Transdisciplinarity: Towards Anticipatory Models of Evolutionary Learning ?

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Abstract

What will Happen in Case, and Why ? How will future development turn out? In pursue of well founded rational answers by *anticipating,* science explores the behavior and emergence of *complex* systems. To understand them pragmatically, object- and issue related, transdisciplinary co-operation is challenged. To this end recently the need for *transdisciplinary* models and semantics is stressed. Transdisciplinarity inquires into the shared base of disciplines. *Systemics* and *Evolution* approach in particular qualify as (also ontological) bases.

Keywords: Anticipation Transdisciplinarity Systemics Evolution Complexity

Prologue: Anticipatory Support for Innovative Policy

Ubiquitous change demands comprehensive policy guidance and support. Both need build on grounded concepts assessing the possible and probable courses of development potentials. To attain referent parameters, systems in question, e.g. societal systems (Giddens 1997; Luhmann 1984; Loomis 1976; Parra-Luna 2000) are approached as *anticipatory* systems. A 'strong' and a 'weak' definition are to be distinguished. "Strong anticipatory systems" deal with anticipation embedded in the systems themselves as given in incursive systems (Dubois 2000, 2001a, 2001b) on a mathematical base. 'Weak anticipatory systems' refer to a predictive model of the system, that is systems containing models of themselves inhering decisive potentials which will shape their future development (Rosen 1985, 1991, 1999). The latter are linked strongly to biological (also biosemiotic), that is variatis variandis to life, living and viable systems. [For a concise definition see (Dubois 2005)]. Society seen as a life system this paper will be close to the 'weak' concept.

As well on the strategic as on the operational level e.g. societal systems reflect high degrees of complexity: in dynamics, detail, networking etc. To deal with complexity, in particular in the pragmatic context, widely differing disciplinary scientific attempts are requested. They extend from formal approaches as Mathematics, Synergetics (Corning 2003; Haken 1978); Anticipatory Computing etc. to referring material disciplines as e.g. Sociology, Demography or Economics (Dopfer 2005).

To integrate the disciplinary research results and not least to enable an *issue related* interpretation an *transdisciplinary* dialogue has been demanded (Klein Thompson 2001). So far *interdisciplinary* efforts have been severely limited by differing methods, non-compliant semantics and non-compatible interpretation background. Such principal difficulties can be overcome only by a transdisciplinary advance to complexity research.

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Such a comprehending attempt needs a shared *semiotic base* connecting to a transdisciplinary set of models and methods, which will preclude a *transdisciplinary scientific paradigm(s).* Reconsidered *ontological* fundaments need be included. As sources for transdisciplinarity qualify, each in its comprehensive meaning, *Systems*/ systemics, *Evolution* and *Complexity* sciences, *Semiodynamics* (as christened by the author) and Noo-sphere.

To transfer transdisciplinary attempts into research operation *modeling and si*mulation, but also *representation geometry* e.g. as the *Phase Space Concept* (Poincaré) can be employed (Loeckenhoff 2004). Complementing other modes of complexity handling they serve in particular as heuristic and integrative tools. Based e.g. on *Bayesian Syllogism* and Maturana's (Maturana 1987) *Natural Drift* a model of *Guided Evolutionary (Control) Learning GECL* is proposed (Loeckenhoff 1997, 2004). As a transdisciplinary base it may help to design a *innovative society.* To do so the anticipatory qualities of an innovative need be marked.

During the last two decennia guided policy in the societal domain grew both more important and increasingly more difficult to design (Oliga 1996). The societal sector constitutes no longer a matter of interior policy only. Globalization, from resources to economics to demography and migration, determines also the home affairs down to detail. In parallel the indigenous home conditions continue changing. Aggravating each other the changing sceneries have challenged and often toppled the existing political base. They led to the revival of ideology, lack of competence and knowledge, knowledge being replaced or clouded by emotions and ethnicity. The overtaxing of societal institutions as social welfare, employment or education built up tensions. Lack of reforms and erroneous reaction of voters –if there is conscious voting - leads to a distorted style of government. Anticipatory knowledge and knowing how to guide and govern a society have to be learned and relearned, have constantly to be regained and to be adapted. The task appears the more demanding since with the material/ economical/demographic base also the behavioral propensities and the value systems, the world view and self-understanding of people changed (Bühl 1990; Eibl-Eibesfeld 2004; Schmid 1999). The latter phenomena concern such fundamental attitudes as to expectations concerning a worthwhile life, to self-responsibility and to procreation. All these challenges call for the support of advanced also 'anticipatory' sciences.

Expressed in the language of systems, policy, in particular societal policy, has to deal with ever more complex systems, factors, networking and mutual influences. It finds itself confronted with what may be named *dynamic uncertainty*. Any political decision may procure unprecedented and eventually unwanted side effects (Atteslander 1999). Under the pressure to produce advantageous short term operational results *long term consequences* often are not calculated. Means to strategic assessment are missing. The support of numerous 'think tanks' (Decker, 2005), even if not ideologically twisted, remains difficult to assess; a consequence of different, controversial views and of the confrontation with vastly varying acceptance of recommendations. The fact also reflects the vague ideological and the uncertain scientific base. The rational scientific part of policy advice need be subject to a thorough re-formation, that is rethinking, abandoning cherished convictions and integrating new approaches e.g. from complexity research.

So far policy is mostly seen, for practical reasons, from roughly two levels. *First*, it has to explore and to design general *strategic issues*, fields of probability and the strategic frames for measure programs to transfer targets into operation. On the *operational level*, *second*, policy needs to control – in the comprehensive sense from orientations to implementation and corrective measures – the efficiency and the effectiveness of both the strategic targets of the policy as its operational result (Oliga 1996). Experience as well as research point to a third intermediate *tactic level* as the connecting area of transfer. Feasibility and acknowledgement of each operational action are addressed as a step within a strategic path. Experience tells that before feasibility and short term objectives long term issues as e.g. sustainability often are neglected.

The above considerations set the scene for a fresh look on the science based *anticipatory fundaments* of policy support. The following paper intends a preliminary and restricted overview concerning material, societal and political aspects. It will focus on attempts science undertakes to integrate different and in their base differing sets of assumptions, models, modes of research and the basic paradigmatic models behind. Support and guidance of societal policy present a highly complex issue, which might be dealt with exclusively from a multi- approach: multi-level, multi-method, trans-disciplinary approach (Klein Thompson 2001). A merely *inter*disciplinary dialogue, has turned out insufficient if not impossible. E.g. congruence of disciplinary models and a shared semiosis are missing. Recently from different points of departure, the search for a transdisciplinary base proposes basic, model task and operation oriented concepts, emerging e.g. from *systems* and *evolution* research. It proves essential for the development and application of anticipatory scientific attempts for policy support.

1. Coping with Complexity Evolvement

The term complexity covers a plethora of topics, aspects and interpretative domains. In the context given it designates a more general, wide understanding of *'complexity' with regard to living and viable systems* and their dynamics. Dynamics, their causes and qualities are again understood in their widest meaning: including inner, outer, situation bound and developmental aspects, that is the entire dynamics of the process of *evolution* (Nalimov 1985). The view is focused on *evolutional learning*. Relevant detail aspects of complexity research have been discussed (Loeckenhoff 2004).

The kernel and the condition sine qua non of *policy support* contain the ability to provide grounded assumptions on the development of a system in case over the elapse of time. They depend, fore shortened, on both *material* aspects and *formal* parameters. On the on hand, *material* aspects can generally be described by the classic scientific, professional or other, object/project bound disciplines. *Issue* and *purpose* (Blalock 1985) behind the actual case determine the specific direction and constraints. They also influence the specification of the systems description: inner system, environments, requisite holisticity of the concept and depth of details (Schwaninger 1997). *Formal* aspects, on the other hand, include the (hard) systems and (in a sense, also 'soft') systemic qualities, extending as well to the object/target system in focus as to the systems of exploration and evaluation.

A detailed analysis of the densely enmeshed (meta-) methodical mutuality as above in *systems inquiry* and *systems control* is dealt with by *cybernetics of higher order*. The but superficial reference here intends first to point out the necessity of a careful analysis and design of the *methodical options*, their constraints and the design of purpose oriented methodical solutions. Examples can be found in the tradition of systems analysis as well as in the soft systems domain; in particular in the attempt to integrate both methods by an Integrated Systems Method for practice issues (ISM) (Schwaninger 1997). Second, the urgency of a transmethodic and transdisciplinary approach is stressed. Knowledge gained by ISM could be employed also in the domain of projects for political support. Cybernetics provides a point of depart for *transdisciplinary modeling,* for a *transdisciplinary methods base* and not least for *transdisciplinary semiotics.*

Results from complexity research in progress (Regsdell 2001) contribute to transdisciplinarity. The character of *complexity evolution* is understood more thoroughly, benefiting from research e.g. into non-linear mathematics, into synergetics, into branches of *chaos theory*. They profit from insights into living and *viable systems*, comprising the systems and *evolution biology* as biological *synergy* and the *emergence of consciousness* (Capra 2002; Laszlo 1987, 1996). In particular evolution research stimulates the complementing approach to systems from the *functional* view of the *system in situ* by the understanding of the system as it *evolved in history*. Theory, pragmatic concepts and experience from actual projects drive each other.

The transfer into practice will rely on *modeling and simulation*, the computation of evolution processes based on models of society (Blalock 1985; Conte 1997; Epstein 1996; Fleissner 2005; Loeckenhoff 2004).

2. Grounding Transdisciplinary Mutual Learning for Sustainability

Science rests on human curiosity exploring 'the' real (and non-real) world to find potential sources to live upon, environments to live in, to cope with problems etc. That is true for basic as for applied research. Within a general scenery of mounting societal complexity and dynamics the calls for and the emergence of transdiciplinarity ascend from various sources. First, on-sided single disciplinary attempts to serve societal issues have been failing or disastrous – see e.g. the *tragedy of the commons*. [Schmitt St. 2005]. Instead *Multi-level approaches* are increasingly successful, accounting for the many layers of a 'real world problem' and employing accordingly different methods of analysis and design. Second, complex societal issues include *human behavior* on all levels from the individual to (in-)formal groups, societies and the human world at large. There are many owners of the problems, many *stakeholders*, and hence likewise many views on the problems, many *value systems and evaluation criteria.* Naturally, third, *conflicts* will arise which need be creatively solved. The transdisciplinary dialogue will always extend to views and values, to targets, efficient *and* ethically *acceptable methods*. It will discuss *side effects* still tolerable, handling the *winners and the loosers* of an actual solution and so on (Bouecke 2005). Fourth, the path to joint action will be *mutual learning* from each other and concerning the qualities of the actual challenge in question. Fifth, knowledge attained needs *be 'socially robust'* not only by agreement of the stakeholders, but also in terms of *sustainability*. Sustainability implies the continuous 'learning' of long term potentials and of designing referent and rejuvenating strategies. Policy needs open new potentials, not close them or run into a cul-de-sac. Not least, those qualities rest on *reflection and self-refl*ection capabilities, on *meta-learning*, that is to learn how to learn more effectively.

A plethora of related actual disciplinary domains appears obvious when envisioning transdisciplinary research and action as a *social and societal process of co-operation*, as *co-operative learning*. For example *engineering aspects* often clash with value systems and *cultural traditions*. Agricultural projects may change the life environment and thus may mean societal disruption. Programs to empower women may set up the traditional family structures. The need for a densely networked systems strengthened demands for a *'contextualisation'* of scientific research. Consequentially, *stakeholders* representing the 'contexts' are to be given a membership in Participative Research (PR). [Notably the concept goes back to the early fiftieths of the previous century under the heading of Participative *Action Research (PAR]).* By participation it will be possible to become aware of and define the e.g. cultural, societal, economic, religious etc. domains implied, and include them into mutual learning cycles. Projects have, additionally, be explained and 'sold' to the general public via its media, opening another aspect of 'robustness' and qualities which enable its transfer in communication.

Within these societal contexts particular qualities are required from *'knowledge'*, scientific/ conceptual or pragmatic/ operational (de Zeeuw 2003). Restraining here to the societal aspect, knowledge needs be *robust* as to possible understanding, sharing and to prevent misunderstandings, accidental or willfully procured. Knowledge has to be *transgressive* not merely within technical and scientific domains, but also within differing cultures. The shape of knowledge needs, on the systemic top level, support what is often referred to as the 'ménage à trois', that it the dynamic balancing between *Democracy, Economy and Science*. To meet these challenges a *new kind of knowledge* in terms of its *societal instrumentality* is requested. The requirements range from the power to illustrate ('Anschaulichkeit') to interpretability and capacity to provide the base for a creative dialogue, which releases potentials and *encourages novelty*.

The intent of this paper does not permit to discuss relating topics as e.g. the connection to social, intellectual and knowledge capital and its fostering. It will restrain itself to aspects of theory of science and scientific knowledge; paradigms, concepts, methods, language and possible predictive qualities.

3. Towards a Basic Transdisciplinary Paradigm

Science can be perceived as a particular mode to look upon and to communicate with the world. Scientific operation is signified by a certain *rationality*, a systematic, a terminology; by what has been called the *scientific paradigm*, that is e.g. the basic assumptions and the models, the methods and procedures aligning. From philosophical, culturally shaped origins gradually a more independent canon of models and rules emerged. At the same instant it dispersed into specific paradigms serving the needs of scientific disciplines following particular aspects and intensions. Such specification was necessary to explore in depth and detail. It was tolerable as long as the technical, societal, environmental and worldwide free developmental space permitted knowledge to be gained and transferred into action on a base restricted by disciplinary paradigms. Actual challenges, worldwide and highly complex issues demand sustainable, integrated solutions. They require scientific effort across and *transgressing* traditional disciplines, basic research and task-oriented *transdisciplinary operations*. Complex challenges force *transdisciplinarity,* permitting co-operation and co-learning of individual disciplinary approaches and their integration towards the solution of an actual problem.

To achieve task- integrated results a shared *transdisciplinary* base is requested, a shared model, a shared paradigm of science and scientific procedures. This is not a claim for a comprehensive model of the world and the universe, for a a 'theory of everything'. More modest, it holds sufficient to look for *shared elements* in the disciplinary paradigms. Concerning the basic understanding of the very nature of science, the history of Post-Renaissance science knows the predominance of the *'physical'* paradigm up the middle of the 20th century. Gradually and but partly so far 'physicalism' gave way to a paradigm influenced by *biology*. With the rise of systems sciences, complexity theories, non-linear math and a refined understanding of (biological) evolution, the comprehension of science became and still remains multi facetted. From math to psychology multi-aspectual experiences undergo rapid development. In parallel, often as an undercurrent to the mainstream, central assumptions and axioms are questioned and reformulated. New phenomena and insights stimulate the reconciliation of hitherto accepted basic models. The entire scene appears far from regular or consistent. *Pre-sciences*, as Pre-geometry, Pre-logic [Formal logic [Frege] or Syllogism as the basic figure?]; Order Theory, re-understanding SpaceTime, Non-Linear Math etc. are involved. As are renewed scientific attempts as *Nomology* (decision theory; CM Brugha 2004), *Biosemiotics* and, in a particular mode, *Anticipatory Systems*. Evolution Theory undertakes to explore the emergence of human higher consciousness; computer sciences pursue Artificial Intelligence. Agent Based Theories open new vistas; *Cellular Automata* (Wolfram, 2001) even announce a 'New Kind of Science'. Systems Sciences from General Systems to Cybernetics resume basic research into their principles. At the same instant they influence the virtually better part of disciplines as e.g. Systems Biology, Systems Economics etc. Recently the change of basic assumptions and models fostered a renewed interest into their *ontological base* and reconsideration of *ontology* in general. In the same context *taxonomy* (see e.g. biology)m and classification are questioned. The mutual influence and the networking of these rather different lines of basic research cannot be pursued here.

Even a markedly sober look on the variety of approaches as above must concede the necessity as well as the potentials for transdisciplinary research. A first step will be, from the view of those general models aforementioned, the *detection of shared part models and features*. For example the systems sciences penetrated Life Sciences as (e.g. Systems Biology) as well as Management or Economics, resulting in systems-hyphen-subdisciplines. How far and how fast the shared e.g. systems/systemic part models, modes and procedures will carry remains open. Also whether they will lead to shared more comprising and consistent general models, modes and procedures depends on research jointly done. A basic *transdisciplinary model*, as which's defined subtypes disciplinary models can be identified, will most probably remain a far vision as e.g. a really *'universal' classification*. However, as an 'ideal type' ('Idealtypus' M.Weber) the vision of such a base transdisciplinary model or a set of models should not per se abandoned. Best candidates to contribute appear the systems and evolution approach.

Especially the *evolutionary paradigm* (Dopfer 2005; Edelman 1992; Krugman 2005) will lead to *anticipation and anticipatory models*. Evolution can be seen as a dynamic process, obeying sets of rules e.g. concerning the system in evolution and its co-evolution, its interactions – developments within and with environments. Evolution happens in space and in time; it is connected to both the *past* and the *possible futures*. It inheres also a model of its own *procedural* future: the fact permits not so much prediction but anticipation of future development courses. That includes the principles of evolutional procedures and their revelation in actual historical evolution. The co-evolving interplay between the system/ environment; it's eigen-dynamics (which are also an outcome of evolution) and the rules of evolution set the field of *potential / probable futures*.

4. Heuristics for Development Potentials

Savoir pour prévoir, prévoir pour pouvoir : again, the new kind of knowledge demanded as to solve highly complex societal problems in Participative Action Research also asks for a new kind of scientific *transdisciplinary co-operation*. Considerations as follow will focus on the paradigm of *evolution* as a basic paradigm, on models, modes and procedures as a transdisciplinary base. Comprehension refers to the actual discipline one is working from. It also attempts to explore the shared foundation and the interfaces for transdisciplinary co-operation. Two examples may be addressed. *The Evolutionary Foundations of Economics* (Dopfer 2005) contribute an inroad to economics exploring evolution processes as driving and shaping forces of economic development. The *Theory of Neural Group Selection TNGS* (G. EDELMAN 1992) proposes a particular process of evolution leading to consciousness and human higher consciousness. Seen from anticipation both are mainly addressed in their *heuristic capacity*.

As a means of anticipatory heuristics the *Phase Space Concept* (PSC) is discussed as proposed by Poincaré. It helps to constitute a system of evolutionary learning by combination with the *Bayesian Syllogism*, the concept of *Natural Drift* from Systems Biology (H. Maturana, F. Varela 1987) and other e.g. statistical regularities (The Economist, 2006).

Restating the obvious but not trivial: one essential problem facing science is that of *change and change control*. To describe, to understand and to cope with change requires a set of *ontological axioms essential to dynamics and development*. *Static* axioms are ruled out because they describe but a specific, that is a static case, and are insufficient to depict development. Moreover, change does not follow *mechanistic* rules, but the rules of what may be summarily described of *complexity and complexity* *emergence*. The modes of *change are subject to change itself.* Each actual change, even if following evolutional/developmental rules, is unique. It obeys the laws of *probability, of stochastic* sequencing, and is subject to fundamental uncertainties as in *bifurcation* or in *phase transition*. In consequence the *ontology,* the axioms about the qualities of the 'real world' needs be that of change. The statement is the more salient as it also rooted in modern physics, namely thermodynamics, synergetics etc. *Non-linear mathematics* provide the formal base. A paradigm will constitute by the model of evolution; by biological, including viable organisations and societal systems. K. Dopfer (Dopfer, 2005) points this out for *societal systems* in his brilliant, seminal overview in the introductory chapter: 'Evolutionary Economics: a Theoretical Framework'. He discusses the ontological and epistemological preconditions and consequences against the framework of theories of science.

Societal change and in particular change guidance/control has to account for the emergence and the development of *human consciousness and higher consciousness*. Human behavior depends on higher consciousness concerning the everyday individual, the social and the societal co-living. Higher consciousness plays the essential role (or hopefully does so) also when experiencing, reacting to and eventually controlling social and societal change. As systems biology and cybernetics of higher orders have shown, human beings see the world as learned from experience and evaluating observation. There is no 'neutral' observer or meta-observer. The result of observation is by nature subject to the influences of worldviews, ideologies, illusions and intent driven observation. The subjectiveness and momentary quality of 'facts' observed, opinions and convictions held, chances spotted etc. may severely distort the mental picture of the 'real world'. Distortions will cloude reactions to be expected from 'reality' when control measures are designed and exerted. As policy failure indicates, human behavior need be understood not merely from its actual state, but also from its evolution, from the priorities set in the course of evolvement and from the functions for survival, development and procreation. Moreover, in 'Bright Air, Brilliant Fire. On the Matter of Mind' G. Edelman (Edelman, 1992) attempts to build a bridge between natural sciences and mental processes, providing a path from space/time physics to the emergence of higher consciousness. Phenomena like atmospheric feeling, so called *'qualia',* elude scientific analysis. Nevertheless the Edelman establishes a point of departure for better grounded hypotheses and concepts also of human political behavior, e.g. in the domain of societal control and policy.

Both the 'economic' and the 'mental' concepts of evolutionary processes provide a base for anticipation. In the concluding chapter a anticipatory evolutional model of guidance and control learning will be proposed. The attempt precludes a particular mode of representational geometry possessing exceptional heuristic potentials; the aforementioned *Phase Space Concept* (PSC) proposed by Poincaré at the turn of the 19th to the 20th century (Loeckenhoff 2004).

Again: Research is constituted as a continuous dialogue between the observer and the object of research, mediated by an appropriate mode of representation. For policy support the complexity of societal phenomena needs be focused into a few long range *macro curves* indicative for the topic. For the research process itself an efficient tool is desired to find the right questions to be put and the answers to be interpreted/ integrated into e.g. a recommendation. Critical transparence, retraceability, the use of mathematics and computer programs for simulation of a model is a matter if course. In this respect the phase space approach qualifies in particular as a *heuristic instrument*.

The application of the PSC in societal research has been dealt with in detail elsewhere (Loeckenhoff 1997, 2004). The basic ideas seem simple. The Phase Space concept enables to describe multi-factorial complex developments in a two space coordinate system. The *ordinate* represents the parameter *time*; the *abscissa* the numerical value of the *macroscopic property*. Within the coordinate system phase space describes the sequence of actual states of the system. It does so in depicting the actual states of all the elements which are rendered conclusive for the macroscopic state. For example the macro curve of development of a society is conceived as the resultant of the states of the conclusive elements as e.g. persons (micro), institutions (meso) or economy sectors (macro). Such a presentation precludes, on the base of grounded *qualitative* models, a set of (conclusively) networked *quantitative* models of the elements. Quantitative Phase Space representation serves as a comprehensive heuristic method as to the also quantitative structure and the processes of the developing system. A heuristic means to analyze complex systems, PSC forces to identify elements, functional (quantitative) connections, structures and processes. PSC stimulates to explore alternative understandings of the actually system from various aspects, purposes etc. From that base the specific models can be designed, be connected, be quantified and programmed. The resulting program may be used for *simulation* under defined variations to explore essential properties as eigen-dynamics, robustness, sensitivities and so on. Variatis variandis, a systematic variation of *possible paths of evolution* may be simulated under retraceable conditions.

The heuristic qualities of PSC extend necessarily to the very foundations of *science theory*. They relate e.g. to the bases of modeling, as to identifying purposes, essential elements, connections, their values and change over time for particular elements and models. How to integrate them properly, on which shared fundamental models base? How to identify fields of possible interpretation under given auspices and preconditions? Answers again needs be given from a point of transdisciplinarity.

5. Guided Learning From Evolution

It needs be tested in detail elsewhere in which respect and why the base model of evolution per se is to be seen as *transdisciplinary*. Likewise it should be questioned whether and why evolution seems per se *anticipatory*. It needs be argued in greater detail, too, how far anticipation needs to proceed in a transdisciplinary mode when applied to complex systems.

However actual results may turn out, evolution theory can be employed to construct the model of a *learning system* and a learning process capable to anticipate fields of possibly evolvement of complex e.g. societal systems. To this end it has to be combined with the *Bayesian Syllogism* and the *'Natural Drift'* proposed by Systems Biology.

The base model is given by the *Phase Space* coordinate system. X- respectively y-axis signify the parameters 'Time' respectively 'Value of the macroscopic development'. Following the *Bayesian Syllogism* it is assumed, that each point in time is co-determined also by the past states, the past developmental stages of the actual system modeled. It should be noted that the Bayesian logic is referred to as a Syllogism (Nalimov 1985). For the simple base application is presupposed that crucial qualities of the actual system will remain stable also under changing conditions; they will change only peripherically. Also central qualities of the developmental process will remain constant. Likewise, within a certain span of time, (macro-) phases and spans of development referring to the time span can be covered by the actual model without presuming change inferred from environment and by changes in the course of change itself. Simplified: actual development of an authentic system can be assumed to be essentially determined by its inherent model of itself and of its possible futures. The space of the latter will be circumscribed by Bayesian structured probability fields, involving the systems history, environmental states and inner models of possible futures. Also the environments are presumed to include a model of themselves and of their possible future development (as also part systems of the system in case will).

Summing up: the process of development on all levels and from all aspects follows the rules of evolution. They are represented and acting within probability fields, structured by prevailing historical and functional preconditions into fields of higher or lower probability. To explain the actual developmental course of living (conscious) systems System Biology (Maturana, Varela 1987) postulated the concept of *'Natural Drift'*. Learning from cooperation with environment also changes the internal model of the system of itself. The systems model of itself ands its future course of development changes within a process of *Drift Learning*. This leads, in the long run, to characteristic courses of the evolution of actual systems.

Within the general framework as described above a more detailed and in depth analysis will reveal additional principles and rules e.g. referring to *complexity sciences* as synergetics, bifurcation, phase transition and not least to etc. Analysis will refer also to the evolutional features discussed in the *anthropologies and the humanities*. To understand their co-action again the transdisciplinary approach is condition sine qua non. (The above consideration suggests an *evolutionary approach to each and all disciplines* to provide a crucial base for transdisciplinary models. (For example see Dopfer 2005 and Edelman 1992 as aforementioned).

Following, first, *systems* as the basic transdisciplinary model, second, *evolution* as its dynamization and third, complexity qualify as transdisciplinary models. *Semiodynamics* (as christened by the author), fourth, covers the dynamics of the emergence *of meaning*. Particular forms of consciousness and meaning as relating to religious feelings, to beliefs, to convictions, to rare normal phenomena as altered states of consciousness etc., fifth, are hypothesized in a *Noosphere*, the term coined by Teilhard de Chardin. This proposed (non complete) set of transdisciplinary models is seen here in particular providing a platform for *transdisciplinary learning*.

Any developmental process constitutes essentially a *learning process*. As a model of evolution (in the extended transdisciplinary sense as above), learning can be viewed as *self-organizing* ; referred to in other contexts as *meta-learning.* The phenomenon has been described originally by e.g. biological sciences and psychology. Seen from social sciences the growing influence of consciousness and in particular higher consciousness in human creatures and their collectives added the quality of purposeful, intentional and *decision based intervention* into the natural evolvement process. The model of intentional and controlled learning has been christened by the author *Guided Evolutionary Control Learning (GECL)*. The anticipatory qualities of the system are here used for *orientation and prognosis* of the probability fields referring to possible future development. Analysis constitutes the option and action space whereupon *targets and strategies are set.* Targeting is followed by *planning*, transferring objectives into *measure programs for implementation*. Necessarily it is assumed here, that the essential qualities of the actual *and* of the GECL system at large will *not change fundamentally* during the planning cycles. Also specific developmental, e.g. *learning curves*, need be presupposed. If a significant change is expected, the learning system at large has to be redesigned anew for each new situation after the change (meta-learning).

Simplified, GECL can be viewed as overlapping twin cycles. The first 'basic' cycle of planning and subsequent action, that is from orientation to implementation, has been commented above. It is concerned with analysis, evaluation, decision and transfer into results from action. The second 'operational' cycle signifies the process of learning from experience and the reaction based on what has been learned. Results as achieved are compared with results planned. The difference (Delta; Δ) is analyzed as to is causes: mistaken preconditions, or failed planning or poor implementation. According to the causes learned the situation is re-scanned and re-evaluated. *Corrections* – in targeting, planning, implementation measures – are effected. Existing plans are changed, ongoing actions intervened. Hence the second cycle is seen as the actual *controlling cycle.*

Meticulous planning for example referring to projects has to cope with high degrees of uncertainty. After each step of implementation the design of the entire GECL, assumptions as well as actual planning, have to be reconsidered from the scratch. Though the actual base learning model can be rendered universal, GECL serves best for transparent systems, spanning foreseeable time in stable general environments. Actually the concept emerged from industrial planning practice. In altered versions, is practiced by societal units. As the practice of political support shows, the art in this domain remains in rather early stages of development.

GECL comes, by nature of its complex set of actual parameters, anticipatory and transdisciplinary. The more (disciplinary) aspects are taken into consideration, the more reliable, comprehensive, robust and sustainable knowledge will be gained. The better oriented to purpose and target, the more successful decisions can be made and put into action. Equally important, GECL provides a frame of reference where the conceptual/ factual challenges of both anticipation and transdisciplinarity can be studied and established using authentic cases. Not least the change of the anticipatory qualities of systems e.g. in the course of natural drift and evolution might be explored.

Epilogue: Re-Inventing the Learning and Innovative Society

The last decennia are marked by an ever widening gap between the dynamics of worldwide societal evolution on the one and the capacity of societal learning for conscientious adaptation on the other hand. The necessity to reform often is addressed but scarcely if ever sufficiently implemented. The resulting frictions appears the more dangerous as they cannot be bridged by known concepts projected forward and by policy as usual. Proven methods turn out obsolete and inapt, leading to further encrustation and ossification. Part of the problem is located in the mental/behavioral and the political side. Under pressure policy tends to seemingly simple solutions: to emotion instead of reason, to ideology, to cloud cuckoo, to illusion. Short range measures are at best appropriate to pacify. As ideologies they do not solve but create and aggravate problems. The other part is the (non-)existence of sufficiently precise awareness of challenges and modes to cope with them sustainably. Society remains stagnant where it urgently should be innovative.

An innovative society rests on a full awareness of the challenge and a reliable knowledge base how to meet it. Both need be congenial to the complexity, the domains and the structures constituting a society and the course of societal development. Knowledge needs be a *learning knowledge*, permanently and continually upgrading. Knowledge needs be *founded* and *basic*, meeting the requests of fundamental change. These fundamental qualities as well as the heightened uncertainty of future developments require *transdisciplinarity*. Future needs face a variety of tasks. Direct to the eye appears the - *problem oriented* – connection between the individual disciplines. Behind such a transferability, an integration of knowledge from different origins lies the request for *shared basic models*, for a shared point of departure to understand science. Science is seen as a mode and a tool to *support societal policy*. Innovative policy rests on both *historical and systemic* understanding. On the dual base *anticipation* becomes an option; the identification of the actual state as a defined state/phase of societal development and of the *potentials for further evolution*. Points and domains of *intervention* can be explored, possible (side) effects assessed and compatibility with ethic principles considered.

Innovation needs *specific, pragmatic knowledge*, which is provided from individual, often highly specified disciplines. *Transdisciplinary* approaches complement and support individual disciplines, for example opening new vistas for research. They will comprehensively support an innovative science pertaining to anticipatory societal development.

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