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der Universität des Saarlandes

Sonderheft 3

Dietrich Fliedner

Physical Space and Process Theory

Some Theoretical Considerations from
an Historical Geographic Viewpoint

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Physical Space and Process Theory

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Vorwort der Herausgeber

In der Publikationsreihe „Arbeiten aus dem Geographischen Institut der Universität des Saarlandes“ sind bereits in den Jahren 1968 und 1970 zwei Sonderbände publiziert worden. Die Arbeiten LIEDTKE: „Pfälzer Wald“ und FAUTZ: „Neuseeland“ wurden damals als Sonderbände veröffentlicht, weil sie aus finanzierungstechnischen Gründen nicht in den wissenschaftlichen Schriftentausch des Geographischen Instituts der Universität des Saarlandes einbezogen werden konnten.

Jetzt haben sich die Herausgeber der „Arbeiten“ entschlossen, die Sonderserie fortzusetzen. Allerdings ist die Zielsetzung eine andere. Die Sonderserie soll nun solche Hefte, meist geringen Umfangs, umfassen, die keine abgeschlossenen Monographien enthalten, sondern methodisch neue Forschungsansätze, erste Ergebnisse von Forschungsarbeiten, sehr spezielle regionale Untersuchungen aus dem Nahbereich der Universität des Saarlandes, angewandt-geographische Projektstudien und anderes, also Studien zu sehr heterogenen Themen. Insgesamt werden die einzelnen Hefte den Charakter von Diskussionspapieren haben, die die methodologische Diskussion fördern, zu Vergleichsstudien anregen, alternative Lösungsvorschläge provozieren sollen.

Die Sonderserie ist für einen systematischen wissenschaftlichen Schriftentausch wenig geeignet, weil sie Themen behandelt, für die sich manche Tauschpartner nicht interessieren. Es ist daher vorgesehen, die Hefte selektiv und gezielt nur denjenigen der Tauschpartner (zusätzlich zur Hauptserie) zuzustellen, bei denen ein Interesse an dem jeweiligen Thema vermutet werden kann. Alle Tauschpartner der Hauptserie werden über die Publikationen in der Sonderserie informiert und können bei gegebenem Interesse die Hefte (auch die Sonderbände 1 und 2) anfordern; sie werden ihnen dann im Tauschverkehr überlassen.

Die drucktechnische Gestaltung der Hefte der Sonderserie (die ab dem vorliegenden wegen des normalerweise geringen Umfangs nicht mehr als „Sonderbände“ sondern als „Sonderhefte“ bezeichnet werden) wird der der Publikationen der Hauptserie weitgehend entsprechen; es ist lediglich eine andere Farbgebung des Umschlags gewählt worden.

Die Herausgeber der „Arbeiten“ hoffen, mit den Sonderheften einen breiten Kreis von Interessenten auch außerhalb der engeren geographischen Fachdisziplin anzusprechen und damit die interdisziplinäre Zusammenarbeit zu fördern.

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Introduction

It is strange to note that the discussion of the physical traits of space has, with few exceptions, shifted on the one hand into atomic, and on the other into cosmic dimensions, thus departing from the historical geographic order of magnitude and from the sphere of experience of Euclid and Newton. As a result, the amount of apparatus and mathematical effort put in has steadily increased, while at the same time, the scientific works on the subject have become less and less accessible to the representatives of other disciplines, and more and more difficult to fathom.

On the other hand, the discussion of theories relating to space are of paramount importance to geography and history, sociology and anthropology alike; these sciences are thinking in three-dimensional space¹⁾, but it seems clear, that the actions and processes taking place in human society, and between human being and the environment, are only comprehensible in a spatiotemporal context. In physics for more than half a century four-dimensional space is a basic assumption, but a comprehensive theory which unites space, process, hierarchy, matter, structure, and energy is not yet achieved. The following paper will be an attempt to approach this subject-matter in the historical geographic order of magnitude again, from the point of view of human society. The treatise is based on inductive theory and is concerned with mankind and its populations in the environment, as well as its systemic build-up and the processes maintaining or changing it²⁾. An investigation of structures and processes in the world of our daily experiences has the advantage of direct observation.

Although this paper is written by a geographer, the addressees should be first of all natural scientists, especially physicists and astronomers. Later on, in a second step, the position of geography, history, sociology, anthropology and other sciences in the frame of this theory should be examined.

May a non-physicist and non-mathematician thus be permitted to present some findings and considerations that could be of interest for discussions of physical space in general.

The hermeneutic approach was given special attention for this purpose, according to which the meaning of the phenomena and processes on society or nature is sought and an interpretation attempted from there³⁾. The chief object of these lines is to introduce the basic theoretical conception, though a subtle discussion of the thoughts related to existing physical theories is not intended. This aspect will have to be dealt with in later papers. The same goes for the formalization of the statements made. It is my opinion, that theories must first be conceived verbally as logically self-contained constructs before a mathematical definition can be ventured.

System and process

Energy may be interpreted as an attribute of physical space; its existence becomes manifest when a division is made between order and disorder. According to the second law of thermodynamics, order would change into disorder if energy were not added⁴). To arrange in order means reducing entropy to facilitate the flow of energy. When a large number of elements are connected in such a way that the unrolling of specific processes is made possible, we refer to them as ordered. The ordered elements constitute a system and this in turn is not isolated, but has a certain meaning and function, namely to enable a process to come about for the maintenance or enlargement of a superior system⁵). The terms system and element are here conceived of as capable of being localized in a concrete sense, and of being delimited against an environment.

In human society, populations, e. g., families or peoples, constitute such systems (Table 1). Of course, this does not mean that human decisions are predetermined, though they too must be governed by certain physical rules. Due to this, the creation of systems theoretical models that overlap into various disciplines, as practiced in the natural sciences as well as in the Arts, is possible. The human populations are in themselves arranged in hierarchical and (three dimensional) spatial patterns, are provided with a supply of energy and accomplish certain tasks, i. e., they are the sustainers or carriers of processes, under charge to a superior population, for which they produce certain forms of energy. Populations thus only exist in a flow of energy. They convert energy and refine it, so that it can be assimilated by the superior population. With regard to the refining process itself (internal linkage of the system-elements), populations are closed systems, and with regard to their incorporation into the environment and the superior flow of energy (outer linkage), they are open systems⁶).

Let us next take a look at the population in the flow of energy:

At the beginning, the population registers an additional requirement of specific products, i. e., of refined energy in the superior system, as a consequence of increasing entropy in the latter. At this point, a process is set into motion in order to close this requirement gap. It ends with the delivery of the product.

The increase in production is exponential, as in the course of time more and more elements (= the inferior systems or populations) take part in production. Then the superior population signals saturation of the additional requirement in these products. At this point, the process changes its trend; less and less new elements become involved, until a certain production level is reached in the population. There is generally even a short-term overshooting of the process. Then production fluctuates around a certain

processes resp. populations	task categories	perception	determi- nation	regula- tion	organiza- tion	dynami- zation	kineti- zation	stabi- lization
social processes (adaptation)	induction processes	magic science education („bildung“)	religion	govern- ment power	traffic	economy (input, in- vestment)	economy (production)	trade
	reaction processes	emergence of encoun- ter groups	division of labor (groupings with di- stinctive charac- teristics)	social strati- fication (hierarchy)	emergence of city- umland- population	emergence of aggre- gates	emergence of process- sequence	emergence of sec- ondary po- pulations
biotic processes (reproduction)	induction processes	art	conception of the world	limitation, reproductive isolation	migration	adaptation, consumption	propagation (production)	coloniz- ation
	reaction processes	?	emergence of lifeforms (groupings with di- stinctive charac- teristics)	diplomacy	concentration	emergence of lifeforms (aggregates)	generative behaviour	emergence of primary populations
performing resp. emerging populations	primary population	race ?	tribe, people	ethnic group	local group	family		
	secondary population	mankind	cultural population	state population	city- umland- population	community	organise	individual

Table 1: Important processes, institutions and populations maintaining the mankind

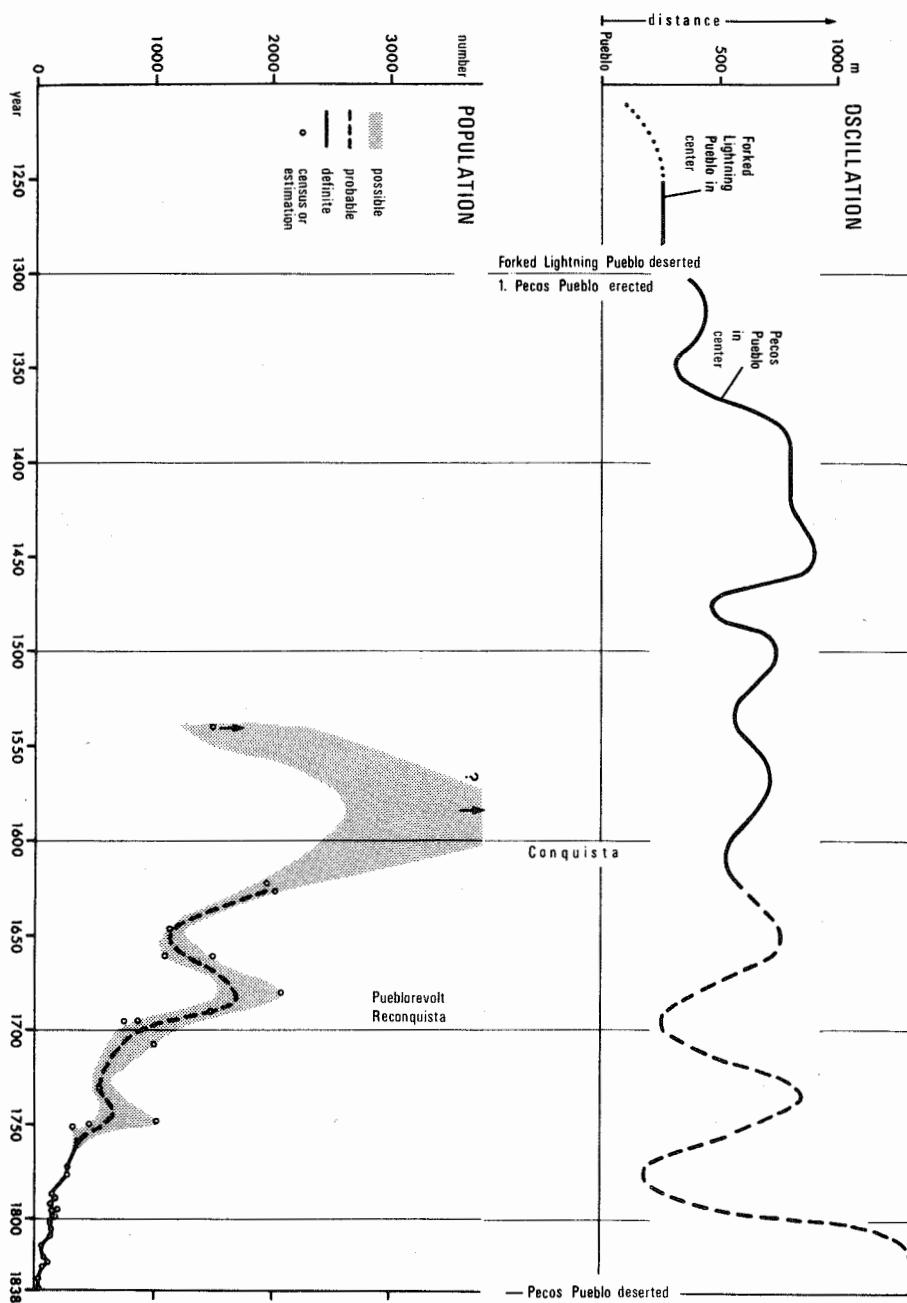


Fig. 1: Pueblo Pecos, ca. 1250—1838 A. D., population numbers and medium distance of the tillage area from the village (Source: D. Fliedner, cf. note 2 and 9)

value. The system has reached a new state. Thus the process ends⁷⁾. As against the exponential increase, there is a logarithmic decrease in growth, so that a logistic curve comes about. Underlying this is the Boltzmann equation $S = k \log W$ (where S stands for entropy, W for the probability and k for a factor). In agronomy and economics, the "law of diminishing returns" is referred to⁸⁾.

If in the course of the process, the population which required the products is supplied sufficiently, it can accomplish its tasks, i. e., it can expand its own production. Thus one process entails the next one. Let us, as an example, take a look at the behaviour of the Pecos tribe in its natural environment. This Indian population lived in New Mexico until well into the last century. An investigation revealed that population numbers and the area of cultivated land were increased resp. decreased in a rhythm of approx. 60 years (Fig. 1)⁹⁾. Apparently the reproduction of people and the production of food were related to each other (Fig. 2):

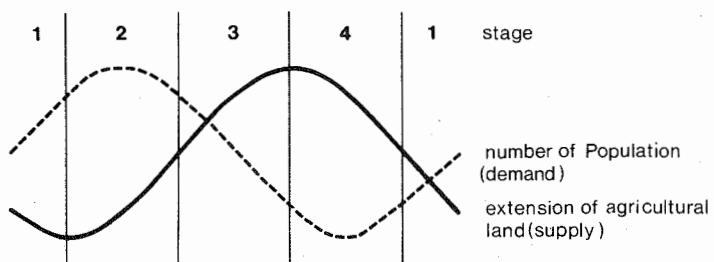


Fig. 2: Mutual influence of population numbers (amount of consumption) and field area (amount of production). Schematic diagram

1st stage: population numbers increase, food becomes scarce;

2nd stage: population numbers exceed their maximum due to food scarcity. Meanwhile, fresh woodland is being cleared in order to increase the yield;

3rd stage: population numbers drop, the agricultural yield increases;

4th stage: food-supply exceeds demand the cultivated area decreases. The trend in the development of population numbers passes through its minimum.

Here, two processes influence each other. The first process emanates from the population as a biotic unit and consists in the reproduction of the population, serving to maintain the population as a constituent part of mankind. As such, it is superior to the other process, the production of food, which emanates from the population as a unit of working human beings. The re-

production of the population is a biotic process, and the production of food a social one. Basically, it can be stated that the success of the social processes enables the human species to prevail over the other species in the living world (on the hierarchy of populations and processes, cf. below).

The two kinds of production do not, however, have a direct influence on each other. Rather, the population with its individual human beings interpolates. The individuals are the producers and consumers. As producers, they participate in the processes with their activities; thus they play specific roles in the systems¹⁰). The individuals of the Pecos people, for instance, were involved in the economic production and in the biotic reproduction. On the other hand, they had a specific requirement as consumers that had to be covered to enable them to exist and to accomplish their tasks for the population. The intake-capacity of a population as the carrier system of the processes, limits the production. In order to facilitate a further increase in production within the scope of the one process, the production in the scope of the other process must be expanded. However, the two processes are insufficiently adjusted to each other. Not until a certain amount of energy has been produced resp. converted in the course of one process, is the population stimulated to set the other process in motion.

If the processes cannot be better adjusted to each other, oscillations arise, i. e., the population (number of individuals) and the productive area of cultivation expand or contract in a certain rhythm. Seen another way, a constant alternation of absorption and flow off of energy results from contacts between the processes (i. e., food production and reproduction of population), brought into connection by the working and consuming population.

However, changes in the internal linkage within the system, i. e., in the population-structure, also take place in a corresponding rhythm, in adjustment to the requirements of each process. The energy coming in from outside and originating in the preceding process, acts as a stimulus to the process being carried out by the populations as a whole. However, the structure of the population is fashioned from below, by the individuals as system-elements. They are involved in the flow of energy of the population system, require a certain input for their own existence and, on the other hand, they have to refine a certain amount of energy, i. e., produce, if they want to secure their existence. In this way they are kept in a kind of equilibrium in the energy-flow¹¹).

In the energy-flow, differentiated populations are structured heterogeneously in themselves. This is conceivable with regard to 1) (substantial) differences (linkage-density, cf. below), or 2) (temporal) succession, or 3) (hierarchic) superposition, or 4) (spatial) juxtaposition. The fact that this corresponds to the coordinates in four-dimensional space, shall be shown later on.

If the individuals do not differ in their positions in society, each one of them has to carry out the work (according to the seven task categories, cf. below) necessary for self-maintenance, on his own. Interactions related to these

activities do not exist, so that we cannot yet refer to a population as a system. If population density is too high compared to the amount of available, i. e., self-produced, refined energy, stress will arise. Certainly, every individual has a certain amount of free play and can be stressed within certain limits, like any other system; but strong competitive pressure causes input to fall below the limits of tolerance, so that change is aspired to. Every individual, as a consumer with a certain requirement, is first and foremost obliged to secure his share for himself. As all individuals try to do so, production has to be increased. One way out is specialization, a qualitative separation of competences and actions¹²). Each step in the process-sequence (cf. below) requires a different input of information or raw materials compared to the preceding or following step, according to the exponential increase in energy in the course of the process. It may be significant that the individuals, being provided with different traits, can choose their professions, i. e., their roles, in the process-sequence according to their qualitatively different talents. But even more important is the fact that the operational steps can be coordinated, so that much useless labor (e. g. in the transportation of goods) can be avoided. So the flow of energy is facilitated. The less the different processes merge, the lower entropy is. The more distinctly separate the individual activities are, the clearer they can be linked up, in a substantial sense, in temporal succession, hierarchic superposition and spatial juxtaposition. These interactions cause the previously undifferentiated mass of individuals to form a system, a differentiated population. Due to the increase in production, reflected in the higher amplitude of the waves of the oscillations, a greater number of producers and consumers, i. e., of individuals, can participate. Thus, population density can increase. The population can better stand its own in the competition battle with other populations. According to the degree of differentiation, we distinguish between primary and secondary populations (Table 1).

Therefore 2 types of processes can be distinguished:

1. the induction-process, emanating from the superior system; the population receives energy, refines it and passes the products on to the system next in line in the flow of energy;
2. the reaction-process, emanating from the system-elements; the elements receive their positions according to their capabilities, with the aid of selection mechanisms, so that the system is provided with a structure, or order. Reaction-processes produce negentropy.

In the course of the oscillations, the two kinds of processes are connected in sequence (cf. below). Induction-process, reaction-process and population together define energetic space. Thus, space and time are not regarded as self-sufficient absolute quantities, but are interpreted as dependent on the energy content¹³). [It may be assumed that the physical background of the biosocial oscillations, which are referred to in this context, does not differ basically from that of the mechanical and electromagnetic oscillations; if so the definition of space would claim to be of general validity.]

Process-sequence

The processes are subdivided in themselves again and consist of partial activities or process-stages. To start with, the induction-process, on an individual level, as an action¹⁴). Throwing the ball in a game of basket-ball shall serve as an example:

1. Receiving the ball; the team expects it to be passed on (input in the individual system): perception
2. Decision on subsequent behaviour (whether to pass the ball on another player or to aim at the basket, etc.): determination
3. Action-planning, i. e., planning the shot: regulation
4. Getting ready to throw, getting into position: organization
5. Directing the body's energy to action, raising the arm to throw: dynamization
6. Throwing (as "production"): kinetization
7. Taking back the ball by the team (output of the individual system). Player returns to his previous position in the team: stabilization. (Successful or unsuccessful throw stimulates learning-routine as a reaction-process in the player).

This single action shows a sequence consisting of 7 stages. However, not only individuals, but also, as stated above, the populations as systems are units with certain tasks to accomplish and are structured along these lines. Thus in their case, a process-sequence can be noted. This shall be demonstrated by the establishment of an industrial plant:

1. An industrial syndicate infers from the economic situation on the market that there is a demand for certain products: perception
2. Deciding on the development of a plant: determination
3. Planning the operational steps and priorities: regulation
4. Establishing the locality and the dimensions of the building: organization
5. Procuring material, building the plant, equipment with machines (investment): dynamization
6. Production: kinetization
7. Absorption of the new products by the market (adjusting the production volume to a certain level): stabilization

In general, the process-stages can be defined as task-categories¹⁵:

Perception: due to the demand, process stimulation, and thus general orientation, by the superior system (information input)

Determination: decision, task-setting, process specification

Regulation: planning, transfer to inferior, and thus controlled systems or elements (information output)

Organization: arranging the spatial order (conceived of as three-dimensional) of the process between the elements (of the same order of magnitude)

Dynamization: absorbing energy from the inferior, thus controlled systems, and energy-transfer, so that production can take place (input of raw materials and raw products)

Kinetization: production (in accordance with determination)

Stabilization: products are passed on and taken up by the demanding superior system (output). (This stimulates adjustment of the system to new production volume in the reaction-process.)

In a concrete sense, the processes become manifest in innovations, i. e., in changes in the type and orientation of production¹⁶). They usually occur several at a time and cause an increase in production. By this means, the specific task of the process is to be accomplished. In the individual process-stages therefore, the way in which the system-elements are linked varies (cf. also Fig. 4). Step by step the energetic linkage density in the system (information, products) increases in the course of the process-sequence; i. e. the task-categories, which are characterized at first only in a qualitative way (perception, determination, etc.), can be defined quantitatively by linkage density. Thus qualitative traits are measurable, at least in principle¹⁷).

The sequence of process-stages is irreversible and binding if the process is conformed to the system, i. e., if it serves the flow of energy. This is a consequence of the second law of thermodynamics¹⁸). There is, however, an extensive temporal overlapping of the process-stages (Fig. 3). Process-stages that were not successfully brought to completion are usually repeated, whenever this is possible. On the other hand, two process-stages can be carried out in one oscillation phase. In the first case, the process-development is slower, in the second case it is faster.

In the last, or stabilization stage, two directions of development should be distinguished:

1. the input, i. e., the transfer of the products causes the superior population to turn to its next task. In the sequence of the superior population, this means kinetization, while taking over the products means dynamization (Fig. 4)
2. on the other hand, stabilization causes the start of the restructuring of the population itself by the reaction-process, emanating from the elements.

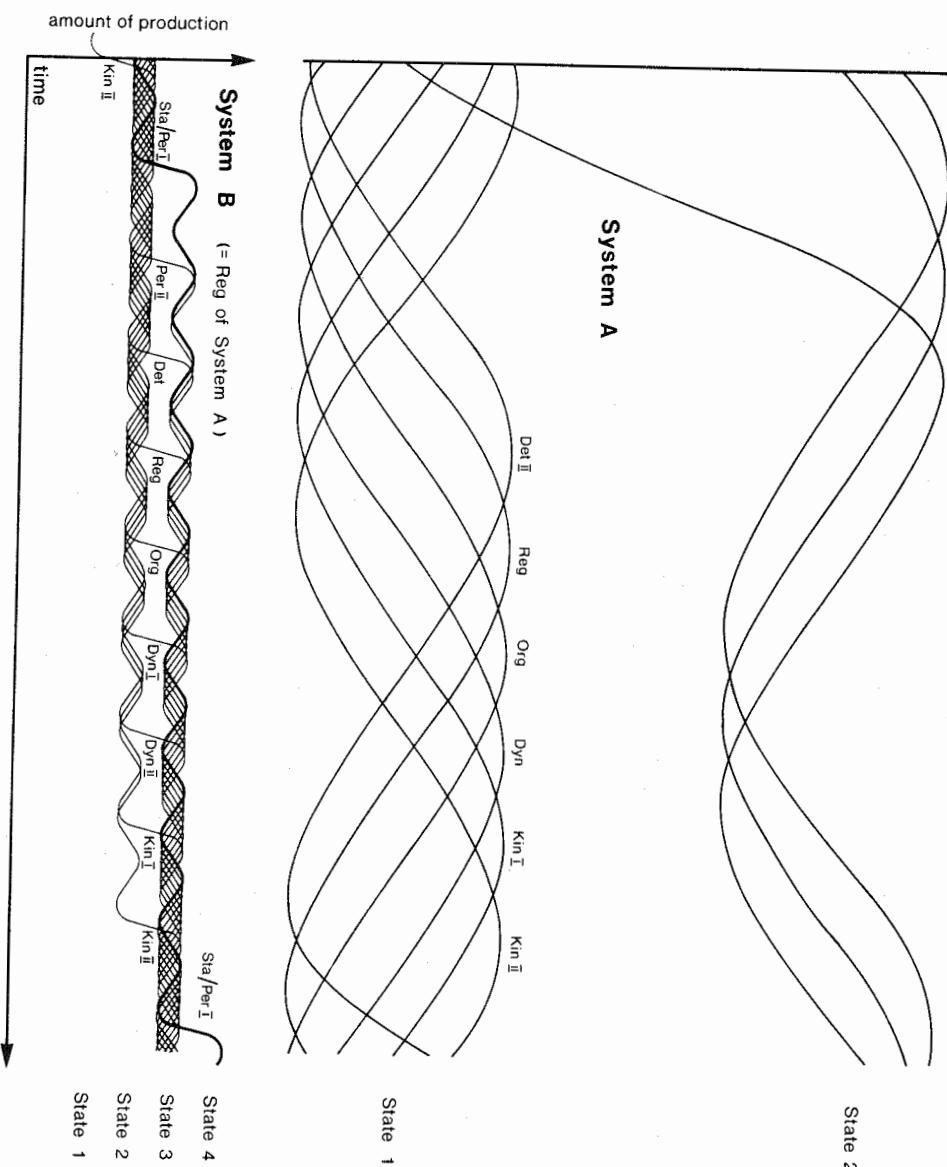


Fig. 3: Oscillations and process-sequences in two orders of magnitude.
Schematic diagram

The reaction process creates structural traits that facilitate further induction-process. Such structural traits are:

Perception: contact groups at the population/environment boundary surface; they facilitate input, the receiving of information from the superior system.

Determination: classes of traits brought about by the qualitative separation of elements oriented in the same way. Division of labour. Thus, the operational steps in the course of the process can be established.

Regulation: vertical ranking of the elements which are arranged during the determination stage. Enables the population to control and stimulate the inferior populations and individuals as system-elements (cf. below).

Organization: ring structure; in space (conceived of as three-dimensional), the flow of information is optimized between the elements from the center to the periphery and the flow of products from the periphery to the center (cf. below).

Dynamization: aggregate structure; concentration of elements of the same kind to form homogeneous sets (cf. below). Enables the system to take over the products supplied by the inferior populations and individuals. Thereby a selection takes place between the elements.

Kinetization: production-sequence, in the course of which the refining of energy by the previously arranged elements is optimized.

Stabilization: the population in its environment. Enables the delivery, the output of the products to the superior system to come about.

The performance of the concrete induction-processes is made possible by institutions (Table 1); they give them significance, contours and steadiness which allow them to keep on course. Such institutions are e. g. the economy, government, traffic, involving patterns of structure, feasibility of control (norms, rules etc.), establishments etc.¹⁹⁾. They are products of the reaction processes and constitute the internal linkages of the systems according to their determination. Institutions may be considered as strategic arrangements of society. Due to the existence of the institutions, all processes could be regarded as inertial systems. The processes may finish earlier (under influence from outside, for instance), but cannot be altered as far as their objective is concerned.

Reaction-processes change the structural traits of the population in the opposite direction to that used by the induction-processes, like the retroaction resulting from traffic congestion (Fig. 4): So in the course of the

Reaction-process, the structural traits serving the	Induction-process
Perception phase	" Stabilization phase
Determination phase	" Kinetization phase
Regulation phase	" Dynamization phase
Organization phase	" Organization phase
Dynamization phase	" Regulation phase
Kinetization phase	" Determination phase
Stabilization phase	" Perception phase
become altered.	

This countercurrent motion is made possible by structural symmetry as

1. the system-character of the population is defined by the interconnection with the environment on the one hand (perception), and internal cohesion on the other (stabilization)
2. the division of labour on the one hand (determination), means a modelling of production units and sequences on the other (kinetization)
3. the hierarchy signifies a superposition of aggregates on the one hand (regulation), which on the other hand are homogeneous in themselves (dynamization) and
4. the ring structure consists of a radial succession of aggregates which allows both a centrifugal flow of information and a centripetal flow of material products (organization).

Thus energetic space is symmetrically oriented from a structural viewpoint, but asymmetrically from a kinetic viewpoint²⁰.

If we look at the populations as the carrier systems, we see a discrete structure of the society; if we look at the counter-current motion of the processes on the other hand, we might regard the populations as standing waves. The processing and transfer of the energy takes place in quanta²¹). All processes in society have fundamentally the same structure. [We suppose that this is also true of the processes in inanimate nature.]

Hierarchy

The induction and reaction processes are, as mentioned above, arranged in an opposite sense in the hierarchy²²). The induction-process, going out from the whole population, follows a downward course in the hierarchy with its subordinate systems until it reaches the individuals (Fig. 4). Thus it is divergent and controlled; there is an exponential dispersion of information. The transfer of products in the stabilization phase is carried out by the individuals and inferior populations; it leads back to the superior, demanding population. At this point, the reaction process simultaneously starts, emanating from the individuals to the respective superposed popu-

lations. The process thus follows an upward course and is, inasmuch, logarithmically convergent and uncontrolled.

The structural transformation brought about by the reaction processes, takes place in order to maintain the structures of the superior populations. Otherwise the latter would disintegrate, due to the fact that entropy grows in closed systems. In accordance with the process-sequence in six stages (or together seven, but the stabilization phase is identical to the perception phase of the following process-sequence), the reaction-process strives to create a social structure consisting of six levels. For the induction-processes maintaining mankind in its entirety as a society, e. g., the cultural populations have to take care of determination, the state populations of regulation etc. (Table 1; Fig. 4).

In this way, the induction processes maintaining mankind, are given stable persistence. This hierarchy, consisting of six, or if the individuals are also counted, of seven levels, is fully developed in the European (-North American) cultural population, while it is only starting to develop in less differentiated cultural populations with their tribes and local groups (e. g. Pueblo cultural population which the Pecos Indians belonged to). As a rule there is also evidence of hierarchization within the populations (social stratification)²³).

The number of populations thus increases exponentially from the top to the bottom, from mankind to the families (resp. organisates; Table 3; Fig. 4) and individuals. According to the degree of differentiation, a further factor needs to be added. In primitive societies it is smaller than in societies with a highly differentiated social structure.

The duration of the process-phases reveals a basically corresponding hierachic arrangement. The latter differs fairly exactly from one population level to the next by the factor 10, a fact that may be considered a consequence of entropy which increases in the course of the process. There are thus 10 phases available for six successive process-stages. In order to be able to carry out the induction-process via the sequence (despite growing entropy), energy must, as we have already established, be supplied to the population (dynamization). As the process procedes, production is speeded up; from mankind (as a society), down to the individual, the phase duration is squeezed together from one process-stage to the next, from 5000 years down to a single day (Table 3; examples, Fig. 6).

By differentiation, not only the induction-process is subdivided, but also the reaction-process, as every process-stage of induction is followed by the reaction (Fig. 3).

The social processes in the populations are, first of all, induction processes, they are controlled. As stated earlier on, the uncontrolled reaction-processes connected with them, serve the purpose of providing a social structure for mankind. Thus the reaction processes, as mentioned above, cause growing differentiation; they could be regarded as parts of the biotic evo-

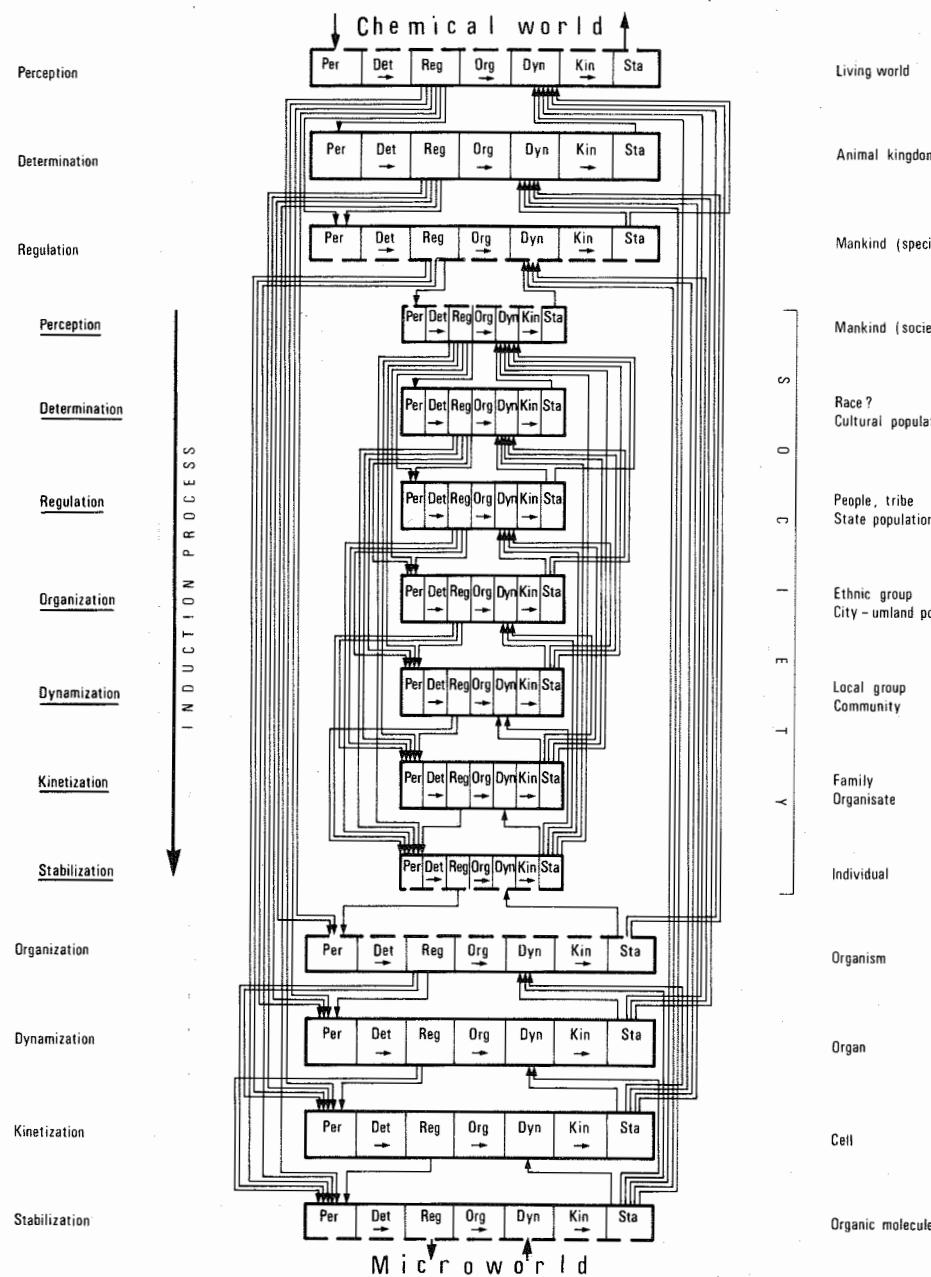


Fig. 4 A: Hierarchic order of living world and human society. Induction processes

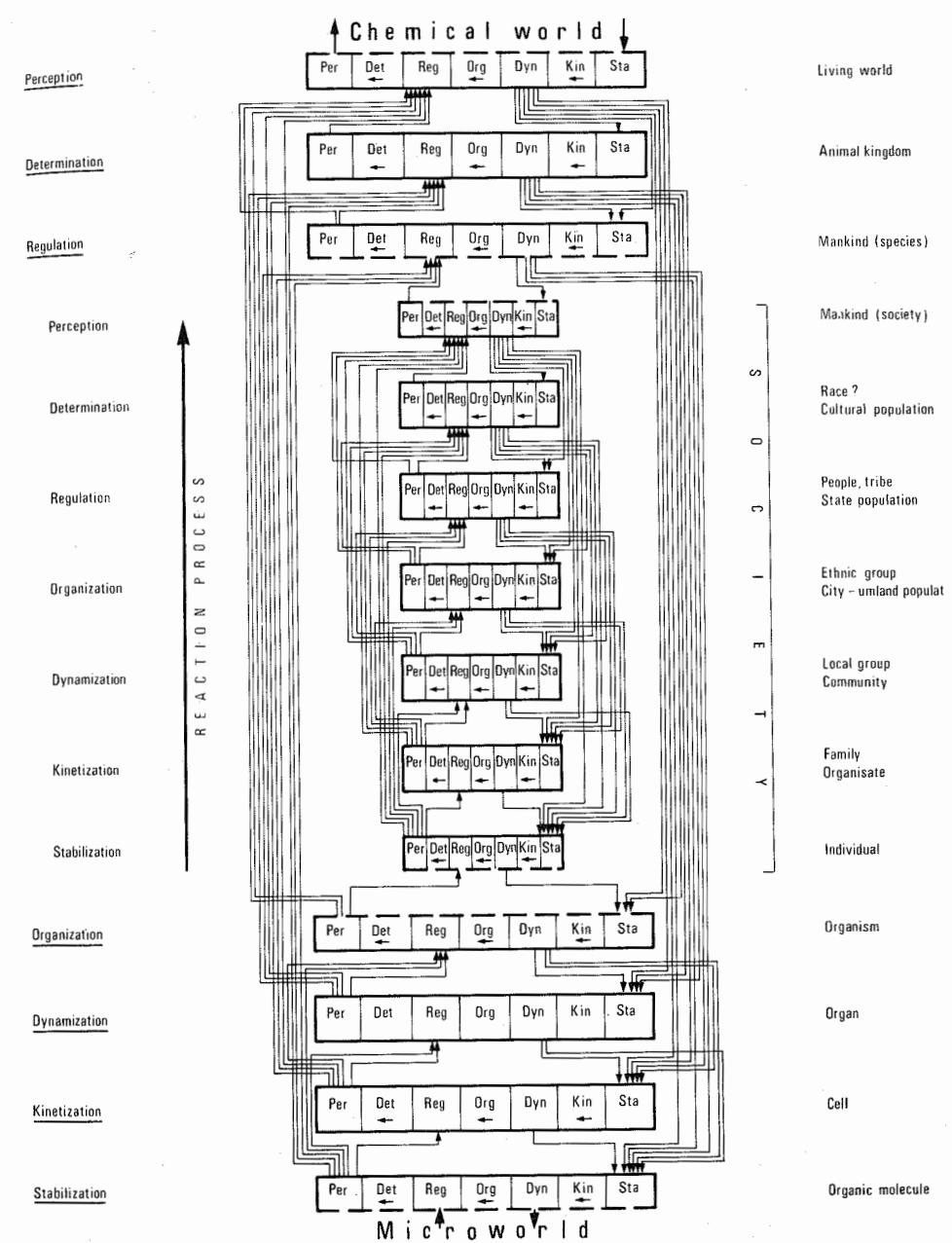


Fig. 4 B: Hierarchic order of living world and human society. Reaction processes

lution, as the superposed process, whose populations as carrier systems represent the living world in its entirety²⁴⁾. Mankind as a society provides energy for mankind as a biotic species (cf. above). In this superior process, it takes care of dynamization, on whose success kinetization, i. e., the reproduction of the population, depends (as was shown in the beginning using the Pecos population on a tribal level as an example). Human beings have been particularly well able to stand their own against the other species, due to their social performance. Evolution as a whole must be assessed as a reaction-process. In the sequence, it follows a course from the smaller units in hierarchy to the larger ones and is thus convergent and thereby uncontrolled (Fig. 4). The selection principle takes effect. The induction-process belonging to this system consists of processes that are peculiar to the species, also including for instance, the social processes of mankind. On the living-world level, the induction-process recedes into the background. Conversely, the induction-processes must be considered dominant on the level of the species and the pertaining reaction-processes on the other hand, as receding and serving them (Fig. 4). In the living world, the fashioning of substance is the principal "product" of the process sequence.

[In extrapolating the previously developed ideas some — perhaps speculative — thoughts may be added:

The distribution of the tasks within the hierarchy of the living world can be established with fair certainty. In the molecules, information is formed and fixed (perception). The cells are always the same in their basic make up, but fashioned in a specific way, according to their tasks or functions (determination). The organs regulate the flow of information and energy (regulation). In the organisms, they are arranged in (three-dimensional) space, and are adapted to their position in the ecosystems (organization). The species take care of dynamization (cf. above). The plant resp. animal kingdoms constitute the large units with homogeneous production (kinetization), and the living world as a whole faces the inorganic world and must become stabilized in the latter as its environment (stabilization).

One could go one step further on the hierachic step-ladder, to the universe, which seems to consist of several types of worlds with different features. If we regard the universe with the maintaining processes as an energetic space as well, we must attempt to interpret these worlds as agents accomplishing certain tasks (Fig. 5). Our living world and the inorganic world (which itself is represented e. g. by crystals, rock layers, continents) will belong as sub-types to the chemical world in which the conversion or refining of energy is optimized. We could thus describe its task as kinetization. The living world is given a special position therein, for the organisms, as elements of the living world and energy carriers, can reproduce themselves. In the microworld, (which consists e. g. of atom particles, atoms, molecules), the stabilization of all processes of the universe must take place, it seems to terminate the universe at its basis. Above the chemical

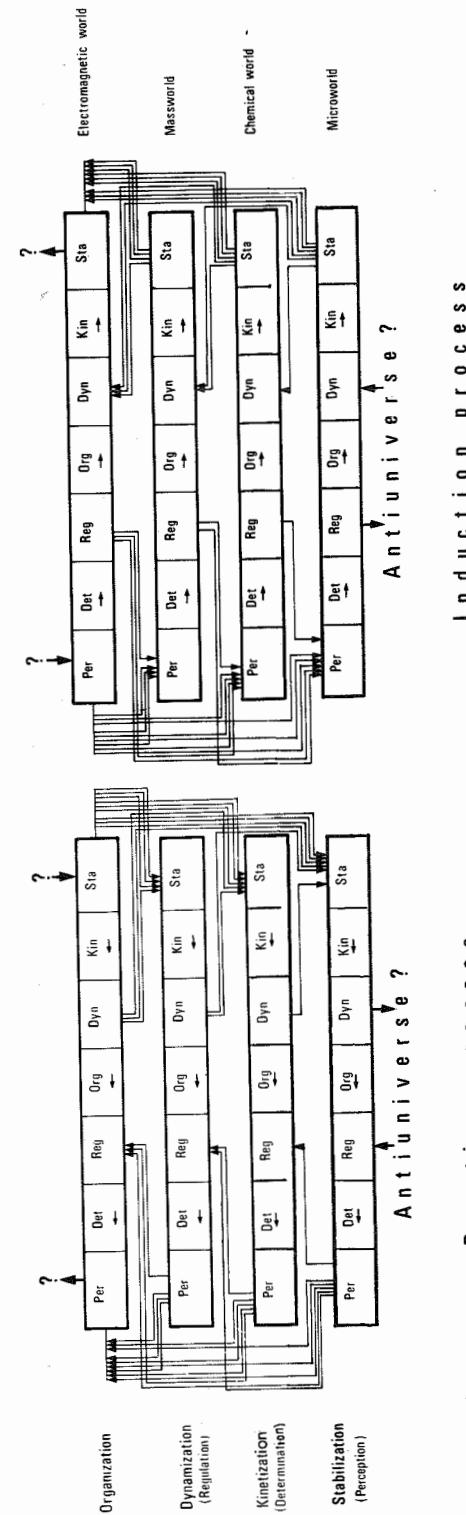


Fig. 5: Hierarchie order of the universe.

world, we suppose the existence of the massworld, covering the stellar order of magnitude (represented e. g. by stars, planet systems, galaxies).

This world appears to provide optimal conditions for the production of material, thus representing dynamization. Electromagnetic forces, as autonomous physical phenomena, seem to guarantee (3-dimensional) spatial order in an ideal form. Thus, one could imagine that there exists an electromagnetic world, superior to the massworld, in which organization is optimized. Each of these worlds seems to possess a specific speed of production (cf. below).

One could expect there to be, according to the process-sequence, even greater worlds above the electromagnetic world, unknown to us, in which regulation, determination and perception take place. If this should be the case, it cannot be substantiated, for spatial order can only be recognized as "gestalt" as a result of organization and particularity of the reaction process, due to the electromagnetic field and the radiation related to it (cf. below). Thus we can assume that the hypothetical electromagnetic world is the greatest of the worlds. Control (regulation), task-setting (determination) and information-intake (perception) resp. hierarchy (originating perhaps in polarization), orientation (originating perhaps in rotation and spin) and systemic character resulting from the related reaction-process, appear to be produced by the mass-, chemical- and microworld respectively²⁵). This is conceivable on account of the symmetrical structuring of the universe like any other system (cf. above).

The process on a universal level would thus start as a reaction-process, i. e., beginning with the formation of structure and substance. The reaction and induction processes would then be united in one sequence and revert into themselves. So the universe would be a curved space continually producing material and negentropy for self-maintenance.

Outside the universe, and as its counterpart, one will have to assume the existence of an anti-universe. Here, entropy prevents order from being maintained. In our historical-geographic dimension, the anti-universe frequently manifests itself in signs of desintegration. Thus settlements are abandoned, for instance, cultures decline, states break up, or life-forms die, are decomposed down to molecular level by being absorbed into the food-cycle before supplying fresh energy for other life-forms. This means that substance is reintroduced into the microworld and forms the construction material for new life-forms. Ultimately the antiuniverse seems to be the main source of dynamization of the universe.

A divergent process course is characteristic for the reaction-processes of the anti-universe, a convergent one for the induction-processes. A convergent induction-process causes a reduction in information, while a divergent reaction-process causes the dissipation of energy. Disorder and chaos develop in organization. Thus the structure of the anti-universe might be

imagined as being a reflection of the universe. Processes that conform to the systems are set against processes that follow a course contrary to the systems.]

(Three-dimensional) spatial order

As described earlier on, the induction-processes follow a downward course in the hierarchy, leading divergently with every step into another set of elements. In the same order of magnitude in each case, these constitute homogeneous structures, or aggregates. The elements of these aggregates compete with one another for the absorption of information or energy. Conversely, all processes terminate in aggregates, in the dynamization phase of the superior system (Fig. 4). The different inferior populations offer their products to the population or to the superior system. There is competition here as well, as the products must be taken over. In thermodynamics, these homogeneous structures are called conservative²⁶). During the vertical transfer of information and products, selection takes place; it is meant to create the prerequisite conditions for the competitive success of the most suitable systems.

The process begins at an initial point, i. e., an element of the aggregate is the innovation center. Here, stabilization of the preceding process and perception of the subsequent one become linked up. These innovation centers often move from one population to another (rotation). An example is the inner area of the European cultural population (Western, Central and Southern Europe) whose state and national populations constituted an aggregate during the last five centuries in which the innovation centres changed place from time to time. Thus nearly all the nations occupied a position of leading political power for a certain length of time, i. e., each one constituted an innovation center within the scope of regulation of the European cultural population.

On the level of a state population, regulation is optimized, and on the level of the city-umland population, organization (Table 1). Here the innovation centers are established in the center²⁷). Adapting to the induction-process-sequence, a central peripheral differentiation has come about. As different to the aggregates, these are so-called dissipative structures, consisting of concentrically arranged rings. The information input or perception takes place in the retail stores of the central business district of the city. Here the production is linked with the consumption of the population in the city-umland region. The rings in which determination, regulation etc. are located, proceed towards the outside and on the outer margin the population is stabilized (Table 2; Fig. 7)²⁸). Thus the induction-processes are taken step by step to the periphery. In the case of the reaction-processes on the

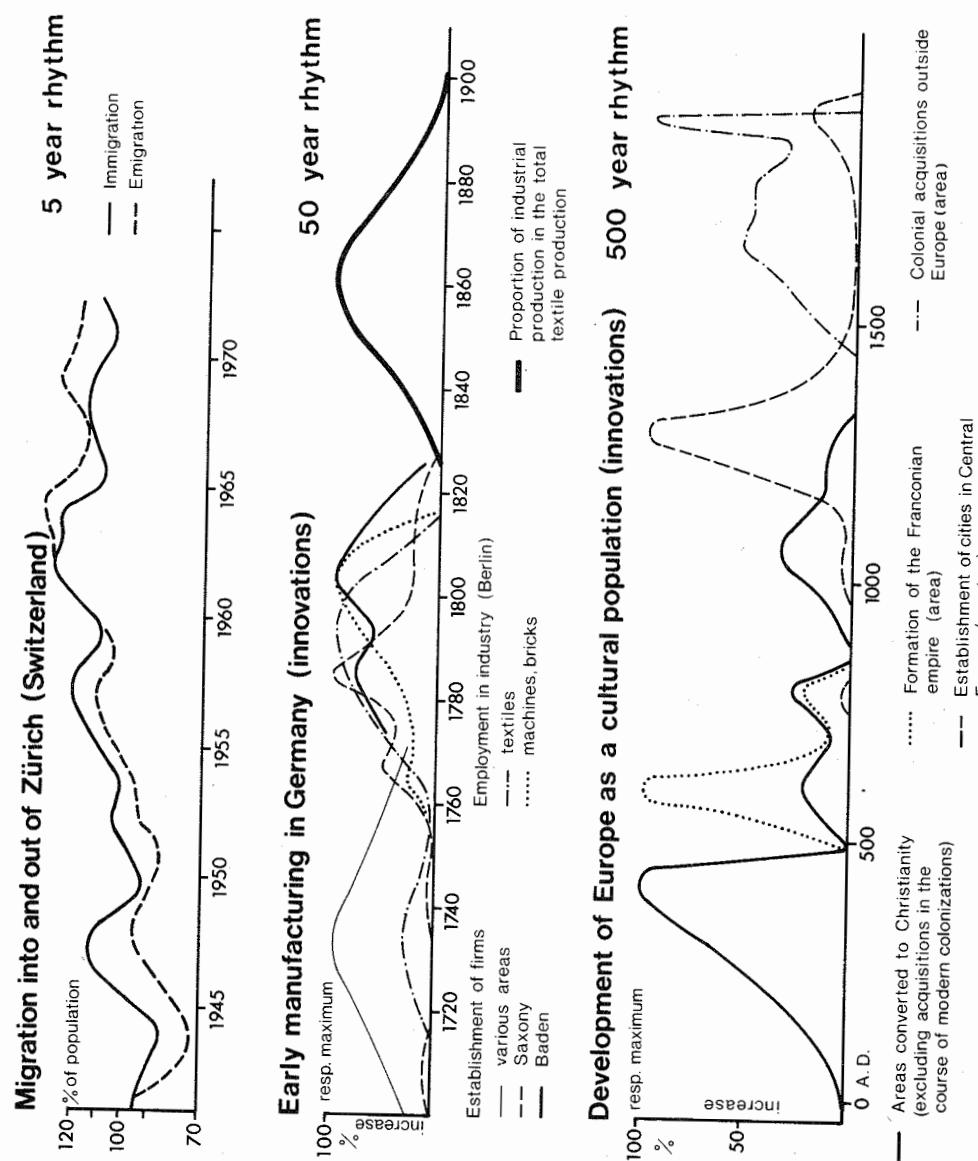


Fig. 6: Examples of oscillations in mankind as a society. 5, 50 and 500 year rhythms. (Source: D. Fliedner, cf. note 2)

task category	most important institutions	most important establishments (organisates)	preferred activity areas
Perception	retail trade	store	central business district (shopping center, shopping street)
Determination	(private) management, service, banking	(private) office, bureau	central business district (office building district, banking quarter)
Regulation	(public) administration	(public) office, administration board	governmental district
Organization	dwelling	apartment house, bungalow	residential quarter
Dynamization	economy (second sector), processing	factory, industrial plant	industrial district manufacturing belt
Kinetization	(short range) traffic, transport	transport firm, vehicle holder	umland, commuter area
Stabilization (in natural and competitive environment)	primary sector (especially agriculture), subordinate central services	farm, ranch; office, store small plant	area with agricultural land use and subordinate central places

Table 2: The city umland population

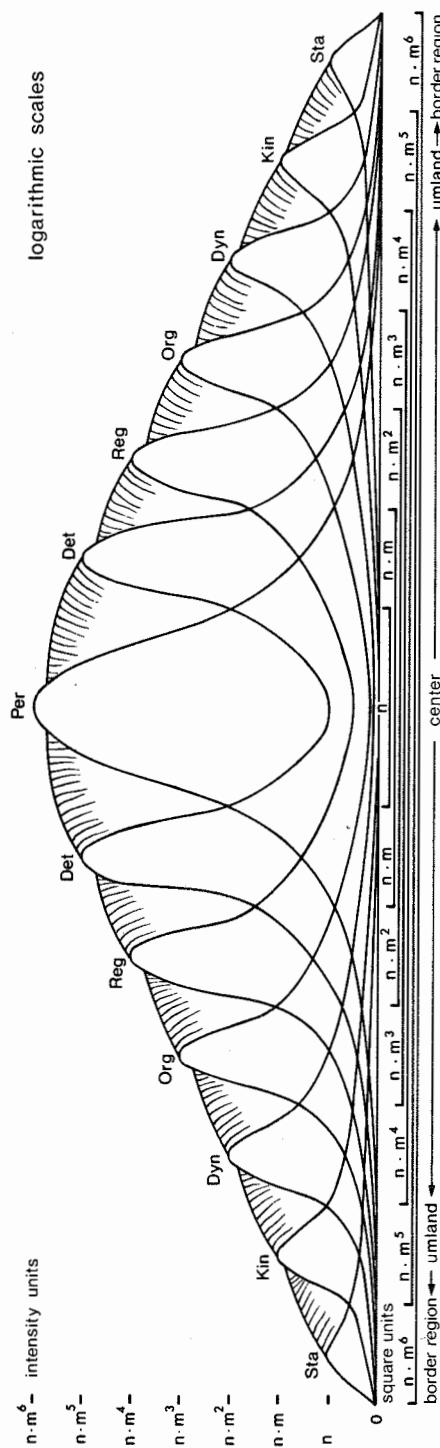


Fig. 7: City-umland-population, distribution and intensity of activities in the different task categories. Schematic cross-section. (Source: D. Fliedner, cf. note 2)

other hand, which form the structure of the population as the carrier system, the process-sequence follows the opposite course, from the outside in. The transfer of the energy refined during the process-stages is temporally fixed. Every population type has its own specific oscillations; this means, for instance, for the European (-North American) cultural population, approx. 500 years. During this period, the process-sequence must be carried on in the oscillation rhythm of the inferior populations. These next subordinated populations are the peoples or state populations; the process rhythm belonging to them takes about 50 years, so several phases of the process-sequence can be repeated.

The speed of transfer of energy during refining, or of the propagation of the production waves, is thus fixed. If we calculate an oscillation period of 50 years for the peoples or state populations, and a diameter for their living spaces of about 500 kms, a speed of approx. 10 kms a year results. Approximately the same rates are obtained if we take the average community diameter per year, the diameter of city-umland regions per 5 years²⁹⁾ or the diameter of cultural regions per 500 years. Obviously, this kind of estimate is only possible for highly differentiated populations, as otherwise the process-sequence can only be vaguely localized in (three-dimensional) space. 10 kms per year constitutes the speed of energy transfer peculiar to society; a higher speed of production and of the progress of the process-sequence is on an average not possible. As mankind represents one species among others, this value can probably be taken as basic constant to apply to the entire living world, perhaps to the entire chemical world. This requires further investigation, of course.

[Extrapolating the results, we may continue the train of thought which we began above:

In a similar way, the speed of sound may be considered the production velocity of the massworld (measured in perfect gas, as in liquid or solid material electromagnetic transferences might make a difference), and the speed of light as that of the electromagnetic world. To be more exact: speed of light, belonging to electromagnetic world, 3×10^5 kms/sec, speed of sound, belonging to the massworld $3,3 \times 10^{-1}$ kms/sec, speed of production (obtained from mankind as society), perhaps belonging to the living world (also to the chemical world?) approx. 3×10^{-7} kms/sec.

If these values are extrapolated to the micro-world, a corresponding value is obtained, differing by the factor 10^6 kms/sec, i. e. approx. 3×10^{-13} kms/sec. Whether this corresponds to reality will have to be established by investigations.]

This (3-dimensional) spatial transfer of energy is based on the rhythm of production, i. e., on kinetization, according to the system's determination. From this, a second kind of energy transfer must be distinguished: transport in mankind and the living world in general, radiation in the other worlds. In these cases, energy is transferred in the system without being converted.

As mentioned above, the individuals and the populations occupying a low position in the hierarchy produce faster than those in a higher position, due to the fact that they have a shorter rhythm of oscillation (e. g., individuals in days, communities in years, as against cultural populations in 500 years; cf. Table 4). These products, whether they consist in information (signals) or material goods, must also reach the elements of the larger populations in the shortest possible time in order to secure the maintenance of these systems.

The speed of transport is a good deal higher than the speed of production of the whole population (cf. above). Transport of signals and goods makes use of a variety of media, whether these are peculiar to the living creatures themselves (voice, limbs for movement) or invented ("transport media"). These media may consist of the carrying material of the superior worlds, a consequence of the greater production speeds peculiar to them (e. g., sound waves and electromagnetic waves for transmitting information).

[Similarly, the systems in the micro- and massworld probably make use of electromagnetic waves, for instance, for conveying energy (rays). However, the speed of light is the very highest.

Transportation always leads from a source area to a target area. A ray must also lead from a point of emission to a point of absorption if it is conformed to the system and accomplishes its task of transporting information (signals) or other energy-products. Accordingly, there are emitting and absorbing structures in the systems. Transportation and radiation result from tension and follow gradients, i. e. fields must exist as an expression of organization. According to the four types of production speed in the different worlds, we can expect there to be four types of field which can be distinguished in each case by the steepness of their radially aligned gradients. For instance, the electromagnetic field can be included here, or the gravitational field and the transport field resp. their substitutes in the other worlds. Of course, these assumptions are very hypothetical. Whether they correspond to empiric observations must be tested.]

In populations which are only little differentiated, the direction of transportation is diffuse. Conversely, in highly differentiated populations, dissipative structures arranged in a mainly central-peripheral manner are recognizable (cf. above). Here, the field character of the systems becomes clearly observable. There is great tension in a radial direction. In a tangential direction, i. e., within the rings which are characterized by inferior aggregates or conservative structures, tensions are low.

The higher the degree of differentiation, the wider the ring structure becomes. This means greater effort with regard to central-peripheral transportation. The size of the dissipative structures depends in all systems on the ability of the traffic or radiation to keep these structures supplied; this causes equifinality³⁰). Hypothetically the size of any system (probably also of the universe) grows with increasing differentiation.

Defining energetic space

The points of departure for our considerations were, apart from empirically obtained findings:

1. the four-dimensionality of energetic space, and from this, the process-character
2. the seven task categories and their realization in the process-sequence resp. system structure
3. the exponential/logarithmic linkage of the process stages.

The remaining statements were derived from these basic assumptions. A graphic representation along each axis produces a logistic curve, where the exponential branch represents the induction-process supplying energy; the logarithmic branch is contemporary to the reaction-process supplying negentropy. The starting point for the system of coordinates should be placed at the point of connection of the two processes. Table 3 shows the course of the processes. Thus, energetic space can be metrically described³¹). The position of an element in energetic space along the four axes can be defined by using the seven-graded scale based on the task-categories. The spatial units thus described can again be subdivided in the same way. The scaled energetic space of mankind as a society is shown in Table 4.

[This table can be extrapolated upwards in the hierarchy via the animal kingdom and the living world (chemical world) into the massworld and the electromagnetic world, as shown in Fig. 4, or downwards via the organisms, organs and cells into the micro-world. Whatever the case may be, in the course of the extrapolation it will be found that the energetic spaces, comparable to mankind as a society, are spaced closer together in the hierarchy, and the stages follow one another more closed than one would expect. It would seem then, that the spaces overlap in the hierarchy. On the other hand, as stated above, there are ten phases available for six process-stages in the process-sequence.]

The basis of the theoretical considerations was formed by mankind as a society. It could be objected that mankind in its unique position in the universe eludes an interpretation as energetic space, that human beings are free to make decisions and that history is not predetermined. However, if we do not wish to suggest that human actions are pointless and social structures incidental, we have no choice but to take the fact into account that events in history too, are designed. In the determination stages of the process-sequences, the populations decide on the ways and means of completing the task. Here the ways and means become institutionalized, so that regional individual development and historical variety result. The fact that many processes fail or have unintended consequences had rightly been

emphasized by Popper³²). History, then, is extremely complex, consisting of processes that conform or act contrary to the system, are controlled or uncontrolled. The idea was to show in theory that the processes and structures have a physical background and should be placed in a higher context.

The theory seems simple and complete in itself. The statements and conclusions substantiate one another. Now its value and practicability ought to be tested by means of observations within, and in particular outside society. So e. g. the meaning of the different astronomical phenomena (e. g. stars, planet systems, galaxies, clusters of galaxies, quasars, white dwarfs and black holes) should be examined, also the phenomena in the micro-world such as quarks, elements, atoms and molecules, their task in the universal energy flow. Moreover the theory ought to be given mathematical foundations. Certainly corrections will have to be made here and there, because the author, being a geographer, was lacking several findings of physical research. However, a great deal will already have been gained if the division made between the natural sciences and the Arts, is counteracted. No doubt this division was necessary seen in the light of the history of science, but today it seems problematical. I believe that not only the historian, but also the physicist will have to ponder both the cause and the meaning of the phenomena. To my mind, finality as well as causality are necessary for explaining four-dimensional energetic space.

dimension, coordinate axes	Type of processes	universe		antiverse	
		processes conformed to systems	processes contrary to systems	Induction processes	Reaction processes
		in the course of the processes		in the course of the processes	
perception / stabilization (x-axis, informations, material), linkage density		increasing	decreasing	decreasing	decreasing
determination / kinetization (t-axis, duration) oscillation frequency		increasing	decreasing	decreasing (convergent)	increasing (divergent)
regulation / dynamitization (y-axis, hierarchy) number of elements		increasing (divergent)	decreasing (convergent)	decreasing (centripetal)	increasing (centrifugal)
organization (z-axis, 3-dimens. spatial order), volume		increasing (centrifugal)	decreasing (centripetal)	decreasing (centripetal)	increasing (centrifugal)

Table 3: Behaviour of the system in the course of the induction- and reaction-processes along the 4 coordinate axes

Stage in process-sequence		Induction process						Reaction process						
		1	2	3	4	5	6	7/1	2	3	4	5	6	
Perception /Stabilization (x-axis)	Lin-ka-ges	tasks	Per	Det	Reg	Org	Dyn	Kin	Sta	Kin	Dyn	Org	Reg	
Determination /Kinetization (t-axis)	Pro-cess-es	number	k_x	$k_x \cdot 10^1$	$k_x \cdot 10^2$	$k_x \cdot 10^3$	$k_x \cdot 10^4$	$k_x \cdot 10^5$	$k_x \cdot 10^6$	$k_x \cdot 10^5$	$k_x \cdot 10^4$	$k_x \cdot 10^3$	$k_x \cdot 10^2$	k_x
Regulation /Dynamicization (y-axis)	Ele-ments (popu-lations)	dura-tion	$k_{11} \cdot 5$	$k_{11} \cdot 5$	$k_{11} \cdot 5$	$k_{11} \cdot 5$	$k_{11} \cdot 5$	k_{11}	k_{11}	k_{11}	k_{11}	$k_{11} \cdot 5$	$k_{11} \cdot 5$	$k_{11} \cdot 5$
Organization (z-axis)	Volu-mes	oscillation frequency	k_{12}	$k_{12} \cdot 10$	$k_{12} \cdot 10^2$	$k_{12} \cdot 10^3$	$k_{12} \cdot 10^4$	$k_{12} \cdot 10^5$	$k_{12} \cdot 10^6$	$k_{12} \cdot 10^5$	$k_{12} \cdot 10^4$	$k_{12} \cdot 10^3$	$k_{12} \cdot 10^2$	k_{12}
number of space units		primary	race?	tribe	ethnic group	local group	family group	indi-vidual	family group	local group	ethnic group	tribe group	race?	man-kind
		secondary	kind	cultur.	state-city-um-land pop.	commu-nity	organ-i-sate ²⁾	organ-i-sate ²⁾	commu-nity	organ-i-sate ²⁾	city-um-land pop.	state-land pop.	cultur.pop.	man-kind
		number	k_y	$k_y \cdot 10$	$k_y \cdot 10^2$	$k_y \cdot 10^3$	$k_y \cdot 10^4$	$k_y \cdot 10^5$	$k_y \cdot 10^6$	$k_y \cdot 10^5$	$k_y \cdot 10^4$	$k_y \cdot 10^3$	$k_y \cdot 10^2$	k_y
number of space units		position	center (inner ring)	2 nd ring	3 rd ring	4 th ring	5 th ring	6 th ring	7 th ring	8 th ring	9 th ring	10 th ring	11 th ring	center (inner ring)
		number of space units	k_z	$k_z \cdot 10$	$k_z \cdot 10^2$	$k_z \cdot 10^3$	$k_z \cdot 10^4$	$k_z \cdot 10^5$	$k_z \cdot 10^6$	$k_z \cdot 10^5$	$k_z \cdot 10^4$	$k_z \cdot 10^3$	$k_z \cdot 10^2$	k_z

- $k_x, k_{11}, k_{12}, k_y, k_z$ are constants, depending on measure system, grade of differentiation etc. of the population
- ¹⁾ Real duration of process deviates from expected duration because of astronomically determined duration of days and years
- ²⁾ Organisates are production establishments like industrial plants, farms, offices, schools, shops etc.

Table 4: Scaling of the energetic space of mankind as society

Notes

- Discussions about geographical space cf.:
 Bartels, D.: Zur wissenschaftstheoretischen Grundlegung einer Geographie des Menschen. = Geographische Zeitschrift, Beihefte, Wiesbaden (Steiner) 1968
 Schmittüschen, J.: Allgemeine Geosynergetik. Grundlagen der Landschaftskunde. = Lehrbuch der Allgemeinen Geographie, Bd. 12. Berlin/New York (de Gruyter) 1976
 Wirth, E.: Theoretische Geographie. Grundzüge einer Theoretischen Kulturgeographie. Stuttgart (Teubner) 1979
- Fliedner, D.: Bevölkerung, Gesellschaft und Umwelt. Versuch einer theoretischen Grundlegung aus historisch-geographischer Sicht. Manuscript. (550 pp., 29 Fig.) Dec. 1978. To be published
 Geosystemforschung und menschliches Verhalten. In: Geographische Zeitschrift 67, 1979 (Festschrift J. Schmittüschen), pp. 29 - 42
 Der Prozeß, ein zentraler Begriff in der historischen Geographie. To be publ. in: Tagungsberichte und Wissenschaftliche Abhandlungen, Deutscher Geographentag, Göttingen 1979
- On explanation cf.:
 Dilthey, W.: Der Aufbau der geschichtlichen Welt in den Geisteswissenschaften. 1910. Reprint Frankfurt/Main (Suhrkamp) 1970
 Stegmüller, W.: Probleme und Resultate der Wissenschaftstheorie und Analytischen Philosophie. Berlin/Heidelberg/New York (Springer) 1969/73
 Faber, K. G.: Theorie der Geschichtswissenschaft. 2nd ed. München (Beck) 1972
 Hempel, C. G.: Philosophy of Natural Science. Englewood Cliffs (Prentice Hall) 1966
 Mohr, H.: Der Begriff der Erklärung in Physik und Biologie. In: Die Naturwissenschaften, 65. Jg., 1978, pp. 1 - 6
 Harvey, D.: Explanation in Geography. London (Arnold) 1973
- Time in Science and Philosophy. Ed. by Jiri Zeman. Amsterdam/London/New York (Elsevier) 1971 (E. g. articles by Brouillin, Cailleux, Prigogine, Szumilewicz, Zeman)
 Entropy and Information in Science and Philosophy. Ed. by Libor Kubát and Jiri Zeman. Amsterdam/Oxford/New York (Elsevier) 1975 (E. g. articles by Davies, Gal-Or, Harrison)
 v. Weizsäcker, C. F.: Zum Weltbild der Physik. 12th ed. Stuttgart (Hirzel) 1976
 Eigen, M. and R. Winkler: Das Spiel. München/Zürich (Piper) 1975
 Moreover, cf. note 26
- On general systems theory e. g.:
 v. Bertalanffy, L.: General System Theory. New York (Braziller) 1968
 v. Bertalanffy, L.: The Theory of Open Systems in Physics and Biology. In: Science. Vol. 111, 1950, pp. 23 - 29
 Laszlo, E.: The Systems View of the World. New York (Braziller) 1977
 On systems theory in social sciences e. g.:
 Parsons, T.: The Social System. Glencoe (Free Press) 1951
 Luhmann, N.: Soziologische Aufklärung. 2 Vols. Opladen (Westdeutscher Verlag) 1970/5
 Sutherland, J. W.: A General Systems Philosophy for the Social and Behavioral Sciences. New York (Braziller) 1973
 Langton, J.: Potentialities and problems of adopting a systems approach to the study of change in human geography. In: Progress in Geography, Vol. 4, London (Arnold) 1974, pp. 125 - 179
- Homans, G. C.: The Human Group. London 1950. He distinguishes between inner and outer system of the social group. Social group and population are structurally identical; the term population also includes greater units.
 These problems are interpreted in: D. Fliedner 1978, cf. note 2
- On innovation waves and processes from a geographical viewpoint cf.
 Hägerstrand, T.: The propagation of innovation waves. In: Lund Studies in Geography, Ser. B, 4, 1952, pp. 3 - 19

- Rogers, E. M. and F. F. Shoemaker: *Communication of innovations*. New York (The Free Press) /London (Collier-Macmillan) 1971
- Bahrenberg, G. and J. Loboda: Einige raumzeitliche Aspekte der Diffusion von Innovationen. In: *Geographische Zeitschrift* 61, 1973, pp. 165 - 194
- An insight into the historical process research provides the reader
Historische Prozesse (Ed. K.G. Faber and Chr. Meier) München (DTV) 1978
8. Mitscherlich, E. A.: Das Gesetz des Minimums und das Gesetz des abnehmenden Bodenertrags. In: *Landwirtsch. Jahrb.* 38, 1909, pp. 537 - 552
- Kilger, W.: *Produktions- und Kostentheorie*. Wiesbaden 1958
9. Fig. 1 shows the medium distance of fieldhouse ruins from the pueblo; the fieldhouses are indicators of tillage in the immediate vicinity. They are dated by archaeological methods, especially by the determination of sherds. Until about 1600/1620 (when the Spaniards arrived) acreage and medium distance of the fieldhouses developed in the same manner. During the last two centuries, however, the number of fieldhouses (and thus the acreage of tilled fields) decreased, parallel to the population numbers (shown at the bottom). The decreasing acreage is not visible in this diagram, while on the other hand the oscillations are better recognizable. — The population decline was caused ultimately by the impact of the European culture on the Puebloan culture. After 1800 only two small areas, far away from the pueblo, were used, showing the very few connections and interactions that existed between the Indian families who had survived the development. The population disintegrated and the last families left the Pecos area in 1838.
10. On roles cf. e. g.
Parsons, T.: *The Social System*. Glencoe 1951
- Dahrendorf, R.: *Homo sociologicus*. 10th ed. Köln/Opladen (Westdt. Verlag) 1971
11. Most systemtheoretical investigations, e. g. in ecological research, refer to the problem of energy flow in equilibrium systems.
v. Bertalanffy, L.: *The general System Theory* (cf. note 5)
- Stoddard, D. R.: Geography and the Ecological Approach. In: *Geography* 50, 1965, pp. 242 - 251
- Ellenberg, H.: Ziele und Stand der Ökosystemforschung. In: *Ökosystemforschung*. Berlin/Heidelberg/New York (Springer) 1973, pp. 1 - 31
- Schmithüsen, J.: *Allgemeine Geosynergetik*. Berlin/New York (de Gruyter) 1976
12. Cf. as early as Adam Smith: *An Inquiry into the Nature and Causes of the Wealth of Nations*, 1776
13. Elucidating the relations between energy, motion and space is a basic concern of the special relativity theory.
Lorentz, H. A., Einstein, A. and H. Minkowski: *Das Relativitätsprinzip*. 7th ed. Darmstadt (Wissenschaftl. Buchgesellschaft) 1974
- Einstein, A.: Über die spezielle und allgemeine Relativitätstheorie. Braunschweig (Vieweg) 1916. 21 st. ed. Berlin/Oxford/Braunschweig 1973
- Albert Einstein, Philosopher, Scientist (Ed. P. A. Schilpp). Evanston, Ill. 1949 (E. g. articles by de Broglie, Einstein, Reichenbach, Wenzl)
- Albert Einstein, Sein Einfluß auf Physik, Philosophie und Politik (Ed. by P. C. Aichelberg and R. U. Sexl). Braunschweig/Wiesbaden (Vieweg) 1979 (E. g. articles by Bergman, Miller, v. Weizsäcker)
- Jammer, M.: *Concepts of Space*. Cambridge, Mass. (Harvard Univ. Press) 1953
- v. Weizsäcker, C. F. (cf. note 4)
14. The theory of action is particularly concerned with the stages 1, 2, 6 and 7; cf. e. g. from a sociological viewpoint
Parsons, T.: Some fundamental categories of the theory of action. (Ed. by T. Parsons and E. A. Shils). New York 1951
15. On the tasks of the populations cf. Fliedner, D., note 2
16. On innovations cf. note 7
17. These considerations are an attempt to relate to the basic concern of the general relativity theory, i. e. the formulating of the (qualitatively different physical phenomena) mass and energy as metric values of the time space continuum
Cf. Lorentz, Einstein and Minkowski (cf. note 13)

- Einstein, A.: Über die spezielle und allgemeine Relativitätstheorie (cf. note 13)
Albert Einstein, Philosopher, Scientist (cf. note 13; e. g. articles by de Broglie, Einstein, Infeld, v. Laue, Robertson, Wenzl)
- Albert Einstein, Sein Einfluß auf Physik, Philosophie und Politik (cf. note 13; e. g. articles by Bergman, v. Weizsäcker)
- Jammer, M. (cf. note 13)
- v. Weizsäcker, C. F. (cf. note 13)
18. On the irreversibility of the processes cf. e. g.
Glansdorff, P. and I. Prigogine: *Thermodynamic Theory of Structure, Stability and Fluctuations*, London/New York/Sydney/Toronto (Wiley) 1971
Time in Science and Philosophy (cf. note 4)
- Entropy and Information in Science and Philosophy (cf. note 4)
Albert Einstein, Philosopher, Scientist (cf. note 13; article by Reichenbach)
19. The problem of the institutions is treated e. g. by:
Allport, F. H.: *Institutional behavior*. 1933. Reprint: New York (Greenwood) 1966
- Malinowski, B.: *A Scientific Theory of Culture*. New York/London 1944
- Parsons, T. (cf. note 14)
- Hertzler, J. O.: *American social institutions*. Boston (Allyn & Bacon) 1961
Zur Theorie der Institutionen (Ed. by H. Schelesky) = *Interdisziplinäre Studien* vol. 1, 2nd ed. Düsseldorf (Bertelsmann) 1970
Extensive interpretation: D. Fliedner, 1978, cf. note 2
20. On symmetry and asymmetry cf. notes 4 and 18
21. Cf. the discussion on the dualism of wave—corpuscle. The term quantum does not refer to the smallest energy unit only, but to any energy quantity which in the course of the process is limited in its origin, size and termination by production
Hierarchical Structures (Ed. by L. L. Whyte, A. G. Wilson, D. Wilson) New York (Elsevier) 1969 (E.g. articles by Bunge, Gerard, Harrison, Kaufman, Mesarovic and Macko, Pattee, Rosen, Schlichta, Smith, Whyte, A. G. Wilson and D. Wilson)
22. Several disciplines are engaged in research on hierarchy; but it seems very difficult to find a common basic concept. Cf. e. g.:
Soziale Schichtung und soziale Mobilität. = *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 5. Sonderheft, 1961
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23. On social stratification cf. e. g.:
Soziale Schichtung und soziale Mobilität. = *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 5. Sonderheft, 1961
24. On the relations between evolution and thermodynamics cf. e. g.:
Schrödinger, E.: *What is life?* London (Cambridge Univ. Press) 1945
- Prigogine, J., G. Nicolis and A. Babloyantz: Thermodynamics of evolution. In: *Physics Today* 1972, Nov. (pp. 23 - 28) and Dec. (pp. 38 - 44)
- Eigen, M. and R. Winkler (cf. note 4)
25. The problem of the orientation of space is discussed e. g. by:
Freudenthal, H.: Die Orientierung des Raumes. 1964. Reprinted in: *Raumtheorie* (ed. by H. Freudenthal) = *Wege der Forschung*, Bd. CCLXX. Darmstadt (Wiss. Buchgesellschaft) 1978, pp. 395 - 408
26. On conservative and dissipative structures cf.
Glansdorff, P. and I. Prigogine (cf. note 18)
Time in Science and Philosophy (cf. note 4, article Prigogine)
Physicist's Conception of Nature (Ed. by J. Mehra). Dordrecht, Holland/Boston, Mass. 1973, pp. 561 - 593
- Eigen, M. und R. Winkler (cf. note 4)
27. On ring structures and central places cf.:
Thünen, J. H.: *Der isolierte Staat in Bezug auf Landwirtschaft und Nationalökonomie*. Reprint of the 3rd edition (1875), Darmstadt (Wissenschaftl. Buchgesellschaft) 1966

- Christaller, W.: Die zentralen Orte in Süddeutschland. Jena (Fischer) 1933
 Lösch, A.: Die räumliche Ordnung der Wirtschaft. Jena (Fischer) 1943
28. In Fig. 7 the intensity of human activities (or interactions) could be measured e. g. by the number of the adults multiplied by the duration of presence per day and per square unit. Cf. also the distribution of land values.
29. Here the socalled „Oberzentren“ are the centers of the city-umland populations; Kluczka, G.: Zentrale Orte und zentral-örtliche Bereiche mittlerer und höherer Stufe in der Bundesrepublik Deutschland. = Forschungen zur deutschen Landeskunde, 194. Bad Godesberg 1970
30. On equifinality cf. e. g.:
 Driesch, H.: Philosophie des Organischen. 4th ed., Leipzig 1928
 v. Bertalanffy, L. (cf. note 5)
31. Cf. note 17
32. Popper, K.: The Poverty of Historicism. London 1957
 Popper, K.: Prediction and prophecy in the social sciences. In: Proceedings of the Tenth International Congress of Philosophy, Vol. I. Amsterdam 1949. pp. 82 ff

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Zusammenfassung in deutscher Sprache

Die Theorie basiert auf historisch-geographischen Untersuchungen, wendet sich aber vor allem an Naturwissenschaftler, die an dem Problem des (4dimensionalen) Raumes arbeiten.

1. Die Menschheit läßt sich in Populationen gliedern (Tab. 1). Sie haben den Sinn, bestimmte Aufgaben im Rahmen der Erhaltung der Menschheit als Art durchzuführen. Jedes Individuum ist Mitglied, Element jedes Populationstyps und spielt hierin seine spezifische Rolle. Zur Erfüllung ihrer Aufgaben produzieren die Populationen bestimmte Produkte, seien es Informationen, seien es Substanzen. In diesem Sinne sind sie sinn- und zielorientierte, im Zuge ihrer Aufgabenerfüllung geschlossene Systeme, konkret definierbar und begrenzbar. Andererseits erhalten sie Produkte von den über- und untergeordneten Populationen, sind also in diesem Sinne offene Systeme. Populationen stehen so im Energiefluß, sie wandeln Energie um und erhalten sich dadurch selbst.
2. Populationen sind so Träger von Prozessen: die übergeordnete Population benötigt für ihre Existenz bestimmte Produkte, die dieser untergeordnete Populationen übernehmen die Aufgabe. Auf den einzelnen hierarchischen Ebenen nehmen jeweils nach und nach immer mehr Populationen die Anregung zur Produktion auf (Diffusion), bis soviel produziert wird, daß Sättigung eintritt und der Prozeß endet. Die Zunahme der Produktion ist exponentiell, die Abnahme logarithmisch („logistische Kurve“). Anhand von Untersuchungen zu einer (im vorigen Jahrhundert abgegangenen) Pueblo-Population wird das Zustandekommen von Prozessen deutlich: Nahrungsbedarf stimuliert eine Ausdehnung der Wirtschaftsfläche, bis mehr Nahrungsmittel produziert als benötigt werden; denn in der Zwischenzeit nahm die Bevölkerungszahl ab, so daß der Nahrungsbedarf sich wieder vermindert hatte. Es sind also zwei Prozesse aufeinander bezogen: biotische Reproduktion und wirtschaftliche Produktion. Dadurch, daß sie schlecht aufeinander abgestimmt sind, entstehen Schwingungen im jeweiligen Produktionsablauf (Abb. 1 und 2).
3. Die Population als aufgabenbezogene Einheit ist Produzent, die Menge der Individuen in dieser Population dagegen Konsument. Die Struktur der Population bzw. der für diese spezifischen Prozesse werden den Notwendigkeiten angepaßt, um diese in Zukunft zu erleichtern. Das führt zur Differenzierung der Population (Arbeitsteilung, Hierarchie usw.). Stark differenzierte Populationen werden als Sekundärpopulationen bezeichnet (Tab. 1). Im thermodynamischen Sinne wird Negentropie produziert. Dadurch wird der Energiedurchfluß erleichtert, die Amplitude der Schwingungen vergrößert. Es können mehr Elemente, also Individuen der Population angehören, d. h. die Bevölkerungsdichte kann erhöht werden. Es ist also jeder der zwei anhand der Pueblo-

lation vorgeführten Prozesse in sich wiederum in zwei Prozeßtypen zu gliedern: den Induktionsprozeß, bei dem Energie umgewandelt wird, und den Reaktionsprozeß, der Negentropie schafft. Will man den physikalischen Raum definieren, so wird man ihn als zielorientiertes System im Energienfluß auffassen können, in dem man Induktions- und Reaktionsprozeß sowie das diese Prozesse tragende System, hier die Population, unterscheiden kann. Man könnte dieses Gebilde auch energetischen Raum nennen.

4. Der so definierte Raum ist in sich weiter strukturiert. Anhand von Handlungen und Prozessen läßt sich eine Sequenz von 7 Gliedern rekonstruieren. Alle Induktionsprozesse laufen nach dem Schema Perzeption (Informationsempfang, Stimulanz zum Prozeß) — Determination (Entscheidung Zielorientierung) — Regulation (Kontrolle, Weitergabe der notwendigen Informationen an die untergeordneten Populationen) — Organisation (3-dimensional räumliche Ordnung des Prozesses) — Dynamisierung (Aufnahme der Produkte der untergeordneten Populationen als Input) — Kinetisierung (Produktion) — Stabilisierung (Output, Übergabe des Produkts an die nachfragende, übergeordnete Population) ab (Tab. 1 und 4). Das Stabilisierungsstadium ist gleichzeitig mit dem Perzeptionsstadium des nächsten Prozesses auf derselben Populationsebene. Die einzelnen Stadien bedeuten die Erfüllung von Aufgaben, die kategorialen Charakter besitzen. Sie werden durch Innovationen sichtbar; in ihrem Verlauf wird die Produktion in den Populationen neu orientiert. Der Prozeßablauf ist irreversibel, er wird im Rahmen der Menschheit als Gesellschaft durch Institutionen kontrolliert. Jedes Stadium markiert innerhalb des vierdimensionalen Raumes einen Schritt in eine andere Richtung (wobei die Reihenfolge der Bezifferung der Dimensionen willkürlich ist): 1. Dimension: Eintritt in das System als Information (Perzeption) und Austritt aus dem System als Produkt (Stabilisierung); 2. Dimension: Sinnorientierung, also zeitlicher Vorgriff (Determination) und Produktion entsprechend der Determination, also zeitlicher Rückgriff (Kinetisierung); 3. Dimension: Weitergabe der Anweisungen in der Populationshierarchie von oben nach unten (Regulation) und Befolgung der Anweisung durch Lieferung der benötigten Produkte als Rohmaterialien für den Prozeß von unten nach oben (Dynamisierung); 4. Dimension: dreidimensionale räumliche Ordnung des Energienflusses (Organisation). Jeder Schritt in der Sequenz bedeutet, daß im System eine neue Verknüpfung in den Prozeß einbezogen wird. Anders ausgedrückt: Im Prozeßablauf wird mit jedem Schritt dem System eine neue Eigenschaft gegeben. So wird im Verständnis des Prozeßverlaufs die Qualität durch Bestimmung der Bindungsdichte definierbar.
5. Reaktionsprozesse sind unkontrolliert, sie werden vom Output des Induktionsprozesses her durch Rückstau in das System getragen; so wird das System von unten her in der umgekehrten Prozeßabfolge (Stabilisierung

- Perzeption) umstrukturiert. Der Ablauf der den verschiedenen Aufgabenkategorien zuzuordnenden Prozesse wird dabei durch bestimmte strukturelle Eigenschaften erleichtert (Tab. 1). Jedem Induktionsprozeß folgt ein Reaktionsprozeß; im Schwingungsbild folgt dem Aufstieg in jeder Phase der Abstieg. Die Zuordnung der Prozesse im Ablauf und in der Hierarchie zeigen Abb. 3 und 4. Die Prozesse sind in ihrem Erfolg und ihrem Verlauf nicht vorbestimmt, sondern nur strukturell im Rahmen physikalischer Notwendigkeiten. Mit der Determinationsphase wird den produzierenden Systemen, auch den Individuen, die Entscheidung ermöglicht. Einzelne Prozesse können wiederholt werden; umgekehrt können mehrere, in der Sequenz aufeinanderfolgenden Aufgaben gewidmete Prozesse in eine Phase zusammengedrängt werden.
6. Die Hierarchie der Population in der Menschheit als Gesellschaft ist ein wichtiges Ergebnis der Reaktionsprozesse. Jeder Populationstyp ist für die Erledigung der Aufgaben in einer Kategorie zuständig (Abb. 4). Die Dauer der Prozesse, d. h. die Phasendauer der Schwingungen ist in entsprechender Weise hierarchisch angeordnet (Tab. 4); sie unterscheidet sich durchschnittlich in den einzelnen Stufen um den Faktor 10, entsprechend der exponentiell-logarithmischen Verknüpfung der Prozesse, wenn nicht astronomisch bedingte Abweichungen eintreten (Jahres-, Tagesdauer; Beispiele von Innovationen Abb. 6.).
 7. Die im Bereich der Menschheit als Gesellschaft entwickelten Überlegungen lassen sich als Hypothese auf das Universum ausweiten; die Menschheit wird als eine Art als der Lebewelt untergeordnet betrachtet, die ihrerseits der Chemischen Welt zuzuordnen ist (Abb. 4 und 5). Auf dieser Ebene werden Mikrowelt, Chemische Welt, Massenwelt und Elektromagnetische Welt unterschieden. Jede der Welten stellt einen energetischen Raum dar, der die jeweils verschiedenen Aufgabenkategorien im Rahmen des Universums vertritt (Abb. 5). Der diesen Welten zuzuordnende Prozeßablauf ist insofern besonders zu werten, als nur 4 hierarchische Stufen den 7 Gliedern der Sequenz gegenüberstehen. Möglicherweise beginnt der Prozeß in der Mikrowelt als ordnungs-, strukturbildender Reaktionsprozeß und führt in die Elektromagnetische Welt hinauf, um von dort als energieumwandelnder Induktionsprozeß wieder zurückzulaufen zur Mikrowelt. Strukturell wäre das Universum dann symmetrisch, kinetisch gesehen aber asymmetrisch. All diesen systemkonformen, ordnungsschaffenden und energieveredelnden Prozessen des Universums wären die systemkonträren Prozesse im Antiuniversum gegenüberzustellen, die den Zerfall der Ordnung und die Zerstreuung von Energie beinhalten (Tab. 3).
 8. Der dreidimensional verstandenen räumlichen Ordnung als Ergebnis der Organisation hat schon immer das besondere Augenmerk der Geographie gegolten. Es lassen sich zwei Typen von räumlichen Zuordnun-

- gen der Elemente erkennen: 1.) Es sind gleichartige Populationen niedriger Ordnung miteinander vergesellschaftet und stehen in Konkurrenz miteinander; sie bilden ein Aggregat (in thermodynamischer Sicht „konervative Strukturen“). Unter den Populationen findet eine Auslese statt. Aggregate bilden das Substrat der Innovationsdiffusionen. 2.) Dem gegenüber stehen ziel- oder sinnorientierte Systeme, z. B. Populationen; sie streben danach, sich selbst so zu ordnen, daß die Populationen niedriger Ordnung entsprechend ihrer verschiedenen Orientierung in konzentrische Ringe sortiert sind (in thermodynamischer Sicht „dissipative Strukturen“). Innerhalb der konzentrischen Ringe (eigentlich Kugelschalen, auf der Erdoberfläche aber Ringe) schließen sich die gleichartigen Elemente zu Aggregaten niedriger Ordnung zusammen. Entsprechend der Prozeßsequenz werden die Induktionsprozesse von innen nach außen geführt; die Reaktionsprozesse haben deshalb das Bestreben, die Populationen so zu gestalten, daß die Stabilisierung außen, die Perzeption im Zentrum erfolgen kann. Die Stadt-Umland-Population ist als Beispiel zu nennen (Abb. 7 und Tab. 2); ihre Aufgabe ist im Rahmen der Menschheit als Gesellschaft die Organisation (Abb. 4 und Tab. 1).
9. Diese Ringstrukturen werden durch den Verkehr als Institution aufrechterhalten, kontrolliert. Es sind im dreidimensionalen Raum zwei Geschwindigkeiten zu unterscheiden: 1.) die Produktionsgeschwindigkeit, mit der die Energie im Prozeßablauf weitergegeben (und dabei umgewandelt) wird, und 2.) die Verkehrsgeschwindigkeit. Die Produktionsgeschwindigkeit ist an die Schwingungsfrequenz und die Populationsgröße gebunden, die Verkehrsgeschwindigkeit dagegen nicht; der Verkehr kann sich verschiedener Medien bedienen:

Jeder der vier Welten ist eine spezifische Produktionsgeschwindigkeit eigen (Elektromagnetische Welt Lichtgeschwindigkeit, 3×10^5 km/sec; Massenwelt Schallgeschwindigkeit, $3,3 \times 10^{-1}$ km/sec; Menschheit als Gesellschaft, vielleicht auch Chemische Welt ca. 3×10^{-7} km/sec; extrapoliert man diese Werte, müßte der Mikrowelt eine Produktionsgeschwindigkeit von ca. 3×10^{-13} km/sec angemessen sein). Strahlung und Verkehr kann man als grundsätzlich gleichartig interpretieren (wenn sie auch verschiedenen Welten zuzuordnen sind); es handelt sich um Energieübertragung zur Erhaltung von dissipativen Strukturen. Die in der Hierarchie tieferstehenden Welten können sich zu ihrer Erhaltung der höheren Produktionsgeschwindigkeiten der Wellen der übergeordneten Welten als Medien bedienen (z. B. Übertragung von Signalen in der Tierwelt durch Schall), wobei die Produktionsgeschwindigkeiten aber oft nicht voll erreicht werden können. Entsprechend den vier angenommenen Geschwindigkeiten kann man auch jeweils vier Feldtypen in den einzelnen Welten erwarten.

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