER, Gary A. and Peter OLSON (2005): Geheimnisvoller Geodynamo. In: Spektrum der Wissen-schaft, Sept. 2005, pp. 54-61.

GLOZER, Laszlo (1981): Westkunst. Zeitgenössische Kunst seit 1939. Ausstellungskatalog. Köln (DuMont).

GOMBRICH, E.H. (1950/96): Die Geschichte der Kunst. 16th edition. Berlin (Phaidon).

GREENE, Brian (2004): Der Stoff, aus dem der Kosmos ist. Raum, Zeit und die Beschaffenheit der Wirklichkeit. (Transl. from Engl.) München (Siedler).

- (1999/2006): Das elegante Universum. Superstrings, verborgene Dimensionen und die Suche nach der Weltformel. Zuerst 1999 erschienen. Aus dem amerikanischen Englisch. München (Goldmann).

Graphik. Das große Lexikon der Graphik (1989). Künstler, Techniken, Hinweise für Sammler. Köln (Tigris), Braunschweig (Westermann).

GRIBBIN, John und Martin Rees (1989/91): Ein Universum nach Mass. Bedingungen unserer Existenz. Zuerst 1989 publiziert. Aus dem Englischen. Basel, Boston, Berlin (Birkhäuser).

HABERMAS, Jürgen (1981): Theorie des kommunikativen Handelns. 2 vols. Frankfurt am Main (Suhrkamp).

- (1985): Die neue Unübersichtlichkeit. Frankfurt am Main (Suhrkamp).

HAFTMANN, Werner (1954/76): Malerei im 20. Jahrhundert. Eine Entwicklungsgeschichte. 5th edition. München (Prestel).

HÄGERSTRAND, Torsten (1952): The Propagation of Innovation Waves. = Lund Studies in Geography, Ser. B., No.4. Lund.

- (1953/67): Innovation Diffusion as a Spatial Process. (Translation and postscript by Allan Pred). Chicago, London (Univ. of Chicago Press).

- (1973): The Domain of Human Geography. In: Chorley, R.J. (editor.): Directions in Geography, London, pp. 67-87.

HAHN, Helmut (1957): Sozialgruppen als Forschungsgegenstand der Geographie. Gedanken zur Systematik der Anthropogeographie. In: Erdkunde XI, pp. 35 - 41.

HAKEN, Hermann (1977/83): Synergetik. Eine Einführung. (Transl.from Americ.). 2nd edition. Berlin/New York (Springer).

HAMBLOCH, Hermann (1982): Allgemeine Anthropogeographie. Eine Einführung. 5th edition = Erdkundliches Wissen, vol. 31. Wiesbaden (Steiner).

- (1983): Kulturgeographische Elemente im Ökosystem Mensch-Erde. Eine Einführung unter anthropologischen Aspekten. Darmstadt (Wissenschaftliche Buchgesellschaft).

- (1987): Erkenntnistheoretische Probleme in der Geographie. In: Münstersche Geographische Arbeiten 27 (Ludwig Hempel zum 65. Geburtstag). Paderborn.

HANDBUCH. Die Geschichte des Christentums. (Transl. from Engl.) Editor: Tim Dowley. Wuppertal/Zürich (Brockhaus).

HARD, Gerhard (1970): Die "Landschaft" der Sprache und die "Landschaft" der Geographen. = Colloquium Geographicum, vol. 11. Bonn.

HARD, Gerhard (1973): Die Geographie. Eine wissenschaftstheoretische Einführung. Berlin/New York (de Gruyter).

HARTKE, Wolfgang (1953): Die soziale Differenzierung der Agrarlandschaft im Rhein-Main-Gebiet. In: Erdkun-de VII, pp. 11-27.

HARTMANN, Nicolai (1933/49): Der Aufbau der realen Welt. 2nd edition. Meisenheim am Glan.

HARVEY, David (1973): Social Justice and the City. Baltimore (John Hopkins University Press).

HEIDEGGER, Martin (1927/76): Sein und Zeit. 13th edition. Tübingen (Max Niemeyer Verlag).

HEINRITZ, Günter (1979): Zentralität und zentrale Orte. Eine Einführung. Stuttgart (Teubner).

HELD, Klaus (1990): Edmund Husserl. Transzendentale Phänomenologie: Evidenz und Verantwortung. In: Fleischer, M. (ed.): Philosophen des 20. Jahrhunderts. Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 79-93.

HETTNER, Alfred (1927): Die Geographie. Ihre Geschichte, ihr Wesen und ihre Methoden. Breslau (Hirt).

Historischer Weltatlas (1997/2004): Editor: Leisering, W. Wiesbaden (Marx).

HOLENSTEIN, Elmar (2004): Philosophie-Atlas. Orte und Wege des Denkens. Zürich (Ammann-Verlag).

HOLLAND, John H. (1998): Emergence. From Chaos zu Order. Oxford/New York (Oxford University Press).

HORGAN, John (1995): Komplexität in der Krise. In: Spektrum der Wissenschaft, Sept. 1995, pp. 58-64.

HUBBARD, Phil, Rob KITCHIN, Brendan BARTLEY, and Duncan FULLER (2002): Thinking geographically. Space, theory and contempory human geography. London/New York (Continuum).

HUNDERTMARK, Edeltraut (1965): Der Landkreis Braunschweig. = Landkreise in Niedersachsen, Band 22. Bremen-Horn (Walter Dorn Verlag).

HUNTINGTON, Samuel P. (1996): Kampf der Kulturen. Die Neugestaltung der Weltpolitik im 21. Jahrhundert. Trans. from Americ. München/Wien (Europa-Verlag).

HUSSERL, Edmund (1913 etc./1985-86): Ausgewählte Texte I (Die phänomenologische Methode) and II (Phänomenologie der Lebenswelt). Stuttgart (Reclam).

IMDAHL, Max (1981): Bildautonomie und Wirklichkeit. Zur theoretischen Begründung moderner Malerei. Mittenwald (Mäander).

Informel (1983): Symposion 8.-12.Okt.1982: Die Malerei des Informellen heute. Editor: Költzsch, G.W., Moder-ne Galerie des Saarlandmuseums. Saarbrücken.

ISARD, Walter (1956/68): Location and Space-Economy. Cambridge (Mass.) and London (MIT-Press).

JAMMER, Max (1960): Das Problem des Raumes. Die Entwicklujng der Raumtheorien. Darmstadt (Wissenschaftliche Buchgesellschaft).

- (1974): Der Begriff der Masse in der Physik. Darmstadt (Wissenschaftliche Buchgesellschaft).

JANTSCH, Erich (1979/93): Die Selbstorganisation des Universums. Vom Urknall zum menschlichen Geist. München/Wien (Hanser).

JOHNSTON, R.J. (1983/86): Philosophy and Human Geography. An Introduction to Contemporary Approaches. 2nd edition. London.

JONAS, Hans (1979): Das Prinzip Verantwortung. Frankfurt a.M.(Insel Verlag).

KENNEDY, Paul (1987/89): Aufstieg und Fall der großen Mächte. Ökonomischer Wandel und militärischer Konflikt von 1500 bis 2000. (Transl. from Engl.). Frankfurt a.M. (Fischer).

KESSEL, John L. (1975): The Pueblo de los Pecos. A documentary history 1540 - 1838. Manuscript (by order of the National Park Service, USA). Albuquerque. [Now published]

Kirchengeschichte (1987/2004): Atlas zur Kirchengeschichte. Die christlichen Kirchen in Geschichte und Gegenwart. Hrsg. Hubert Jedin, Kenneth Scott Latourette, Jochen Martin. Freiburg etc. (Herder).

Klang der Bilder (1985): Vom Klang der Bilder. Die Musik in der Kunst des 20. Jahrhunderts. Editor: v. Maur, Karin. Katalog. München (Prestel).

KLEIBER, J. and K. Jüngling (1931): Physik für die Oberstufe. 17th edition. München and Berlin (Oldenbourg).

KLUCZKA, G. (1970): Zentrale Orte und zentralörtliche Bereiche mittlerer und höherer Stufe in der Bundesrepublik Deutschland. = Forschungen zur deutschen Landeskunde 194. Bad Godesberg.

KLUG, Heinz und Robert LANG (1983): Einführung in die Geosystemlehre. Darmstadt (Wissenschaftliche Buchgesellschaft).

Knaurs neuer historischer Atlas. (1996): Editor Geoffrey Barraclough. 5th edition. München (Bechtermünz Verlag).

KNIFFEN, Fred (1951): The American Covered Bridges. In: Geographical Review, vol XLI, pp. 114-123.

KNOX, P. (1982): Urban Social Geography. An Introduction. London, New York (Longman).

KONDRATIEF, N.D. (1928): Die Preisdynamik der industriellen und landwirtschaftlichen Waren. Zum Problem der relativen Dynamik der Konjunktur. In: Archiv für Sozialwissenschaft und Sozialpolitik 60, pp. 1-85.

KREYSZIG, Erwin (1985): Statistische Methoden und ihre Anwendungen. 7th ed. Göttingen (Vandenhoek & Ruprecht).

KROHN, Wolfgang und Günter KÜPPERS, editors (1992): Emergenz: Die Entstehung von Ordnung, Organisation und Bedeutung. 2nd ed. Frankfurt a.M. (Suhrkamp).

KUHN, Thomas S. (1962/67/88): Die Struktur wissenschaftlicher Revolutionen. (Transl. from Americ.) Frankfurt am Main (Suhrkamp) StW 25.

- (1995): Weltbilder der Wissenschaften. Ein Interview. In: DIE ZEIT Nr. 18, 28. April 1995.

LANGTON, Christopher G. (1989): Artifical Life. = Santa Fe Institute Studies in the Sciences of Complexity, Vol. 6. Redwood City, Cal. (Addison-Wesley).

LENK, Hans (Editor) (1977-1982): Handlungstheorie interdisziplinär. 4 vols. München.

LESER, Hartmut (1976): Landschaftsökologie. Stuttgart (Ulmer, UTB).

LEWIN, Benjamin (2002): Molekularbiologie der Gene. (Translated from Engl.). Heidelberg, Berlin (Spektrum Akademischer Verlag).

Lexikon der Alten Welt (1965/95). Editors: C.Anresen, H.Erbse, K.Schefeld, K.F.Strobecker, E.Zinn. 3 vols. Reprint. Augsburg (Weltbild).

LILIENTHAL, Karl (1931): Jürgen Christian Findorffs Erbe. Ein Beitrag zur Darstellung der kolonisatorischen Entwicklung der Moore im alten Herzogtum Bremen. Osterholz-Scharmbeck (Saade).

LORENZ, Konrad (1965): Über tierisches und menschliches Verhalten. Aus dem Werdegang der Verhaltenslehre. Gesammelte Abhandlungen. 2 vols. München (Piper).

LORENZ, Kuno (1990): Einführung in die philosophische Anthropologie. Darmstadt (Wissenschaftliche Buchge-sellschaft).

LOTKA, A.J. (1925/56): Elements of Mathematical Biology. Reprint. New York (Dover).

LUHMANN, Niklas (1970/75): Soziologische Aufklärung. 2 vols. Opladen (Westdeutscher Verlag).

- (1984): Soziale Systeme. Grundriß einer allgemeinen Theorie. Frankfurt a.M. (Suhrkamp).

- (1998): Die Gesellschaft der Gesellschaft. 2 vols. Frankfurt a.M. (Suhrkamp).

LYNCH, K. (1960/65): Das Bild der Stadt. (Transl. from Engl.) 1st edition 1960. Berlin/Frankfurt/Wien.

LYOTARD, Jean-Francois (1979/99): Das postmoderne Wissen. (Transl. from French: La condition postmoderne. 1st ed. 1979). Wien (Passagen-Verlag).

MAINZER, Klaus (1991/2004): Thinking in Complexity. The Complex Dynamics of Matter, Mind, and Mankind. 4th edition. Berlin/Heidelberg (Springer).

Malerei (1986): Lexikon von A bis Z. Geschichte der Malerei von den Anfängen bis zur Gegenwart. Köln (Lingen-Verlag).

MALINOWSKI, B. (1944/75): Eine wissenschaftliche Theorie der Kultur. (Transl. from Americ.) Frankfurt.

MANDELBROT, Benoît B. (1977/1987): Die fraktale Geometrie der Natur. (Transl. from Americ.: The Fractal Geometry of Nature, 1st ed. 1977). Basel/Boston (Birkhäuser).

MARX, Karl (1867/1962-64): Das Kapital. Kritik der politischen Ökonomie. In: Lieber, H.-J. und B.Kautzky (editors): Karl-Marx-Edition. Vols. IV-VI. Stuttgart.

MATURANA, Humberto R. and Francisco J. VARELA (1984/89): Der Baum der Erkenntnis. Die biologischen Wurzeln des menschlichen Erkennens. (Transl. from Spanish: El árbol del concocimiento, 1st ed. 1984). München (Scherz).

MATURANA, Humberto R. (1998): Biologie der Realität. Frankfurt a.M. (Suhrkamp).

MEADOWS, Dennis, Donella MEADOWS, Erich ZAHN and Peter MILLING (1972): Die Grenzen des Wachstums. Bericht des Club of Rome zur Lage der Menschheit. (Transl. from Americ.). Stuttgart (Deutsche Verlagsanstalt).

MEADOWS, Donella, Dennis MEADOWS, and Jörgen RANDERS (1992): Die Neuen Grenzen des Wachstums. Die Lage der Menschheit: Bedrohung und Zukunft. (Transl. from Americ.) Stuttgart (Deutsche Verlagsanstalt).

MEITZEN, A. (1895): Siedelung und Agrarwesen der Westgermanen und Ostgermanen, der Kelten, Römer, Finnen und Slaven. Berlin.

MENSCH, Gerhard (1975): Das technologische Patt. Innovationen überwinden die Depression. Stuttgart (Umschau).

MEURERS, Joseph (1984): Kosmologie heute. Eine Einführung in ihre philosophischen und naturwissenschaftlichen Problemkreise. Darmstadt (Wissenschaftliche Buchgesellschaft).

MEYERs Handbuch Weltall (1994). Von Krauter, J., E. Sedelmayer, K. Schaifers and G. Traving (7th edition). Mannheim (Bibliographisches Institut).

MINGERS, John (1995): Self-producing Systems. Implications and Applications of Autopoiesis. New York, London (Plenum Press).

MINKOWSKI, H. (1908/74): Raum und Zeit. In: Lorentz, H.A., A. Einstein, H. Minkowski: Das Relativitäts-prinzip. Eine Sammlung von Abhandlungen. 7th. edition. Darmstadt (Wissenschaftliche Buchgesellschaft). pp. 54-71.

MÜLLER, Paul (1979): Tiergeographie. Stuttgart (Teubner).

- (1981): Arealsysteme und Biogeographie. Stuttgart.

MÜLLER-KARPE, Herrmann (1998): Grundzüge der Menschheitsgeschichte. 5 vols. Darmstadt (Wissenschaft-liche Buchgesellschaft).

MÜLLER-MAHN, Detlev und Ute WARDENGA (editors; 2005): Möglichkeiten und Grenzen integrativer Forschungsansätze in Physischer Geographie und Humangeographie = Forum IFL, vol. 2. Leipzig (Leibniz-Institut für Länderkunde).

MURPHY, R. (1971): The Central Business District. A Study in Urban Geography. London (Longman).

NEWTON, Isaac (1681/1725/1963): Mathematische Prinzipien der Naturlehre. (Transl. from Lat. Philosophiae naturalis principia mathematica, 1st ed. 1681). Editor: J.Ph. Wolfers 1872. Reprint. Darmstadt (Wissenschaftliche Buchgesellschaft).

NICOLIS, Grégoire and Ilya PRIGOGINE (1987): Die Erforschung des Komplexen. Auf dem Weg zu einem neuen Verständnis der Naturwissenschaften. München/Zürich (Piper).

NIEMANN, Hans (1995): Populismus in der Philosophie. Nicholas Reschers wissenschaftlicher Relativismus. In: Conceptus XXVIII, pp. 271-300.

NOSTRAND, Richard (1995): The spread of Spanish settlement in greater New Mexico: An isochronic map, 1610-1890. In: Journal of the West, Vol. XXXIV, No 3, July 1995, pp. 82-87.

OBST, Erich (1926/69): Die Thünenschen Intensitätskreise und ihre Bedeutung für die Weltgetreidewirtschaft. In: Wirtschaftsgeographie (editor: E. Wirth). 1st edition 1926. Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 195-198.

OVERBECK, Hermann (1954/78): Die Entwicklung der Anthropogeographie (insbesondere in Deutschland) seit der Jahrhundertwende und ihre Bedeutung für die geschichtliche Landesforschung. In: Probleme und Methoden der Landesgeschichte (editor: Fried, P.). 1st edition 1954. Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 190-271.

- (1957): Das politisch-geographische Lehrgebäude von Friedrich Ratzel. In: Die Erde IX, pp. 169-192.

PARTZSCH, D. (1965): Die Funktionsgesellschaft und ihr Verhältnis zur Raumordnung. In: Die Mitarbeit, Zeitschrift zur Gesellschafts- und Kulturpolitik 14, vol. 3, pp. 34-44.

PEET, Richard (1998): Modern geographic thought. Oxford (Malden).

PENCK, Albrecht (1924/69): Das Hauptproblem der physischen Anthropogeographie. In: Wirth, E. (ed.): Wirtschaftsgeographie. Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 157-180.

PHILIPPSON, Alfred (1921/24): Grundzüge der Allgemeinen Geographie. 2 vols. Leipzig (Akademische Verlagsanstalt).

PITTENDRIGH, C.S. (1958): Adaptation, natural selection, and behavior. In: ROE, A., G.G. SIMPSON (eds.): Behavior and Evolution. London/New Haven (Yale Univ. Press), pp. 390-416.

PLANCK, Max (1938/48): Determinismus oder Indeterminismus? Vortrag. 2nd edition. Leipzig (Johannes Ambrosius Barth Verlag).

POHL, Jürgen (1998): Von der agrarischen Lebensform zur postmodernen Patchwork-Identität: Die Funktion der Sozialgeographie im Wandel der Zeit. In: Günter Heinritz & Ilse Helbrecht (editors): Sozialgeographie und Soziologie. Dialog der Disziplinen. = Münchner Geographische Hefte, 78. Passau (L.I.S.Verlag), pp. 57-73.

POP ART (1991): Katalog. Hrsg. von Marco Livingstone. München (Prestel).

POPPER, Karl (1934/89): Logik der Forschung. 9th ed. Tübingen (Mohr).

- (1960/87): Das Elend des Historismus. Die Einheit der Gesellschaftswissenschaften, vol. 3. 6th edition. Tübingen.

- (1987): Die erkenntnistheoretische Position der Evolutionären Erkenntnistheorie. In: Riedl, R. and F.M. Wuketits (editors): Die Evolutionäre Erkenntnistheorie; Bedingungen, Lösungen, Kontroversen. Berlin/Hamburg, pp.29-37.

POSER, Hans (editor; 1982): Philosophische Probleme der Handlungstheorie. = Series: Praktische Philosophie. Freiburg/München (Karl Alber).

PRIGOGINE, Ilya (1979): Vom Sein zum Werden. Zeit und Komplexität in den Naturwissenschaften. (Transl. from Engl.). München/Zürich (Piper).

PRIGOGINE, Ilya und Isabel STENGERS (1981): Dialog mit der Natur. München/Zürich (Piper).

PRINZ, Friedrich (2000): Von Konstantin zu Karl dem Großen. Entfaltung und Wandel Europas. Düsseldorf/Zürich (Artemi & Winkler).

Propyläen Geschichte Europas (1975-1976). 6 vols. (Authors: H.D.Diwald, E.W.Zeeden, R.Mandiou, E.Weis, Th.Schieder, D.Bracher). Reprint 1998. Berlin (Propyläen Verlag).

Propyläen Technik Geschichte (1990-1992). Ed. Wolfgang König. 5 Vols. Reprint 1997. Berlin (Propyläen Verlag).

RANDALL, Lisa (2005/06): Verborgene Universen. Eine Reise in den extradimensionalen Raum. Zuerst 2005 publiziert. Aus dem Amerikanischen. Frankfurt am Main (S.Fischer).

RASMUSSEN, Carl (1989/2004): Historisch-geographischer Atlas zur Bibel. (Transl. from Engl.) 3rd edition. Holzgerlingen (Hänssler Verlag).

RATZEL, Friedrich (1882-91): Anthropo-Geographie. 2 vols. Stuttgart (Engelhorn).

- (1897): Über den Lebensraum. In: Die Umschau, vol. 1, pp. 363-366.

REICHERT, Dagmar (1987): Zu den Menschenbildern der Sozial- und Wirtschaftswissenschaften. In: Bremer Beiträge zur Geographie und Raumplanung, vol. 11 (D. Bartels zum Gedenken), pp. 27-48.

RELPH, E. (1991): Post-modern Geography. In: The Canadian Geographer 35, pp. 98-105.

REMMERT, Hermann (1984): Ökologie. Ein Lehrbuch. 3rd edition. Berlin/Heidelberg (Springer).

von RICHTHOFEN, Ferdinand (1903): Triebkräfte und Richtungen der Erdkunde im 19. Jahrhundert. In: Zeitschrift der Gesellschaft für Erdkunde zu Berlin, 1903, No. 9 (separate print).

RICKERT, Heinrich (1902): Die Grenzen der naturwissenschaftlichen Begriffsbildung. Tübingen/Leipzig (Mohr)

RIEDL, R. (1979/88): Biologie der Erkenntnis. Die stammesgeschichtlichen Grundlagen der Vernunft. München.

ROGERS, E.M. (1962/83): Diffusion of Innovations. 3rd ed. New York, London.

ROTERS, Eberhard (1981): In Bernhard Schultzes Wäldern. In: Schultze, Bernhard: Im Labyrinth. Katalog. Saarbrücken (Moderne Galerie), pp. 55-60.

RUPPERT, Karl (1968): Die gruppentypische Reaktionsweite – Gedanken zu einer sozialgeographischen Arbeits-hypothese. In: Münchener Studien zur Sozial- und Wirtschaftsgeographie 4 (Festschrift W. Hartke), pp. 171-184.

SACHSSE, Hans (1979): Kausalität – Gesetzlichkeit – Wahrscheinlichkeit. Die Geschichte von Grundkategorien zur Auseinandersetzung des Menschen mit der Welt. Darmstadt (Wissenschaftliche Buchgesellschaft).

SALTHE, Stanley N. (2001): Summary of the Principles of Hierarchy Theory. http://www.nbi.dk.~natphil/salthe/hierarchy_th.html

DE SAPIO, R. (1978): Calculus for the Life Sciences. San Francisco (Freeman and Co.).

SARTRE, Jean-Paul (143/97): Das Sein und das Nichts. Versuch einer phänomenologischen Ontologie. (Transl. from French). Reinbek bei Hamburg (Rowohlt).

SAUER, Carl Ortwin (1952): Agricultural Origins and Dispersals. New York (American Geographic Society).

SCHAFFER, Franz (1968): Prozeßhafte Perspektiven sozialgeographischer Stadtforschung – erläutert am Beispiel von Mobilitätserscheinungen. Münchener Studien zur Sozial- und Wirtschaftsgeographie 4 (Festschrift W. Hartke), pp. 185-207.

SCHEDEL, Hartmann (1493/2004): Weltchronik 1493. Kolorierte und kommentierte Gesamtausgabe. Faksimile-Druck nach einem Exemplar der Anna-Amalia-Bibliothek Weimar. Einleitung und Kommentar von Stephan Füssel. Augsburg (Weltbild).

SCHELER, Max (1928/47): Die Stellung des Menschen im Kosmos. 2nd edition. München.

SCHLÜTER, Otto (1906): Die Ziele der Geographie des Menschen. München/Berlin.

SCHMIDT, Holger (2004): Theorieimport in die Sozialgeographie. Eine Analyse und Interpretation von Texten und Interviews mit Helmut Klüter und Benno Werlen. = OSG-Materialien Nr. 55. Osnabrück.

SCHMIDT-ROTTLUFF, Karl (1991): Aquarelle. Editor: M. M. Moeller. Stuttgart (Verlag Gerd Hatje).

SCHMITHÜSEN, Josef (1959/68): Allgemeine Vegetationsgeographie. = Lehrbuch der Allgemeinen Geographie IV. 3rd edition. Berlin (de Gruyter).

- (1976): Allgemeine Geosynergetik. = Lehrbuch der Allgemeinen Geographie XII. Berlin/New York (de Gruyter).

SCHOPENHAUER, Arthur (1819/o.J., ca. 1890): Die Welt als Wille und Vorstellung. (1st edition 1819). 2 vols. Leipzig (Reclam).

SCHULTZE, Arnold (1962): Die Sielhafenorte und das Problem des regionalen Typus im Bauplan der Kulturlandschaft. = Göttinger Geographische Abhandlungen 27, Göttingen.

SCHULTZE, Bernard (1981): Im Labyrinth. Werke von 1940-1980. Katalog. Editors: Harten, J., R. Szymanski, P. Weiermair, and G.-W. Költzsch. Saarbrücken (Moderne Galerie).

SCHUMPETER, Joseph Alois (1939/61): Konjunkturzyklen. Eine theoretische, historische und statistische Analyse des kapitalistischen Prozesses. 2 vols. (1^{st} ed. 1939). Göttingen.

SCHWARZ, Reiner (1981): Informationstheoretische Methoden. = Geomod (Modelle und Methodender Geogra-phie 2. Paderborn (Schöningh).

SEGAHL, Tino (2005): Diskussionsbemerkung in: Kunst im Futur II, der Künstler Tino Segahl und der Philosoph Peter Sloterdijk - ein ZEIT-Gespräch zur Biennale in Venedig. In: DIE ZEIT Nr. 24 vom 5.6.2005, p. 51.

SINGER, Peter und Dietrich FLIEDNER (1970): Niedersachsen. München/Frankfurt (List).

SHANNON, Claude E. und Warren WEAVER (1949/76): Mathematische Grundlagen der Informationstheorie. (Transl. from Americ.: The Mathematical Theory of Communication, 1^{st} ed. 1949). München/Wien (Oldenbourg).

SLEVOGT, Max (1992): Gemälde, Aquarelle, Zeichnungen. Katalog. Hrsg. von E.-G. Güse, H.-J. Imiela und B. Roland. Stuttgart (Verlag Gerd Hatje).

SOCAL, Alan, and Jean BRICMONT (1979): Elganter Unsinn. Wie Denker der Postmoderne die Wissenschaft mißbrauchen. (Trans. from Engl.) München (Beck).

SOCHAVA, V.B. (1972): Geographie und Ökologie. In: Petermanns Geographische Mitteilungen, vol. 116, pp. 89-98.

SOJA, E.W. (1989): Postmodern Geographies. The Assertion of Space in Critical Social Theory. London/New York.

SÖLCH, J. (1924): Die Auffassung der natürlichen Grenzen in der wissenschaftlichen Geographie. Innsbruck.

SPATARU, A. (1973): Theorie der Informationsübertragung, Signale und Störungen. Braunschweig (Vieweg).

SPIEKERMANN, K. und M. WEGENER (1993): Zeitkarten für die Raumplanung. In: Informationen zur Raumentwicklung 7, pp. 459-487.

STEGMÜLLER, Wolfgang (1987-89): Hauptströmungen der Gegenwartsphilosophie. Eine kritische Einführung. 3 vols. 7./8th edition. Stuttgart (Kröner).

STEINMETZ, S.R. (1913/35): Die Stellung der Soziographie in der Reihe der Sozialwissenschaften. In: Steinmetz, S.R.: Gesammelte kleinere Schriften zur Ethnologie und Soziologie. Groningen/Batavia, pp. 96-107.

STEPHAN, Achim (1999): Emergenz. Von der Unvorhersagbarkeit zur Selbstorganisation. Dresden (University Press).

STOOB, Heinz (1956): Kartographische Möglichkeiten zur Darstellung der Stadtentstehung in Mitteleuropa, besonders zwischen 1450 und 1800. In: Forschungs- und Sitzungsbereichte der Akademie für Raumforschung und Raumordnung, vol. VI (=Historische Raumforschung I), pp. 21-76.

STRAHLER, Arthur N. and Alan H. STRAHLER (1973): Environmental Geoscience: Interaction between Natural Systems and Man. Sta. Barbara, Cal. (Hamilton Publ. Company).

SUTHERLAND, John W.(1973): A General Systems Philosophy for the Social and Behavioral Sciences. In: Laszlo, E. (editor): The International Library of Systems Theory and Philosophy. New York (Braziller).

TAYLOR, P.J. (1913): Die Grundsätze wissenschaftlicher Betriebsführung. German edition from R. Roesler. München/Berlin.

THOMALE, Eckart (1972): Sozialgeographie. Eine disziplingeschichtliche Untersuchung zur Entwicklung der Anthropogeographie. = Marburger Geographische Schriften 53. Marburg.

THÜNEN, Johan Heinrich v. (1826/1921): Der isolirte Staat in Beziehung auf Landwirtschaft und National-ökonomie. 2nd ed. (H.Waentig ed.). Jena.

TICHY, Gunther (1994): Konjunktur. Stilisierte Fakten, Theorie, Prognose. 2nd ed. Berlin/Heidelberg (Springer).

TISDALL, Caroline (1979): Joseph Beuys. Katalog. New York (Solomon R. Guggenheim Museum).

TUAN, Y.-F. (1984): Review of Gould, P. and G.Olsson (editors, 1982): A Search for Common Ground. In: Annals of the Association of American Geographers 74, pp. 174-178.

UNSÖLD, Albrecht und Bodo BASCHEK (2002/05): Der neue Kosmos. 7th edition 2002. Reprint. Heidel-berg/Berlin (Springer).

VESTER, F. und A. v.HESLER (1980): Sensitivitätsmodell. Regionale Planungsgemeinschaft Untermain. Frankfurt a.M.

VIDAL DE LA BLACHE, P.M. (1911): Les genres de vie dans la géographie humaine. In: Annales de Géogra-phie XX, pp. 193-212, 289-304.

VOGT, Klaus Dieter (1968): Uelzen – Seine Stadt-Umland-Beziehungen in historisch-geographischer Betrachtung. = Göttinger geographische Abhandlungen, vol. 47. Göttingen.

Völker, Staaten und Kulturen. Ein Kartenwerk zur Geschichte (1970). Editors: Hans-Erich Stier, Ernst Kirsten etc. Braunschweig, Berlin etc. (Georg Westermann Verlag).

VOLLMER, Gerhard (1985-86): Was können wir wissen? 2 vols. Stuttgart (Hirzel).

- (1994): Evolutionäre Erkenntnistheorie. 6. Auflage. Stuttgart (Hirzel).

Von hier aus (1984): Zwei Monate neue deutsche Kunst in Düsseldorf. Köln (Dumont).

WAIBEL, Leo (1927/69): Die Sierra Madre de Chiapas. In: Wirtschaftsgeographie (editor: E. Wirth). (1st publ. 1927). Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 242-248.

- (1933a): Probleme der Landwirtschaftsgeographie. = Wirtschaftsgeographische Abhandlungen No. 1. Breslau (Hirt).

- (1933b): Was verstehen wir unter Landschaftskunde? In: Geographischer Anzeiger, 34. Jahrgang, pp. 197-207.

WALDENFELS, Bernhard (1991): Michel Foucault. In: Fleischer, M. (editor): Philosophen des 20. Jahrhunderts.. Darmstadt (Wissenschaftliche Buchgesellschaft), pp. 191-203.

WARNKE, M. (1988): Gegenstandsbereiche der Kunstgeschichte. In: Betting, H., H.Dilly, u.a. (editors): Kunstgeschichte. Eine Einführung. 3rd edition, Berlin, pp. 19-44.

WEBER, Peter (1966): Planmäßige ländliche Siedlungen im Dillgebiet. Eine Untersuchung zur historischen Raumforschung. = Marburger geographische Schriften, vol. 26.

WEBER, Max (1920): Die protestantische Ethik und der Geist des Kapitalismus. In: WEBER, M.: Gesammelte Aufsätze zur Religionssoziologie, vol. 1. Tübingen, pp. 18-56.

WEBERLING, Focko and Thomas STÜTZEL (1993): Biologische Systematik. Grundlagen und Methoden. Darmstadt (Wissenschaftliche Buchgesellschaft).

von WEIZSÄCKER, Carl Friedrich (1976): Zum Weltbild der Physik. 12th edition. Stuttgart (Hirzel).

WELSCH, W. (1987): Unsere postmoderne Moderne. Weinheim (Acta Humana).

WERLEN, Benno (1988): Gesellschaft, Handlung und Raum. Grundlagen handlungstheoretischer Sozialgeo-graphie. 2nd ed. Stuttgart (Steiner).

- (1995-97): Sozialgeographie alltäglicher Regionalisierungen. = Erdkundliches Wissen, vols. 116 and 119. Stuttgart (Steiner).

WHITAKER, Randall (ca. 1995): Encyclopaedia Autopoietica. Compiled and edited by R. Whitaker.
http://www.informatik.umu.se/~rwhit/EAIntro.html

WHITTAKER, Robert H. (1970/75): Communities and Ecosystems. 2nd ed. New York (Macmillan) and London (Collier Macmillan).

WIENER, Norbert (1948/68): Kybernetik. Regelung und Nachrichtenübertragung in Lebewesen und Maschinen. (Transl. from Americ.: Cybernetics or Control and Communication in the animal and the machine, 1st ed. 1948). Reinbek bei Hamburg (Rowohlt).

WIESER, Wolfgang (1998): Die Erfindung der Individualität, oder die zwei Gesichter der Evolution. Heidelberg/Berlin (Spektrum).

WIGGERSHAUS, R. (1986): Die Frankfurter Schule. Geschichte, theoretische Entwicklung, politische Bedeutung. München/Wien.

WILSON, Edward O. (1975): Sociobiology. The new synthesis. Cambridge, Mass. and London, England (Belknap).

WINDELBAND, Wilhelm (1894): Geschichte und Naturwissenschaft. Rede zum Antritt des Rektorats. Straßburg.

WINDHORST, Hans-Wilhelm (1983): Geographische Innovations- und Diffusionsforschung. Darmstadt (Wissen-schaftliche Buchgesellschaft).

WIRTH, E. (1981): Kritische Anmerkungen zu den wahrnehmungszentrierten Forschungsansätzen in der Geographie. Umweltpsychologisch fundierter „Behavioral Approach“ oder Sozialgeographie auf der Basis moderner Handlungstheorien? Geographische Zeitschrift 69, pp. 161-198.

WISSEL, Christian (1989): Theoretische Ökologie. Eine Einführung. Berlin, Heidelberg, New York (Springer).

WITTGENSTEIN, Ludwig (1922-1953/1990): Tractatus logico-philosophicus. Philosophische Untersuchungen. Leipzig (Reclam).

WOLPERT, J. (1963/70): Eine räumliche Analyse des Entscheidungsverhaltens in der mittelschwedischen Landschaft. In: Wirtschafts- und Sozialgeographie (editor: D. Bartels). Köln/Berlin (Kiepenheuer & Witsch), pp. 380-387.

WUCHTERL, Kurt (1961): Ludwig Wittgenstein. Sprachanalyse und Therapie. In: Fleischer, M. (Editor): Philosophen des 20. Jahrhunderts. Darmstadt (Wissenschaftliche Buchgesellschaft), pp 41-56.

YOUNG, E.C. (1924): The Movement of Farm Population. Cornell University Agricult. Experim. Stat. Bull. No. 426. Ithaca, New York.

ZEILINGER, Anton (2005): Einsteins Spuk. Teleportation und weitere Mysterien der Quantenphysik. München (Bertelsmann).

Zeit, die vierte Dimension in der Kunst (1985). Katalog einer Ausstellung in Mannheim. Hrsg. Michel Baudsen. Weinheim (Acta Humaniora).

ZIPF, G.K. (1949): Human Behavior and Principle of Least-Effort. Cambridge, Mass. (Addison-Wesley). Reprint (Hefner).

ZÖGNER, Lothar (1966): Hugenottendörfer in Nordhessen. = Marburger geographische Schriften, vol. 28. Marburg.

Notes on the figures:

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

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

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

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

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

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

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

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

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

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

Fig. 22:
Density of sherds and stone implements, found in fieldhouses at various distances from Pueblo Pecos as indication of the intensity of agricultural and hunting activities. Sherds: n = ca. 600, stone implements: n > 2000 fragments.
Source: Fliedner 1981 (fig. 5, p. 52 and 273).
Field work in the years 1975/76.
Around the 1838 deserted Pueblo Pecos in New Mexico are the ruins of ca. 1200 small (mostly only one room) houses. Only identifiable rim-sherds of the P IV or modern period were taken into consideration, i.e. not Black-on-White or Culinary-Ware, because in the P III-period not Pecos (Quadrangle or North Pueblo) formed the central point, but the Forked-Lightning Pueblo approx. 300 m away. With the stone implements (resp. their fragments) a similar age differentiation could not be attempted. However, considering the small amount of fragments found near the pueblos, it seemed legitimate to neglect this aspect.

Zones, each covering a distance of 200 m were set up around Pueblo Pecos and the fragments found in them counted.

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

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

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

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

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

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

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

Fig. 44:
Channel model in which various terms of information theory (fourth bonding level) are explained.
Source: Schwarz 1981, p. 59.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Fig. 80:
Max Slevogt: Forest landscape near Neukastel (1921).
Source: Slevogt 1992, fig. 170.

Fig. 81:
Karl Schmidt-Rottluff: Bend in the path (ca. 1960).
Source: Schmitt-Rottluff 1991, fig. 98.

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

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

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

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

Step 1: $y_1 = y_0^a * k$

Step 2: $y_2 = y_1^a * k$

In the analytic representation, the radial scale is as follows:

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

In the case of the city-umland population Saarbrücken, the values used are *(y_0=0,6; a=1,06; k=2,1).* The centre is the crossroads Bahnhofstrasse and Sulzbachstrasse.
- b) The diagram:
Around this centre, circles were drawn according to the radial scale. The individual land-use rings (1987, p. 113):
I. The demand for products from the superior environment is received (perception). The retail trade appears as an institution.
II. This information is passed to the manufacturing units (determination). Private offices, concern administration, banks etc. appear as institutions.
III. The individuals processing the information receive the instructions as workers (regulation). At the interface between the requirements of the system

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

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

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

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

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

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

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

Fig. 110:
Processes in centennial rhythms. Source: Fliedner 1981 (fig. 23 and p. 281) and 1997 (fig. 17 and note 76). These sources are intended as an indication for reference purposes only. They are based on historical publications which permit evaluation of time sequences. In the diagram, the strongest growth was generally taken to be equivalent to one hundred to make comparison possible.
Note on the individual graphs (about the institutions see section 2.5.3.1):
- Perception: The data on the lives of Greek and Roman authors (philosophers, poets, grammarians, mathematicians, scientists, orators, geographers, historians) were used as indicators for the institutions of art and science (Lexikon der Alten Welt 1965/95). Only data are used which can be fitted into periods of time each covering 20 years. This was simplest in cases where the biographies are known (dates of birth and death). However, in many cases, only information such as "around 300" or "beginning of 2nd century A.D." is given. In these cases, two periods each covering 20 years were entered which correspond to this information (i.e. for the above examples, 280 - 320 and 100 - 140). When only the date of a certain work by the author is known, this was used. On the other hand, no entry was made when only the century is known. The results were smoothed for 3 periods, i.e. a total of 60 years. In all, approximately 1500 single dates referring to around 600 persons were used in this one graph reflecting perception.

- Determination: Areas of Christian conversion (areal growth). Sources: Völker, Staaten und Kulturen 1970, p. 26; Bibel und Geschichte 1997, p. 74-81; Kirchengeschichte 1987/2004; Historischer Weltatlas 1997/2004, p. 33; Handbuch, Geschichte des Christentums, pp. 64-65; Knaurs neuer historischer Weltatlas 1999, pp. 92-93.
For Antiquity uncertain data.
- Regulation: Formation of states in Central and Western Europe (Franconia, Holy Roman Empire. Areal growth). Sources: Knaurs neuer historischer Atlas 1999, p. 106-107; Völker, Staaten etc. 1970, p. 30-31.
- Organisation: Emergence of cities in Central Europe. Source: Stoob 1956.
- Dynamisation: Acquisition of colonies outside Europe. Areal growth. Ten year averages. The number of new colonies acquired by political means on politically foreign ground, taking possession by means of peace treaties etc. The setting up of trading posts is assessed in the same light. The surface area involved was not of major importance for inclusion here; particularly for early centuries the area controlled cannot be established accurately. Moreover, the size of the area under command does not necessarily reflect the importance of the colony (cf. military bases are usually only a few sqare kilometers in size but of great strategic value). Sources: Propyläen Geschichte Europas 1975-76/1998; Knaurs neuer historischer Weltatlas 1996; Völker, Staaten und Kulturen 1970; Propyläen Technik Geschichte 1990-1992; Historischer Weltatlas 1997/2004, p. 162.

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

Fig. 112:
Processes in decennial rhythm: Development of mining and other industries in Germany.
Source: Fliedner 1981 (fig. 14 and p. 276/7). The sources used by me are listed here. The graphs are based on historical and economic studies and handbooks. They are quoted in the above work.
a) Pre-industrial and early industrial activities: 10-year averages, unsmoothed. To assure comparability, the maxima of the growth rates (foundation dates) were regarded as being equivalent to 100.
b) Mining and industrial production; five year averages, not smoothed. Related to the number of inhabitants.

Fig. 117:
The Creation as described in Genesis. Hartmann Schedel (1493).
Source: Schedel 1493/2004. Sheet VI.

Fig. 120: Genetic expression and self organisation.
Source: Author's own diagram based on Lewin 1997, p. 173 and Chaos, Quarks etc.. 1995, p.79.

Fig. 121:
Shoot and root shape occuring in coastal grasland ("Bottensimsen-Salzrasen") in the western Baltic region. Source: Dierßen 1990, p. 88.

Fig. 122:
Ecological niche, population response to two environmental gradients.
Source: Whittaker 1970/75, p. 123.

Fig. 123:
The basic structure of the foodchain in the ecosystem.
Source: The review of the processes in an ecosystem was already published in Ellenberg (1973), Fig. 1, p. 3.
This graph was used in simplified form by Klug, H. and Lang, R. (1983), Fig. 22, p. 85.
The drawing is based on this simplified graph.

Fig. 124:
The (deserted) Pueblo Pecos (New Mexico), oscillations in field exploitation.
Source: Fliedner 1981 (fig. 10, p. 75).
Position and dating of field houses: field work.
It was possible to date the periods of field utilisation by means of the ceramics found in the houses, but only in the ruins which really represent relics of field houses. Many of these contained datable sherds. However, many of the houses were used not only as shelter during periods of field work, but were also used as temporary accomodation for hunters, as is indicated by the (undatable) stone tools frequently found in them. Uncertain or unsubstantiated data (single houses after 1600, population numbers before 1620) have not be used because the population declined sharply through attacks by nomadic Indian tribes and the arrival of the Spaniards.
The sherds were dated by me in the Laboratory of Anthropology, Santa Fe. For details, literature on the subject and the support which I received, see Fliedner 1981.

Fig. 125:
Tangential rotation in agricultural land of the (abandoned) Pueblo Pecos (New Mexico) before the arrival of the Spaniards (Conquista).
Source: Fliedner 1997 (fig. 12, p. 74). The graph is based on field work, mapping of the field houses (see fig. 10).
Through the position of the field houses, it was possible to determine which parts of the potential field land was actually used at a particular time. Many houses were occupied over several (ceramic) periods. In all, it proved possible to assign around 1000 field houses to a certain period (multiple use counted accordingly). In order to obtain a cartographic picture of the rotation in field utilisation, the following steps were necessary (Fliedner 1997, page 165):
1. Compiling a 16-part compass rose in order to define in which direction (with reference to the main pueblo), i.e. in which sector the ruins of the field houses are located.
2. In order to eliminate statistically the edaphic differences (between favourable and unfavourable parts) in the land, it first had to be determined how many of the datable field houses were distributed over each sector. The average number of field houses existing in each sector was then calculated, thereby achieving the deviation of the actual distribution from the average distribution for each sector. In each case, this can be expressed by a factor.
3. The number of field houses for every sector and period, then had to be determined and the figures obtained multiplied by the appropriate factor. In this way, the statistically adjusted number of field houses in each sector for each period was obtained. The adjusted figure appears in the drawing.

Fig. 126:
The Spanish colonisation of New Mexico 1692 - 1860.
Source: Fliedner 1975 (fig. 3, p. 25/26. For a more detailed description of procedure, see pp. 94/95).
Dating of settlements, migration links: Archives in Santa Fe (Spanish Archive) and Mexico (Archivo General de la Nacion). In addition, datable information in a number of publications listed in the above-mentioned book.
The entry of the individual settlements on the map is based on the first foundation. If a settlement area was abandoned for less than ten years, this was not taken into account.
Criteria for dating of settlement:
1. Written mention: the "merced" documents (= "grant" documents) governing the allocation of land provide important points of reference. In many cases, it was not possible to take account of the fact that the first settlement did not take place until some years after the allocation. In most cases, the land would have been colonised relatively soon as the governor was empowered to re-possess land still uncolonised after a period of three years.
2. With the merced areas of the 18^{th} century relating to around five settlements, it was assumed that the foundation of a settlement took around two years and that the ground was occupied piece by piece. This figure was deduced

from the sequence of merced allocations in relation to the number of settlements in the colonisation phases.
3. The criterion given in 2 above can only be used when all the settlements belong to a planned type of settlement (in particular fields divided into wide strips), and common planning is apparent. If several types of settlement exist and no definite names are mentioned in writing, the basis is less certain.
4. This applies in particular to the irregular small farm groups and block fields in the large Merced areas of the 19th century. In these cases, points of reference are provided only by the censuses, which frequently included wide areas and did not always mention individual settlements by name. In these cases, the dates of foundation were distributed evenly over the period between the granting of the mercedes and the appropriate census date (1850 or 1860).
5. Forms whose dating basis is too uncertain, do not appear in the figures. These are relatively few in number (approx. 5 - 10%).
6. Outside the area shown, there were only very few places of settlement. The migrations between 1692 and 1700 were not entered as these involved mainly people who used Santa Fe as a staging point only, but who came from Mexico or El Paso. Also, the indian pueblos and missions were not shown from 1692, but only from 1700, as in many cases re-settlement took place immediately after the Reconquista.
7. Of the settlements in the border areas, especially in the north (Conejos, San Luis), some were only founded shortly after 1860. For more details on the settlements founded after the colonisation period, i.e. after 1860, see Nostrand 1995.

Fig. 127:
The phases in the colonisation of New Mexico by the Spaniards 1598 - 1860.
Source: Fliedner 1975 (fig. 25, p. 70). The sources used by me (historical plans and documents, literature data, aerial photographs, field work) are listed here (see also fig. 120).
An important aid in identifying the type of settlement is the irrigation ditches dug during the settlement. Without these, definite classification would have been impossible in many cases. The ditches represent a stabilising factor in the development. Land consolidation was carried out wherever roads and railways were built, but these had no effect on the types of settlement.

Fig. 129:
Population-density profile along the main settlement axis in New Mexico 1776, 1860 und 1970.
Source: Fliedner 1981, p. 154.

Fig. 130:
The age structure of the population in the developing and industrialised countries around 1985. According to Bouvier.
Source: Bähr, Jentsch und Kuls 1992, p.183.

Fig. 131:
Diagram of the phases of demographic transition.
Source: Bähr, Jentsch and Kuls 1992, p. 481.

Fig. 132:
Model of population distribution according to coastal distance and degree of latitude on the ideal continent.
According to Staszewski.
Source: Hambloch 1982, p. 245.

Fig. 133:
Carrying capacity (population size) of the earth taking into consideration the development of foodstuff availability, mineral resources, industrial output and environmental pollution.
According to "Club of Rome".
Source: Meadows, Meadows and Randers 1992, p. 248.

Glossary

Acceptance: (According to the process theory) 2nd stage of the basic process.
Action motion: see movement.
Action project: see movement project.
Adoption: In non-equilibrium systems, the 1st stage of the main process in which the stimulus (information) is received and prepared for the production (first part of the induction process).
Alignment: 2nd operation of the emergence code. Here, the previously bundled systems and their former process structure are prepared for a task in the process sequence being formed for the system of higher complexity, i.e. they are aligned for the new system.
Artefact: A product made by man for improved adaptation to his environment, for acceleration and specification of actions and processes, for presentation etc. In the process theory, we distinguish between immobile ("earth-bound artefacts") and mobile artefacts ("media").
Atoms, sphere of: Sphere in the universal system (in the microcosmos, in the 4th sphere, seen from above in the hierarchy).
Autopoietic system: System of the 6th stage of complexity. It reproduces itself materially within the universal system. Example: living organisms, molecules, atoms, solar systems.
Basic process: Smallest process unit consisting of 4 stages. Input (from the environment) - acceptance (in the system) - redirection (towards outlet) - output (into the environment). The content of the stages materialises differently according to the type of process at the different levels of complexity.
Biosphere: Sphere in the universal system. The biosphere (in the spatial sense) is identical with the global ecosystem (in the structural sense). Its position is in the transitional area between macrocosmos and microcosmos (in the macrocosmos the 7th sphere seen from above, in the microcosmos the first sphere seen from above). Probable task: stabilisation resp. perception.
Bonding level: System horizon and element horizon in flow-equilibrium and non-equilibrium systems exist according to their exposure to the flow of information and energy between the superior (energy-demanding) and inferior (energy-supplying) environment, each possessing two bonding levels.
Bundling: 1st operation of the emergence code. Here, the systems of each lower complexity level with their process structure are combined or bundled for the new system of higher complexity being formed.
Carrier: The material skeleton (hardware) of the system which gives the links and processes their stability. Thus, for example, the systems, processes, hierarchical structures and spatial links receive their stabilising framework from their substantial carriers (e.g. matter, populations, individuals).

Cell: Autopoietic system, according to the process theory, an element of a living creature in the biosphere (as part of the micro cosmos). See living creature.
Characteristic group: Statistical group of individuals, which, through 1 characteristic e.g. 1 task, obtains its specific peculiarity. Typical of equilibrium systems.
Chemosphere (chemical sphere): Sphere in the universal system (in the macrocosmos, in the hierarchy 6th sphere from the top). Probable task: kinetisation.
City-umland-population: Population (non-equilibrium system) of mankind as a society, belonging to the 4th uppermost level of the hierarchy. Task: organisation.
Coherence: The holding together of the elements in a system (e.g. of the individuals in a population) caused by the wish or compulsion to make and maintain contact.
Community: Population (non-equilibrium system) of mankind as a species (primary population) and as society (secondary population), belonging to the 5th uppermost level of the hierarchy. Task: dynamisation.
Compartment: Structurally, a flow-equilibrium system in the flow of energy, given material form by a carrier and earthbound artefacts (e.g. group of organisates which compete with one another).
Complexity: State of being all embracing, interwoven, difficult to comprehend, entangled. The term "complexity" has its roots in the greek "πλεκω", which means to weave or tie together, and in the latin "complico", which means to fold or wind together, i.e. different objects are connected with and arranged around one another in such a way that they yield something coherent which we can study in detail and as a whole. A complex formation can be represented as a system which is composed of many parts and elements interacting with one another, possibly showing co-operative behaviour. According to the process theory, this means a fabric of processes, information and energy are exchanged, the individual flows are channelled but also screened from one another. These flows join to form process sequences which maintain or alter the system. Depending on how strongly the flows of information and energy are interlaced with one another and the extent to which the systems demonstrate independence, we distinguish 6 different levels of complexity. Complexity in its actual sense exists when the system does not react linearly to a stimulus. This normally applies both to flow-equilibrium systems as well as more complex systems.
Control process: In non-equilibrium systems, a process at the 3rd process level consisting of 4 control-process stages. The control process regulates the internal relations of the system, especially between the bonding levels.
Conversion process: The process maintaining and altering the non-equilibrium system. The process transforms energy (matter) into products. It is divided into stages. The induction process with 7 task stages is superior environment (e.g.market) oriented while the following reaction process, also with 7 task stages, alters

the system. The tasks must be solved in a certain well defined order. In this way, the system organises itself.
Cultural population: Population (non-equilibrium system) of mankind as a species (primary population) and society (secondary population), belonging to the 2nd uppermost level of the hierarchy. Task: determination.
Determination: 2nd task process stage. Decision on further proceeding, i.e. the stimulus is prepared for the system.
Dimensions, system(ic) (according to the process theory): Measurable extension of basic characteristics through which the size of a system or the position of part of a system can be defined. There are four system(ic) dimensions: quantity (energy of a certain quality, 1), time (2), hierarchy (3) and space (4).
Division of labour: Action projects (equilibrium processes) and flow processes in the production process carried out by individuals or populations (in non-equilibrium systems, hierarchical systems, and the universal system) are divided and then re-assembled according to thematical criteria. They are not carried out by one person after another, but by several persons at the same time. The projects and processes of the various participating workers or populations are adapted to one another in accordance with a plan. The division of labour forms the basis for differentiation, among other things of mankind as a society.
Dynamisation: 5th task process stage: energy is supplied to the elements.
Earthbound artefacts: Immobile constructions and earthworks (buildings, roads, ditches, fields etc.) formed by man.
Ecosystem: Multifarious biotic system belonging to the 6th level of complexity and composed of different types of systems (equilibrium, flow equilibrium-, non-equilibrium systems, hierarchical systems). Man also has his place within the ecosystem. From the point of view of mankind, the ecosystem is the most important energy resource. The global biosphere (in a spatial sense) is identical with the global ecosystem (in a functional sense).
Elements: 1. (according to the traditional system theory): Separable and measurable material and energetic components or parameters of a flow-equilibrium system. 2. (according to the process theory): parts (solida or inferior nonequilibrium systems) of which the system consists. Depending on system type, with varying degrees of independence in the system compound. Example: individual molecules in a liquid, individuals in their roles in a population.
Elementary process: In non-equilibrium systems, processes of the 4th process level consisting of 4 elementary process stages.
Element horizon: In flow equilibrium systems and non-equilibrium systems the two lower bonding levels which bind the system to the (energy-supplying) inferior environment. Cf. system horizon.
Emergence: Etymologically, the term "emergence" is derived from the latin "emergo": to come to the surface, come up, appear. Here, it means the transition from one level of complexity to the next higher level. The elements form themselves into larger units

without this process being explicable in terms of the elements themselves. These transitions can be simulated by 4 operations according to the emergence code.
Emergence code: Code which directs the transition from one level of complexity to the next higher level. 4 operations are necessary (bundling, alignment, interlacement and folding).
Emergence process: Process which executes the transition from a simpler to a more complex type of system.
Energy: The ability to do work. It occurs in various forms, is bound to material or particles of material (foodstuffs, electrical energy etc.) or to energy fields (electrical fields etc.). Energy can be transmitted, distributed (in flow-equilibrium systems) or transformed (in non-equilibrium systems). In the course of the flow of energy, energy must be supplied to the demander qualitatively according to his exact requirements. The quantity manifests the first system dimension.
Energy flow: Transmission, i.e. distribution and/or processing of qualitatively specific energy or matter containing energy (e.g. products) inside or outside the system. The flow of energy must be channelled and, to avoid dissipation, screened off from other flows of energy. In general, the flow of energy leads from the (energy supplying) inferior environment via the elements and the system horizon to the (energy demanding) superior environment which transmits it in turn to the higher system level. The systems are links in chains of energy transfer. The energy flow is optimised in the flow-equilibrium system (3rd complexity level). Examples are product chains in and between populations and food chains in ecosystems.
Entropy: The more differentiated the internal division of a system, i.e. the higher the order, the less risk there is that energy flows are mingled and that energy is lost. The entropy is a measure of disorder. The higher its value, the lesser the order. In the information theory by contrast, the term entropy is applied as a measure of order. From the point of view of the process theory, we use the term (neg)entropy. The system can be re-ordered through differentiation, i.e. (neg)entropy can be supplied.
Environments: (According to the process theory): The completing areas necessary for the existence of systems, divided according to the system dimensions:
1. (Stimulating, energy-demanding) superior resp. (stimulated, energy-supplying) inferior energetic environment.
2. Temporal environment preceding resp. succeeding the process.
3. (Controlling, ordering) hierarchically superior resp. (controlled, obeying) inferior hierarchical environment.
4. Spatial environment adjacent to the system or process (acting as an initial locality and/or an envelope).
Equilibrium process: Movement projects or a group of movement projects constitute the equilibrium system.
Equilibrium system: A system with its elements in energetic equilibrium. 2nd level of complexity. This system defines itself by the number of its elements. It responds linearly to a stimulus. It is altered by movement projects (e.g. action projects) or

larger equilibrium systems. It orders itself. Examples: a statistically measurable characteristic group in a spatial context (e.g. members of a profession, commuters etc.). In earlier publications (so 1993) I called this sytem type “Merkmalsgruppe”.
Ethnic group: Population (non-equilibrium system) of mankind as a species, belonging to the 4th uppermost level of the hierarchy. Task: organisation.
Family: Population (non-equilibrium system) of mankind as a species, belonging to the 6th uppermost level of the hierarchy. Task: kinetisation.
Feedback: With flow-equilibrium systems or more complex systems, regulation of the subsequent course of the process by comparing the supply at the end with the demand at the beginning (e.g. of the induction or reaction process or a process stage).
Fit, accuracy of: Flows of information and energy must connect precisely to one another to avoid noise or dissipation.
Flow-equilibrium system: A system consisting of parts in the flow of information and/or energy, which regulates itself by feedback. 3rd level of complexity. It has tangible form, for example, as a compartment. Information and energy are distributed according to supply and demand. The flow-equilibrium system uses the inferior environment as a source of energy. Between the superior environment as energy demander and the inferior environment as energy supplier, the system is divided into 4 bonding levels. The system maintains or alters itself by means of flow processes and feedback (self regulation). Oscillations are created through a delay in supply (energy flow) in relation to the demand (information flow). Examples: quantities of predators or prey in predator-prey relationships in ecosystems, number of deman-ding or supplying organisates in markets in economic systems. In earlier publications (so 1993) I called this system type “Gleichgewichtssystem”.
Flow processes: The flow-equilibrium system is altered or maintained by flow processes. Distribution process. The 4 bonding levels in the flow of information are passed through from top to bottom and in the flow of energy from bottom to top.
Folding: 4th operation of the emergence code. Here, the second part (e.g. the reaction process) of the newly created process sequence is folded behind the first part (induction process). In this way, the beginning and end of the process sequence are linked with one another in such a way that control becomes possible and the stabilisation of the process can be achieved (i.e. here, the system is created structurally).
Hierarchy: Arrangement of systems in levels. In non-equilibrium systems (individuals or populations) the hierarchy serves to control (through order and obedience) the process sequen-ces. The superior non-equilibrium systems surround and control (usually several) inferior non-equilibrium systems. Manifestation of the 3rd system dimension. It is optimised in the hierarchical system (5th level of complexity).
Hierarchical system: Multiple-stage system, whose hierarchic levels are composed of flow equilibrium systems or/and non-

equilibrium systems (sub-systems). The lowest stage is the level of the elements. For example, mankind as a society consists of 7 hierarchic levels com-posed of populations (at elementary level, of individuals). The hierarchical system creates itself structurally. 5th level of complexity.
- Specification hierarchy: Each level has a task for the hierarchical system in the vertical process, identified by basic institutions. Information and energy transfer by oscillations of flow equilibrium systems (Lotka Volterra relations).
- Scalar hierarchy: Non-equilibrium systems are subdivided, the hierarchical system serves to optimise control. Order and obedience should be equal to one another. A vertical process holds the different levels together.
Individual: Element in the hierarchical system of mankind as a species (as living creature) and as society (in its socio-economic role). Task: stabilisation.
Induction process: Process in non-equilibrium systems consisting of 7 task stages in which the stimulus is accepted from the superior environment (adoption) and the energy from the inferior environment is transformed according to the information (production).
Information: Message which stimulates a system (e.g. a population) to production, maintenance or alteration of itself. The information content reflects the novelty value (the surprise effect). Information can be processed (in non-equilibrium systems) or passed on and spread out (in flow-equilibrium systems).
Information flow: Passing on and/or processing and distribution of information which is qualitatively specific and therefore screened from other flows (of information and/or energy) in order to avoid noise. It may be demand, order etc. The flow of information generally leads from the superior environment down the hierarchy inside the system to the inferior environment.
Initial locality (place, region): Starting area of a stimulus or a process.
Input: (According to the process theory) 1st stage in the basic process. The stimulus is put in.
Institution: (Qualitative) material form of the tasks in a stage of a process in a population or a hierarchic system. Institutions are structered as flow equilibrium systems. In the hierarchy of mankind as a society and as a species, the basic institutions give material (thematical) form the tasks in the vertical process (e.g. religion as basic institution, task: determination).
Interlacement: 3rd operation of the emergence code. Here, the newly formed process sequence is (mathematically) reversed, either from the vertical to the horizontal or vice versa (depending on the type of the new system). In this way, the individual inferior process sequences are interlaced.
Ions, sphere of: Sphere in the universal system (in the microcosmos, in the 3rd sphere seen from above).
Kinetisation: 6th task-process stage, energy is transformed into products.

Living creature, organism: According to the process theory, an autopoietic system, part of the global ecosystem or the biosphere (as part of the macrocosmos).
Long-range effect: Spatial and temporal influencing of systems and processes within the context of an equilibrium system. The intensity decreases with increasing distance from the initial location.
Main proceses: In non-equilibrium systems, processes of the 1st process level consisting of 4 main process stages.
Mankind as a population: Hierarchically the uppermost population (non-equilibrium system) of mankind as a species and as a society. Task: perception.
Mankind as a society: Highly differentiated hierarchical system which has come into being in the course of cultural evolution. The groups of humans and populations are divided up or linked with one another through processes and division of labour. Humans in their roles, through their social and economic involvement, are the essential factor constituting mankind as a society. Secondary populations form the sub-systems, the individuals in their roles, the elements.
Mankind as a species: Hierarchical system which has come into existence in the course of evolution. The man in its capacity as a biological being is the essential factor constituting mankind as a species. Primary populations form the sub-systems, individuals as living creatures the elements.
Market: Economic contact zone between two compartments (flow-equilibrium systems) in mankind as a society and mankind as a species, in which informations, energy and products of the populations (non-equilibrium systems) are demanded, supplied and divided.
Matter, substance: The perceptible material, capable of being shaped, transported, combined with other materials. A system or a structure is concretised through matter (see carrier). Every transfer of energy has to rely on substance.
Molecular sphere, sphere of the molecules: Sphere in the universal system (in the microcosmos, the 2nd sphere from the top of the hierarchy).
Movement, simple: Basic unit of energy transmission (1st level of complexity). A solidum is moved, controlled by the environment. Example: action motion.
Movement project: Basic unit of the processes forming an equilibrium system (2nd level of complexity). The movement project consists of many movements. It is ordered temporally and pursues a uniform aim. Example: action project.
Negentropy: see entropy.
Non-equilibrium system: Entity in the flow of information and/or energy, composed of parts (elements) remote from energetic equilibrium. Information and energy are transformed, products manufactured. The composition of the elements is heterogeneous, division of labour is characteristic. The non-equilibrium system maintains or alters itself through the conversion process which proceeds at 4 process levels which control themselves

hierarchically. Through this differentiation of the process sequence, the non-equilibrium system optimises the time sequence. Examples: biological and social populations, as well as atoms, molecules, cells, organisms which likewise belong to the autopoietic systems.

Organisate: Population (non-equilibrium system) of mankind as a society of the 6th uppermost level of the hierarchy. In the organisate, production takes place in accordance with division of labour. Task: kinetisation. Examples: companies, shops, public offices.

Organisation: (according to the process theory) 4th task-process stage; the system is connected spatially with the inferior (energy supplying) environment. The main process stages of adoption and production or reception and reproduction are linked with one another.

Organism: see Living creature.

Output: (According to the process theory) 4th stage of the basic process.

People: Population (non-equilibrium system) of mankind as a species, belonging to the 3rd uppermost level of the hierarchy. Task: regulation.

Perception: 1st task-process stage: acceptance of the stimulus from the superior (energy-demanding) environment.

Planets, sphere of: Sphere in the universal system (in the macrocosmos, 5th sphere from the top in the hierarchy). Probable task: dynamisation.

Population: Carrier of a non-equilibrium system in the context of mankind as a species (primary population) or mankind as a society (secondary population). Populations consist of individuals who co-operate with one another on the basis of division of labour. They are spatially ordered and delimited, are distinguished by qualitative definability and have a certain task for mankind.

Primary population: Population (non-equilibrium system) of mankind as species (e.g. tribe, people, family). The individuals, as living creatures, are the elements.

Process: The term "process" is derived from the Latin "processus" which means proceeding, progress or from "processio" which can be translated as "advance".

1. In the flow-equilibrium system (possibly wave-shaped) diffusion process (e.g. spread of an innovation). The flow-equilibrium system is changed from one state to another (changing process).

2. In the non-equilibrium system (e.g. population) identical with the conversion process: sequence of stages arranged in a certain order with differing tasks in the flow of information and/or energy. It serves for production (e.g. for the market) and maintenance or change of the system size and/or structure. Through the division of labour and the differentiation of the course of the process (process sequence) the utilisation of time in the system is optimised.

3. Conserving and changing process in the various types of system (e.g. flow-equilibrium and non-equilibrium systems). Either only the quantity of the elements (and sub-systems) is preserved or

changed (size-conserving or size-changing process), or the structure (structure conserving or changing process).
4. Main, task, control and elementry process (see appropriate definitions).
5. Emergence process (see appropriate definition).
Process level: Within the non-equilibrium systems, the main processes, task processes, control processes and elementary processes are carried out (depending on the system dimensions). The processes at the lower levels are assigned to the processes at the higher levels.
Process sequence: Sequence of task processes in which information and/or energy is converted or processed in the non-equilibrium system or more complex types of system (e.g. induction and reaction process).
Process theory: Theory which attempts to explain the flows of information and energy on the basis of the observation that every process is structured within itself and divided into phases, and of analysis of system structures and spaces, and to approach the problems of emergence and complexity in a new way. The starting point was formed by studies of social systems.
Process train: Path of the process sequences.
Product: Product with a certain content of information and energy supplied by populations as a result of the induction process. It is demanded by the superior environment and must fit exactly into the flow of energy.
Production: In non-equilibrium systems, the 2nd main-process stage in which energy is converted in accordance with the stimulus (information). This stage is the second part of the induction process.
Reaction process: Process consisting of 7 task stages in which the non-equilibrium system is maintained or altered according to the results of the preceding induction process. The stimulus is received (reception) and the work executed accordingly (reproduction). The self-organisation of the non-equilibrium system takes place in the reaction process.
Reception: In non-equilibrium systems the 3rd main process stage in which the system is stimulated to maintain or alter itself according to the result of the induction process (planning of self organisation).
Redirection: (According to the process theory) 3rd stage in the basic process. Change in the process sequence in the system from inward to outward.
Regulation: 3rd task process stage. The stimulus is passed on to the elements (e.g. individuals). The elements are coupled to the system (e.g. population) by the stimulus.
Reproduction: In non-equilibrium systems the 4th main process stage in which the system is maintained or altered (concretisation of self organisation) according to the result of reception.
Rotation: Irregular rotation: Shifting of the activity centres (e.g. initial places) in the flow equilibrium systems. The tangential rotation leads around a centre.

Secondary population: Population (non-equilibrium system) of mankind as society (e.g. state, city-umland-population or organisate). The individuals in their roles are the elements. They are related to one another through division of labour.
Self-organisation: Non-equilibrium systems are able to organise themselves chronologically and spatially. See also reaction process.
Solar systems, sphere of: Sphere in the universal system (in the macrocosmos, 4th sphere from the top in the hierarchy). Probable task: organisation.
Solidum: Something created of substance, representing the lowest level of the scale of complexity. Solida move, act or react as a unit and are identifiable as a form. The solid is moved and/or altered (e.g. by humans through actions) thereby transferring energy.
Space: (According to the process theory) Through its attachment to a system type, through specific qualitative characteristics, through a certain position in a process sequence and in a hierarchy as well as through extension and outer limitatio defined order. Space manifests the 4th system dimension. The shaping of space is (in connection with matter) optimised in the universal system (6th level of complexity). Expressed differently: space is that geometrically 3-dimensionally quantifiable scope which is required by the solida and systems for their motions and processes.
Sphere: According to the process theory, the universal system is composed of shells which enclose space and which are arranged hierarchically above one another, the so-called spheres. Each of these is formed by materially and spatially differing types of autopoietic systems (e.g. atoms, molecules, organisms, stars etc.). The result is that the universal system is constructed like the skins of an onion, seen from the point of view each autopoietic system.
Stabilisation: 7th task process stage. Release of products to the (demanding) superior environment.
State: Population (non-equilibrium system) of mankind as a society, belonging to the 3rd uppermost level of the hierarchy. Task: regulation.
Stimulation, stimulus: A process is stimulated by the input of information (e.g. demand for energy).
Structure: Arrangement of the elements of a whole.
1. The temporal structure of a system is identical with the process structure, i.e. the construction and duration of the process between preceding and succeeding environment.
2. The hierarchical structure is formed in the flow of information between the superior and inferior environment. Within the flow-equilibrium and non-equilibrium systems, the system as a whole is hierarchically superior to the elements. In the hierarchical system and universal system, systems as sub-systems at higher levels are superior to those located further down.
3. The systems and processes also enclose the elements spatially. This is why we speak of a spatial structure.

System: The term "system" is derived from the Greek "συστημα", which originates in turn from the verb "συνιστημι" and therefore means something which is a unified whole which is assembled from several parts. Every system consists of a material carrier and possesses a temporal, hierarchical and/or spatial structure. Different types of system can be distinguished: equilibrium system, flow equilibrium system, non-equilibrium system, hierarchical system and universal system. See appropriate definitions.
System horizon: The two upper inner-system bonding levels in flow-equilibrium systems or non-equilibrium systems which represent the whole of the system in close contact with the (demanding) environment. Cf. element horizon.
Task: Typologically defined determination of the content of a system, process, or process stage (perception ... stabilisation). It has to be fulfilled in order to maintain or alter the structure of a superior entity (a system, a process).
Task process: The 2nd process level in the non-equilibrium system process, consisting of 4 task process stages in each main process stage. By combining these, process sequences of 8 (through overlapping of the final and initial stages 7) (induction or reaction process) or 16 stages (total process) may exist.
Time: (According to the process theory) Succession of events in a system which is divided up by the process sequence in the course of the flow of information and/or energy. Time manifests the second system dimension. It is opened in the equilibrium system (2nd level of complexity) and optimised in the non-equilibrium system (4th level of complexity). Expressed differently: time is a linear span defined by measuring devices which the motions of the solida or the processes of the systems require and utilise.
Tope: Smallest non-divisible delimited unit in the flow of energy at the corresponding level of scale, concretised by a carrier (e.g. a small department of an organisate) and permanent artefacts (e.g. work room). Ecotope is the smallest unit of landscape with an internally unified functioning ecological structure.
Tribe: Population (non-equilibrium system) of mankind as a species, belonging to the third and/or fourth uppermost level of the hierarchy. Task: regulation and/or organisation.
Twin processes: Conversion processes consist of induction and reaction processes which follow two different process trains. These cooperate with each other.
Universal system: (According to the process theory) The whole of the universe composed probably of 16 spheres (or 13, due to overlapping) in the macro and microcosmos. 6th level of complexity. The spheres are distinct from one another materially and spatially (e.g. the sphere of the molecules from the biosphere) and have their specific task as elements in an overriding process sequence. Materially, the spheres are composed of autopoietic systems (e.g. molecules, organisms). A hierarchical order exists. The biosphere has the position of an intermediary between the microcosmos and the macrocosmos. The spheres of the macro and microcosmos are linked with one another functionally and

spatially in pairs in such a way that the autopoietic systems in the microcosmos are the elements of the autopoietic systems in the macrocosmos (e.g. the cells are the elements of organisms, molecules the elements of chemical systems). Thus, the universal system creates itself as a substantial and spatial whole.