

God's Heart and the Stuff of Life

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Introduction

In June 1995, a meeting was held in Granada bringing together European specialists in the field of Artificial Life. A first draft of the following text was presented during this colloquium.

Surely it would have been easy, when it came to publishing this essay, to erase all traces of its origin. It is not out of honesty that I have chosen to retain the style of the original, save to write this introduction. Indeed, I do not regard this work as an essay, but rather as a 'performative' attempt, belonging to what I've since referred to as an ecology of practices. In this case, it was a matter of addressing oneself to practitioners in the field of Artificial Life in a mode which was not 'critical', which did not seek to remind them, as critique is wont to do, of the limits inherent to their activity, the set of renunciations that they would have to accept in order that the difference between dream and reality, illusory and rational knowledge, could be recreated with regards to their practice. It was a question of trying to 'dream along with them', which is to say, of attempting to propose other ways of dreaming, other ways of addressing themselves to what they do, and therefore other ways of addressing others. Or equally, other ways of presenting themselves, both to themselves and to others.

The ecology of practices takes stock of the fact that the innovative dynamics of technical and scientific knowledge has very little in common with the 'critical' partition which puts the dynamics and the innovation on the side of 'rationality' and equates the dream to the essentially static eternal return of parasitic illusions which must be eliminated. It is not a question of purifying technical and scientific practices from the dreams associated with them, but instead of addressing these dreams themselves,

or rather of addressing the one who endeavours to do so at his or her own risk. The very existence of a field such as Artificial Life refers first of all to new possibilities which have arisen in the fields of robotics, computer simulation, but equally so to the appearance in the past twenty years of the new regimes of collective functioning which have been exhibited in computer simulation (flock and swarm models, for example) as well as by physico-chemical systems (far from equilibrium dissipative structures) or networks of interconnected automata (neo-connectionist networks, neural networks, etc.). These have elicited confidence in an approach characterised as 'bottom-up', in opposition to 'top-down': that which is to be realised is no longer conceived of as being 'at the top', then organising 'down' the means for its realisation. We now may begin with a 'coupling causality', that is, a causality whose subject is a whole interconnected population (bottom), and it is the intervention on the coupling *as such*, and not on every individual interaction, which confers on the collective behaviour (up) this or that meaning.

Granted, no bottom-up functioning does exhibit as such the characteristic behaviours of living systems. However, these models do transform the problem of the selective history of the living such as it has come to dominate this century. The selectionist explanation is a direct descendant of the great historical figure of the watchmaker, and has indeed been famously associated by Richard Dawkins with the figure of the "Blind Watchmaker". Contrary to the Divine Watchmaker, selection is blind, it knows not what it does, but like any watchmaker, it deals with a matter which is essentially 'stupid'. The watchmaker image thus designates selection as the only one responsible, the only *raison d'être* for the traits and behaviours of the living. However, and this is the meaning of the statements made by one of the more prominent figures in Artificial Life, Stuart Kauffman, once we are no longer dealing with an essentially passive and indifferent matter, but rather with a multiplicity of correlated local activities, capable of specific collective behaviour, the figure of the watchmaker, whether blind or not, loses its relevance. Natural selection is no longer responsible for an assemblage, it participates in the transformations of an assemblage. It is no longer in the position of a determining cause, but rather part of an opportunistic 'negotiation', which prohibits and confirms, profiting from the emergence of new collective behaviours by channelling them or instrumentalizing them. In other words the capacity for self-organisation, linked since Kant to the question of the living organism, can no longer serve as the dividing line between vitalist

and mechanist doctrines. The field of Artificial Life stems from this new configuration: it corresponds to the wager that the difference between the living and the non-living can become an object of practices instead of definitions.

Nevertheless, there are quite a few ways of presenting this novel approach. The birth of Artificial Life in 1987 was announced by a manifesto written by Christopher Langton of the Santa Fe Institute.¹ Langton defines it as “the study of artificial systems that exhibit behaviours characteristic of living systems” and regards its ultimate goal as “to extract the logical form of living systems”. Moreover, Langton declares that the imminent acquisition of a capacity for synthesising new forms of life, *in silico* as well as *in vitro* “will present humanity with the most far-reaching technical, theoretical and ethical challenges it has ever confronted”. The field born in 1987 is therefore defined not by a problem but by a postulate: there must be a logic belonging to all living systems, a logic common to living beings on earth, but also common to all life-forms possibly existing elsewhere, and it is this logic, this substrate-independent logic, which will characterise the artificial living beings that are to be constructed *in silico* and *in vitro*. Predictably, such a postulate immediately connects with the great classic theme of man appropriating the secret of his existence, becoming God’s equal, unless it is God who finds Itself lowered to a status in which It comes to resemble man...

Nevertheless, there is another way of presenting Artificial Life, quite common amongst European specialists and well-represented, notably by Francisco Varela. According to this version, Artificial Life learns from the ambitions associated with Artificial Intelligence, and from the very failure of these ambitions. In order to develop a being capable not only of reasoning from precisely and explicitly defined situations, but also capable of learning how to address a situation, one must equip this being with a body. Only a being capable of encountering an ambiguous and uncertain world with which it can interact effectively will be able to construct, in real time, that which was presupposed by the entities created by Artificial Intelligence: the relation between ‘description’ and ‘pragmatics’. It is no longer a question of a unitary logic, but rather of the creation of new types of artefacts. To produce a ‘robot mouse’ capable of behaving like a genuine one may suffice to satisfy the most ambitious dreams, and the discovery of all that is required by an ‘artificial body’ capable of behaviour

¹ Quoted in S. Levy, *Artificial Life: The Quest for a new Creation* (Penguin Books, 1993), p. 113-114.

which we take for granted implies a wholly different notion of ‘logic’: a risky logic of capture, giving primacy to heterogeneity, to a ‘grasping together’, actualising traits belonging both to the environment and to machinic functions which did not pre-exist as such, independently of the event of their inter-capture.

Whatever its mode of presentation, it is not obvious that the field called Artificial Life survives. One could already affirm that in the United States it is restricted today to some computer-related disciplines such as genetic algorithms, whilst robot designers have already established new collaborations, namely with biologists who no longer are interested in the “logic belonging to all living systems” but rather are concerned with *a* characteristic behaviour in certain *specific* circumstances.

The existence of a new scientific field, when it regards itself as interdisciplinary, always depends upon its capacity to mobilise. To succeed, it is necessary that those whom the field seeks to assemble accept its proposal, that is to say, agree to identify that which they produce as expressing the progress of the field itself. Today, the greater part of those whom Artificial Life seeks to assemble under its banner seem to prefer presenting their products in the more traditional perspective of technological innovation. In much the same way as the field of Artificial Intelligence will finally have produced a series of ‘intelligent languages’ without having thereby truly redefined in scientific and technical terms the question of ‘intelligence’, it is quite possible that Artificial Life will be dispersed into multiple productions of new artefacts characterised by bottom-up causality.

The fact remains that the production of artefacts which are not only new but could perhaps be of a ‘new type’ constitutes an event. It is this event that I tried to ‘celebrate’ in Granada with regard to a particular problem. In many articles, both announcing and describing the production of these new artefacts, the emphasis seemed to be placed, in a rather unilateral way, on what the artefact did ‘by itself’, ‘on its own’, while the manner in which its designer guided it and intervened was often downplayed, if not altogether ignored. The dream is clearly that of capacities which refer to a ‘machinic self’. Insofar as this dream leads to presenting each new apparatus from the point of view of its performance alone - “look what it’s capable of !” - I have taken it upon myself to show that we are dealing with an impoverished dream, one which veils the potential novelty of the situation.

Whilst the critical approach aims most often at undermining novelty, at demonstrating that that which presents itself as new is always already bound to the self-same limits, the ecology of practices, of which the following text is an example, does not allow itself to deny the novelty to which the practitioners bear witness. From an ecological point of view, such a denial is in itself a failure, a breaking of the very links which this ecology seeks to cultivate. The ecology of practices also does not allow *its* practitioners to spell out the identity of this novelty, knowing that this work is up to the novelty-producing practitioners themselves, and that there is no privileged position which would allow one to anticipate them. However, it does allow them - once again in the name of no *a priori* decision upon the difference between rational knowledge and dream, but rather at their own risk - to be among the many heirs to the novelty. As such they may identify the modes of presentation which appear to diminish the interesting aspects of novelty, leading it back to the ancient dreams it was in fact seeking to challenge.

The ecology of practices is not political in the common use of the term, in the sense that it would indict both abuses of power and questionable ambitions. Indeed, what could be easier in this case? The wager which characterises the ecology of practices is nevertheless of a political sort: not to engage in denunciation, which results in the offended practitioners forming into mobilised 'blocks', but rather to attempt a displacement of the interests involved in order to divide them. To actively create the possibility of new types of 'we' which will undo the molar socio-professional strata and their order-words. This is why the question I asked in Granada was: "What are we trying to do?"

Taking Artificial Life Seriously

One reason why philosophers are invited to scientific meetings is to try to answer questions without a definite answer. An instance of such a question could be "what is life?". Another, which is the one I will address, is "What are we trying to do?", in other words, "What is the specificity of this field we call 'Artificial Life'?". Obviously the answer I will give will not be true, meaning adequate to the facts. Rather, I will try to explain what can, and I hope, will, become singular with Artificial Life, the kind of novelty it could bring into the scientific enterprise at large.

First I will address the name, ‘artificial’ ‘life’. The project it points towards is not in itself an innovation. Francisco Varela has told us about cybernetics and the already interdisciplinary enterprise which started fifty years ago, which tries to connect life and computation. We can go even further back, towards myths about men creating life, such as the Golem or Frankenstein’s monster. However, we can also take these two words seriously - artificial and life - and see them as defining the field for a confrontation, the confrontation between two kinds of creation.

On the one hand, we have the explicit, ‘artificial’ creation, associated with mathematical, technical and computational knowledge, the creation which modern science and technology have made it their business to extend, creating more and more artefacts defined through scientific knowledge, taking into account more and more of the demands, risks and implications involved in these scientific definitions. When Chris Langton emphasises that in spite of its diversity, life on earth is just one *case*, while Artificial Life should deal with life *in general*, he situates himself in the classic perspective of modern science: understanding means first of all succeeding in transforming a situation into a case, belonging to a more general ensemble. Ever since Galileo and Newton, the falling apple, the Moon and the Sun are just cases, and we are thus always able to add new cases, for instance satellites orbiting the Earth or exploring devices reaching Mars. Here, ‘artificial creation’ is an integral part of the very process of definition. It is only if, and because, the definition successfully separates the general case from the factual particularity, that artificial creation may always add new cases, leading also to the claim that the definition is not relative to interests alone but answers instead to ‘objective reality’. This strong interconnection between ‘objective’ definition - defining the object in such a way that anyone should recognise that the definition is not our own creation but has instead been forced upon us ‘by the things themselves’ - and creation of new, very interesting and very useful artefacts, is the royal road of modern science and technology: obeying ‘nature’ in order to master it.

On the other hand, when we deal with Life, I would claim that we are also dealing with a ‘creation’. This is a risky claim, which would seem to lead us straight into vitalism, while the whole trend of current molecular biology succeeds in explaining biological functioning solely in terms of molecules and their interactions. I would propose that biology is indeed different from physics or chemistry even when it is only dealing with molecules. The point is that for a physicist or a chemist, the difference

between this or that matter of fact is clearly related to his or her own interests. If chemists succeed in designing a pathway leading to the synthesis of a particular kind of molecule, the success will be their own. The 'molecular reality' they deal with is quite indifferent to this or that molecule being synthesised. It is not so when biochemists study biochemical pathways. The question is then for instance: how does this cell manage to do that, knowing full well that if it did not, it would probably not succeed in staying alive and functioning. Similarly, when physicists or chemists, in order to produce a model of global functioning, try to simplify, to exclude some aspects which only produce negligible consequences, they are always at risk: in some circumstances what has been put aside may suddenly become important and must be taken into account if the model is to retain its relevance. But when biologists model a biological function, they address something which has in a sense already produced its own model. What is to be taken into account, and with what consequences, is here a matter of life and death. The possibility that in some circumstances the whole description of the function must be transformed is a matter not of caution on the part the scientist but of interest for the living, functioning, being: has such a possibility been defined by this being as meaningful, leading to a new way of functioning, or does it designate a boundary which, when crossed, signifies disorder and failure? Also, if your model gives you to understand that the whole observed functioning depends on the rate of this or that process being very slow in comparison with that of some other processes, you may also guess that keeping it slow has been a constraint and a stake in the evolutionary process leading to this functioning.

In other words, I would claim that the more biologists address the same kind of molecular reality as physicists or chemists, the more the difference becomes obvious. If you deal with ecological situations, the difference between success and failure is not necessarily obvious, but if you are dealing with biochemical pathways, all your descriptions, indeed the very possibility of describing something, is dependent on a success which is not your own. The question is most often "how does it work?", that is to say, a question which comes *after* something has succeeded working. And the answer to this question may be compared to a kind of 'celebration'. A biological function which, from the logical point of view, seems very simple, requires in fact a very complicated and precise set of correlations between multiple chemical processes. You do not reduce biological

functioning to molecular reality, you explode it into molecular multiplicities.

As a consequence, the pragmatic position of experimental biochemists is not that of experimental physicists. They are not free to prepare a situation in order to test an hypothesis, and they are usually quite unable to get to some kind of general and abstract case, which the functioning they study would illustrate. They have to negotiate with a concrete situation which is already meaningful. They have to insinuate their questions in order to distinguish, clarify, make explicit or identify, but the answers do not lead them away from the concrete success they explore towards some kind of general definition of what it is to succeed in living. Even contemporary biotechnology has not created 'new cases' starting from the general definition of a type of functioning, rather, it has succeeded in exploiting the activity of living beings in new contexts. Technology here is no longer strongly connected to the power of definition, and is much closer to the usual meaning of diverting something which is already working in order to have it work for you.

The very fact that we speak about biological functions is another way of stating the same contrast. When Galileo's polished spheres rolled along inclined planes, as the first experimental objects, their motion exhibited submission to a mathematical function, but this submission designates the motion as actively defined by the inclined plane and through the ideal of a frictionless motion. Try it with a snow or mud avalanche: you will need all the power of computer simulations to get some relevant description of the event. The polished spheres' frictionless motion as defined through experimental devices did answer simple mathematical questions, and this is the very reason why they were defined as 'objects'. But biological functions do not depend on the laboratory and on the values human scientists confer upon the possibility of mathematical understanding. It is not the scientists, it is the very 'functions' the scientists deal with which create meanings and values, which gamble on the fact that something they define as poison will not appear too frequently in the environment, while something they require as food will usually be available. As such they act as a lure for our many definitions, inspire vitalist doctrines and the widest set of political, social and technological metaphors. 'Artificial Life' is itself an answer to such a lure. No longer are they just words celebrating a success, but now devices endeavouring to achieve the same kind of success. Artificial Life is thus a confrontation between human language, which is also to say human devices, and non-human creation. It is a

confrontation whose first object is the ability for human languages and devices to capture relevant features of life, and it is a speculative confrontation because it is not life, it is our human languages and devices which are put to the test, and whose limitations, possibilities and demands are measured against the task of putting Life both into words and into technical or mathematical operations.

Put in this way, there is a strong contrast between the Artificial Life and Artificial Intelligence fields. In the case of Artificial Intelligence we had no such confrontation, and I am not sure we have it in the present day field of cognitive science. Intelligence was never accepted as 'non-human', as challenging human definition. Intelligence was accepted as socially, culturally, historically and politically constructed, well before the creation of the Artificial Intelligence field, but also well within the Western tradition: as the producer of rational knowledge, that special normative knowledge which is meant to be able to justify its conclusions and to give an account of its procedures.

I have tried to emphasise the contrast between the positions of the experimental sciences and of biology. The symbiosis uniting theoretical understanding and artefact-producing activities which characterises experimental sciences cannot be simply reproduced. If it is to come about it must be invented again. If we wish to take seriously the idea that Artificial Life intends to address the problem of life 'in general', and not the problem of this or that aspect of a living being which we might construct, then this ambition implies a new invention of what we mean both by theory and by artefacts. I will address these two aspects of the situation in turn.

Life as such?

I will first try to indicate why in claiming that there is something to understand about life 'in general' or 'as such', Artificial Life goes against the main trend of contemporary molecular biology, the very triumph of which lay in affirming that there is no point either in wondering about 'life as such' or, in other but complementary words, about what kind of 'stuff' life requires.

"We no longer question life in our laboratories", François Jacob triumphantly concluded in *La logique du vivant*. Seen from the point of view of the DNA molecule as a program, life appears indeed as something

akin to miracle, not as the result of any kind of natural process. This was precisely Jacques Monod's central thesis in *Le hasard et la nécessité*. There was no use in wondering what the stuff of life is because there is no stuff, only a statistical miracle reproducing and amplifying itself through selective evolution. Life was defined as completely singular, compatible with, but not deducible from, the behaviour of matter, just as a clock is compatible with the laws of mechanics but cannot therefore be deduced from those laws.

Among biologists, the ones who did mostly resist against the 'selectionist' explaining away of 'life as such' were embryologists such as Conrad Waddington or Paul Weiss. They would not accept that the spontaneous self-production they were studying could be explained if DNA and selection were the one and only final word, if any property of any living being had as its sole reason its selective advantage, under the all-powerful process of natural selection. It is interesting that those embryologists found this view of innovation, of production of a new being though trial and error, as repulsive as an artist would find it with regard to his or her own process of creation. The point was not to deny the importance of the DNA molecule or of biological selection. The point was to resist the anthropomorphic metaphors which are used in order to 'explain' life in terms of DNA and selection: program, blueprint, information, coding for a character, and all that.

The trial and error interpretation is a very good device to explain everything and nothing in particular, that is, to simply explain away. In order to resist this (dis)solution of the problem, demanding and precise empirical questions are of great interest. In an argument against socio-biology, the biologist Stephen J. Gould pointed to the importance of seemingly humble quantitative empirical questions in testing the plausibility of 'just so stories' about adaptation. Questions such as the correlation between the so-called adaptive trait and a precise genetic difference, the evaluation of the benefit of this feature, the intensity of the corresponding selective pressure and the number of generations needed for the genetic difference to become prevalent in a population. However, as long as selection is the only answer to the question "what is the specificity of life?" which would not end up in a vitalist claim, 'just so stories' are to be found everywhere. Just like in the famous parable of the lamp around which somebody is looking for lost keys: selection gives the only source of light, so let us try to keep our questions in the illuminated area.

Trying to grasp how what I call ‘life as such’ could constitute another source of light poses considerable difficulties. The embryologist Conrad Waddington called for a theoretical biology, but what theory means in this case is part of the problem. Stephen Gould’s formulation is worth quoting because it spells out what a natural biologist would demand from a theoretical understanding of life: “We need a richer theory, a structural biology that views evolution as an interaction of outside and inside, of environment and the structural rules for genetic and developmental architecture - rules set by the contingencies of history and physicochemical laws of the stuff itself. The downfall of pop socio-biology will be a small benefit of this richer theory; its chief joy will be the deep satisfaction of integration: environment and organism; function and structure; current operation and past history; the world outside passing through a boundary into organic vitality within”.² What Waddington called a theoretical biology, what Gould calls a richer theory, a structural biology, these imply quite a new meaning for theory. Usually the call for a theory means the call for power, the power to judge, to separate and define what is essential and what can be ignored. This time the need for a theory can be spelled out as the need to become able to meet the singularity of life, the question life imposes upon us.

I would claim that the very interest of the Artificial Life field might lie in exploring the possible meaning of what can be called theory in biology. It is a matter of life and death for this field, because if the blind watchmaker is the answer, it will never be able to go beyond producing devices upon devices, never learning anything from these devices themselves. In other words, Artificial Life must side here with ‘creation’: if trial and error were to be the answer, if evolution were only linked to the accumulation of random mutations selected for adaptive advantage, there would be no point in trying to go beyond exhaustive description. If the blind watchmaker truly were the answer, life would be artificial indeed, but in the most disappointing way, the ends, i.e. the selective advantage, being the only reason for the existence and correlation of the means.

In a way, we are back to eighteenth century materialists such as Denis Diderot. Diderot asked what kind of ‘stuff’ life requires in order not to be a miracle inside a world where non-life would be the only predictable, normal way of being. It is striking that his answer was a bit similar to ours, and especially to the ‘flock and swarm’ approach. His own illustration was

² S. J. Gould, “Cardboard Darwinism”, in *An Urchin in the Storm* (Penguin Books, 1990), p. 50.

indeed the beehive, and he argued that if life is related to a collective behaviour, a togetherness of elementary locally interconnected entities analogous to bees, we have to attribute to those entities some kind of elementary spontaneous activity and sensitivity. The main difference is that Diderot was arguing against the mathematical mechanist conception of matter while today mathematical, physical and chemical physical references help to destabilise the blind watchmaker's unilateral responsibility: chaotic systems, edge of chaos systems, dissipative structures, neural networks, all those objects have opened up new possibilities, new problems and new bridges. In other words, Diderot has 'won'. Artificial Life does not start with entities described by the great laws of physics but with 'promising' non-living 'stuff', which can, in one way or another, be associated with generic properties of 'self-organisation', emergence of qualitatively distinct types of collective behaviour, path-dependent evolutions leading to the actualisation of one possibility against many others.

To be surprised by one's own creation

If the prospect of a theoretical biology implies the downfall of the blind watchmaker, I will now show that the prospect of a new and strong correlation between theoretical understanding and the creation of artificial entities may imply a new image of the artefact-maker.

As I already emphasised, the very object of experimental laboratories is indeed to create a correlation between theory and artefacts: when spheres started rolling along Galileo's inclined plane, they also started testifying for the way they should be described. As such these spheres were truly artificial, the product of an active redefinition of a natural phenomenon creating a being endowed with the very strange and unusual power to tell us how it should be described. All laboratory phenomena are artificial in this sense and since our theories do not describe the world as it is but as it can be met through experimental devices, all our theories are grounded on the creation of artificial entities.

Galileo's polished spheres testified in favour of Galileo's theory through their obedience to this theory, through the way this theory gave the power to predict and anticipate their behaviour. However, this is not exactly what an artificial living system should do. We all know that in one way or another it should surprise us. And this surprise should not be the

one we may easily get when confronted with unpredictable behaviour, such as chaotic systems may produce. In one way or another the surprise should concern some kind of an 'answer' given by the system to a situation. It should concern the way our artificial living being 'understood', in some sense, the situation and solved the problem as it corresponded to its understanding. The answer should thus make sense, but only *after* the event, when we understand, from this answer, how the being which confronted the situation *itself* understood it. In one way or another, this surprise is linked to the possibility of claiming some kind of 'pragmatic' autonomy for the being we have created.

Autonomy is a crucial point in the confrontation between our artificial creations and life as such. And the very central and interesting problem is that it implies quite a new demand on our experimental devices.

'Obedience', as the very practical aim and ideal achieved by the usual artificial entities created inside scientific laboratories, means that the *a priori* identification of the relevant variables defining a situation is the key to the whole of experimental practice. Experimental success consists in the possibility of claiming that the defining variables are not imposed by scientists but instead truly characterise their object. Autonomy, however, means something else: the very selection of the relevant variables defining a situation should belong in one way or another to this concrete entity itself rather than characterise it as a well-defined object. In the usual experimental setting the definition of the variables is part of the question: "which variables do you, as an object, obey?". Instead here the question is: "which variables will you take into account?". The scientist must now be able to demonstrate that he or she has been able to create a situation in which the system indeed answered the experimental question, i.e. actually defined for itself what it would take into account.

In biology, the usual experimental ideal can be achieved for bacteria, at least as long as we address them as the product of a success-story, each individual testifying for it as a well-defined and stable end-result. However, as soon as we address beings as able to 'learn', or 'produce interpretations', this ideal becomes a way to reduce what we are dealing with to 'as-if appearances', insofar as it links success with the discovery of 'obedience'.

This, by the way, is the curse on experimental psychology. In experimental psychology laboratories the scientist fully intends to be the one asking the question, identifying the relevant variables in the situation, whilst the subject is to play its usual role as the reliable experimental

witness testifying for the relevance of this identification. In this case however, scientists can never know if the experimental subject was truly a reliable witness. We face here what I would call, in the most generic sense, the problem of imagination. We cannot have a human being forgetting that he or she is being asked questions in the name of science, in a scientific laboratory. We cannot have complete control over the interpretation he or she will give to this situation.

This was dramatically illustrated by research in the field of experimental hypnosis. At first sight, hypnosis was an ideal situation for experimentation. The scientist induces hypnosis through a standard, reproducible procedure, and then tests and measures the changes of behaviour which he or she will correlate with this 'state'. But it is not that simple. The main result of experimentation in this field until now is that those measured changes do not testify in a reliable way about hypnosis. Indeed, the experimental subjects' behaviour cannot be dissociated from their ideas about what hypnosis produces, what it is to be hypnotised, and what it means to be or not to be sensitive to hypnotic induction. Their behaviour also incorporates their knowledge that they are in the hands of scientists as well as their guesses about what the scientist is looking for. In other words, the experimental setting here does not purify a common phenomenon in order to produce a reliable witness, defined by well controlled variables. It produces an artefact in the negative sense of the term, a false or complaisant witness. This 'artefact' does not testify for the purified isolated phenomenon ('pure hypnosis'); it does not, though it might seem to, answer the scientist's explicit question, but answers instead the whole situation, including all of its implicit dimensions.

The point to be emphasised with regard to this situation is that the notion that the whole of experimental research on hypnosis was a failure is closely related to the very definition of the type of artificial beings which are created through the usual experimental setting. The behaviour of the hypnotised subjects was defined as that of artefacts devoid of any scientific value because they were meant, just like Galileo's rolling spheres, to be artificial products reliably answering and testifying for the variables they obey, that is to say, products of human art, actively redefined in order to serve as proof in scientific argumentation. In this context, whatever the reason for the artefact, be it contingent, as is the case with a badly controlled experimental setting, or essential, as with the scientist's inability to control the subject's imagination, the result is the same: a scientific failure. The scientist was looking for a reliable witness

and instead produced something which is ultimately unable to sustain that claim. This is the very limitation of our usual experimental ideal as soon as it is enacted in a field like psychology, taken as the science dealing with living beings' active and interpretative relation with others and the environment. From the point of view of this ideal, the active and interpretative character of this relation appears as nothing but an obstacle, a source of artefacts.

Thus the ambition of the Artificial Life field, to create artificial entities which we would address as able to produce their own point of view about their situation, is a very crucial one, not only for the problem of life, but for what we call science, and proof in science. A new appetite is indeed being produced among some of those who continue the grand tradition of science conceived of as a discipline which relates the production of artefacts and the production of scientific knowledge. They want to be surprised by their artefacts, they want their artefacts to succeed in producing something meaningful, but which they would be unable to deduce starting from the knowledge of their creators. They want to be creators of artificial entities that they cannot master.

Here we obviously encounter a very rich mythical ground, dealing with the master/slave relation. Clock-making was the leading image for the situation of complete slavery: the clock is able to escape fulfilling its master's command only in one way, by losing its functional behaviour and being thrown away. But as soon as we come to the Golem, or Frankenstein's monster, or the Terminator's robots, the artificial beings become able to resist, to rebel, to take power. This, however, may not be the most relevant myth and dream for Artificial Life specialists. It gives the impression that the matter is closed, that success is at hand. It gives no sensitivity and appetite for what I consider to be the true, that is the new and relevant, problem they have to face: having to prove that an artefact is indeed autonomous, whilst knowing that proof has been until now linked with obedience.

In order to enhance and dramatise this aspect of the situation I have chosen another mythical situation, as created by Richard Wagner in the *Walküre*, the second piece of his famous *Ring des Nibelungen* tetralogy.

Wotan's dilemma

Wagner's plot is quite complicated and I will not inflict it upon you. The point is that Wotan desperately needs, in order to break the curse which

undermines the very foundation of his power, somebody, a hero, to take the famous ring from Fafner without anybody being able to say that in so doing this hero was obeying Wotan's order or following a path Wotan would have set for him. Here is how Wotan describes his problem:

Only one person could do what I may not: a hero to whom I never deigned. A stranger to the god, free from his favours, unwitting and unprompted, out of his own needs, with his own weapons, could do the deed which I must avoid, and which I never suggested even though it is my only wish. This man who, opposed to the gods, will fight for me, this friendly foe, how can I find him? How can I create a free agent whom I have never protected, who by defying me will be most dear to me?

Wagner's solution will come in two steps. In the first step, Wotan thinks he has found his hero, Siegmund. Siegmund has already acquired, apparently all by himself, the sword with which he should be able to defeat Fafner and take back the ring. However, a true 'controversy' erupts between Wotan and Fricka, his offended wife: Fricka is the Goddess of marriage and tradition and she cannot accept another aspect of the situation, Siegmund's love for his own sister Sieglinde.

Using the term 'controversy' I intend to emphasise that we deal with the kind of situation the Artificial Life field could produce. No longer the "is it really proof?" controversy around the reliability of an experimental witness, but one which revolves around the question: "is it truly autonomous?" In other words, is your surprise an 'as-if surprise' only, or can you claim that your artefact's behaviour shows that it truly did something 'by itself'?

Fricka wins the controversy against Wotan. She convinces Wotan that he cannot claim that Siegmund was free when getting the sword: *Are you going to deny, she sings, that your cunning alone brought Siegmund to where he would find the weapon? No, Siegmund was just like the others. Who inspires men with bravery? Who lit up those fools' eyes? Under your protection they appear strong; through your goading they have their aspirations. You alone inspire these whom you praise so to a Goddess. In Siegmund, she concludes, I find only you since through you alone he can act boldly.*

This aspect of the controversy is quite relevant. Whatever the artefact, it will always be possible to reduce its so-called autonomy to an 'as if' situation: 'as if' an artificial being, which we know obeys rules since we

have built it to follow those rules, was nevertheless autonomous. Which kind of test will be demanded in order for this 'as if' to be accepted as something more than an appearance? Fricka was a very hard critic of Wotan's claim. She knew that whatever the reason for men's eyes lighting up, it came from the Gods, that the Gods are the source for men's every aspiration. She thus had no difficulty in recognising her husband's tricks, the way he had prepared the situation for Siegmund to take the sword 'as if' by himself.

Wotan admitted defeat. He had to recognise that he himself provoked Siegmund to boldness, that he defrauded himself in believing Siegmund was a free man. Wotan can only create subjects to himself. And he accepts Fricka's conclusion. Siegmund must die. I believe Wagner is right: the claim that an artefact is autonomous will always be in a position of weakness if it accepts the either/or dilemma: either the artefact is autonomous, or it is just a slave.

Here however begins the second step with Brunnhilde, Wotan's cherished and obedient daughter, at the centre. She is the one who will finally be 'autonomous', disobeying the will of her father, trying to save Siegmund and thereby becoming the cause for the saving of the unborn Siegfried, who will eventually, this time truly without Wotan's help or protection, snatch the ring. But the interesting point is that Wotan is quite unable to understand that his project is actually being realised. He only sees his daughter's treason. He complains:

No one but she knew my inmost thoughts; no one but she knew whence my wishes sprang. She herself was my desire's fertile womb. Now she has broken the sacred alliance, disloyally she has defied my will/, her master's orders she has openly scorned, and taken up arms against me, though only my wishes brought her to life. And he accuses: Through my will alone you existed, and you have willed against it. My orders alone you carried out, but you gave orders against me. Agent of my wishes I made you, but you turned your wishes against me.

Here we thus have a true surprise, for which the master was indeed not ready. Brunnhilde was defined as the very expression of Wotan's will, and suddenly she betrays this explicit will. She was delegated to kill and tried to save. The plot will be of interest however only if we can truly understand this surprising change. If we can understand that she did not, by some kind of miracle, escape the rules, but that she instead obeyed her

nature, which was to be a true delegate for Wotan. This is a crucial point since we here have a case where a subject escapes her master's will and answers to a situation from her own viewpoint, even though she should not have any viewpoint other than Wotan's.

Why did Brunnhilde disobey? She can explain it, but only after the fact, as being herself the product of the fact. She did it because of a factor which was not taken into account in the controversy between Wotan and Fricka: Wotan loved Siegmund. I quote Brunnhilde:

I knew the dilemma that compelled you to entirely forget about this one thing. ... Because my eyes are yours I held to the one thing which the alternative forced you in a painful dilemma to turn your back on. When Wotan is at war I guard his back, and this time I only saw what you could not see: I had to see Siegmund.

Thus, if Brunnhilde betrayed Wotan's will, it was because she obeyed her nature, which was to be a true delegate for Wotan. Being a true delegate, she was unable to follow his explicit command. She thus expressed the difference between Wotan's deliberate, rule-following, decision, Wotan as conceived from the point of view of the controversy against Fricka, and Wotan's enacted being, Wotan as he had changed through the story he shared with Siegmund.

Wotan could only see the explicit alternative that defined the controversy with Fricka: either Siegmund is free, or he remains, whatever the tricks, subject to Wotan's will, and can be discarded as devoid of any value. But Brunnhilde saw something else. Is Wotan the true master of the situation? Is he himself truly free to decide Siegmund's fate? No, not any longer. And the reliable witness for a Wotan who is no longer free is Brunnhilde herself, insofar as she felt unable to carry out Wotan's order. She was unable to kill Siegmund precisely because she was the true expression of Wotan's will, including this dimension of Wotan's will which was itself the product of the situation, not its master, creator and judge. Brunnhilde had to "see Siegmund", she says, and she thus had to experience Wotan's love for Siegmund, a fact which Wotan knew but did not recognise as a legitimate part of the problem.

In Wagner's plot, love transformed the problem, giving a new meaning to the situation, unaccounted for in the controversy with Fricka. The solution Brunnhilde produced against Wotan's explicit will is new or 'autonomous', but not in the sense of coming from nowhere, not in the sense of having no explanation. It has an explanation but only after the

actual enactment of the situation, as Varela would put it; an actualisation taking its own place in its own time. It can only be explained after what was originally not meant to enter into the problem actually redefined it.

Love is not a good argument in a controversy, and this may mean that the usual forms of scientific controversy could very well fail to be the relevant form of togetherness among specialists in Artificial Life.

Maybe Wotan's problem and Brunnhilde's solution could be taken as one of the myths which can tell us something about the complex situation the field of Artificial Life finds itself in today, as characterised by its paradoxical ambition: the ambition to delegate into concrete situations artificial beings which follow rules and have to manage those situations one way or another according to those rules, but must also support the claim that they, in one way or another, did not obey but rather produced their own autonomous answer to the situation. Moreover, it points to one relevant aspect of the contrast between two kinds of artefacts and, more precisely, to the contrast between the makers of those two kinds of artefacts.

Wotan may well have tricked Siegmund, goaded him into taking the sword 'as if' by himself, as Fricka claimed. The point of view the artificial being produces with regard to its world, the world with which it meaningfully interacts, may well have been induced by the scientist. But this is not the whole truth. In the very process, something else did happen. Wotan came to love Siegmund's bravery even if he himself was responsible for this bravery. Never could Galileo come to love his experimental objects.

This is not to deny the strong link between scientists and the experimental devices they are constantly in the process of setting up and fine-tuning. The point is that the final achievement also signifies the cutting of this link. The device has successfully become something anyone can manipulate, obtaining the same results. The successful scientist has to become anybody. This is why any experimental setting may be dismantled and discarded after the work is done and recognised. It may be true that some scientists will keep an emotional attachment to their old device, but they will keep it private, and this is by itself the true testimony that the explicit aim of the setting, putting a functional description to the test, is indeed sufficient to describe what specifically happened inside the laboratory. The emotional residue is not specific: it may also be hard to discard an old and loyal car, or an armchair.

An interesting point is that this is already no longer the case in all laboratories. For instance, the scientists who try to teach apes some kind of language face the problem of what to do with the ageing apes. They are unable to kill them or send them to a life of misery in a zoo. A bond has been created which transcends the explicit goal of the work: to test the ability to learn a language and to study the difference between the apes' use of their language and our human use. Furthermore, we can guess that this bond is not some kind of irrational or emotional supplement. It is probably a necessary condition for the apes to learn. They could not have learned with an indifferent scientist, and maybe Wotan would not have been able to trick Siegmund into having the boldness to take the sword if some kind of a trusting relation had not been established between them. Trust is one of the many names for love, and you can never be indifferent to the trust you inspire. This is what both Wotan and the experimenters with apes testify.

With all those stories of love and trust we are apparently very far from the Artificial Life field. Maybe not so far however. Maybe the way in which Wotan's paradoxical project, to create something meant to be autonomous, ceased being paradoxical when Brunnhilde was included, tells us something about what life as such demands in order to be understood.

Since Galileo, we have learned how to address many phenomena which have become objects for physics, chemistry or molecular biology. Learning how to address is not the result of a scientific theoretical understanding, it is the very condition for this understanding. Maybe the way Wotan had to address Siegmund in order to goad him, or the way scientists have to address their apes in order for them to learn, is relevant. Maybe it tells us something about the challenge the new kinds of laboratories associated with the artificial life project will have to face in order to deserve a knowledge which would qualify as an understanding, not just a collection of descriptions and 'just-so stories'.

God's heart

In order to verify this intuition let us turn to the way Stuart Kauffman defines his own scientific ambition as a theoretical biologist. I quote from Steven Levy's book, *Artificial Life*: "I've always wanted the order one finds in the world not to be particular, peculiar, odd or contrived - I want it to be, in the mathematician's sense, generic. Typical. Natural.

Fundamental. Inevitable. Godlike. That's it. It's God's heart, not his twiddling fingers, that I've always in some sense wanted to see".³

As you probably know, scientists are not crazy. In particular, they are not crazy when they use God in their metaphors, even if perhaps they are a bit ambitious. What they mean through such metaphors is that they want to understand their object from the best possible point of view, that is, as it demands to be understood and not from a point of view only relative to our own tools, words, beliefs. If God was a clock maker in the past, it is because the truth of the world was that of a clock. If It became a mathematician, it was because physicists are looking for the mathematical equation which tells the whole story, at least in principle. If we are back, in molecular biology and neo-Darwinism, with God's twiddling fingers, it is because there is no other truth in life than the correlation between some genetic difference and some difference in the structure or functions which in turn make, or made, some difference in survival value.

Usually when God intervenes in a theoretical scientist's metaphor, it is not Its fingers nor Its heart, but Its mind that expresses the ideal knowledge which is to be obtained. "What was in God's mind when It created the Universe?": this is the ultimate question that both Einstein and today Hawking gave physics the responsibility and privilege of solving. In order to better understand the contrast between God's mind and God's twiddling fingers, it is best to recall the difference between a pendulum and a clock. The pendulum both follows and exhibits, through its pure, regular, frictionless oscillation, an intelligible law. To understand the law is to understand the pendulum. A clock, on the other hand, may well, as eighteenth and nineteenth century clocks did, incorporate a pendulum (or a string), it nevertheless needs the clock maker's twiddling fingers. Indeed, while the pendulum has no outside, interacts with nothing, simply takes into account the presence of the Earth through the weight of the oscillating body, the clock is intended to tell the time, and thus must include a reference to the outside user for whom time must be displayed. This is why the pendulum motion is enslaved: it is framed in a mechanism which both uses the pendulum motion in order to drive the clock's fingers, and makes contact with a descending weight in order to compensate for frictions and keep the pendulum motion going. The whole mechanism can be understood starting from the same kind of laws as the pendulum, but the twiddling fingers, i.e. the craft, of the clock maker or of God are required in the picture because, while all pendulums are alike, there are good and

³ S. Levy, *op. cit.*, p. 128.

bad clocks. It is a question of precise adjustment, and this adjustment expresses the contrived coincidence between the functioning inside and the functioning outside of the clock.

Twiddling fingers thus point to the necessity of a contrived coincidence, a coincidence which served for a long time to adjust the idea of an aimless, regular, intelligible physical reality, a single, 'catholic' reality as Robert Boyle characterised it, testifying for God's mind, with the fact our body and the whole divine creation exhibit a lot of aims and rather lack physical regularity.

The twiddling fingers may also be the fingers of the blind watchmaker. Like his divine precursor, he deals with stupid, aimless, indifferent matter and is quite free to enslave it at his best convenience. This is why there can be no theoretical, or structural biology as long as the blind watchmaker rules: the very metaphor implies that the whole responsibility of biological order rests on its (blind) craft.

But what about God's heart? More precisely, if we forget about the fingers, what is the difference between mind and heart, that is between the ideal goal of a theoretical physicist like Hawking and of a theoretical biologist like Kauffman? And how is this difference expressed in the difference between the usual experimental setting and the eventual Artificial Life setting?

When I looked in my dictionary for the meaning of 'hearty' - I was wondering if life could be called hearty while it may be mindless - I did find among other meanings 'robust'. This should recall us that heart is far from being only a metaphor for sentimental love. We may we speak both of a hearty guy and a hearty meal. This is not an idle play with words. Very often the wide scope of a word tells you something useful if you wonder why people created links between those various meanings. It seems to me that 'heart' with its many meanings is related to some kind of an 'inside' but not to a self sufficient closed inside as the perfect clock would be, succeeding in enslaving the pendulum without a loss. It is related to the way this inside is actually, and not potentially, interacting with the outside. There is a great difference between this and the mind. In all metaphors of God's mind you have to distinguish between two aspects: the mind is responsible for the conception of the world, for the idea this world will realise. But in order for the realisation to proceed you also need a decision, the act of going from the inside idea to an outside creation. It is not so with the heart. To speak about God's heart implies an actual relationship between God and Its creation, the kind of relationship Wotan

had to entertain with Siegmund in order to trick him into taking the sword, the kind of relationship that scientists who try to get their apes to speak must entertain with them.

As Brunnhilde's disobedience testifies, this relationship escaped Wotan's explicit calculation, the dilemma as it was conceived by his mind before he actually came to know Siegmund well enough to influence him. Siegmund had to be demonstrably free, or else he would be devoid of value, as enslaved as a common clock. It also evaded the intentions of the scientists who first wanted to use apes in order to prove something against their colleagues. They were surprised by the problems that the well-being of their ageing apes would impose on them. In other words, I would propose that the God whose heart Kauffman wants to see, meaning the model for the theoretical understanding we can conceive of as demanded by 'life as such', is not God, creator of the world (or microworlds) for one and all, but God as It is Itself transformed through Its actual, hearty relationship with Its creation, a God in the process of becoming, together with the actual process of creation in which It participates. A God that may be surprised by the feeling Its creation produces back on Itself. If the God Kauffman associates with Artificial Life has a heart, it means that we cannot conceive of life without an actual, meaning-producing relation.

Maybe some of you have remarked that I used two words, 'inside' and 'outside', which we have already come across. We encountered them in Stephen Gould's definition of what a theory should bring in order for biology to escape 'just so stories', adaptive stories contrived by the twiddling fingers of natural selection. Such a theory, Gould claimed, should succeed in producing a conception of evolution as an interaction between outside and inside. It should integrate couples of terms which are both needed, which are, if I may say, imposed on us by the problem of life. I recall them: environment and organism; function and structure; current operation and past history; the world outside passing through a boundary into organic vitality within. In one way or another, the problem is each time the couple 'outside' and 'inside'. Environment, function, current operation all point to the outside, to the way the living being addresses its world. Organism, structure, past history, that is either inherited genetic rules or any kind of memory, all point to the inside, to what Varela would call the autopoietic dimension of the living being.

Usually, I mean in the usual molecular biology and neo-Darwinian story, there is no actual interaction, nothing to be understood in a generic, robust, or typical way. There is only a very contrived coincidence: an 'as

if' referring to natural selection as the blind contriver of interaction. I would assert that Kauffman's and Gould's positions share the same refusal, the same demand for an understanding of the singularity of life. But we have to go further. Is there an interesting relationship between the two most metaphorical expressions they use for this demand: Kauffman's wish to see "God's heart", and Gould's "world outside passing through a boundary into organic vitality inside"?

We are all familiar with situations in which "the world outside passes into vitality inside". We call them learning, being suggested, playing, or guessing. In all these cases something given from outside, a problem, a puzzle, a remark, passes inside in such a way that it is truly appropriated by someone who is thereby transformed. He or she both gets it and is got, or even begot, by it. I use the very strong term 'begot' in special reference to the case of the infant. Indeed, if you accept the infant as described by the ethologist Daniel Stern, we have a case where we can truly contemplate or even participate in a process which perfectly illustrates Gould's requirement. How does Stern's baby become able to speak? Following Stern in *The Interpersonal World of the Infant*,⁴ it takes a two-way interaction between two very interested actors, the adult and the infant. The adult lives in the world of language, of intentions, and the infant does not. But there will come a time when the infant starts behaving in such a way that the adult who takes care of it will be unable *not* to attribute an intention and a sense of self to this infant. The caretaker is truly driven, or goaded, to address the infant 'as if' it had an intention: "You threw away your spoon because..." The child outside passes into an intentional child inside the caretaker. This is, following Stern, a "mistake". There was no intentional reason behind the throwing away of the spoon. But the child is thereby addressed in a new way and this makes a difference. As Whitehead⁵ would say the child's behaviour acted as a lure for feeling for the caretaker. It produced the caretaker's feeling that this behaviour was supposed to mean something, and now the caretaker produces new lures for the child's feeling, which "pass in turn into organic experience inside". In other terms the 'as if' becomes true and the child progressively enters into an interpersonal world of shared meanings and intentional actions. This actual relation, which Stern calls "attunement", started as a relation of suggestion, of mutual but asymmetrical suggestion. The child suggests,

⁴ (New York: Basic Books, 1985)

⁵ A. N. Whitehead, *Process and Reality* [corrected edition] (London: The Free Press, Macmillan, 1979)

without knowing it, that its actions are supposed to mean something, and in turn the suggested caretaker, acting 'as if' it was true, creates a new outside world for the child, a world actively suggesting that this child is able to take an intentional stance. The 'as if' produces its realisation but it produces it only because there is an actual interaction, an interaction which, to go back to Kauffman's metaphor, is mistaken from the point of view of the observer's mind, but which nevertheless produces a possibility of becoming for the correlated hearts of both the caretaker and the infant.

Boundaries

Certainly, edge of chaos systems are not infants. We must regard them as completely indifferent to the way they are addressed. However, I think we have here a precious indication about what Gould called the kind of boundary specific to life, the boundary through which the world outside passes into the organic vitality inside. Indeed what has changed is the boundary between the scientists and the artificial system. It is an artificial system, the scientists know that better than anyone since they are the ones who produced it. But they still do not address this system as masters but as, if I may say so, caretakers, which means as interested in its possible becoming. In other words, the scientists' hearts are involved, not just their minds.

This is indeed what happened in the neo-connectionist story in which Kauffman was a key actor. The very empirical discovery of the robust behaviour of randomly connected Boolean automata goaded scientists into wondering: now they could be able to learn how to recognise, that is to say, to reach the same robust, attractor, behaviour for different starting conditions we categorise as 'the same'. This created a new boundary between the network and the scientists, a new kind of interaction between the inside working of the network, and the outside world, i.e. the scientist who gives a meaning and a value to the result and reacts accordingly. Scientists learned how to address the system, they learned how to get an outside meaning or an outside value to pass into the network's inner workings, without their twiddling fingers enslaving the inside in order to have it fulfil the project their mind conceived.

More generally, I would propose that the innovation associated with what is usually called the bottom-up approach is not, as far as the Artificial Life field is concerned, that we have some kind of bottom functioning, or

bottom stuff, able to produce *by itself* emergent, or 'up', properties. What we have instead, and this is best symbolised by God's heart replacing God's twiddling fingers, is the possibility of a new kind of mutual, asymmetric learning situation between the system and the scientist. The scientist does not know how the system manages to produce its emerging properties. In fact, he or she does not care. The scientist's care is addressed not to this or that emergent collective property as such, as having a meaning by itself, testifying for instance for this or that configuration of the automata's interconnections. It is addressed to *possibility*, to the possible meaning or relevance such an emergent property could acquire from his or her outside point of view. From this point of view, emergence is not interesting as a 'spontaneous' process but as the ground for a bottom-up actual production. This production includes the emerging possibilities which this emergence entails for scientists - that is to say the modification of the boundary between scientists and their system - and the consequences of this modification - that is to say the new way the interested scientists will interact with the system, the means and tricks they will use in order to test, characterise, select, confirm or stabilise the possibilities induced in their imagination by the system's behaviour. In other terms, both the bottom activity, the hypothetical 'stuff of artificial life' activity, and the scientist's appreciative and speculative activity are needed. In principle both should be taken into account as ingredients of the emergent process.

My conviction is thus that the neo-connectionist networks, edge of chaos systems and other complex dynamical systems act as new types of lure for feeling. And the result of these new types of lure is expressed by the heart of God replacing Its mind. It is true that in many present day Artificial Life situations the scientist knows beforehand what kind of emergence he or she has decided to stabilise. The important point, however, is that this is not required by the experimental situation. My guess and my hope would thus be that the future of the field is not linked so much with the production of this or that particular property or performance through selective interaction, but rather with the exploration of the evolving boundary between the system and the scientist, that is with learning what a meaning-producing relation as such demands.

Such a guess and hope can be seen as disappointing since they presuppose and do not explain the solution of the 'origin of life' problem, the emergence of systems with a kind of boundary such that the interaction must be described in terms of 'passing through'. This is not surprising. The

artificial experimental situations we create inside laboratories never answer what I would call pre-existing ‘deep’ questions. As I have already remarked, the laboratory is not a place for discovering reality as it would ‘exist by itself’. Rather it is a place for discovering the possibility of a confrontation between human demands and the phenomenon’s demands, the way the phenomenon demands to be addressed in order to answer significantly. If the usual experimental laboratory creates new questions, it is because these questions correspond to the active invention of what it means and implies to give a phenomenon the power to tell how it should be described. Thus I would say that the Artificial Life field may be the field for an active invention of ways in which some important aspects of life should be addressed.

My guess and hope also leave open the question of the ‘caring God’ induced by my description of emergence. Indeed this description tells us that emergence cannot be a matter of selection alone, and that it cannot be explained by properties of the ‘stuff’ either. Those properties cannot explain by themselves what they require, i.e. a specific kind of interaction with the outside world. Siegmund had to be goaded. For some biologists, it may well be that a ‘caring’, that is also an ‘opportunistic’ God, taking advantage of possibility, both induced and goading, will sound as a defeat. The blind watchmaker represented the usual triumphant claim about the hypothesis of God: we no longer have any use for this hypothesis. I must admit I am indifferent to this kind of triumph. The idea that scientists can prove the world they study has no need of God is as poor an idea as the one that they can prove, in their labs, the existence of God. The point is not theology but pragmatics. The point is not to deride Chris Langton and others when they compare their own position to that of God, the point is to produce a concrete, relevant characterisation of this position. Again, this has always been the meaning of God’s appearance in scientific dreams: never the God of religion, demanding worship and gratitude, but God as taking the position of the ideal interpretant: “even God cannot get a better grasp of this or that situation”.

Nobody can guess how far the Artificial Life field will develop in the direction it has assigned to itself. Some sceptics could claim that each time a new important family of technological devices has appeared, there were people around who dreamed that producing life was becoming a possibility. Artefacts and the relation between artefacts and their makers or users are one of the main sources of our dreams, speculations and models. And, I wish to add: rightly so. Our artefacts indeed transform not only the

scope of what we can do, but also what we are. I am the child of printing and word processors, and in some years, younger people will not be able to understand how one could survive without the Web. However, each new family of artefacts has its own style, and what I have tried to enhance is the importance of the eventual new maker-artefact mode of togetherness that corresponds to the artefacts at the centre of today's Artificial Life. As such, the 'Heart of God' metaphor may mean the invention of a new model for experimental practices.

Lures for feeling

Let us first be precise on one point. I am not opposing some kind of a 'good', human, caring, warm, technology to the usual one, which would be cold, objective, calculating. If it needs to be said, I will say it: 'manipulation' is also one of the names of the game I am describing. Moreover, I would never deny that clockmakers (not the Blind one) care when their twiddling fingers and their mind interact in order to enslave the mechanisms to the project. Again, the difference is not between 'warm' and 'calculating', but between two distinct meanings of what can be called 'success'. When the clock works by itself, separation prevails, it can be sold. Such a separation is not necessary however, and myths like that of Pygmalion's love for his own creation are there to recall it. But the fact that Pygmalion can be seen as falling into a trap that threatens all creators tells us again about the difference. Wotan's love for Siegmund, or the scientists' care for their ageing apes have nothing to do with Pygmalion. They tell us about the 'bond' which has to be produced in order for the learning relation to proceed.

When 'scientific knowledge' is concerned, the very success of our technical artefacts as experimental devices has led us to value them first of all as means at the service of the production of an opposition between 'as if' and 'truth': the production of scientific facts as distinct from sheer artefacts. This evaluation is still at work when Artificial Life specialists try to downplay their part in the emergence of such or such interesting behaviour. However such an evaluation no longer needs to take place when we deal with Artificial Life systems. Indeed, such systems suggest questions like: "what could it become able to perform?" The scientist does not wonder if the experimental situation will obey a predicted behaviour nor does he or she does just contemplate an erratic behaviour testifying for

chaos. The scientist is not, like a clockmaker, or the maker of a experimental device, confronting what is obtained and what was expected, adjusting, fine-tuning, taking into account new distinctions or difficulties. No, the system's behaviour suggests other questions, suggests the possibility of something significant and new. The scientist is interested in such systems because he or she feels such systems may be addressed 'as if' they could produce something akin to 'autonomous ways'.

Also, in usual experimental situations, it is assumed that scientists may forget about themselves. After all, they are just producing the situation. They may well control the boundary conditions but they can claim that this control does not induce new qualitative possibilities, it is just a matter of getting the possibility of a clarified testimony, of a reliable witness. This means that for the system's behaviour it shouldn't make any significant difference if the environment is indifferent to the consequences of the system's behaviour, or is instead a controlled experimental environment meant to produce knowledge, arguments, and proofs. The meaningful character of the boundary defined through laboratory devices can thus be both recognised when the quality of the device is discussed and forgotten when the discussion is successfully closed. Again, this no longer needs to be the case with Artificial Life systems. Here the boundary may take on a very different meaning. It can stop being identified with conventional boundary conditions, producing a reliable separation between the system and its environment in order to produce 'objective' knowledge. It may become an intrinsic boundary which both situates and identifies the role of the scientist. He or she is playing the active part of the outside world and as such may appear as an active partner in the emergent process of interaction of the artificial being.

Such a situation is quite new and it is also quite interesting since in the domain of modern science, laboratory results are always the predominant source of authority. Indeed, even in scientific fields in which laboratories are unable to create artificial situations that give an object the power to tell how it should be described, scientists still try to mimic the usual experimental situation and forget about the difference. As I have already emphasised, this is what happened in the laboratories where hypnosis was investigated: because scientists wanted to forget about the small difference between someone obeying someone else, on the one hand, and an experimental system obeying rules or laws, on the other; they had to forget about themselves, about their part in the play, and about the meaning of the whole operation. The point was however that the hypnotised subjects

did not forget about it. When it was discovered, when it was accepted, that those subjects could thus not be identified as reliable witnesses regarding some kind of hypnotic state existing as such, independently of the actual meaning of the scientific exploration, scientists lost interest and discarded their results as valueless. The traditional mind-body problem also mimics the usual experimental situation. The brain as such should be able to explain mental activity while we know very well that this activity is related to an outside world (including the body) and has no meaning independently of this outside world. This primordial fact is neglected in the 'scientific' definition of the brain, it is considered as some kind of epiphenomenon. But any scientific result about mental activity obviously requires what is officially neglected: if experimental subjects produce this or that observable, well-defined activity it is because they first accept the strange 'outside world' which is the experimental situation and wish to cooperate with the scientist who asks them to perform in this or that way.

As a contrast, I would recall the great tradition of 'animal magnetism'. There was a true bond created between the (usually male) magnetiser and his (usually female) subject. The magnetiser did actually cultivate this bond, goading the subject into the exploration of her talent. And the starting point of the tradition was indeed the Marquis de Puységur being surprised by what Victor, a sick, illiterate young peasant, would tell him when magnetised. Starting from this surprise Puységur turned himself into a lifelong guide for Victor, Victor guiding his guide in return about the right way to guide him. The magnetisers strongly disagreed when the new hypnotists choose, at the end of the 19th century, to discard this cultivated togetherness in order to address their hypnotised subjects as reliable witnesses for their own state. In the name of science, magnetisers said, you turn your subjects into puppets, and you will never achieve the prodigious hyper-lucidity which is the true aim of magnetism. You will only get what you deserve: since you induce submission, you will get submission...

The possibility that, when the new kinds of artefacts at the centre of Artificial Life are concerned, the creation of a bond between the maker and the artefact would come to be considered not as an expression of human irrationality but as a legitimate condition for fabrication would be an important event indeed. Obviously, it would not concern the whole field of the humanities, but it could be crucial for a more specific set of problems related to what can be called 'emergence' and 'autonomy' in the most general sense, i.e. including practices such as 'learning', 'suggesting', 'empowering', i.e. all those situations characterised by a

reciprocal, asymmetric relation. When we deal with such relations, we are always burdened by 'Wotan's dilemma', or by the 'fact/artefact' experimental opposition. Indeed they cannot be cleanly cut in 'either-or' categories. How does one avoid learning to be somebody who submits to a transfer of knowledge? Is suggestion an irrational influence or a transformative proposition? Is 'empowering relation' not a contradictory expression? In all these cases, central to human life and beautifully exemplified by Stern's description of the adult-infant relations, we meet the same obstacle. Again and again we tend to oppose, 'as if' and 'truth'. This is what the end of animal magnetism rather sadly exemplifies. Trying to oppose what was truly specific to 'hypnosis', as they renamed magnetism, and what was presented 'as if' it was due to magnetism, but was 'only' due to the long-term bond between the magnetiser and his subject, scientists destroyed the cultivated bond and had to keep on destroying any bond whatsoever: in each pseudo-experimental situation, a no longer cultivated but nevertheless influential bond was discovered to be at work, and had to be purified away. We are now asked to accept as an interesting conclusion to such a long story the now prevalent one that it is finally only a matter of 'role playing'. Is Stern's infant just playing the role of an intentional, self-conscious child?

The bottom-up approach central to Artificial Life may indeed act as a lure for feeling regarding the possibility of describing emergence beyond 'Wotan's dilemma' between 'slave' or 'free'. It tells us about the non-separability between 'as if' and 'actual', not in the sense of confusion but in terms of an interplay. Let us recall in brief the pragmatics of the situation. Typically the 'stuff' must be promising, but not promising for itself. It acts as a 'lure for feeling' for another distinct term (whatever it may be, maybe even 'in the same brain'): it is 'as if' the stuff suggested it is able to produce novelty. Here an opportunity emerges. To whom does it belong? Is it a fact, or an illusion? If we search for the means to decide about this question, we destroy the opportunity. It is thus better to say it is a third term, emerging from the relation between the first two, and it emerges for the second one who entertains it as a possibility induced by the first. The feeling of this possibility may produce the conditions for the 'actual' emergence, that is the second term 'addressing as if', 'confirming', 'guiding', 'goading'. Who suggested whom? Certainly, it is the one who 'knows' (by contrast with the one I called the 'stuff'), who entertained possibilities of meaning and values, but the possibility he or

she entertained was induced by the stuff's actual behaviour, just as Wotan first had to be induced in order to then successfully goad Siegmund.

Such a double emergence process is very schematic and much too simple. But it offers the great advantage of clear pragmatic consequences: the first emergence can be called virtual because its way of existing only makes a difference through the feeling of a possible process of actualisation, and this process implies, indicates and induces the existence of a 'bond', something which can neither be put to the test nor challenged to justify itself without being destroyed. We deal with a pragmatics of trust, not of separation of facts against artefacts. Its only justification is the actual emergence, a new kind of 'outside' creatively passing into a transformed inside.

What we do not know, what nobody should feel authorised to know because it pertains to the future, is the scientific fruitfulness of this kind of new approach if it were ever to be accepted by scientists. As a philosopher I can only recall that science has never discovered answers to questions it had not first learned how to ask, or, in other words, answers it had not first learned to deserve. It may be that the Artificial Life field will play an important part in the process through which our science will become able to ask new kinds of questions and deserve new kinds of answers. Which is also to say, to produce new kinds of scientists.

Einstein once told philosophers: do not listen to us, just look at us. This is what I have been trying to do, not to listen to descriptions of the performance of already realised artefacts but to the *way* they were described. Indeed, in order to take seriously the double demand entailed by the two terms, artificial and life, there was only one degree of freedom. What kind of maker do the new kinds of artefacts demand? My answer is: a maker with a heart, not a sentimental heart but a caring one, because heart is involved each time 'as if situations' turn into actuality, each time imagination turns into innovation. Proposing the myth of Wotan and Brunnhilde as a 'dream' for the field does not mean that we are dealing with tragedy. In fact my conclusion is that the Artificial Life field may be turning Wagner's tragedy into some kind of scientifically productive comedy. Maybe one day Artificial Life scientists will feel as unable to kill their creatures as Brunnhilde or the ape-scientists were. But since they will remain scientists we may hope they will remember it is something which has happened to them, not a proof that they have truly created Artificial Life. Wotan's mind was unable to recognise the innovative truth of his own heart as expressed by Brunnhilde's choice. In the scientific comedy, I

hope scientists will be able to heartily laugh when they understand that their bond with their creation has actually transformed them, lured them towards new feelings, new possibilities, new ways of becoming.

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