The Modeling of Nature as a Glass Bead Game

Rainer E. Zimmermann

IAG Philosophische Grundlagenprobleme,
FB 1, Universität, Nora-Platiel-Str.1, D – 34127 Kassel /
Clare Hall, UK – Cambridge CB3 9AL[1] /
Lehrgebiet Philosophie, FB 13 AW, Fachhochschule,
Lothstr.34, D – 80335 München[2]
e-mail: pd00108@mail.lrz-muenchen.de

I

In his novel *The Glass Bead Game*, Hermann Hesse introduces an essentially cosmic game within a symbolical Universe which recently has been compared with a „neuronal network of the cosmic mind".[3] In his game all those games which are known to us today appear to be summarized. Hence, by closer inspection, the glass bead game shows up as a *meta-game*, a *proto-game*, and as a *playful paradigm of playing*, at the same time. As its rules it encompasses all what characterizes the reflexive activity of humans within the worldly environment. It thus aims towards all those fields of the sciences and arts which are available as the inventory of human orientation. Hesse describes the rules as such: „These rules, the sign language and grammar of the game, represent a kind of highly developed secret language, in which several sciences and arts, in particular mathematics and music (or the science of music) participate which are able to express the contents and results of practically all of the sciences and relate them to each other."[4]

This systematic form of approach to a universal game, conceptualized in a global manner, implies an important methodological consequence. Hesse continues therefore: „The glass bead game is thus a game with all the contents and the values of our culture, it plays with them, as in the heyday of the arts a painter may have played with the colours on his palette. What humankind has produced in its creative epochs in terms of knowledge, noble thoughts, and works of art, what the successive epochs of learnt reflexion have conceptualized and claimed as intellectual property, all of this extraordinary material of intellectual values is being played by the glass bead player like an organ is played by the organist, and this organ is of a hardly graspable perfection, its manuals and pedals are scanning the whole spiritual cosmos, its registers are almost uncountable, theo-

[1] Permanent addresses.
[2] Present address.
[3] Cf. www.glassbeadgame.com
[4] Hermann Hesse: *Das Glasperlenspiel*. Fretz & Wasmuth, Zürich, 1943. Quoted here according to the two volume jubilee edition for Hesse's hundredth birthday, Suhrkamp, Frankfurt a.M., 1977, I, 12 sq. (Here and later always my translation.)

retically, the complete intellectual contents of the world could be reproduced by playing."

Today, the idea of such a playful simulation of the world has become more common than this could have been the case in the time of Hesse himself. Our modern attitude to visualize the world in strict analogy with a computer such as to utilize the *concept of the computer* itself as a guiding paradigm of grasping the world, facilitates it considerably to understand processes as those which emerge within a playful construction. In this sense, the world appears to us as the programmed result of some matrix which relates to what we call „world" as a master programme does to a subroutine. And the aspect of simulation is not a conceptual problem for us any more, since we have learned by now that *all of our perception* is nothing but an interpreting mapping, in the first place, so that the perceptive as well as cognitive work is very similar to the process of simulation, from the outset. Hence, there is no question of an eventually restricted authenticity anymore.[5] Of course, we have to notice that the computer as a paradigm is not somehow equal to those computers we are actually capable to construct and built. Instead, it is the *structural concept of a computer* which serves us here as an orientation.[6] The same is true as to the generalization of the concept of „programme". Because a programme is less something which fixes what can be actualized during its processing, but more the *framework of what is possible of being actualized* at all. Hence, it is a „field of possibilities" from which the process can actually choose. With a view to the organ metaphor Hesse can continue therefore: „These manuals, pedals, and registers [of the organ] have been fixed by now, any changes or attempts to perfect their number or order are possible only in theory: The enrichment of the game language by means of introducing new contents is delegated to the possibly strictest control by the superior game's steering committee. But within this fixed construction or, for staying in our picture, within the complex mechanics of this giant organ, the single player is given a whole world of possibilities and combinations, and that among thousand games performed according to the rules only two of them are more similar to each other than merely at their surface, is practically outside of the range of possibility. Even if it happened once by coincidence that two players would choose the same selection of topics as contents of the game, these two games could look and run completely differently according to the style of thinking, the character, mood, and virtuosity of the player."[7]

As Hesse describes in his novel the glass bead game as result of a long development, he sheds some light onto the sciences and arts as they are available to us today exhibiting a permanent striving for epistemic unity: „ ... each attempt to approach the unity of the exact and of the more liberal sciences, each attempt to

[5] Hence, there cannot be something like an ontological proof for the existence of human consciousness. This is so despite the elegant construction of proving one's own authentic existence as given in Stanislaw Lem's famous novel „Solaris": See e.g. the German edition of 1983, dtv: München, 57 sqq. with the description of Lem's *experimentum crucis*. As far as I can see the conclusion there is not completely flawless.

[6] Recent movies like „The Thirteenth Floor" or „Matrix" give a clear impression of this.

[7] Hermann Hesse: Das Glasperlenspiel, op.cit., ibid.

reconcile science and art or science and religion is based on the same eternal idea which has gained its shape for us in the glass bead game.“[8]

Hesse does not even flinch from introducing those fields of human thinking into the game which cannot be grasped and expressed in clear communicative terms of some linguistic discourse, as it is otherwise the case for the sciences and most of the arts. He states: „As the glass bead game had been grown from its beginning in terms of technique and scope up to the infinite, and had become a high art and science in itself, as far as the intellectual claim of the player is being concerned, there was nevertheless something missing. Up to then, in fact, each game had been a chaining, ordering, grouping and confronting of concentrated ideas from many fields of thinking and of beauty, a quick remembering of eternal values and forms, a short masterly flight through the empires of the mind. It was not before considerably later that from the intellectual inventory of the educational system, and in particular from the habits and customs of the Riders of the East, the concept of contemplation came into play ... This was the turn against the religious. It was not anymore the point to simply follow the series of ideas and the complete spiritual mosaic of a game with alert concentration and practised memory in an intellectual manner, but now the demand emerged for a deeper and emotional devotion. After each sign now which the respective director of the game had conjured up, this sign was being made the object of a strict and silent consideration in terms of its contents, origin, and sense, which forced every player to make the sign’s aspects themselves intensively and organically present. The technique and practise of contemplation was exercised by all members of the order and the playing guilds from the élite schools where the art of contemplating and meditating was attended to with greatest care. This was the reason for saving the hieroglyphs of the game from degenerating into mere letters.“[9]

Hence, the game shows up as a process which unfolds under two chief aspects, the one aiming at the universal which is part of the social collective, the other aiming at the singular which is represented by the individual. The first aspect refers to the constellations of thinking which are transported by cultural tradition: „In the designations, keys, signatures, and abbreviations of the game language a formula of astronomical mathematics, the form principle of an ancient sonata, an aphorism of Kungfutse and so forth had been stored. A reader who should not be acquainted with the glass bead game can visualize such a scheme as being similar to the scheme of a game of chess, only that the meanings of the figures (pieces) and the possibilities of their relations among each other, and of their interactions, would have to be thought of as being multiplied, and each figure (piece), constellation, move would be associated to an actual contents symbolically designed by the chosen configuration.“[10] The second aspect aims at the practical introspection of the person playing: „The formal game aimed at a har-

[8] Ibid., 13.
[9] Ibid., 37 sq.
[10] Ibid., 130.

mony and an as dense as possible, unbroken, formally perfect unity to be composed by the material contents of each game, the mathematical, linguistic, musical and so forth. The psychological game, on the other hand, looked for the unity and harmony not so much according to choice, ordering, linking, chaining and confrontation of the contents, but more according to the meditation following each stage of the game onto which it put all its emphasis."[11]

Hesse's game can thus be visualized as a *game of interpretation*, as a game of interpreting the world within the questionable, observable worldly. Even if the world permanently presents itself to interpretation as one which is questionable: It is the concentrated and complete taking in sight which guarantees that interpretation is not being lost in the undeterminedly arbitrary: „We shall direct the attention to everything, because everything can be interpreted."[12] And this interpreting, as the main activity of the primarily hermeneutically constituted human, shows up as the translation of what has been perceived into a human universal language. The search for the latter is another ancient project of humankind: „[To study the whole game from the beginning to the end means] ... I work through each of its propositions, translate them from the game language back into its original language, into mathematics, into ornamentics, into Chinese, into Greek and so forth ... [W]e have invented and expanded the glass bead game in the run of centuries, as a universal language and method, in order to express all intellectual and artistic values and concepts and to bring them to a common measure."[13]

With the formulation „to bring them to a common measure" a universal human measure is actually being referred to. This is so because if it is anthropological qualities which are made the object of action in the glass bead game, what should have become clear by now, then we deal with the humans altogether indeed. And if humans are subject to what within the wordly are the actions of what they are able to perceive, then the problem is their own positioning with respect to that perceived, it is the uncovering of the relationship between person and world and between person and human collective. In other words: By means of inserting oneself into the world and by means of communicating about this with the others the sense of the game unfolds and offers itself to interpretation, at the same time. Essentially, the world communicates with itself and utilizes humans as an organ of communication. But the constitution of these humans is important, in the first place. Hence, the conception of the game reflects the picture of humans involved: „The human we mean and we would like to have, who to become is our objective, would be able to exchange every day his science or art with any of the others, in the glass bead game he would bring the most crystalline logic to light and within grammar the most creative phantasy."[14] Hence, the game approaches a concrete utopia: „[The ideal], the thought of the interior

[11] Ibid., 210.
[12] Ibid., 82.
[13] Ibid., 125.
[14] Ibid., 83.

unity of all intellectual efforts of humans, the thought of universality, has found its perfect expression in our noble game.“[15]

When we ask today what remains of this literary conception of Hesse’s and what we can still utilize, then we discover in the anthropological centre of his ideas aiming at universality something which is still of importance, especially as far as the recent developments in the sciences and the arts are being concerned. Of course, we have to think of alterations in detail, because some of the concepts depend on the socialization of those who utilize them, and a straightforward translation is sometimes difficult, if not completely impossible. A central concept of this kind with Hesse is that of *meditation*. It should be difficult to find a satisfactory answer as to its universal meaning. Hence, we would prefer to actually replace this concept by that of *association* which appears to be more universal in semantic terms. This is especially so, because association is obviously a permanently present constituens of our everyday life, particularly in the sciences and arts, where it is condensed to an epistemic means of knowledge and understanding. Also, association introduces the aspect of the coincidental which appears to be relevant for human thinking, by being able to spontaneously shed light on an otherwise hidden sense. If asking what an actually playable version of the glass bead game could be today – presently a project under development indeed – then deterministic (logic, algorithmic, propositional) reflexion and prereflexive (non-propositional) association will be fixed ingredients.[16] The route towards a concrete version (possibly arranged as a computer game) is long however, although a suitable project is under way already.[17] The Tones & Notes project[18] is one step towards the objective. But it is obvious that such a project asks a lot of its participants, especially what individual openness of the mind is being concerned with a view to a multitude of fields involved and the readiness to accept system and method of the others. In other words: *It matters to assume nothing except the criteria of adequacy themselves*. Hence, the project is also an *ethical* project. In this sense, the appeal is to found many „forest cells“: „Gignit autem artificiosam lusorum gentem Cella Silvestris. (The forest cell [Waldzell] however produces the elaborate people of the glass bead players.)“[19]

[15] Ibid., 249.

[16] In the internet one can find a large number of groups who deal with the development of a playable version of the game. As far as we can recognize, all of these approaches are not very satisfactory until now.

[17] Rainer E. Zimmermann: *Topos der Materie*. Neue Anleitung zum Glasperlenspiel. In preparation for Mentis, Paderborn, 2004. For a first introduction see id.: *System des transzendentalen Materialismus*. Mentis, Paderborn, 2003, in press.

[18] Andreas Kuhn, Constantin Carl, Rainer E. Zimmermann: FarbTöne. (Exhibition, Presentation & Discussion) Pasing (München), July 2003. See also my „manifesto“ for this occasion which is added here in the appendix.

[19] Hesse, op.cit., 82.

II

In order to illustrate the heuristic power of a glass bead game of the kind described here, though visualized with respect to modern science alone for the time being, we choose an example from recent conceptualizations in physics, namely Smolin's *principle of cosmological natural selection*. Obviously, we cannot unfold the complete scope of all the interdisciplinary results which may be achieved by a conceptual game of the glass bead type, but what we would like to do here is simply to give a first impression of the basic problems involved. A more detailed example has been discussed in a recent book of mine.[20] I follow here the line of argument as displayed in a recent summarizing paper.[21]

1. Introduction

Following the book publication by Lee Smolin[22], I have discussed his model of cosmological natural selection twice elsewhere[23], pointing to a number of inconsistencies of the model and possible variants which may be helpful in solving one or the other problem with it. After these preliminary discussions we are now capable of re-formulating Smolin's conception in a generalized way by means of applying directly the somewhat corrected version of the analogy between physics and biology actually being put forward. The advantage is to concretely establish *selection* as an intrinsically universal principle indeed. The Universe in the *facon de parler* of Smolin's is then nothing but the individual sample whose type is the analogue of the *phenotype*. Hence, we shift from the concept of selection to what we call *superselection* in order to point to the fact that the principle invoked here acts upon *networks* (populations) of Universes which have to be classified according to their type. The latter is being defined in the sense of the excess productivity of black holes actually achieved, and is a measure therefore for the possible number of „offspring" of Universes which may be eventually produced. We have thus a population of Universes which can be stratified into sub-populations reflecting the various phenotypes. (The question as to whether a population may contain Universes which are not space-times, simply due to epistemological reasons, we leave aside for the time being.[24]) These phenotypes

[20] See note 17 above. – Note that in the meantime most of my Los Alamos archive papers have been collected in my: *The Physics of Logic*. Kassel University Press, 2002.
[21] Rainer E. Zimmermann: Cosmological Natural Selection Revisited. Some Remarks on the Conceptual Conundrum and Possible Alleys. http://www.arXiv.org/pdf/physics/0304053 (I utilize here a shortened und revised version of this preprint.)
[22] Lee Smolin: *The Life of the Cosmos*. Oxford University Press, 1997.
[23] Rainer E.Zimmermann: *The Klymene Principle.* Kassel University Press, 1999. – also under: http://www.ernst-bloch.net/akt/mitbei/klymene.zip. See also: Rainer E.Zimmermann: *System des Transzendentalen Materialismus*. Op. cit.
[24] Rainer E.Zimmermann: Loops and Knots as Topoi of Substance. Spinoza Revisited. In: http://www.arXiv.org/pdf/gr-qc/0004077 v2. – See also: Spinoza in Context: A Holistic Approach in Modern Terms, in: E. Martikainen (ed.), Infinity, Causality, and Determinism, Cosmological Enterprises and their Preconditions, Finish Academy of Sciences Colloquium. Lang, Frankfurt a.M. etc., 2002, 165-186.

are involved in competition among each other. Superselection acts thus onto these phenotypes according to the environmental structure in which the subpopulations participate. Hence, what we need is the equivalent of an environment, some *intercosmic mediator*.
But let us first have a look onto the interior „ecology" of a *single* Universe: A generic Universe consists of a hierarchic structure of galaxies (supercluster, cluster, local groups, individual samples of galaxies). It is indeed the *stellar ecology* of galaxies which explicitly determines the production rate of black holes. Hence, also a galaxy can be visualized as an analogue to local ecosystems containing populations of phenotypes. In this case the types are *stellar* types plus a mediator which is given in terms of the *interstellar matter*. The Universe appears thus as a hierarchically organized population of populations of local ecosystems. But if the stellar type (described by the spectral class of stars) is a local version of a phenotype, what is then the associated genotype?
Remember that biology is essentially organized in terms of three structural and functional levels which we can call the molecular, cellular, and organismic levels, respectively. The last one is directly associated with the phenotype. The molecular level coincides with the level for which this expression has been introduced in the first place, namely the chemical level. So what is the cellular level? This would be exactly that level on which the „cosmogenetic" coding is being stored, in a place which would be the equivalent of a *cell nucleus*.
A short intermediate remark to the utilization of Smolin's selection metaphor: Indeed, at the occasion of a short discussion of the topic some time ago[25], Smolin has not shown much enthusiasm when being confronted with the arguments unfolded above. Instead, he seemed to be pointing to the fact that this metaphor chosen by him would only be applicable in a somewhat limited way and could not directly be transferred to a physical terminology. But here we have to object that the metaphor is apperently of *some* use after all. However, this being the case, it has to be developed with all its consequences. And the latter are to be examined carefully with a view to their consistency. If they turn out ot be inconsistent, the principle has to be given up. But there cannot be a mere *semi-metaphor* in sufficiently general terms. Hence, a complete discussion of the principle introduced is what is being asked for.

2. A First Ansatz

Hence, what we do is to start in a straightforward manner from the original analogy which is itself referring to the organismic structure of organization as known from biology: Therefore, phenotypes are types of organisms which are themselves structured in a molecular way and constituted on that molecular level by means of the respective genotype. It is important here to remember oncemore

[25] Discussion with Lee Smolin at the occasion of the conference „Key Tests for Cosmogenic Theories", Newton Institute, Cambridge (UK), 6.-9.12.1999.

that we will not expect that we actually deal with explicitly biological quantities after all, but that instead we will have to deal with physical quantities only. Insofar the metaphor stays nothing but a metaphor. On the other hand, we know of course, that biological systems are again nothing but chemical and thus complex physical systems themselves. Hence, we can legitimately argue to found the further analogy onto the relative orders of magnitudes being actually involved: The individual body of human beings e.g. represents a sample of the human phenotype and thus constitutes the organism on the macroscopic level in terms of biological aspects. Let us say that the human body contains some 10^2 organs, which are composed of different sorts of webs (according to the various fields of sensory perceptions, food processing, motion, reproduction, and so forth). With roughly 10^{14} cells per organism this comes to about 10^{12} cells per organ. (The molecular mass of human cells is at about 10^{15}.) Hence, the ratio of the „highest“ to the „lowest“ level of organization is about 10^{10} or 10^{12}, according to whether one refers to the organs or the whole organism.
On the other hand, the Universe contains about 10^{11} galaxies of which each for itself contains 10^{11} stars on the average. The galaxies are organized in clusters and superclusters with about 10^6 and 10^9 galaxies, respectively. Hence, it is intuitively clear, within the chosen analogy, to actually identify the level of superclusters with the level of organs, and the level of galaxies with the level of cells. The „scalelessly“ mediated orders of magnitude among clusters refer then to the levels of different biological webs. Note that in biology however, organs are usually not only classified according to their *structure*, but also according to their *function*. That is, organs have a specific function within the whole organism. Moreover, there must be a *fine tuning* of functions among each other, because any malfunction has to be compensated for a while for not endangering the organism altogether. In the long run, any malfunction will put the organism at a decisive risk. Nothing else is the case with the physical functions of the constituents of the Universe.
If now galaxies are the equivalent of cells, what would be formally equivalent to the nucleus of a cell? The point is that the biological analogy can be carried quite far in the case of galaxies, because like cells they indeed perform specific functions of some „metabolism“ and can therefore be visualized as regulatory systems. (This is in fact what we also claim when speaking about body cells of an organism.) The sort of metabolism mentioned here is however one of a cosmic exchange of matter, where the important things happen in places we cannot observe very well: in the dark spaces in between spiral arms of galaxies. Because this is where stars are being „cooked“ which „cook“ themselves other matter then and so forth. It is from then on that they become visible to us. Hence, the complete galaxy gains the connotation of a self-organizing (massively parallel) computational system, very much like the biological cell.
The cells utilize the information which is contained in the genetic structure and is actually stored in the cell’s nucleus, and produce proteins from it. The DNA is

very much like a hard disk, while the proteins are a sort of RAM.[26] We can claim something similar with respect to the galaxy, provided we think of its „nucleus“ as of a comparable system for storing and processing information. Indeed, there is a literal nucleus to most galaxies which is represented by a *central massive black hole*. In other words: It is such a black hole which would be the adequate place to „store the laws of nature in some symbolical manner“ as Smolin is himself asking for. (He actually disputes the possibility of such a storing of symbolical information though. But that is a point where doubts should be in order.) Obviously, the next question is *how* the relevant information could be stored in black holes. Unfortunately, the interior of black holes is not well-known until now.[27] However, massive black holes in the centres of galaxies as they have gained renewed relevance since the beginning of 2000 when the Chandra satellite observatory did its first impressive series of X-ray photos, could well be visualized as that „gates towards a new physics“ as Martin Rees has introduced them recently.[28] The characteristic „careers“ of black holes have been studied in detail some time ago by Kip Thorne among others.[29] Many aspects recovered here correspond nicely to what Smolin proposes in his approach.

These aspects by the way imply also the absence of the fundamental categories of space and time which we have discussed elsewhere.[30] Thorne e.g. compares them within the context of a black hole with a piece of wood soaked with water coming into a fire. Time (the water) evaporates and the remaining space (dry wood) becomes ashes (Wheeler's quantum foam).[31] And indeed, within this physics of the quantum foam we should look for the analogy of (cosmic) nucleotides. Not in the foam itself (because the storing of information should not be subject to random fluctuations), but as its first product. The latter might turn out as *spin networks* in fact.[32] Hence, the clarifying of the analogy is closely related to the problem of developing a TOE.

The same is actually true for what we can visualize as „intercellulary“ space: The respective region in between the galaxies carrying the reserves for the latter's metabolistic functions is typically visualized as an almost perfect void. But even if this should be true, there is still gravitation. Also within galaxies, the pat-

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[26] Cf. Tom Siegfried: *The Bit and the Pendulum*. From Quantum Computing to M Theory – The New Physics of Information. Wiley, New York etc., 2000. Note in particular chapter 5: The Computational Cell. (95-113)

[27] A long time ago I have worked myself on the inside story of black holes before changing into other fields. In the meantime, I noticed that presently, there is (as far as I can see) only one group engaged in this topic, namely that of Werner Israel in Canada (and its former members elsewhere in North America, to be more precise). And the insight gained recently is not very much impressing, to say the least.

[28] Martin Rees: Before the Beginning. Our Universe and others. Simon & Schuster, London, 1997. In particular chapter 5: Black Holes: Gateways to New Physics.

[29] Kip S.Thorne: Gekrümmter Raum und verbogene Zeit. [The Einstein Legacy. Quoted here according to the German edition.] Droemer-Knaur, München, 1994 (1993), 524, 545. As to wormholes cf. 556.

[30] See also more recently Rainer E.Zimmermann: Recent Conceptual Consequences of Loop Quantum Gravity. Part III: Postcript On Time, http://www.arXiv.org/pdf/physics/0108026 .

[31] Thorne, op.cit., 544.

[32] Rainer E.Zimmermann: Recent Conceptual Consequences of Loop Quantum Gravity, Part I: Foundational Aspects, http://www.arXiv.org/pdf/physics/0107061 .

terns of interstellar matter recently observed could be understood as resulting from exterior „environmental“ inputs establishing explicit forms of harmony.[33]

3. Computational Aspects

But there is still another point to that: The internal structure of the Universe alone cannot be decisive for superselection, because we deal with *populations* of Universes in the first place. That we can retrace the basic structure of selection also within the individual sample and all of its substructures is only an epiphenomenon of the underlying model's scale independence (which is actually a necessary condition for our evolutionary principle in order to adapt it to self-organized criticality in the sense of the Santa Fe school). Hence, we have to differ between *internal* selection in the sense of Smolin (within a given Universe subject to its stellar ecology) on the one hand, and *external* selection of types of Universes (superselection) on the other hand. Obviously, the one has to be fitted to the other. In fact, what we can do is actually to visualize internal selection as a projection (more precisely: a projected image) of superselection. In other words: The biological selection proper shows up then as a mere differentiation of superselection projected onto the planetary ecology. This would indeed shed some light on the question of possible earth-like planets.
But if so, the remaining question is for the „cosmic mediator“ already mentioned. It would define the background of Universes on which populations unfold. Hence, it could be visualized as that environment whose structure gives the initial drive for the competition of phenotypes in the first place, because it is only a *finite* environment, one with *restricted* ressources, in other words: a *physically deficient* environment, on which selection can be sufficiently founded. It may be worthwile to look for this mediating background (which is not a geometrical background as we know it, because we are talking about a region which is *beyond* Universes, and thus beyond space and time) in the loops of loop quantum gravity itself. In a first instance, the concept of spin networks is relevant here. The problem is that we have to permanently think „in terms of space and time“ so that we cannot abstract from these fundamental categories, even if talking about their factual absence. As I have discussed elsewhere[34], spin networks can be visualized as the *boundary* of space-time, and as such they are also the (epistemological) boundary of substance (in some modern sense).[35] But the point is that there is no real transition from the one (the world) to the other (substance) and viceversa across that boundary, because substance *is always everywhere* (thus non-locally) underlying the world which we can observe, but which is nothing but a back-projection of substance (which we cannot observe). The questi-

[33] Smolin, op. cit., 132. – Cf. more recently: Nature 394 (1998), 524 (when S. Battersby is talking on B. G. Elmegreen et al. in Ap.J.Lett. 503 (1998), 119-122).
[34] Cf. note 30 here.
[35] Cf. notes 21, 22 here.

question is whether seen under this ontological perspective, it is useful to think of physics as the foundation of biology all the time, while not thinking of the viceversa: that also biology would have something to contribute to the foundation of physics in turn. This may be so because after all, physical theories are being produced by biological living beings according to what the latter can actually perceive. This perception however, together with the thinking applied to it, is primarily biologically constituted. Recently, Louis Kauffman has oncemore reminded on this point and tried to describe a relationship between biology and logic which might be of a specific systematical meaning for what we have said here.[36] Again, there is another parallel to the conception of visualizing the Universe altogether as an emergent computational system which in the case of biology differs from the computers as we know them only in the fact that it is software and hardware at the same time.

4. Black Holes

But the essential problem with black holes is as to their eventually becoming „quantum“: Originally, the programme was quite straighforward. If a star with a certain minimal mass underwent gravitational collapse, then sooner or later a horizon would form defining the black hole‘s boundary. And the work concentrated on describing horizon properties. The actual vicinity of the singularity was then cut out from both the space-time manifold and from the discussion, respectively. That was what we learned as students when reading one of our three bibles at the time.[37] Things became more complicated however when Hawking, Bekenstein and others started to discuss quantum aspects of black holes. From the beginning on, the suspicion emerged that classical concepts would be carried over to quantum situations without being really justified. Not that this would have been something new when dealing with quantum physics (indeed it actually established a great deal of distinction for those who worked in „classical“ field theories when visualizing the whole Schroedinger programme as some kind of elaborate guessing according to concepts of classical physics). But in the case of black holes it seemed somehow to go too far. All of this despite some very attractive aspects of the new conceptions such as Bekenstein’s idea of treating black holes as an analogue to atoms in pre-quantum physics and so forth. However, with the advent of *black hole thermodynamics* and in particular with the treating of the horizon as a material membrane in the sense of Thorne, things became very interesting, and one was somewhat distracted from the quantum problems lurking underneath. As it turns out now, the very terminology utilized when talking about quantum black holes is covering most of the problems which still have remained. Take the example of the celebrated *Planck mass* which serves as a criterion of talking about a domain where all relevant forces actually

[36] Louis H. Kauffman: Biologic. http://www.arXiv.org/pdf/quant-ph/0204007 v2.
[37] Namely the books of Hawking and Ellis, of Misner, Thorne, and Wheeler, and of Weinberg, respectively.

meet[38]: It is the frequent changing of the systems of units involved what is diverting from the fact that it is not the Planck mass which is relevant at the Planck level, but instead it is the dimensions involved which are relevant. In other words: If you have a piece of matter with roughly 10^{-8} kg of mass, then you do not have normally any problem with quantum fields or quantum gravity as to that – because it is only when you compress this mass to the small Planck length dimensions that it would become theoretically relevant. So it is the *volume* rather than the mass which is important after all. Obviously, when dealing with stellar black holes, you are not dealing with any Planck mass whatsoever, by the very definition above. In fact, we are talking of several solar masses. And the mass remains conserved. What is changing while the star performs a gravitational collapse, is the mass *density* which is enormously increasing because the available volume is decreasing. (And this tells you something about the characteristic gravitation involved which points towards tidal forces rather than to anything else – which also tells you something about the entropy change being involved and explains why a black hole is *not* really a time-inverted white hole.) We know in the meantime from the seminal paper of Rovelli and Smolin and from other papers dealing with its consequences[39] that the volume (as well as the area) of space has to be visualized as a discrete and thus quantized entity. In fact, in case of the volume the quantization is not quite as straightforward as in the case of the area, but we notice that the spectrum runs proportional to ℓ_P^3 as should be expected. This insight has resulted in a number of consequences in the field of quantum information lately.[40] Hence, with respect to what we would like to have in the case of black holes when thinking of what we discussed above, the explicit coupling of gravitation, thermodynamics, and quantum information is very promising after all. Alas, there remains the unsatisfactory situation that the transition of black holes from the classical into the quantum domain is far from clear. The quantization of area and volume of space mentioned above gives some operational rules as to dealing with the computation of quantities at the Planck level. But the important problem here is the following: While undergoing collapse *each* black hole will *necessarily* come into the quantum domain by means of its permanently shrinking volume. And then the question will be how collapse is actually being *halted* at the Planck length, because the true zero-point of length cannot be reached due to the convention of declaring the Planck length

[38] John C.Baez: Higher-dimensional algebra and Planck-scale physics, in: C. Callender and N. Huggett (eds.), Physics Meets Philosophy at the Planck Length, Cambridge University Press, 2001, 177-195.

[39] Carlo Rovelli, Lee Smolin: Discreteness of Area and Volume in Quantum Gravity. http://www.arXiv.org/pdf/gr-qc/9411005 and Jerzy Lewandowski: Volume and Quantizations. http://www.arXiv.org/pdf/gr-qc/9602035 as well as Abhay Ashtekar, Jerzy Lewandowski: Quantum Theory of Geometry I: Area Operators, http://www.arXiv.org/pdf/gr-qc/9602046 and: Quantum Theory of Geometry II: Volume Operators, http://www.arXiv.org/pdf/gr-qc/9711031

[40] Paola A.Zizzi: Holography, Quantum Geometry, and Quantum Information Theory, http://www.arXiv.org/pdf/gr-qc/9907063 (also in Entropy 2 (2000), 39 sqq.), id: Quantum Computation Toward Quantum Gravity, http://www.arXiv.org/pdf/gr-qc/0008049 (also in J. GRG 33 (2001), 1305 sqq.), id: The Early Universe as a Quantum Growing Network, http://www.arXiv.org/pdf/gr-qc/0103002 , id: Ultimate Internets, http://www.arXiv.org/pdf/gr-qc/0110122.

to be the minimum length which could be possibly attained. Hence, we would conclude that there are *no objects* with a length which is smaller than the Planck length. But note that a black hole arriving at the Planck length by means of gravitational collapse will not have any Planck mass then! In fact, the mass will be much larger than that which means that the Compton length is actually *undefined*, because it would be smaller than the Planck length for such cases. In other words: While the black hole is entering quantum dimensions, it does *not behave* like a quantum particle at all. If we cannot ascribe a Compton length to it, then it is not subject to Heisenberg's uncertainty relationship!
In fact, it is quite clear why this should be the case: The reason for this is that within the region of the Compton length, the length scale goes as 1/m, while for the macroscopic region (where the Schwazschild length is of relevance) it goes as m. This is indeed due to the onset of Heisenberg's uncertainty relation. But the question remains why collapsing black holes do not seem to be subject to this transition. On the other hand, postulating *virtual* black holes which are being created by means of spontaneous fluctuations out of the vacuum does not really help here, because then the question remains whether it is legitimate at all to call such objects black holes, if they have not undergone any gravitational collapse before. As it turns out, there are basically two desiderata: One of explicitly demonstrating the transition from a classical volume to a quantum volume displaying the relevant effects such a transition would have for an object undergoing gravitational collapse, and another one of explicitly studying the relationship of length scales at the Planck scale proper as well as defining the state of an object whose Compton length is smaller than its Schwarzschild length, in order to be able to decide whether this could really be called a black hole or not. A first step towards approaching this problem is a recent paper of Paola Zizzi[41]. Further work with more technical explications is in progress.[42] Hence, it is likely to find the information processing mechanism discussed above within the interior of black holes. In the end it is this mechanism on which the concept of cosmological selection is actually founded. But it does not suffice to elaborate further on quantum mechanical details of black holes without being able to say something about the transition from classical to quantum states during gravitational collapse and without clarifying the nature of black-hole like objects at the Planck scale in more detail.

6. Some Conceptual Conclusions

Finally, how to come back to the glass bead game? And what about the interdisciplinary perspective discussed earlier? Note that the leading question of the example discussed in the preceeding is that for the relationship between the world

[41] Paola A.Zizzi: Spacetime at the Planck Scale: The Quantum Computer View. http://www.arXiv.org/pdf/gr-qc/0304032.
[42] Paola A.Zizzi, Rainer E.Zimmermann: Virtuality & Actuality of Black Holes. forhcoming.

and its foundation. Human research activities aim at the modeling of the world. But the world is not enough. There is also its foundation. And in fact, as it turns out, the world as we model it shows up as the foundation's self-recursion. In other words: The categories of space, time, and matter are necessary and sufficient to model both – world and foundation. Although the latter is by definition outside the scope of the mentioned categories. Hence, humans do model the world according to their linguistic capacity, and this in turn is determined by their perceptive and thus cognitive capacity. This is also at the very root of the problem when dealing with populations of Universes as in the case of our chosen example. But from this conceptual starting point we derive further, secondary, problems one of which is that of the universality of a principle (like the principle of natural selection), which reflects the underlying relationship between local and global, and between singular and universal, at the same time. Note also that there is an intrinsic search for harmony included in all these partial approaches to the totality of what we call world. Hence, we are explicitly dealing with the quest for unity within the manifold multitude we actually observe. But, even in conceptual terms, we will never leave the world *as it is perceived*, and we will never grasp the world *as it actually is*. In fact, all these aspects are common to all the various fields involved. This is the reason for being able to display analogies among the sciences and arts, without leaving the conceptual framework of human reflexion. This framework however is essentially founded on the mediation of knowledge and action, hence of epistemology and ethics: Physics models the producing ground of the world and the physical production of logic, at the same time. Hermeneutic is itself logically constituted, because it has a rational nucleus (in the sense of the Leibnizian *nihil sine ratione*), and so is the semantic of signs which can be derived from it in semiological terms. Hence, even aesthetics cannot be separated from physics at all, and, finally, ethics is essentially knowledge of all of this. The actual production of that knowledge progresses in the manner of the glass bead game: The playing board is the local framework of space, time, and matter, the rules are given by logic (but as this is produced itself by physics, the rules of logic directly reflect the laws of nature), the pieces of the game are propositions to be placed into their relational network called theory, and adequate (i.e. ethical) actions are at its stake. In fact, the *form* (Gestalt) of this relational network expresses the theoretical *contents* of what the propositions actually tell. This is what we mean with harmony: the fine tuning of form and contents.[43] But it is a game after all, we never deal with the „real thing" as

[43] This can be clearly demonstrated when breaking the preceeding text on cosmological natural selection up into single propositions and re-arrange them within a relational network of the conceptual context. Imagine them ordered in a three-dimensional lattice with the types of propositions being labelled by appropriate colours. What we get then is the coloured „cloud" of a theory exhibiting a specific shape in our representational 3-space. The idea is then that the form corresponds to the self-consistency of the propositions involved such that we can utilize the form as a macroscopically observable criterion for that consistency. After a while we would be able to deduce from a „good" or „bad" form whether the underlying theoretical contents is useful or not – very similar to the inutitive association generated by the (two-dimensional) shape of the positions of pieces in a Go game. This is indeed a straightforward means of incorporating intuitive association within the reflexive (propositional) thin-

such. This can be clearly seen in case of what we call „laws of nature“, because we refer to them as they are modeled by ourselves, but not as they actually are. The very concept of law itself is nothing but a mapping. Hence, the original definition of games according to Schiller is still valid: To be more precise, in that famous passage, Schiller speaks of the human driving force, the *impulse*, to play and calls it the connection of the impulse to change in order to give time a contents, and of the impulse of form in order to actually negate change and sublate time. Hence, the intention of the game is *to sublate time within time*, and to reconcile being with becoming.[44] This demonstrates clearly the relationship between physics and ethics. So Schiller concludes: „Hence, the impulse to play, in which both of them [the two impulses] act in a connected manner, will compel the mind in moral and physical terms, at the same time; hence, it will also sublate all of the compulsion itself, because it sublates all contingency, and thus sets humans in liberty [releases them to freedom], physically as well as morally.“[45]
Shortly afterwards, Franz von Baader, a friend of Schelling's, published his paper on the „founding of ethics by physics“[46] advocating a concept of nature which visualizes nature as a composing process activity which is structured in itself in a hierarchical manner.[47] Although his approach is definitely one of idealistic, if not even mystical, connotations, its general idea, namely that of a permanently emerging nature, an active *natura naturans* and in the sense of what he chose as first principle of physics: *Ignis ubique latet*.[48] is still of significant relevance for us today. It is in fact latency which underlies human reflexion, and it is reflexion which eventually produces a tendency out of this latency by means of emerging concepts. This is after all what the glass bead game is all about. So Baader's principle can be actually completed by what the materialistic philosopher Ernst Bloch once formulated referring to his own perspective of a somewhat different context: *Quidquid latet, apparebit*.[49] Hence, the worldly process of modeling the world shows up as an experiment the world is performing utilizing itself, and it includes its own recording and produces thus its own narrative. It is the world's foundation though which is playing a game with itself which in turn is the conditional space of free play for the world. The inventory the foundation utilizes has been coined recently SOAPS [= Space Of All Possible States] by Devin Harris[50] so that we could visualize the *experimentum mundi* (in the sense of Bloch) as an actualization of „SOAPS bubbles“.

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king of theory production. This conception is explicated in some detail in my book „System des transzendentalen Materialismus“, op. cit.

[44] Friedrich Schiller: Über die ästhetische Erziehung des Menschen in einer Reihe von Briefen. (14. Brief) In: id., Sämtliche Werke, Band 5, Wissenschaftliche Buchgesellschaft Darmstadt, 8. Auflage, 1989, 612 sq.

[45] Ibid., 613.

[46] Franz von Baader: Über die Begründung der Ethik durch die Physik. (1813) In: Max Pulver (ed.), Schriften Franz von Baaders, Leipzig: Insel, 1921, 1-30.

[47] Ibid., 7, 9.

[48] Ibid., 12.

[49] Ernst Bloch: Experimentum Mundi. Frankfurt a.M.: Suhrkamp, 1975, 148.

[50] Devin Harris: Integrating Absolute Zero into the Set of all Possible States. Preprint, August 2003.

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Appendix

Recte

Tones & Notes
Towards a New Fundamental Form of Expressive Representation. A Manifesto.

The world is being perceived by humans under a special perspective only, in a two-fold manner: on the one hand in the sense that the human viewpoint is generically restricted to what is available to observation – due to biological and anthropological reasons – insofar as humans can merely perceive fragments of the world but not the world as it really is, i.e. as it is independent of their perception. But this perception refers exclusively to what is in the senses, hence what is physical by nature. So human reality is always restricted altogether. On the other hand it is also restricted in the sense that additionally, each person perceives the world under an individual, specific perspective. And the communicative clarification of what has been perceived, which is the condition of intersubjectivity, can only be achieved, if this singular perspective is permanently being reprocessed with respect to all other such perspectives within a process of building a (discursive) consensus. Intersubjectivity thus becomes objectivity and constitutes a governing picture of the world. The two large discursive regions of worldly constitution, the sciences and the arts, are being organized therefore – not the least due to purely pragmatic reasons – in different and clearly differentiated sectors of design which refer to each other like mutually irreducible regions. But they simply represent specific and thus perspectively characterized

fragments of the world which are being perceived by humans and are being modeled according to the perceptions actually made, and re-constructed in a more or less provisorical and thus transitory manner. *In other words, the world as it is, is only one, but the world as it is perceived, can be represented and expressed by many.* Hence, there is an obvious multitude of the world which is nothing but the mapping of the unity of the world. It is straightforward to suppose that the systematic synthesis of the various aspects of that same underlying One will be able to shed some light onto the interactions of these aspects among each other and thus onto the totality of which they are aspects. Hence, how the practical

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interdisciplinarity in the sciences has produced new insight into various sections of reasearch recently, a likewise interdisciplinary approach to the arts can add to a widening of the epistemic horizon and an enlightenment of the relevant context. It is in particular the conceptual though distanced confrontation of otherwise irreducible forms of art which initiate the unfolding of an associative space of free play for those interactions in whose framework traditional categories of viewing the world can be sublated and innovative experiences can emerge. As far as the design of fine arts, e.g. in the case of paintings, works primarily with the category of space, while music works with the category of time, both of them however encompass the complementary category, respectively, it is straightforward to investigate the practical co-operation of both within their space of free play which is spanned by the interaction of these categories. This in turn offers itself to perception in opening up a new combinatoric of harmonical forms which enrich the multitude of worldly forms even more. Essentially, we deal with a topological and geometrical combinatorics which is subject to its own laws of form such that relevant characteristica may be expressed by means of similar structures of mappings: e.g. by means of symmetry principles or symmetry breakings, the modulation of continuous motion, the spontaneous succession of evolutionary jumps and so forth. Hence, the composition of Tones & Notes aims to a reduction of complexity, in the first place. This is so because humans though disposed of selecting available information all the time, for getting rid of irrelevant information, they are exposed, especially within the cultural sector, to an avalanche-like abundance of information which they hardly can cope with anymore. Hence, it appears to be useful to go back onto the fundamental forms of perception and to take the result as a basis for re-assuring itself about the approach to the world. So as far as paintings are concerned, elementary shapes and basic colours and tones shall be in the focus of attention, while as far as music is concerned, the optical impressions shall be complemented by spontaneous compositions (improvisations) in the fundamental notes.