# Cross-, Inter-, and Transdisciplinary Methodologies for Anticipative Systems

**Marilena Lunca**
E-AIPS, Utrecht, The Netherlands
e-academy@planet.nl

**Abstract :** Since the systems' need for anticipating future adjustments widened beyond the conventional anticipative systems, science takes a particular interest in designing methodologies that can ensure the scientific character of *anticipation.* The study defines *methodological theories* that are specifically required by solving problems that only science can solve, on which the likelihood of one future over alternative futures depends. It is argued that: a) problem-solving is the main reason for moving from disciplinary to cross-, inter-, or transdisciplinary research and b) solvability is a function of the (formal) language in which a solving strategy is defined.
Two notable results hereto are that prediction appears as a particular case of anticipation, and the task of methodological theories is to direct-and-control the *sequencing* of cross-, inter-, trans-, or disciplinary phases within a solving programme.

**Résumé :** En tant que le besoin des systèmes d'anticiper leur futures ajustements s'élargit au-delà les systèmes anticipateurs conventionnels, la science est particulièremen intéressée en méthodologies qu'assurent *l'anticipation scientifique*. Cette étude est concentrée sur la définition des *théories méthodologiques* demandées par des problèmes que seulement la science peut solutionner. On va argumenter que : a) solutionner des problèmes constituet la raison principalle de se déplacer de la recherche disciplinaire vers celles croisé-, intér-, ou transdisciplinaire, et b) la solvabilité est une fonction du langage (formel) dans lequel la stratégie résolvante est définie.
Le deux résultats plus notable sont les arguments que la prédicition est un cas particulièr de l'anticipation, et que la tâche des théories méthodologiques est de diriger-et-contrôler la mise en séquence des phases croisé-, intér-, trans-, ou disciplinaires dans un programme de recherche.

## 1. The Scientific Interest in Anticipating

Anticipation is known as the capacity of figuring out one or a number of futures, or the capacity to change the present in order either to meet or to avoid the most likely future, which should be reckon with if *anticipation* is to become a scientific tool of projecting future.
The first reason why anticipation is a challenging scientific matter is that anticipation stretches from the most basic forms of unassuming daily life, to the cutting edge experimental simulations; from the artist's plot to obtain a particular effect by using a certain means, to programming machines to perform a certain task in some t+n instances. Planning some future at all and every social and/or biological levels has never been more purposely pursued than it is nowadays. This brings about the somewhat trivial, but fundamental observation that anticipation is more time-and-agent dependent than it is time-and-context dependent.

In the early 1980s, anticipation became intrinsically associated with the concept of *system* (in the sense of that which anticipates must be a system), and further, with *living systems* (suggesting not only some intelligence, but also a sort of tendency towards survival, towards reaching a next state, at the very least). Most pertinent contributions to this matter leave almost untouched the difference between anticipation and prediction, whereas fruitful advances have been made in defining anticipation in reference to observation/observer (the conclusiveness of data needed for projections), to modelling (the next state), and further afield applications such as decision making, intervention, and problem-solving.

In brief, "An anticipatory system is a system containing a predictive model of itself and/or of its environment, which allows it to change state at an instant in accord with the model's predictions pertaining to a later instant".[1]

In the 1990s, algorithms and methodologies have been designed to define as many common denominators as could be found with a view on refining the intrinsic correlation between anticipating and living (systems). Although not always explicit, the biological dimension appears to be more coherent than the social one, whereas a potentially unifying dimension is that of *learning*. The latter is taken in this study to be closer to the essence of anticipating (as a process) and more appropriate for summarising the main achievements in this field.

A) Since anticipating is not possible without *memory* (implying observation, abstraction, and past trials), *learning systems* represent an extension of living systems (given their biological underling connotation). Yet, it is the intension that matters most because that which is memorised, observed, etc., is information, more precisely, useful information, i.e., knowledge. To be able to understand the dynamics of anticipating, one cannot overlook the material being processed. Accordingly, anticipation appears 'weaker and broader' than prediction, but deeper and closer to the nature of what is processed rather than to who or what the processor is.

B) If anticipating means doing X at $t_0$ in order to (dis)allow Y at $t_1$, than *time* is a succession *stricto sensu* only in exclusively physical systems where a form of causality $X \rightarrow Y$ can be detected. Prediction applies here in the typical, binary reasoning form of 'if X then Y'. Any mixture of physicality and non-physicality alters both the certainty of Y and the arrow of time so much so that the arrow may be bent and even reversed in most informational, social, and psychological systems. It is because of these systems that time only exists as a presence that may be richer or poorer according to the extent of the knowledge about past and potential futures.

C) Although anticipation is a fair and sensitive differentiator of the living from the non-living systems, the question is inescapable as to why systems made of inorganic matter perform the task of processing information whose use can only be 'placed' in some future. This is what quantum systems do when particles look like they communicate prior to occurring in a certain locus on the wave's amplitude. Why, furthermore, biological non-intelligent systems entrust a part (sometimes a specialised sub-system) with the specific task of 'preparing for the future' (e.g., DNA)? As this kind of question makes sense for any system, however simple or complex, the idea emerges that typically anticipative systems may learn from the way supposedly non-anticipative systems do, so to speak, 'select information useful for later on'.

D) The idea of a straight correlation between anticipation and a model of the next state being contained in the present state of a system has been further developed in epistemologies of interpretation[2] and mathematical-computing algorithms. Both developments, but the latter in particular, put scientists on the watch for the source of complexity in those sub-systems that are specialised in anticipating. In other words, the more complex a system is, the wider its specialisation-and-diversification. Hence, *the mere tendency towards a next state is enough for complexity to generate complexity or at least to multiply itself*.
As a result, encoding (information) became the key to work with Grey codes in place of binary codes, which enabled a better translation of internally diversified systems into sets that no longer need to be defined strictly as Cantor sets (set of sets). The model, that Rosen thought of as

---

[1] ROSEN, Robert, (1985), *Anticipatory Systems – Philosophical, Mathematical and Methodological Foundations*, p. 339, Pergamon Press, New York.
[2] ALTAN Henri (1998), Intentional Self-organization. Emergence and Reduction: Towards a Physical Theory of Intentionality, pp. 5-34, *Thesis Eleven*, 52, Sage, Brussels; GLASERSFELD Ernst von, (1997), Anticipation in the Constructivist Theory of Cognition, pp. 38-47, Dubois, D. M. Ed., *Computing Anticipatory Systems*, AIP, Liège.

'contained' in the system, does not need and, indeed can not be entirely contained in the system since the next state 'exists' only as incomplete and potential information.

On these grounds, it is sensible to conclude that ***anticipative** are the systems that process information in order to adjust their state to in-coming information*, and ***anticipatory** are the systems that anticipate on purpose and knowingly*. Binary, linear, and time-directed prediction appears, therefore, as a particular manifestation of anticipating degrees of certainty of alternative Ys. The distinction anticipative – anticipatory is more than that between passive and active; it is related to the need to increase the likelihood of one future over alternative futures. This need would not occur if at least one of the potential futures would not be entropic in nature. More radically put it, anticipation would not be a matter of concern if the in-coming information would not signal a potential 'threat' for a system's continuity. By implication, non-anticipative is the absolute stable and self-sufficient system, whose environment is also stable. At the other end, an anticipatory system can only be a sub-system.
Arguably, the least demanding way of reaching a next state would be simply to accommodate in-coming information, the more demanding one is producing information, and the most demanding is producing knowledge in order to disallow entropic futures to emerge. The latter is called problem-solving, that is, overcoming the obstacle between $t_0$ and $t_1$ by engaging means and resources that otherwise would not be actualised or created. As the most advanced, aim-oriented, and pertinent problem-solver, science has no equivalent in other forms of search for solutions, which only emulate science (by being systematic), but have no knowledge of that for every single 'solved' $t_1$ there is at least one entropic $Ht_1$ (where H stands for entropy).
In other words, because a degree of uncertainty persists in any foreseeable $t_1$, there is no solution that reduces H to zero, and no such thing as a perfect solution. But science is the best, though not perfect, way of anticipating when a solution is iatrogenic in nature before being implemented (in which knowing-and-doing converge, hence, learning[3]).

This is why this study concentrates on the *scientific anticipating, i.e., problem-solving*. Problem-solving consists of removing the obstacle standing between the present and the next state of a system by using scientific means only. When a problem *exceeds the prescribed and known solving procedures*, science has procedural problems of its own that need to be solved. More specifically, the most acute form of anticipating is by solving a problem. And the most acute form of problem-solving is that consisting of the need for science to design a strategy that is new in reference to those solving procedures that *are usually known because they are endorsed by disciplinary methodologies*. Science is one, huge anticipatory system that interferes with all anticipative systems, only that the system 'science' is far too comprehensive to be rendered workable. This is why, science get organized in disciplines specialised in solving problems falling within their competence (like the sub-systems specialised in anticipating).
If one studies the history of science in the last century, the conclusion would emerge that disciplines diversify and multiply mainly because new problems put in evidence the insufficiency of one or another discipline at a certain moment. The disciplinary structure of science is so deep and stable that the first reaction to solvability challenge is by coming with new (sub-)disciplines, and only after disciplinary failure is well-documented, by designing solving frameworks in which disciplines or disciplinary components are integrated or unified (see Section 2.2).

As known, disciplinary problem-solving is less intuitive than routine or trivial overcoming of obstacles, meaning that a research programme is required to be specified to such an extent that a methodo*logy* is in charge with the selection of the most appropriate method(s), language(s) or

[3] By definition, learning means that not all the mistakes are repeated next time, which does not eliminate additional, new mistakes. If the hypothesis of learning systems exceeding the living ones holds some truth, then one may look at the imperfection of Mother Nature in terms of allocating space for unforeseeable possibilities to be actualised in the way in which these can be explained or at least identified. This might be a perfection of higher-order precisely because it accommodated local-temporary imperfections, therefore, room for improvement.

testing setting(s). By implication at least, a solving strategy that is not monodisciplinary would be that much less intuitive, hence that much unavoidable is the need for a theoretic and epistemic frame within which the solving strategy is designed.

The core thesis here is that a methodo*logy* is required to demonstrate that a problem, **P**, is not monodisciplinarily solvable, another methodo*logy* is required to build the solving strategy, and both methodo*logies* need to be rendered consistent with each other. To be able to achieve the latter, a *methodological theory* has to be explicitly formulated. At the very least, this thesis relies on that the *logos*, which stands between a method and a methodo*logy*, casts already the seeds of a theory. In keeping with the line of argumentation developed so far, the higher the complexity of a **P**, the lower its solvability chances, the less disciplinary the solving strategy, therefore the more unavoidable is the need for a *methodological theory designed for that* ***P***.

## 2. Methodological Theories

### 2.1. Disciplinary, Less-, and Non-Disciplinary Languages

The author has extended and specified the foundations laid by the forerunners of cross-, inter-, and transdisciplinary thinking by advancing nearly complete epistemological frameworks in consistent relation to problem-solving and the semantics of (formal) languages[4]. A concise review of key definitions and arguments runs as follows.

What differentiates a discipline[5] from another is its language, **DL**, in which the discipline's object is theorised, specific methods are set, the inner consistency is drawn in epistemological terms, and the discipline's solving competence is outlined. **DL**s range from the narrative (disciplines) to highly formalised (sciences) and formal systems[6]. Because **L** is the universal way of rendering an object intelligible (from heterogeneous to homogenous), **DL**s draw epistemic frontiers and enable **D**s to perform. This is the base for that *disciplinarity is a matter of semantics, ultimately*.
Here it suffices to remind that formal systems are mostly syntaxes, whilst **DL**s are mostly semantics. As computing languages, **Γ**, become increasingly semantic-sensitive (especially with the rise of quantum information theory), they are in a unique position to bridge the divide semantic-syntactic. But because **Γ**s lack the epistemic foundation, they cannot provide tools for unifying **DL**s. Yet, given the **Γ**'s function of encoding information in order to transmit and/or translate it into knowledge, **Γ**s are irreplaceable when integrating **DL**s is required.
As an observable tendency, the less formalised a **DL** is, the more in need it is to make use of other **DL**s, **L**s of formal systems, and **Γ**s in search for methods, variables, inference rules or terminology. Three such cases are of particular interest as far as problem-solving is concerned.

Cross-disciplinary, **CD**, problem-solving is the procedure by which at least two **D**s contribute with some of their *components that were related* even before the need for the procedure occurred.

---

[4] Some of the latest: LUNCA Marilena, (2003), Transdisciplinary Unifying Theory, *EOLSS*, http://eolss.net, EOLSS Publ., Oxford; LUNCA Marilena, (2005) From Quantum Information to Interdisciplinary Knowledge, G. E. Lasker, Ed. *Research-in-Progress. Advances in Interdisciplinary Studies in Systems Research and Cybernetics*, Vol. XI, IIAS, pp. 5-14, University of Windsor Press, Windsor; LUNCA Marilena, (2005), Inter-, and Transdisciplinary Potentials of Information, *Proceedings to the WOSC 13th International Congress of Cybernetics and Systems*, Vol. 4, pp. 27-36, University of Maribor, Maribor.
[5] The term *science* is generic for the reunion of disciplines (e.g., social), sciences (e.g., physics), formal systems (e.g., mathematics), and interpretation systems (philosophies), some of which are formal (philosophies of science). Because 'disciplinarity' designates the internal structuring of *science*, *discipline* is generic for all the science's sub-systems and other systematic activities such as sport, 'media studies' or running a city counsel. *Disciplinary* is the attribute derived from disciplinarity. When *discipline* refers to the less formal, it is specified in the context.
[6] For the almost completely formalised systems, **D** = **L**. For example, logic is its language. When **D** = **L**, the method(s) of that **D** are part of the formalism of that **L.** By contrast, sociology has/uses more than one **L** deeply rooted in natural languages, and its methods cannot be brought to obey the rules of a uniquely formalised **L**.

The most frequent **CD** problem-solving involves commonly shared (or constructed) variables and encoding, and their univocal quantitative treatment. Encoding variables across **D**s means a common interpretation that only seldom is made explicit in a **CD** language.
Interdisciplinary, **ID**, problem-solving is a *research plan in which compatibility amongst disciplinary components is purposely pursued according to the **P** to be solved* (and not according to the rules set by **DL**s). Disciplinary components are not simply chosen and adjusted to each other; they are at least partly re-designed to become compatible with the solving strategy. This is why, an epistemic framework and an interdisciplinary language, **IL**, are needed to *identify incompatibilities and create compatibility in sequences where **DL**s block interdisciplinarisation*[7].
Transdisciplinary, **TD**, problem-solving is that **ID** in which a language, **TL**, *sets and tests* the rules by which compatibility is created and the *sequencing* of the research programme is controlled. This is why a **TL** is a meta-language, **ML**, for the solving strategy and requires in turn an **ML**, in which the validity of **TL** is tested (and **TL** is re-drawn, if necessary). The prefix 'trans'[8] indicates that a formal **L**, **FL**, and a **Γ** (which are neither sciences nor disciplines) are usually used either to assist the construction of a **TL** or to play the role of **MTL**.

These definitions apply to cases in which problem-solving depends on solving problems that science created for itself by becoming disciplinarily specialised, and the evidence is overwhelming that *the least solvable problems are precisely those that do not emerge in the disciplined, learne,d and expected paths*. That the disciplinary frontiers are there to be crossed or disregarded is the anecdotic metaphor of two highly consequential distinctions that hold at the intuitive as well as the formal levels. One thing is solving a **P** occurred in a natural, social, etc. system by solving another **P** of the same origins and known as such, another thing is to solve this kind of **P** by solving a *problem of science*, **Φ**, such as evaluating the appropriateness of a method, and another is to be unable to solve an **Φ** unless another **Φ** is solved. Formally put it,

$$\forall \mathbf{P}(\mathbf{P}) \neq \forall \mathbf{P}(\mathbf{\Phi}) \qquad [1]$$

$$\forall \mathbf{P}(\mathbf{\Phi}) \neq \forall \mathbf{P}(\mathbf{\Phi}(\mathbf{\Phi_i})) \quad \text{where } i \text{ may not be a linear indexation} \qquad [2]$$

Consistent with the theses already argued, two further distinctions are as law-like as [1] and [2]. The function $\mathbf{\Phi(\Phi_i)}$ may take three forms according to whether $\mathbf{\Phi_i}$ is formulated and solvable in the same **DL** as **Φ**; $\mathbf{\Phi_i}$ is formulated and solvable in another **DL**, or $\mathbf{\Phi_i}$ is formulated and solvable in another **DL** plus a **FL**. Needless to stress that each form knows variations as to the number and relatedness of **DL**s, and that the process of semantic disciplinarisation is not linear (at least considering the circularity method↔**L**). More importantly is that a **DL** that would be capable of integrating or unifying other **DL**s would cease to remain *disciplinary*, hence the need for, and assignment of cross-, inter-, and transdisciplinary **L**s, particularly **IL**s and **TL**s.

It took to disciplinarity hundreds of years to construe and refine **DL**s precisely because such a task is an extremely consequential **Φ**, on which solving depends the solving of increasingly complex-heterogeneous **P**s. Therefore, let [2] express the principled distinction of solving not two or a number of **Φ**s, but a *dependence of an **Φ** on another*. The distinctions derived from [2] are: the dependence of an **Φ** on construing an **IL**, **TL**, or a combination thereof (be it called Θ) and the dependence of an **Φ** or **Φ(Θ)** on construing an **ML** (be it called Ξ). Then:

$$\mathbf{P(\Theta) \cong \Phi((\Phi_i)(\Phi_{I/TL}(\Phi_{DL}))_j)} \qquad [3]$$

$$\mathbf{P(\Xi) \cong \Phi\{(\Phi_i(\Sigma\Phi_{DL})) + \Phi_{I/TL}(\Phi_{ML/\Gamma}(\Phi_\Theta)_j)\}} \qquad [4]$$

[7] The term is meant as a process in the making, which (should) apply to all forms of practicing science, including disciplinarisation. The latter, although unremarkable, happens with each new sub-(sub-..)discipline that takes shape.
[8] It is not as much the prefixes as the suffixes that originate confusion. Interdisciplinari*ty* or transdisciplinari*ty* are nouns wrongly used to suggest that there would be an object of the same epistemic value as a disciplinary object, and that a cross-, inter-, or transdisciplin*ary* practice should copy disciplinarity or a discipline-like structure.

In [4], '+' needs to be specified as soon as *i* and *j* are identified, such as to see whether expressing dependencies as functions does not oversimplify by inductive linearity. This is not an operation that can be worked out *in vitro* or in theory only, but in univocal relation to the **P** to be solved. The reasons hereto are that methodologies and **DL**s have been at work in previous attempts to solve that **P**, and less- or non-disciplinary **L**s do not emerge naturally within disciplinarity. As a matter of course, the less solvable a **P**, the more uncharted and even unique the solving strategy. Hence, the need of a theory that 'supervises' the consistency of the research programme with **P**. If the phrase *methodological theory* needed that much explaining, it was because disciplinary epistemologies provide the theoretic justification of 'the most appropriate methods and **L**s', whilst a cross-, inter-, or transdisciplinary programme is due to provide almost every time anew.

## 2.2. Theorising Cross-, Inter-, and Transdisciplinary Methodologies

The outlines of the methodological theory have been drawn by [2] and its derivates, on which base it can be established that any time a **P** satisfies [2] + [3], [2] + [4], or [2] + [3] + [4], that **P** is definitely not monodisciplinarily solvable. In order to establish positively the extent of the less-, or non-disciplinary solving strategy, the same elimination process should be repeated for each sub-system of the so-called **P** space, which is the result of mapping what is known about **P** and identifying the boundaries of **P**'s system at this stage. This allows for two important operations. The first is an estimate of non-independent sub-sub-…systems and the extent of these being traceable in **DL**s. Be it called *I: conceiving the* ***P*** *space in cybernetic systems terms.*
The second is mapping sub-sub-…systems as solving targets and mapping each one's contribution to the overall insolvability in terms of **Φ**s and, as much as possible as **Φ(Φ)** and **Φ(Θ).** Be it called *II: mapping solving targets and their* ***Φ*** *dependencies*. Given **Θ** and **Φ(Θ)**, the following phases may vary greatly as to how far inter-, or transdisciplinary, or a combination thereof the solving programme may become.
The compulsory side of such a programme is sketched below where the III, IV, and V phases involve **IL**s, **TL**s, and an **ML**. These phases are repeated in *sequences* whose extent and succession is yet to be determined by the particular theory of the particular **P** under treatment. Accordingly, the methodological theory is adapted to that much uniqueness, that it is suggestively called a *home-made theory*.

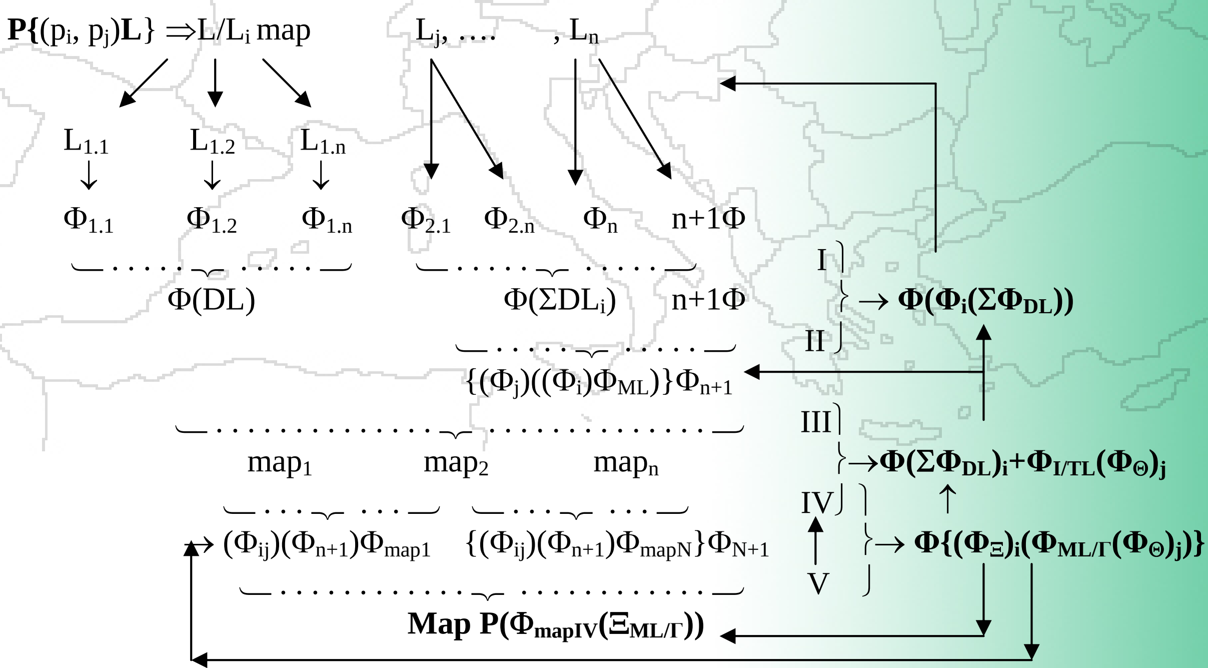


Figure 1. Sequencing cross-, inter-, and transdisciplinary problem-solving

As anticipation is inconceivable without memory, so is problem-solving without procedures. It would be inconceivable that disciplinary problem-solving would be entirely pushed aside by the less-, or non-disciplinary solving strategies. At least the I and II phases are disciplinary by and large. Depending on the number of competing maps that the III phase should reduce according to $\mathbf{\Phi(\Sigma\Phi_{DL})_i+\Phi_{I/TL}(\Phi_{\Theta})_j}$, the sequencing might become as linear as to be able to identify overlapping **IL**, **TL**, and **ML/Γ**. All three work to integrate or unify those **DL**s that block inter-, and transdisciplinarisation because they have been identified as **Θ**s in the cross-disciplinary phase where the specification of $\mathbf{\Phi_i}$ depends on $\mathbf{N(\Phi_{DL})}$.
Figure 1 shows that the phases III, IV and V define a non-uniform, internally divided sequence by the commonly shared task of integrating and unifying **DL**s by using an **ML** or an **ML/Γ**. In fact, an **ML** is being used in what should be called intra-disciplinarisation, that is, re-integration and re-unification of components of sub-disciplines within the field of the root-discipline. Biology and its downwards and onwards ramifications provide the most dynamic example in this sense. Notably, the deeper the order of sub-divisions, the more frequent are intra-disciplinary objectives of study. Such regional **ML**s are implicit (hence, less visible) because they are supported by the regional epistemologies that maintain cybernetic communication with the root-discipline's epistemology. But significantly, the deepening specialisation renders sub-sub-disciplines prone to the need to relate to (sub-)disciplines outside their neighbourhood, as in the case of genetics and information-communication theories. The newly emerged science studies, and science and technology studies provide exemplifications of these conclusions.

But beyond that, the often overlooked, though crucial, distinction consists of the epistemic ground of claiming an *object*[9], which disciplines, sciences and formal systems rightly do (hence, disciplinary object), and the emergence of an amount of *objectives upon that object*. When an objective emerges upon and aside a number of disciplinary objects, we construct an epistemic *enframing* (casting in a frame) *of that objective*. A less-, or non-disciplinary research is generated by an objective, and it should not be forced to work as if it would have an object.
Therefore, integrating or unifying disciplines as monoliths is impossible. Most authors failed to clarify (even played with the lack of clarity[10]) the implicit suggestion that distant and unrelated disciplines may be brought together, which would exemplify transdisciplinari*ty*. Based on the definitions given earlier, neither cross-, nor inter-, or trans-, or disciplinary works would emerge unless an objective would rise the need for. Conversely, depending on the complexity, extension and novelty of the objective, science proceed either disciplinarily or less-/non-disciplinarily. When integration or unification appear *appropriate* methodologically, these apply to disciplinary components, most unavoidably to **DL**s because, as said, they are used to formulate disciplinary objectives and each disciplinary component, most notably the disciplinary methods.

This is why, a firstly-met **P** is a test-case, where disciplinary and the otherwise thinking are, or should be, equipotent at least in the beginning. Because most scientists are disciplinarily trained (and conditioned), the very first attempt is to read in a firstly-met **P** the extent of its disciplinarity. Thus, they create for themselves the same kind of obstacles science gave rise when it got disciplinarily specialised. This is how and why complicated and laborious research programmes need to be designed, and the methodological theories are meant to compensate for the lacking epistemological grounds. An all telling example in this respect is the convergent appeal to both

[9] GRANGER Gilles-Gaston, (1994), *Formes, Opérations, Objets*, Mathesis J. Vrin, Paris.
[10] Some try to define 'transdisciplinarity' by such metaphors as transsiberian or transatlantic, and even worse, use this kind of 'definitions' to state the superiority of transdisciplinarity over interdisciplinarity. There are authors who point to that the involvement of formal theories justifies both the leaps implied by 'trans' and the qualifier 'superior'. The latter in particular betrays a reduction of science to a commodity, whereas the only valid criterion of evaluation should be the adequacy of a scientific procedure to an objective, be it a question or a problem. See HÄRBALI Rudolf et al. and SCHOLZ Roland et al. (eds.), (2000), *Transdisciplinarity: Joint Problem-Solving among Science, Technology, and Society*. 2 vol., Haffmans Sachbuch Verlag, Zurich.

the philosophy of physics and philosophy/theories of language (which control-theorise the use of natural languages' vocabularies in the disciplinary languages' terminology[11]). Both are better consistently structured and more workable than most such philosophies of science as relativism, positivism, and the like.

Accordingly, these and (second-order) cybernetics form the base of obtaining practicable integration or unification. Integrating two **DL**s means rendering them compatible at the so-called articulation nodes, where either the same term is used with more than one meaning, or competing interpretations lead to overloaded and unspecific terminology[12]. Unifying two **DL**s consists of the mutual reduction of *primary terms in each **L** to a univocal terminology that satisfies rules* of variation, derivation, and inference.

**DL**s are well-structured and have been tested by numerous disciplinary objectives. Because of this, **IL**s and **TL**s do need to construe their semantic-syntactic consistency by incremental dialogue with the objective at stake, on the one side, and with the formal rules providers (formal and computing **L**s), on the other[13]. This is why, the sequence consisting of the III, IV, and V phases cannot be pre-planned, but it can be ruled by an **ML/Γ**. For the same matter, neither the disciplinary nor the otherwise problem-solving is 'superior' by default unless and until the objective becomes intelligible and treatable[14], e.g., the problem becomes solvable.

## 3. Problem-Solvers and the Best Future

To the extent to which systems process information whose utility is not immediate, but for later on, the systems' chance to reach a next state depends on that which ensures this particular kind of information processing. This idea is most evident in learning systems, notably in those developing self-organisational resources and structures. Here resides the temptation to consider a straightforward correlation between the extent and capability of the anticipative or anticipatory sub-system and the probability of the entire system to pre-determine its future state. Society, for one, has institutionalised sub-systems specialised in doing just that. Yet, if it would be that simple and straightforward, we might not be confronted with problems, some of which are insolvable.

Indeed, there is an evolution towards developing the anticipative sub-system since energy and equipment are invested towards this end, but the system is not carried to the future by one sub-system in an automatic and teleological way. There must be maintenance and supportive sub-systems there, and definitely an information storage sub-system whether or not as a sub-system of the anticipative sub-system. On the other hand, systems said to be anticipatory surely display some subordination ordering of the functions of other sub-systems by the function of anticipating. Given the vastness of the field studying the inner working of highly specialised sub-systems, here the direction is kept towards considering science as the best problem-solver the system society has ever had. This qualifications holds when other problem-solver sub-systems are considered such as policy, management, and any known form of decision making.

As known, science is not a decision maker (never mind the pretence of politicians and managers of consulting with scientists). Equally known is that nowadays largely unsolvable problems are

---

[11] An explanation as to how this control is worked out and why it generates not only higher degrees of formalisation but also competing side-formalisms is given in LUNCA Marilena, (2005), 0-Order Cybernetics. From the Physical to the Non-Physical Formalisms, *Proceedings to the WOSC 13th International Congress of Cybernetics and Systems*, Vol. 4, pp. 7-18, University of Maribor, Maribor.

[12] Outstanding examples remain: BECHTEL William, Ed., (1986), *Integrating Scientific Disciplines*, Nijhoff, Dordrecht; DEELY John, (1990), *Basics of Semiotics*, Indiana University Press, Bloomington.

[13] AIZAWA Yoji, (1998), Unbroken Wholeness in Nonlinear Processes, *International Journal of Computing Anticipatory Systems*, pp. 235-249, D. M. Dubois, Ed., Vol. 2, CHAOS, Liège.

[14] About the same line of reasoning has been followed in management, for instance, FLOOD Robert L., (1995), *Solving Problem Solving*, Wiley, Chichester.

the result of yesterday's bad decisions and even worse, yesterday's implementations. It is mostly this conjecture that gives sense to the idea that anticipation is time-and-agent dependent.
The time-and-agent dependency implies a theoretic standpoint that applies to all anticipatory (sub-)systems, and in particular to science. It consists of that a sub-system is anticipatory only to the extend to which it is a problem-solver, and that a problem-solver is that much more qualified as it foresees a $t_1$ that has two simultaneously occulting, but asymmetric properties.
One is the *positive induction of the (most) beneficial state*, and the other is the *reduction of the sub-system(s) for which the 'beneficial state' is detrimental*.
In other words, blocking the entropic $Ht_1$ state (always there as potential) is not enough for the removal of the obstacle between $t_0$ and $t_1$, let alone for a solution, and if one or more sub-systems are worse off in $t_1$, this means that the obstacle/problem is re-located rather than removed or solved. These properties are simultaneous but asymmetric because they both actualise in tandem. But the increase in intensity of both cannot be pursued in correlation because the intension of one does not correspond to the extension of the other, hence their asymmetry.

Now, the empirical reason why these properties are asymmetric resides in the very separation of roles. The best problem-solver does not decide, the decider is not the best problem-solver, if at all. Conversely, one foresees, the other designs. But suppose we can think of an ideal situation in which the two properties are not asymmetric because the designer happens to be the most qualified problem-solver. Then, an unexpectedly harsh conclusion would emerge from an incredibly large number of problems created by previous problems that have been scientifically solved, but nonetheless poorly, expediently or wrongly. Science may have done more damage than other problem-solvers. As the implementation of scientific solutions involves necessarily an alteration of the prescription, a wrong solution would only aggravate the problem. Environmental degradation is one thusly aggravated problem, and the studies developed to the day only reinforce this assessment.

However, science is equipped to evaluate its own doings from a perspective that lacks to other solving agents, and this is its capacity to be the least driven by socially rooted interests. The point being made here is not as much pragmatic as profoundly scientific because when alternative futures are competing, interests prevail over knowledge. Technically put it, alternative futures are so multi-conditioned that the time necessary to evaluate each one of them would mean the freezing of all sub-systems of a system into a present state, which is simply impossible. It is all too well-known how difficult is for the observer to overcome the tendency of using ready-made instruments of producing knowledge, let alone the intentionality that comes with the territory, that is with the disciplinarisation of knowledge producing instruments.
If there is the slightest chance of pondering the social agents' interests with the observer's disciplinarily born intentionality, than this chance resides in the observer's equipment, for it is the equipment that allows or not the observer to read in an objective more than a gathering of disciplinary objects. This is what the phase II is meant for, knowing that the description of **P**'s sub-systems in **DL**s engages almost automatically disciplinary methodologies. To the extent to which a cross-disciplinary methodology is conceived and specialists are teamed up, the research strategy is due to be built on solving the **Φ**s emerging in the sequence III-IV-V, and not on foundations pre-determined by disciplinary solving instruments.

To be able to bring this sequence to a workable form, the methodological theory developed so far has to provide practicable ways of solving two sources of **Φ**s: one acknowledged as $(\Phi_{\Theta})_j$, and the other as $(\Phi_{\Xi})_i$. The first consists of *framing the relational properties that are potential extensions over objects estimated to be unknown*. This involves mainly the inquiry into those properties (of objects) that are supposed to predict or anticipate the likelihood of other objects and sub-systems to evolve *in correlation*. Unconventional research, however, needs to test the extension of such properties over previously unrelated objects or sub-systems. It is precisely this kind of inquiry that is often overlooked and its value underestimated because it is time-and-resource consuming. Because it is time-and-resource consuming, the time-and-agent dependency prevails in the way interests prevail over freezing the time until knowledge is being produced[15]. The second source consists in identifying circularities and their formulation in an **ML**. Since [2] has stated unambiguously that we are not dealing with a succession $\boldsymbol{\Phi(\Phi_1,\Phi_2, \ldots, \Phi_n)}$, but with entangled dependencies, local and sequential circularities emerge unavoidably. This means that the sequence III-IV-V is re-designed as many times as necessary for an **ML** to become an integrator and unifier. To be able to achieve this, one should not follow an exclusively formal path because however powerful a formalism may be, it always needs to start from a foundational assumption. In other words, there is always a non-formal contributor to the consistency of a formal solution. The solution advanced here is twofold: preserve the useful formalisation reached when the first source of **Φ**s has been dealt with, but at the same time enable communication amongst those who use **DL**s, i.e., specialists. The two sides of the solution are inseparable, but the second is practicable and a must-do one.

It consists of the duty of each specialist to know the grammar of his/her discipline, that is, the discipline's epistemology. Blind practitioners are not good specialists, and it is a subliminal misconception that specialisation stands in the way of cross-, inter-, or transdisciplinary thinking. A good specialist is utmost knowledgeable in his/her discipline's epistemology. This in itself provides the language-and-reasoning for communicating with other disciplinary epistemologies *via* the epistemologies of root-disciplines. Disciplinary epistemologies are not no-man's land, whether narrowly specialised or comprehensive in reference to the downwards and onwards ramifications of sub-specialisations. The better a specialist is in this sense, the more capable of, and open to communicating with other specialists. As a rule, when specialists are teamed up, do check for their knowledge of their disciplinary epistemologies.

If science is to preserve its status as the best problem-solver there is, then the best specialist is the most inquiring because uses effectively epistemology all the way through, that is from the level of his/her disciplinary epistemology to the philosophies of science. This is not an academic ideal, it derives from the very fact that cross-, inter-, and transdisciplinary problem-solving do not have as solid an epistemic ground as the disciplinary problem-solving does.

*

*    *

The measure of anticipating can only be appreciated by answering the question why would society, throughout history, consecrate the best equipped and most capable individuals to perform activities that are not even remotely related to the production of surviving means. Why indeed, would society nowadays entrust its surviving to policy, management or the like, whereas science and science alone can design the least detrimental futures.

------------

[15] In the studies referred to, the author has developed formalisms for relational properties based on the observer's qualifications and in relation to formally emerging circularities. As known, there are formal theories *of* circularity whose application is increased by cybernetic exchanges with computational complexity algorithms.