Structuring Reality:

The Role of Limits

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Abstract

The paradox of limits lies in the fact that limits combine two opposite functions: setting apart and joining. They partition the world (in fact, all that appears, in any form) into separate areas, in intricate and overlapping hierarchies. But at the same time they structure the interrelationships and communication channels between the pieces into which they seem to have carved up the world.

We can view the world of appearance as an intricate interplay of limits, each acting within their own realm of validity. However, this limiting role is *only* a role. For each context, we can find a wider context within which the limitation implied in the narrower context loses its sting, so to speak. As a consequence, the most basic structure of the world is the notion of role, of 'as'. This view denies the existence of ultimate limits to knowledge, scientific or otherwise, suggesting a radical optimism, in the form of a freedom from identification.

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Introduction

Is scientific knowledge in principle limited? Are there things that we will never know about? Or are there perhaps aspects of reality that we may gain knowledge of, but in a form that cannot be translated into a scientific type of knowledge?

These are bold questions, and not the type of questions that would normally come up during a scientific conference. But in a workshop on *limits to scientific knowledge*, they are unavoidable.

It would be far easier to answer these questions if they were framed in a more relative way. Is scientific knowledge limited in practice? Of course it is: there are economic and political as well as ethical limits to the sort of explorations scientists could be expected to carry out. Are there areas of human knowledge that have not (yet?) been incorporated in scientific descriptions? Certainly, and we do not even have to argue about the status of aesthetics or deep human emotions. Many simple tasks of pattern recognition that even unskilled humans can do instantaneously and without special effort are still beyond the reach of the fastest computer with the fanciest software. It is clear that much of our tacit knowledge of day-to-day circumstances remains largely unexplored in scientific terms.

Scientific research is framed in terms of contemporary limits, and indeed is a continuous battle with limitations on all levels. The expressions most often used already tell the story: work at the frontier of science, research at the cutting edge, struggles to extend knowledge beyond their current limits. Usually these activities take up all the energy and attention of the working scientist. At our workshop, however, we are not so much concerned with the next break-through, or even the whole process of expanding scientific knowledge. Rather, we are interested in the scope and structure as such of the limits that scientists encounter. Hence the bold questions raised above.

Here is a tentative answer: perhaps there are no limits to knowledge, scientific or otherwise. If all limits were only relative to their particular context, none of them would have absolute or ultimate validity. This would imply that knowledge is open-ended, and unlimited in principle.

The Nature and Status of Knowledge

In a nut shell, here are the problem, motivation, and suggested solution. The *problem* at the core of any discussion of limits to scientific knowledge is the question of what knowledge is. The *motivation* for the specific angle of my inquiry into this problem is that I want to avoid a flattening-out reduction, materialist or otherwise, of knowledge – in all its forms, scientific knowledge as well as tacit understanding, meaning and sense, in short, any form of experience. The *solution* I suggest is to explore a world view in which knowledge is not secondary with respect to space and time, neither bluntly (as an epiphenomenon) or subtly (as a supervenient property). Rather, I would like to trace out some of the consequences of a world view in which knowledge is just as primitive an aspect of reality as are space and time.

Together with a tentative answer, here is a tentative model: perhaps knowledge is an integral part of reality, as fundamental as space and time. Space is pervasive, and so is time, albeit in a very different way. Time is not embedded in space, and cannot be localized; it is really on a par with space. We could entertain the notion that knowledge, too, cannot be reduced to patterns in space and time, but is in some sense orthogonal to both.

Just as a speeding bullet does not 'have' more time than a resting rock, perhaps a human brain or an encyclopedia does not 'contain' more knowledge than a rock or a flower. Sure, the motion of a bullet expresses time a lot more vividly than a resting rock does. And sure, a book or a brain may well express knowledge in ways that strike us as being more vivid and more easily recognizable. Time can *express* itself in space in many ways, and so can knowledge. The question is to what extent either of them can be *reduced* to space.

Without clocks, we could not measure time accurately. But this does not mean that clocks somehow 'produce' time. Any and every event can be seen as a witness to time, clocks or no clocks. Without human brains, no human knowledge. But this does not necessarily mean that brains somehow 'produce' knowledge.

The space and matter of a speeding bullet do not generate time. This means that time is not reducible to either space or matter, and has to be invoked as a separate, equally primordial ingredient, in order to describe the situation. True, relativity theory has shown how space and time can partly transform into each other, since they both can be seen as aspects of a more general spacetime. But fundamental distinctions between space and time remain, not the least of which is the directedness of time (the 'arrow of time'), so unlike the more symmetric properties of space. In addition, a notion of spacetime deals with space and time on an objectified level, and it is not at all clear how subjective experience fits into this (the problem of the 'moving now': in objective spacetime, each time has the same status, whereas for us there is always only one subjective now).

Can space and time, together with matter in space and time, somehow generate experience? I would guess that most scientists would answer this question affirmatively. Experience is seen as a something that is 'produced' in a brain, as an epiphenomenon, or an emergent property, or a supervenient aspect. I have two problems with such views.

First, I cannot even begin to see how a collection of molecules, when dancing in sufficiently complex patterns, could 'give rise' to experience. Not only is molecular dynamics qualitatively different from experienced phenomena, it is experience itself that forms the condition of possibility for the arising of phenomena, as well as the arising of an understanding of molecular dynamics.

Secondly, and in many ways more importantly, I am worried about the implications of such type of explanations. When experience is 'reduced' to complex interactions of molecules, there seems to be no alternative other than to continue to play this reductionist game. For example, we can then view all of ethics and aesthetics as properties of the brain, properties with significant survival value, selected by natural evolution. As a result, natural sciences in general, and physics in particular, are what ultimately have value, since they describe the only 'really real' substratum of reality, the material world. All other 'values', including the ones we hold personally most dear, are only derived values, tricks with which evolution has endowed us in order to be more successful in our never-ending struggles of competition.

At the same time, I am struck by the force of the arguments. Indeed, science has been incredibly successful, and indeed, walls of prejudice have crumbled, over and over again. Organic matter turns out to be as mundane as inorganic matter; no wall could be found separating the two. Now that we begin to have the blueprints in hand of some of the simplest organisms, it would seem only a matter of time before we can assemble the first living cell from scratch, from non-living material. When this happens, another wall will come down, and conceptually it has come down already, in anticipation. Why not expect that matter and mind are equally continuous as inorganic and organic chemistry, and as non-living and living matter?

These are forceful arguments. And no piecemeal attempt at denying or ignoring them will hold up to serious scrutiny. The only alternative I can see is a radical one: rather than tinkering with the explanatory structure of events in reality, seen as a stage made up of space and time, I suggest that we extend our view of the stage itself. If the stage includes a third element, on a par with the other two, space and time, then experience could be seen as irreducible to space and time (and matter, for that matter; see below for a connection with modern physics, and its description of matter as waves in fields that permeate space and time).

In other words, the standard scientific view starts off by introducing the existence of not-knowing (not-experiencing and not-conscious) building blocks. When put together in sufficient number and complexity, this view then insists that knowledge somehow emerges out of those entities. Unwittingly, such a view filters down knowledge, degrades it, tames and enslaves it unnecessarily. Rather than letting knowledge bloom and appreciating it to its depth, such a view, in my mind, starts off by approaching knowledge with a built-in set of limitations [1].

The question of the role of knowledge will be taken up again in the last section of this paper. First, however, we will have a look at some particular forms of limits, in the section directly below. The second section will focus on various aspects of objectivity, the cornerstone of science. The third section explores different aspects of limits in its various guises, as edges and boundaries.

Three Explorations of Limits

To begin our investigation of limits, let us start with three journeys, in each of which we will explore a particular limit to our knowledge. The first one will take us to smaller and smaller structures in space. The second journey will take place in time, and will take us back to the beginning of the Universe. The third will not imply any travel in either time or space, but instead will shift our focus away from a purely objective description of the world in order to include the role of the observing and participating subject.

Each of these sallies will lead to a paradox. Whether we will try to push the limits of space, or of time, or of experience, in each of these cases we will be presented with a surprise: after an initial process of narrowing, we will suddenly find ourselves in a realm far wider than the one we started out with.

A Exploration in Space

Let us take a very brief tour, from our human length scale to smaller and smaller scales, in order to get some sense of where scientific investigations have led us, this last century.

We can start with a physical object, a tree for example. What do we find when we analyze its inside? Depending on the scale on which we look, we find either wood and fluids, or wood cells, or molecules and atoms, or subatomic particles, or a seething sea of vacuum fluctuations. Although all of these structures inhabit the same location in space, and somehow together make up the tree, they also seem to inhabit separate worlds: when we go up or down one level of description, the previous level seems to have disappeared beyond recognition.

To be specific, let us choose just one scale, and make ourselves more familiar with it. Let us go to the first subatomic level of description, the one in which we view each individual atom as made up of a nucleus, surrounded by a cloud of electrons. The nucleus itself is made up of protons and neutrons, two types of particles which differ mainly in their electric charge: protons have a positive charge, whereas neutrons are electrically neutral, hence their names (electrons carry a negative charge).

The first thing that is striking on this level is the overwhelming emptiness of the subatomic world. The size of the nucleus is tiny compared to that of the atom, even though most of its mass is concentrated in the nucleus. While the mass of all the encircling electrons makes up only a quarter of a tenth of a percent of the mass of the atom, the diameter of the nucleus is a factor one hundred thousand times smaller than that of the electron cloud. In more striking terms, the nucleus inside an atom, even though it contains nearly all its mass, is like a flea inside a cathedral.

There is a nice anecdote about a popular talk given by Lord Rutherford, who had discovered the overwhelming emptiness of the atom around the turn of the century. When he described his model of the atom, a man in the audience objected saying that this theoretical idea was clearly refuted by the fact that walking into an iron beam was far from an experience of emptiness. Clearly, in such a case the beam is massively present, no matter what an atomic physicist may say. Rutherford's answer was short and simple, something along the lines of "the reason, dear Sir, of your discomfort in walking into an iron beam stems from the fact that your head is even more empty than the iron beam!"

More recently, we have begun to probe the inner structure of protons and neutrons, and found them in turn to be built up out of other particles, such as quarks and gluons. Further investigation may find yet other layers of structure, but let us stay for a moment with a description on the level of neutrons, protons, and electrons as the main constituents of matter. What we find at this level is a very pretty picture indeed.

Isn't it marvelous, to realize such a high degree of unity, underlying the vast diversity of materials and processes in our physical world? Whether glass or stone, wood or water, smoke or mud, all these materials are manifestations of the same three types of building blocks. The differences between different materials are simply consequences of the different configurations of the electrons, neutrons, and protons. These three particles are all that is needed to build up the nearly hundred different types of atoms found in nature. These atoms, in turn, form the components from which a vastly larger — indeed unlimited — variety of molecules can be put together. But for all the differences in appearance between materials, science tells us that we are dealing with the *same* basic constituents. The different properties are consequences only of differences in the *configurations* of the building blocks.

In a very real sense, then, one could assign the properties of different materials not to the protons, neutrons, and electrons they are built out of, but rather to the spatial arrangement of those building blocks. A surprising notion, that all we see around us in its bewildering variety is attributable to spatial, rather than material properties. Sticks and stones and bricks and bones are different by the different way in which the same constituents use space in a different way. So much for our notions of material substance.

The description given here is of course sketchy. An accurate physics description of the model of the atom in terms of protons, neutrons and electrons is rather complicated. It takes into account the quantum mechanical nature of the particles, with its intrinsic limitations to the accuracy and meaning of measurements. It also describes the force fields and potential energy fields between the constituents of the atom. Usually, the different material properties of different atoms and molecules are traced back to differences in these fields. However, since these fields themselves are characterized by the distances and angles between the spatial distributions of the neutrons, protons, and electrons, it seems equally valid to assign those material properties to the space in which the three types of particles are embedded.

A more accurate way to describe this curious state of affairs is to treat matter and space together, in a description of material particles as excited states, waves in a field which by itself pervades all of space. In quantum field theory, the language of modern particle physics, fields are always present, and the presence or absence of a particle is comparable to the presence or absence of a wave in the ocean. In this analogy, it is the interplay of the water, only indirectly visible through the behavior of the waves, which determines the properties of matter.

While we talked about distinct electrons above, as one of the types of building block for matter, this more accurate picture views all the different electrons in the Universe as being only differently localized excitations in the same electron field, different waves in the same ocean. And we may conceivably discover the different fields describing quarks, electrons, and other 'elementary' particles to be only facets or projections of one underlying field. At present, there is a bewildering variety of candidates for more unified theories, some of which even include gravity.

Independent of the details of future developments, however, it is clear that a search for smaller and smaller constituents of matter leads us to a paradoxical situation. At first, a piece of matter can be subdivided into smaller and smaller pieces, down to molecules and atoms. But then, suddenly, the subatomic particles that we find 'inside' an atom turn out to be not really 'inside'. Yes, as an excitation of a field they are largely localized inside. But their very presence requires a corresponding field that fills the whole of the Universe.

It is as if the smallest peeping hole suddenly has given us a view of the largest scales. By trying to brush a crumb from the table, we run into a surprise: what looked like a crumb turns out to be a pattern that is woven into the table cloth. We find ourselves pulling the whole table cloth with us, together with everything that seemed to rest on it.

An Exploration in Time

Let us now shift from space to time, and let us embark on a quick survey of the view science has presented us of our own history, as well as the history of our Universe. The story runs as follows.

The Big Bang started off as a very hot and very dense soup of elementary particles. While rapidly expanding and cooling, some fraction of these particles were converted into hydrogen and helium during the first three minutes of the history of our Universe, following the Big Bang. Then, some time during the first few billions years, much of the primordial mixture of hydrogen and helium gas started to clump, here and there falling together under its own gravity. In this way galaxies were formed, and around this time stars started to form as well, through gravitational contraction on much smaller scales, deep inside the galaxies or proto-galaxies.

Around some of those stars a small fraction of left-over material did not make it all the way in, and later underwent subsequent gravitational clumping to form even smaller bodies circling the parent star: planets, asteroids, and comets. Our Earth is one such planet, and was thus formed as a by-product of the formation of our Sun, a later-generation star, formed several billions years after our Galaxy (visible for us in the form of the Milky Way) was first assembled.

A billion years or so after the Earth was formed, a random interplay of macromolecules led to self-reproducing chemical reactions complex enough to form their own tiny laboratories: the first primitive cells. Inside the first defensive suits, in the form of the cell walls, ongoing chemical experimentation and natural selection worked hand in hand, resulting in further differentiation. This led to the appearance of multicellular organisms, and especially in the last half billion years, to an explosion of diversity of plant and animal life in the sea and on the land.

A few million years ago, homo sapiens appeared as one more product of this evolutionary Monte Carlo game. For a long time we lived as hunters and gatherers, until more and more of us began to settle down some ten thousand years ago. And here we are, a few hundred generations later. We can trace the shapes of our ideas to a few thousands years of civilization. We can trace the shapes of our genes back to the beginning of mankind, and the composition of our DNA's building blocks back to a much earlier origin, billions of years ago. On an even more elementary level, we are literally a form of star dust: the chemical elements making up our body are ashes of nuclear reactions that took place in previous generations of stars, that were born and died before our Sun was formed.

These ashes, in the form of atomic nuclei, are in turn built up out of protons and neutrons, particles that have been around much longer. But they, too, were once assembled from lighter constituents, quarks, at a very early time in the history of the Universe. This happened less than a millisecond after the Big Bang started off. And what about those quarks? Presumably they, too, can be seen as products of even earlier transmutations, although the notion of one type of particle constituting, *i. e.* forming the building blocks for, another type of particle may well break down here (already in the case of quarks, the analogy is less than perfect).

At present, we can only speculate about what happened at much earlier times, when the Universe was so hot that a typical particle in this primordial soup was more energetic than the highest-energy particles that we can produce in our most advanced accelerators. There are clear hints that the behavior of matter is distinctly different at sufficiently high energies, corresponding to an age of the Universe of a mere 10^{-43} seconds or less, when gravitational interactions were at least as strong as other types of interactions between particles.

One speculation is that at times earlier than 10^{-43} seconds, the properties of time and space are radically different from those we have been able to probe so far in the laboratory. Perhaps even notions such as distance and duration are no longer valid. Could it be that at the 'time' of the Big Bang, or soon thereafter, a particular trajectory in time was set up, from within a 'timeless' state that somehow 'preceded' our present cycle of expansion (and possible contraction) of the Universe?

Whatever the answer may be, a search for earlier and earlier phases of the Universe is likely to lead us into a paradoxical situation. The paradox here stems from the fact that the Universe seems to have started at a very definite point in time. This is a startling conclusion. Only a century ago, the leading scientific and philosophic opinion favored a Universe that had been around forever. It was considered all too anthropomorphic to think that the Universe would share such a property of human beings as being born a finite time ago. It seemed clear that an eternally existing Universe was far more attractive.

However, observations told us otherwise. Given the observed expansion of the Universe, general relativity tells us that the Universe has started not too long ago, a mere ten or fifteen billion years before the present. The Universe as a whole is thus not that much older than our home planet, with an age of four and a half billion years.

In a search for earlier and earlier times, we seem to reach a point where time began, and attempts to reach for even 'earlier' times may well lead us into a literally time-less realm, or at least time-as-we-know-it-less realm. As was the case in our exploration of space, an exploration of time, too, may turn out to open up, from a descent into smaller and smaller time intervals, out onto a vista beyond time.

An Exploration in Experience

After having traveled in space and in time, what other direction is there left to travel in, exploring the limits of our knowledge of reality? From the viewpoint of natural science, none, or at least none that has the same level of fundamental significance. But natural science itself is the result of our taking a particular stance towards our experience, in which we filter out certain parts in order to arrive at an objective view of nature. And it is easy to overlook this filtering operation: since we have been so very successful in the scientific enterprise, the temptation is strong to try to stuff everything back into this limited domain.

This sleight of hand works as follows. We take our experience as given, dismiss large fractions of it as (temporarily at least) irrelevant, and use the remainder to build up an objective scientific world view. It is this world view that we have briefly reconnoitered in the previous two sections. And then, at the end of the day, we conclude that all of our experience must be somehow 'produced' by human brains, as a result of complex interplays of large numbers of molecules. In other words, having filtered out most of our experience, and having transformed the remainder in a highly abstract manner, we give our final fiat to the belief that somehow all of experience can be recovered nonetheless, as part of a single objective reality that includes our subjective experience as the output of complex computers called brains.

From Bishop Berkeley onwards, critical voices have been heard, protesting against this glib type of reductionism, but by and large the world view summarized above is the one we use as our standard reference. After all, there seem to be two good reasons to do so. First, there is the fact that science has been so extraordinarily successful, for better or worse. Second, there is the question of what else we can do. What alternative do we have, apart from buying into a scientific world view, if we do not want to wind up with romantic speculation or religious beliefs?

Well, let us explore and see for ourselves. Let us try to drop all forms of dogma and prejudice, including the ones that tell us that our identity is to be found as a highly complex and brittle collection of material particles in space and time. One of these dogmas is that we are completely insignificant with respect to the far vaster Universe we live in, the result of a large variety of random processes, initiated with the Big Bang. Whether these dogmas may or may not be correct is not the point here. The challenge is to put them on hold for a while, and to try to look at the world with fresh eyes.

In other words, the challenge is to make a shift in experience, a shift that is completely independent of the more familiar shifts in space and time, as exemplified by the processes of motion and aging that we are all involved in. The shift in experience I have in mind is the one advocated by the German philosopher Edmund Husserl (1859-1938).

I consider Husserl to be one of the foremost experimental philosophers, perhaps the first philosopher in the age of modern science who managed to carry over the spirit of the method of experimental physics into philosophical research. Husserl introduced a specific experimental method, the *epoche* (from the Greek $\epsilon\pi o\chi\eta$ for 'suspense of judgement'). He advocated a kind of experimentation in which we just pay attention to what appears, while dropping our unquestioned allegiance to the world view we grow up with.

At first, it may seem to be very strange to 'put the world on hold', to drop any believe in an objective reality as the prior and only 'real' form of reality. But there is nothing magic or special in making this shift. It is only the result of the shift that is remarkable, a form of amazement and wonder. In fact, reactions of such a type are the touchstone to check whether a shift really has been made, or whether an attempt to 'put the world on hold' has only been an intellectual game.

Many poets and novelists have testified to such a shift, a dramatic change in experience, away from a belief in a solid world in which we are anchored, and towards a completely open experience of the world as bottomless. Several philosophers, too, have given us an inkling of their experience along these lines. The problem is, in our culture, that poets typically give their experiential report without any theory, and philosophers tend to give only their theoretical reflections while glossing over the experiential component that undoubtedly underpins their theoretical moves towards more open interpretations of reality.

One philosopher who was unusually open and honest about both the importance and personal impact of experiential involvement in philosophy was William James. It was partly through inspiration he received from James, that Husserl made his far more detailed attempts to combine experimental and theoretical philosophy.

When reading Husserl, one is struck by the sense of honest amazement that is conveyed. An amazement about the way we make sense of the world, and a deep sense of surprise about sense, something we find everywhere but something we cannot catch. Like space, like time, sense is for us what water is for a fish. Our lives are embedded in it, given by it, irremovably linked to and through it. (note: I use 'sense' here in its aspect of 'meaning', and I do not imply any connection with 'sense experience' – the word sense conveys more of a grasp of something than the somewhat abstract word meaning).

Sure, we can interpret our world as a world of things. But what is a thing? When we look carefully, then we find that what we considered to be an object appears in our consciousness as a bundle of meanings, draped around sense impressions that are far, far less complete and filled in and filled up than the 'real thing' we feel to be present, three-dimensionally, continuous in time. What then remains of the solidity of the object? It is recognized in its givenness for us through the *sense* of solidity we have. Its continuity? This follows from our *sense* of continuity and identity. Its reality? Nothing but a *sense* of reality. The indubitability of its reality? The only thing we have a real handle on is our *sense* of indubitability of its reality [2].

Husserl himself did give ample indications of the fact that for him the *epoche* was a way of life, and towards the end of his live he described it as a 'complete personal transformation, comparable in the beginning to a religious conversion' [3]. And indeed, recognizing that we live in a world of sense is a shocking experience. Not only do we find the *world* to be dissolved in sense, upon close inspection, but we find that *we ourselves,* too, are known to ourselves only as complex forms of sense. This shift towards sense is far from an armchair philosophy consideration, it takes place in the laboratory of our life, as is nicely expressed by Harvey [4]:

> Husserl's procedural techniques for inducing the "shift" are an attempt to articulate a certain strange experience that has happened to philosophers, to artists and poets, and perhaps to everyone save the hopelessly sane, now and again throughout their personal history. This strange experience is the experience of the strangeness of experience, and of the world. And this strangeness is nothing more (nor less) than the act of *seeing through* the sedimented meanings that one inherits and develops, and that structure one's world.

One important point has to be emphasized here. When we take a turn towards experience as primal, rather than derived, it is not at all clear 'whose' experience we are talking about. We normally assign experience to ourselves, to a person with a certain identity, playing all kind of roles. But aren't all these aspects given as part of experience? In this context, it is interesting to read the Japanese philosopher Nishida's reaction [5]: "Over time I came to realize that it is not that experience exists because there is an individual, but that an individual exists because there is experience." After all, we can only know objects in the presence of a subject, just as we know ourselves as subject only through our interaction with objects, be they thoughts or things or other forms of appearance. And since it all leads back to experience, it does seem reasonable to start there, and to consider both subject and object to be attributes of experience, rather than the other way around.

So it would seem that the whole world dissolves into a world of experience. But that is not quite right. If we put on hold the notion of 'world', 'person', and 'self', then we cannot label what happens as being the experience of a self. Yes, of course, things still happen, but we can refrain from calling it experience. What then to call it? How about calling it appearance. It is clear that something is going on. Something happens. Something appears. What appears? Appearance appears. That's all. We can say more, but anything we say is likely to let us stray away from appearance, into secondary considerations.

We have thus arrived at a third paradox. We started with a vast objective world, and found ourselves as tiny specks in the physical Universe, as individual observers, living on the surface of a particular planet. But such a picture identifies the subject of experience with a particular object, the particular human body that the subject finds in the center of experience. From an objective point of view, such identification of course makes sense. But from a subjective point of view, the locus of experience is not to be found in my head, but everywhere around me. I am not locked up in my head, but I 'am' in my experience. I live in the living world around me, as that world, as the only tangible part of that world, namely as the way in which it appears.

From this latter point of view, the move to ground experience in a brain leads to a similar surprise as the one we have seen before. Starting with space, trying to zoom in on a small part of it, we instead saw all of space reflected in the existence of a single electron. Starting with time, trying to trace it back, we found a starting point in the form of the Big Bang, and a hint of a realm beyond time. And now, starting with experience, trying to trace it back to its source, we again have a similar choice. Do we stop at the brain, waving a magic wand of 'explanation', insisting that somehow experience oozes out of the complex interplay of molecules that makes up the brain? Or do we embrace the whole field of experience, including the experience of the physical universe, as a given, as equally fundamental aspects of reality as space and time?

The latter view, in my opinion, is far more promising than a hierarchical view in terms of mysterious 'emerging' properties. It also seems to offer a common ground for dialogue between a far wider set of world views, European as well as non-European. In the following section, let us contrast this open view of the world, as a world of sense/meaning/knowledge, with the more closed view of the world as an objective realm that we are contemplating, as it were, from the outside, with the God's eye view of the ideal of a detached scientist.

A View from Afar

The desirability of developing a more global and less Eurocentric world view is an idea that is gaining in popularity. However, relatively little concrete development has taken place as yet in that direction. Especially in academic circles, a study of the philosophy and cultural values of non-Western countries is often still classified under 'area studies', and seen as not on a par with the 'real' philosophy that is considered to be the sole birthright of Europe.

Many Western philosophers are quick to point out the extent to which philosophical ideas in Asia are entangled with religion, be it Hindu or Buddhist or Taoist. Rarely do they pause to try to view themselves through reverse eyes, which would bring out the enormous entanglement between Christian dogma and both scientific and philosophic thinking, for better or worse, still very much so in even the latest postmodern way of phrasing the most pressing problems [6].

From an European point of view, we like to stress the tensions that have existed between science and the Christian church. But from a non-European view, the parallels must be far more obvious and striking. If we want to have a close look at the birth of modern science, we can compare seventeenth-century scientific thinking and seventeenth-century Christian thinking. In both cases, we see a tendency to view the world from an eternal vantage point. The Christian notion of a God transcending space and time gave a convenient model for a 'God's eye' point of view, a way to look at reality from the outside, so to speak. This detached and stand-off-ish way of describing the world has led to a world view in terms of objectivity.

We are so much used to thinking in terms of an objective world, out there, mapped to high accuracy by physics, given once and for all. It seems almost impossible to put up for discussion the absoluteness of this objective world view, and the validity of taking such a stance. Questioning the ultimate status of objectivity is often interpreted as threatening the whole notion of a scientific attitude.

In order to study limits to scientific knowledge, we have to be aware of the limitations that are imposed on knowledge in order for it to qualify as scientific. Traditionally, any subjective form of knowledge was suspect in this regard, and generally considered 'off limits' to science. True, any laboratory reading of any instrument ultimately is reported by individual subjects, perhaps at the end of a long chain of automatic measuring devices. In this sense, subjectivity lies at the basis of any form of scientific practice. The traditional justification of objectivity, as a construct on top of this subjective basis, was given by the ideas of verifiability and repeatability. These were invoked to safeguard us against unwarranted subjective interpretations and deviations. However, we have reached a point where we may have to rethink that whole strategy.

In physics, quantum mechanics has shown us that it is wrong to think that measurements can be arbitrarily repeated. Instead, the role of the observer has to be taken into account explicitly in a complete description of a quantum mechanical measurement. In cognitive science, a study of consciousness 'from the outside', in objective terms, can only go so far, and leaves out the 'insider view' of the one who experiences in subjective terms. And finally, when we look at the influence of science on society, we often see egocentric and non-caring attitudes being sold as being 'scientific' and rational. Perhaps the strategy of limiting ourselves to objectivity, useful as it has been in the past, is doing us now more harm than good. But what are the alternatives?

The alternative I have in mind is something I would characterize as 'freedom from identification.' I will come back to that notion later. Let us first have a closer look at objectivity and its limitations.

A Particular Universe

An objective world view describes all concrete occurrences as instances of more general, universal laws. Each particular event that is scrutinized in the laboratory can be reproduced, in principle, by others. They can thus verify the objective validity of the universal laws that are inferred from particular measurements. The universal is what counts, and the particular is considered only in its incidental instrumental value. Laboratory objects (and often laboratory animals-as-objects as well) can be discarded after universal significance has been squeezed out of them. After studying one billiard ball, we can move on to the next, and the same is true of observations of clouds, or stars, or whole galaxies. The situation gets a little more problematic when we focus our gaze at the Universe as a whole. Notwithstanding its name, the Universe for us is not very universal at all, since we cannot trade it in for another one. We are literally stuck with the particular Universe we find ourselves living in.

There is an interesting parallel with the study of experience. In our third exploration we have found that experience can be viewed in two ways. As an object of study, we can observe someone else's experience indirectly, by studying that other person's behavior. And indeed, we can take a theoretical stance, and regard our own experience in a similar way, treating it as an object. But when we take a more directly experimental attitude, we find our own experience to be literally everywhere we look (or think, taste, etc.). We can see everything not only 'in' experience, but in fact 'as' experience. From an experiential point of view, it is impossible to take our own experience as an object, since we simply cannot take up a standpoint that is far enough removed. We cannot step outside our own experience.

This is then the parallel between the second and third exploration we have embarked upon earlier. It is a parallel between the inability to step out of *subjective* experience, and the inability to step out of our *objective* Universe, the one we live in, and the one we have traced back to its origin in the Big Bang. An analogy with mathematics may be helpful here, to shine more light on this comparison.

When we want to describe curvature, for example the curvature of a two-dimensional figure, we can look from the outside, and conclude that a sphere and a cylinder both are curved, while a plane is flat. But when we look from within the two-dimensional worlds, restricting ourselves to measurements that can be done from inside that world, we get a different result. The curvature of a sphere can be measured intrinsically, for example by drawing a triangle, and noticing that the sum of the angles is more than 180 degrees. However, the intrinsic curvature of a cylinder turns out to be zero. The results of any *local* measurements within the surface of a cylinder are indistinguishable from measurements made from within a plane. The only difference comes from the globally different boundary conditions: within the surface of a cylinder it is possible to return to the point of origin by walking in a straight line, something that cannot be done in a plane.

It may seem surprising that curvature can be measured from the inside of a surface, without ever leaving the surface in order to watch its curvature from an external view point. And indeed, in many cases there is no need to take an internal attitude. But there are situations in which no external view point is available. The most striking such example is given in cosmology. When we want to determine the curvature of the four-dimensional spacetime of the expanding Universe, we cannot just leave our spacetime, and travel in a fifth or sixth dimension in order to get a better view. As four-dimensional beings (three-dimensional *qua* space and one-dimensional *qua* time) we are given together with our four-dimensional spacetime, and there is literally no way out.

In the case of cosmology, it still is useful to construct models of the four-dimensional world that are embedded in higher dimensions. Similarly, it is useful to take only, say, two of the four dimensions of the world to illustrate some of its properties. For example, we can compare the expanding Universe with the two-dimensional surface of an expanding balloon embedded in a space with an additional third dimension. Such a model can roughly describe the kinematics of how the Universe expands (all points on the surface of the balloon receding from each other, without any surface point being the real center, the latter being located outside the two-dimensional surface altogether). But it is important to note here that the *external* curvature visualized here is the curvature of the *model.* As far as measurements go of the *real* Universe, such observations by necessity have to be *internal.*

For each individual human being, the challenge to make sense of the field of experience is akin to the challenge cosmologists face. Here is the parallel between observations in cosmology and in human experience. Each one forms a realm with, strictly speaking, no 'outside', at least no outside in its own terms, connected in a continuum with the inside, sharing a common boundary. In both cases, we can only rely on internal measurements in order to understand our reality. If we then decide to construct models of reality, we can of course consider those models from an external point of view. An interesting paradox crops up here: such a model simultaneously *stands for* and is *part of* the Universe or the human experience it describes. Just as a model of our Universe is still part of the Universe, so are our models of experience all part of our experience.

When we now turn to an investigation of our own experience we find that each of us is a professional 'cosmologist.' We spend our working life, as well as the time in which we are sleeping, playing, or whatever, within the 'Universe' of experience.

Experience is the foundation of our knowledge. It is the source, setting, and sphere of reference for all formulated assertions. It is a curious thing, however, that the knowledge we develop out of our experience, namely scientific conceptualization, leads to our providing an explanation of experience that in turn seems to provide a foundation for it. Starting from an internally felt perspective, we seem to bootstrap ourselves up and out to an external perspective. We conclude that the external empirical perspective, that is, the objective observational mode of experience is the more 'real', the more fundamental, precisely in that it seems to provide a form of foundation that cannot be found within experience itself.

Something funny is going on here. That what we consider more 'real' really is a form of abstraction, literally, when we analyze how reality is constructed in our experience. The whole notion of a single objective world, underlying all of our subjective experiences, is a handy and economic extrapolation, but one may wonder whether there is anything more to it than that. We will return to this question later.

Note that there is a potential problem here with the analogy between cosmology and human experience. Is a model of the Universe really 'in' the Universe? Sure, the cosmology books are very much part of the physical Universe, but their message becomes meaningful as a model only in a mind. Is a mind 'part of' the Universe? If the mind could somehow be located 'in' a brain, the answer would be yes, but such a notion of 'in' would seem rather too simplistic. The strong spatial sense of the experience-as-cosmology metaphor can thus be misleading when talking about experience, as if experience were a field of a very peculiar sort that is contained within the physical space-time Universe. This is precisely *not* what the metaphor tries to convey. To the extent that anything is within anything, physical space-time, that is, the dressing of really experienced space-time in the clothing of abstractly formulated scientific concepts, actually is 'within' experience.

Stepping Out of Experience

Let us now take a less modern angle on this whole question of experience and of being 'in'. In talking about the Big Bang, we have used a physics view of the history of the world. Let us now have a look at the historical root of physics itself. How did we arrive at our current notion of an objective world view? In other words, how and when and where did we learn to 'step out of experience', in order to look at the world in a disinterested, non-subjective way?

Our modern notion of an objective world, describable by science in terms of mechanical terms, is an unusually cold and remote one, as far as world views go. In most other cultures, a person constitutes a much more integral part of the world. Somewhere between heaven and Earth, in the grand scheme of things, humans play an important role. And not only human beings, also animals, plants, the whole interwoven tapestry of appearance can present a dimension that elicits wonder and awe.

By and large, we seem to have lost that dimension. Sometimes, in poetry for example, we may detect faint echos of this outlook on life, or better 'inlook' in life. But when we close our poetry book, we again find ourselves as very small entities, almost lost in the vast time and space of the Universe, a product of an extremely lengthy chain of accidental occurrences which finally led to the aggregation of the material constituting our individual bodies.

Our bodies contain a nervous system complex enough to allow reflection on ourselves and our world. We can comfort ourselves perhaps by the fact that, small and insignificant as we may seem to be, we can to some extent grasp the whole Universe in our thought. But this by itself does little to overcome our sense of senselessness of the world. With all our progress in scientific thinking we seem to have lost our integral role in the world. And this loss is serious, and goes far beyond a romantic longing for the days of old. This loss has practical consequences, reflected as it is in the destructive way we treat our environment.

How did we get where we are now? What were the historical processes that have led to the thorough alienation we have arrived at, on many levels (with respect to nature as well as to neighbors, in the work place as well as in the political structures we form part of)? Of course, the development of natural science, over the last few hundred years, has played a significant role. But even earlier than that, there seems to have been a significant shift in attitude, in the way we take up our position towards the surrounding world.

Paintings from the Middle Ages, for example, up until the mid-fifteenth century, show a human world in which the viewer participates. A painting of a city shows a jumble of houses, piled on top of each other, each house showing itself as if you would be just walking in front of it. In contrast, in the late Middle Ages and early Renaissance, we see how the human role changes from a participant to an outsider. The invention of perspective puts the viewer away from the crowd, behind a window as it were, as if looking out from a separate world. According to Romanyshyn [7], this distance-creating move on the level of art prepared the ground for a similar move on the level of science.

This transformation of the human role, from player to spectator, has had profound consequences. Twentieth-century alienation may well have its roots in the invention of perspective in the fifteenth century as well as the founding of modern science in the seventeenth century. This is not to say that taking a detached view is something undesirable in itself. In order to face a complex problem, there is nothing wrong with trying to simplify it first, by reducing its full complexity to something that can be handled more easily. The problem lies in the danger of mistaking such a detached stance as providing a form of absolute reality rather than a tool.

Reductionism

Science would be inconceivable without an initial phase of reductionism. The notion that we approach something at first from a particular point of view, willingly neglecting other aspects, is natural. In fact, our embodiment forces us to look at objects from one perspective at a time, and it is only in our mind that we create an impression of a more 'full' presence of a particular object, even though we construct (our experience of) that presence merely from the various views we take of it, from different angles. Strictly speaking, the experience of a three-dimensional object is a form of reconstruction, in our mind, based on more limited, 'reduced' sense impressions. At least, this is the picture that neuroscience and cognitive science presents us. From this perspective, then, the felt three-dimensional presentation of a flower vase in front of us is a form of theoretical extrapolation, rather than an observation itself, although it is based on two-dimensional observations.

Traditionally, the particular approach to reductionism in science has been one of taking things apart: of an analysis of the whole in terms of its parts. The hope, here, was that a sufficient understanding of the parts, and their relations to each other, would enable us to see exactly in what way the whole is more than the sum of the parts; how exactly it can function in ways that none of the parts, by themselves, can.

In some ways, this hope has been fulfilled beyond expectation. At the beginning of this century, after a few hundred years of remarkable progress in physics, it was still completely unknown why different materials show different colors. Something as mundane as the greenness of grass or the brownness of rust simply had to be treated as a given, and lay beyond the explanation of physics.

Shortly afterwards, a breakthrough occurred. With our understanding of quantum mechanics came the ability to *calculate* properties of matter, such as color, that had previously eluded us. So finally, after a few centuries of treating 'secondary properties' of matter, such as colors, as just that, as secondary citizens, it now was possible to include them within the arena of science. This was a triumph of reductionism: by putting the question of colors off-limits in the seventeenth century, the road was paved for progress in physics that ultimately would cover colors as well, in the twentieth century.

So it seemed that drastic filtering has paid off. But has it, ultimately? Does quantum mechanics really 'explain' color? Yes, we may now be able to calculate how the wave length distribution of white light is affected by reflection off a particular type of material. But no, that is not quite the same as understanding why the experience of a red piece of matter as red has the particular qualitative 'feel' that it does.

Let us illustrate this move towards world reconstruction with a simpler example, also involving color. Photography produces a picture of part of the world, in a two-dimensional projection. At first, black-and-white photography gave us an interesting, practically useful as well as aesthetically pleasing way to 'paint with light'. But of course a lot was missing: there was no depth, and there were no colors. In both ways, a photograph was a projection, a reduction in the range of openness to the rich variety of phenomenal features present in the real world.

Starting from a single such projection, there is no way to reconstruct the original scene. It is impossible to recreate colors by looking at a single black-and-white photograph. We can use cues and make educated guesses, but essential information is lost in the process of reduction. However, it is possible to do much better by using simultaneous projections along different angles (as with stereoscopic cameras) and in different colors (as in color photography, based as it is on the combination of several black-and-white exposures sensitive to different color bands).

One can imagine this process of parallel reduction and multi-faceted reconstruction to reach a state of perfection in which our visual perception can no longer distinguish the photographs (or rather its offspring, virtual reality) from 'real' reality. In fact, all these forms of imaging can do more than simply recreate reality. Photographs can make visible to us forms of information that are not discernible normally, such as the ultraviolet light that some insects can see, or infrared light that allows us to see living bodies and working engines in the dark (well-known in military applications).

Can we say, in all these examples, that technology can succeed in recreating the world, partly (as in photographs) or more completely (as in a future form of virtual reality)? To some extent that is accurate, but it is important to realize one common factor between nature and a technological reproduction of nature. In both cases there is the human observer who is involved in the process of observing and who makes judgments as to similarities and differences between the two.

This special role of the observer is what makes the current state of the art in science so paradoxical. On the one hand, we are confident that we can model, in principle if not in practice, any type of physical process in daily life in considerable detail. Such simulations, either performed approximately by pen and paper or based on complex computer calculations, give us enormous power. We can design new materials, understand the properties of naturally given materials better, and in many ways we have become masters of our physical world.

But on the other hand, it is not clear that we are anywhere near a deep understanding of our own mind. We can measure correlations between objective brain states and our own subjective conscious experience in more and more detail, but it seems that an enormous gap still remains: the gap between a description of physical brain states and the direct personal experience of *qualia*, of conscious sensations such as experiencing the color red, a musical tone, or the smell of roses. And the same holds for thinking, feeling, remembering.

This gap is more than just a gap, it is more like an abyss between a physically objective description of the world, including the brain, and direct subjective experience. At first sight, this abyss seems to separate a scientific, third-person form of knowledge from the first-person knowledge that is the stuff of our life. The latter type of knowledge seems to be off-limits to scientific knowledge, and in that sense scientific knowledge forms a subset of the totality of our knowledge of reality.

Will scientific knowledge always remain a subset? Perhaps not. But before venturing out into speculations about the future, let us look a bit closer at the structure of the scientific framework, its subdivisions into disciplines, and the extent to which these disciplines are built upon each other.

The Hierarchy of the Sciences

Let us quickly review the typical way that scientists deal with the relation between the major scientific disciplines. Chemistry is an explanatory structure that is layered on top of physics. In principle, one might try to argue that any phenomenon in chemistry can be 'explained' (calculated, checked) by physics, although in practice there are many obstacles to such a reduction. Apart from the fact that the computational problem may be intractable even for the fastest computers available now and in the foreseeable future, there is the more fundamental problem that higher levels of description require their own vocabulary which cannot be reduced to lower levels: 'more is different', as Phil Anderson expressed it so eloquently, a quarter century ago [8]. Or in the words of Michael Polanyi, chemist-turned-sociologist [9]:

> Lower levels do not lack a bearing on higher levels; *they define the conditions of their success and account for their failures, but they cannot account for their success, for they cannot even define it.*

For a brief and clear introduction to this problem, starting with Husserl's view of the matter, see the article *Fundierung as a Logical Concept* by mathematician-philosopher Gian-Carlo Rota [10].

Even so, physics is generally considered to be the most fundamental science, with chemistry seen as more derived, and biology in turn layered on top of chemistry, and so on. Let us engage this picture for now, just to see where it leads us, and let us take psychology as the top layer as the study of the human mind (one could continue with sociology, economics, and other disciplines, but let us not make our picture more complicated, at this point).

Is there anything underneath physics, a 'deeper' layer? Well, the natural candidate that would come to mind is mathematics. But as soon as we entertain the notion of 'grounding' physics in mathematics, we face all kind of problems. While chemistry seems to make use of the material substratum provided by physics, mathematics only provides pure form. We are unlikely, in this day and age, to go along with the Pythagoreans who held that all and everything under the sun (as well as the sun and stars themselves) could be reduced to numbers.

However, for all its inadequacies, let us briefly entertain this picture of math providing the foundation for physics providing the foundation for chemistry, etc., until we reach the study of the human mind, in psychology, founded on top of neurobiology, say. Let us look at this picture, and step back for a moment, trying to get a feel for the character of the interrelations between each pair of layers involved, as well as for the relations within each layer.

As soon as we ask the question of how each layer deals with itself, we come to a surprising conclusion. While all layers carry a wealth of information and thus have a lot of interesting stories to tell, they are mute when interrogated about themselves. Physics, for example, indeed needs a form of meta-physics, something different from physics, in order to talk about physics. Physics talks about the physical world, and therefore by construction cannot talk about talking about the physical world. Physics and the physical world are two very different domains indeed. The same holds true for chemistry and biology and other disciplines in natural science. The surprising conclusion then is this: it seems that only the top and the bottom layer, psychology and mathematics, can be truly self-referential.

A model for mathematics can be constructed using pure mathematics. In other words, meta-mathematics can be mapped straight into mathematics, can be constructed as a form of mathematics itself. This is different for physics and chemistry, where the models are not part of their area of study (the physical world) but are couched in mathematical terms. But a model for mathematics, as pure form, is not different in structure from math itself, pure form from the outset.

Moving up the foundational layers from math to physics to chemistry to biochemistry and biology, we can never model any of those disciplines in terms of themselves. At best, we can make mappings, establishing isomorphisms between different systems that obey similar laws. But the laws themselves are of a different nature than the systems described. This holds true for physics, as well as for any 'higher' level, until we reach psychology. In psychology we once more encounter a form of self-referentiality, encountered earlier only in mathematics: when studying consciousness, we use consciousness in order to make models for consciousness. In other words, being aware of being aware is itself again a form of awareness.

Clearly, reductionism in its classical form breaks down in the light of the problems that are inherent in this self-referentiality that we find at both extremes of the hierarchy. Yes, reductionism has played an important historical role in getting science started. But no, reductionism cannot be more than a first approximation. Once the engine of science has been jump started with a few reductionistic strokes, circularity sets in, and a closer scrutiny reveals that there is no way to reduce the scientific edifice to some form of foundation.

The whole notion of foundation is suspect. What would it mean to posit a single grounding layer of explanation at the bottom of reality? Yes, it may well be that a single unified theory will be found that can be seen to underlie all the diverse types of particles and interactions that physics knows about at present. However, it is an altogether different question to ask how we can bootstrap ourselves up from such a 'fundamental' understanding to a more 'applied' knowledge of higher levels of organization, of every-day physics and chemistry, all the way to life, to intelligence, and to conscious experience.

Apart from the 'gap' that opens wide between different layers of explanation (Anderson's 'more is different'), there is an altogether different problem. Sure, within a physics view of the world, we can try to ground physical reality with a few simple rules and symmetries. But what does it mean to take that stance, to 'go into' the world of physics? The whole notion of 'doing physics' is a particular project. A very interesting project, for sure, and a very powerful project, as we have seen from its applications, for better and worse. But still, it is a project, one among many.

The project of 'going into business' is another project. And a business man or woman naturally tends to view the world as one complex business project, just as surely as a physicist tends to see the world through the eyes of physics. An artist may see the world as one huge kaleidoscopic set of art frames, and so on, with an overwhelming choice of projects we can choose from. What is so special about the project of 'doing physics'?

The traditional physics position is as follows. Physics gives a detailed description of the structure of objective reality. And the hope is that future improvements in our understanding of physics, and its derived disciplines layered on top of physics, would asymptotically lead to a complete understanding of objective reality. And here is the intended coup of the physics project taking over all other projects: physics tends to see 'projects' as subjective tendencies that form part of the way that brains function, while brains are part of physical reality, and physical reality is what the project of physics studies. Voilà: the project behind the project of physics is to stage a palace revolution, namely to appropriate all other projects as ultimately derived from the project of physics.

I guess it is clear that I am somewhat skeptical of this move of appropriation. Ultimately the conflict here boils down to the question of where knowledge comes from. Is knowledge something that 'emerges' out of complex physical systems called brains (in which case physics would have at least some chance to claim its foundational role)? Or is knowledge an inherent dimension of reality, more fundamental than any particular form of matter or energy, perhaps equally fundamental as space and time?

As I have tried to argue earlier, the latter view makes much more sense to me. But why argue? Does it really make any difference, in practice, how we view knowledge, and the status and source of knowledge? This question brings me to the more evocative aspects of a discussion of limits, and the related concepts of edges and boundaries.

Limits, Edges, and Boundaries

Let us return to the question we started with. Is scientific knowledge in principle limited, either by the very structure of reality, or by the type of knowledge that qualifies as scientific? My guess for an answer would be 'no'. Of course, there is no way to prove that such an answer would be right or that it would be wrong. Instead, my strategy will be twofold: I will try to make my answer at least plausible, and I will also try to show that, as a working hypothesis, this answer has pragmatic value.

The No-Boundaries Working Hypothesis

Limits are the most paradoxical things we deal with in life. Whatever we encounter, whatever presents itself in the world or in our mind, including the ever-tentative distinctions we make between those two realms, any and all of that is given in terms of limits.

Limits are required for any type of structure, physical or verbal, real or imagined. Limits in the form of boundaries, separating one area from another, are what makes a structure a structure, rather than an amorphous something. In fact, we cannot deal with anything that is not structured in some way or other: notions such as 'amorphous' or 'something' are themselves set apart from other notions, and their meaning is thereby limited and, indeed, structured. Whatever presents itself in our experience is structured by dichotomies: inner and outer, blue and not-blue, good and not-good, and so on. The boundaries that separate them form the very texture of reality as we know it: without limits no knowledge.

The paradox of limits lies in the fact that limits combine two opposite functions: setting apart and joining. They divvy up the world of appearance (mental or physical, mathematical or verbal, or of any other type) into separate areas, in intricate and overlapping hierarchies. But at the same time they structure the interrelationships and communication channels between the pieces into which they have just carved up the world.

A cell wall protects the cell from its environment, and at the same time is a two-way input-output channel, connecting the cell with its environment and allowing metabolism, growth, and production of new cells through cell division. The finite number of rules in arithmetic, separating symbol manipulations into correct and incorrect ones, allow an infinite number of correct calculations to be carried out. Even in modern art, an area where boundaries have perhaps become least defined, each piece of art is given through some form of limit or description, at the very least through the way in which it is presented as set off from the rest of the Universe.

The paradox of limits can thus be summarized: we can view boundaries as bridges. This idea, that boundaries can function as bridges, can be fruitfully recognized and applied in all walks of life, in any type of analysis or activity. We already encountered the business notion that 'every crisis is an opportunity', a very concrete example of the paradox of limits. In scientific research, too, anything unexpected, anything that seems to spoil the expectations of the experimenter working in the lab, or the theorist working with pen and paper or computer, is welcomed. Anything that seems to block further progress is a candidate messenger signaling potential progress into new, possibly totally new, areas.

Another way to interpret the paradox of limits is to say: there are no limits. This no-limit hypothesis denies the existence of any ultimate limits. Limits here are defined as enclosing something, setting part of the world apart from the rest, by making it off-limits. In a relative way, limits can and should succeed in doing so. But at the same time, any limit that is defined within one framework can be transcended within another, wider or simply different, type of framework.

Stating this in another way, I very much doubt the existence of any ultimate boundaries. This hypothesis cannot be proved or disproved, but we can work with it, using it as a guide in our considerations and actions. As a working hypothesis, it can encourage us, stimulating a creative attitude. Like artists, stepping over the bounds of the received way of dealing with things, we can see opportunities everywhere.

In science and technology, research 'at the cutting edge' is what is valued most highly, the locus where important new results can be expected. At this cutting edge, researchers play the modern role of heroes in ancient myths, who placed themselves squarely on the edge of the unknown (with a few minor modifications, such as dragons having turned into tenure committees).

Exploring nature, through science, or exploring one's own nature, through philosophy or religion or arts, all these activities are a form of 'pushing the envelope'. We proceed towards the edge of what is known, and discover that an edge is not something to fall off of: borders are bridges, problems point to solutions. This is the marvelous key to the human condition: close and honest inspection of a border line sooner or later shows new openings in what we thought to be a tightly shut case.

Honest here means: authentic. Inauthentic scrutiny of a perceived border is characterized by a tacit acceptance of the border as border, a form of laziness and conspiracy with received wisdom. In contrast, authentic scrutiny regards a border as a valid boundary of past knowledge, something that may have had a useful role in the past, much as a cast for someone with a broken leg, or a play pen for a child growing up. Useful as these various devices may have been in the past, there comes a time to try to disregard them, in order to open up the received boundary, and go beyond.

This attitude is really a form of working hypothesis. Until new territory is found beyond the existing boundary, we cannot possibly 'prove' that it is possible to cross the boundary, let alone dwell beyond. Until the current boundary has lost its boundary character, its non-boundary character is merely a hypothesis.

Another way to phrase the no-boundary working hypothesis is to say "we are free, we can never be pushed in a corner; there are no corners". In other words, there is always a way out. Perhaps not in the direction we thought of at first. Perhaps in completely unexpected directions. But whatever the situation, there are always new degrees of freedom to be found, new dimensions to be explored. And what looks like a hopelessly encircled situation within a limited number of dimensions can always be seen to be fully open in the direction of new and unsuspected orthogonal dimensions.

There are two main arguments that support the no-boundary working hypothesis, one based on logic and the other on history. The logical one is this: every boundary is a boundary within a certain setting; recognizing a boundary as a boundary already places the boundary in the realm of the known, making it an object of exploration. As soon as we can sit on the wall of the known, we can look out in the opposite direction of the known, and at least catch some glimpse of something that is there. After all, the unknown has at the very least one element in common with the known: the boundary. Here is the gist of the argument: acknowledgement and inspection can turn boundaries into bridges.

The second argument, based on history, runs as follows. In the past, how often have we not seen a firm belief in boundaries crumble! Man was not meant for this or that; nature was restricted to be such or such; this or that race or social class had its own limits. Which of these limits have been left in place? Those that have, upon closer inspection, are most often the result of a renaming of the terms involved. In physics, 'energy' is still conserved, but this new concept of 'energy' encompasses much more than heat and motion, it now includes matter as well. In politics, all 'men' are equal now includes a concept 'men' as 'men and women' in a way that was nearly inconceivable a few hundred years ago.

Whether one is tempted by the evocative form of logic, or the lesson from history, or simply by a curiosity to try out this no-boundary working hypothesis, it is fun to test this hypothesis as critically as possible. The type of questioning that this hypothesis suggests is the most radical form I can think of: a form of inquiry that puts into doubt any and all barriers. Each barrier is seen instead as an invitation to freedom.

On Edge

Life at the edge has always had an appeal, in stories, fairy tales, or epics. Life at the edge of an enchanted forest, or at the edge of a vast desert or mountain range. Or life in a port, at the edge of a vast sea, stretching out to unknown shores; a sea fraught with peril and also beckoning, beckoning beyond the borders of the known.

Martial arts teach a practitioner to be on edge, in an open and attentive way. Expecting nothing in particular, fully open for whatever new situation presents itself, the known past has played out its role, and the unknown future is greeted with open arms. The practitioner is present, here in the present, at the edge between the known and the unknown.

In contrast, a more usual state of presence is to be fully ensconced in the past. Safely residing in the known (complete with insurance policies against assorted known but uncertain threats) the usual state of presence is not very present at all; it is a form of enduring past. Compared to living on the edge of experience, such a state with a cozy past-based perspective seems like a form of sleep, or even death. No wonder that all cultures have myths and parables that encourage us to 'wake up' – to live 'on edge'.

Waking up is an image that occurs in all religions. Being born, or being born again is an even stronger image, familiar in our own Christian heritage: the New Testament's advice "let the dead bury the dead" refers to a life off-edge as 'dead', as opposed to those who are truly alive, living on-edge. When Buddhism talks about life as a dream, it is off-edge living that is fully submerged in the dream, and it is on-edge where awakening can occur.

The notion of living 'on edge' can take many forms of meaning, on a grand scale as well as on the level of everyday life. The expression 'life at the frontier' offers one way of talking about life at the edge, with a grand ring to it. This frontier can take many shapes: an actual battle field, or newly explored territory, or newly conceived activities.

In one way, all of us lead a frontier life all the time, namely in the time dimension, where each moment of being alive is a moment at the frontier. In the very present, there are many years of our life history stretching back in time, and there are billions of years of our Earth's history. All our factual knowledge is concerned with the past. But in the other time direction, even the details of the next second of our life remain unknown – until they are transformed from future to past details.

In yet another way, we all live a frontier life. We always live at the edge of the unknown. Even in our own bodies, there are far more processes going on at any time than we are aware of. And in our immediate neighborhood, we always straddle the borderline between the known and the unknown. And with the pace of change having increased considerably in the past few centuries, both the known and the unknown have become accentuated more and more.

One expression of the borderline nature of modern life is provided by the rapid revolution in information technology. Soon each home will become an information port, an active nerve center for reception as well as generation of data of an as yet unforeseeable variety. This will be a step into the unknown, but we do have an interesting historical parallel, namely the change from travel by ship to air travel.

Only a hundred years ago, port cities played an important and unique role in the geography of a country. Only a seaport gave access to travel to those remote countries that could not be reached overland. Only from the rim of an island or continent could a journey start to other continents or islands.

The invention of the airplane has brought unexpected competition, and has effectively turned every city into a port city; the whole surface of the Earth has effectively been turned into coast line. Airports can be built everywhere on Earth. Even the most remote places have room for at least a helicopter to land, if not a small airplane. In a sense, the border of a continent has stretched itself out over the whole of the inland region: each place on Earth now finds itself 'on edge'.

The inventions of telephone, radio, and television have further brought access to far-away countries. Contact with overseas is now possible without either boat or airplane: each home has already become an information port, even though the exchange of information so far has still been rather primitive. But before long each of us will have the opportunity to get on the road, on the 'information highway' with its growing planetary web of branching and connecting paths. It is the latter aspect that makes this 'highway' so interesting, since it presents us with a system of alleys, byways, and local trails.

Perhaps a better metaphor would be an 'information sea', since a road suggests far too narrow and one-dimensional a picture of what is possible in information land. And indeed, a user of the 'information sea' can quickly feel him or herself at sea, lost between the tidal waves of information that can be unleashed at the push of finger, with only a few key strokes.

With each place on Earth turning into a port, our life is being turned 'on edge' in various ways. New ideas and new possibilities are being 'ported' into our familiar surroundings. All our various landscapes are changing rapidly: job situations, friendships, voting procedures, ways of entertainment, and almost everything else will be affected by the information revolution in ways that we cannot possibly imagine.

Every technological revolution has changed society as well as individual lives in ways that were never anticipated. And in those cases that predictions were made, these predictions almost invariably turned out to be completely off the mark. To mention one glaring case: remember 1984, the year of Big Brother who would keep electronic surveillance over all of us?

That scary vision was understandable in the late forties, when electronics components were so expensive that only large governments could seem to afford them. But now, with everyone getting access to computers, what is the case? Exactly the opposite! Now citizens can band together without any possible way of control by the various governments. Now governments are scared, and scratch their heads in vain in search for solutions to keep their citizenry down on the farm, away from the information sea –

but in vain.

In 1989 there were not yet enough fax machines in China to convey widespread information about the repression at T'ien-An-Men square, even though Chinese from Hong Kong managed to reach thousands of friends and business relations this way. Now there is no such limitation any more in China, and soon no longer in any country on Earth.

No, life in a port city is not a bowl of cherries for would-be dictators. My guess is that their days are numbered, and that a constructive and balanced form of anarchy will finally be possible, for the first time in history – not only possible, but necessary: "once they've emailed to Paris, how are we going to keep them down on the farm" must be the sigh of many a politician. All politicians will become civil servants, they have to, or else: information, and hence termination of their privileged position.

Plurality

Returning to the no-boundaries working hypothesis, we have to face the question of what it means for scientific knowledge to be not limited, in principle. Does this imply a vision of the future in which science will cover everything, as a steamroller flattening other fields of knowledge, subordinating them to a given fixed 'scientific method'? Obviously, such a notion would be far too narrow. Science is something dynamic, something evolving, something that escapes any attempt to catch it into timeless dogma.

Scientific research is a style, constantly shifting, opportunistic, one that in principle can be adapted to study anything. Modern physics is a perfect example of how a form of rationality can be tailor made to fit something that at first may have seemed very strange and rather unreasonable. Even something so counter-intuitive as quantum mechanical phenomena, where one particle can be thought to 'exist' at different places at the same time (not to mention being able to go back in time), has been incorporated in the formalism of physics.

It is an interesting thought experiment, to imagine a physicist from the eighteenth or nineteenth century visiting us in the twentieth century. A fair fraction of the fundamental concepts that such a person grew up with have been dethroned. Absolute space and time are out the door. Energy conservation does not hold strictly true anymore for sufficiently short time intervals. Deterministic systems are known to show truly chaotic behavior. We could continue the list for quite a while.

But what is most interesting is this: such a visitor, once made familiar with our current ideas, would probably have little difficulty recognizing our enterprise as still being scientific. A good scientist recognizes a reasonable scientific approach, independently of the details, even if those details have earlier seemed to be absolutely essential.

Science thrives in an atmosphere of open rationality. This openness is something that allows responses in a playful way to any changes that may be required. Rationality implies an adherence to a form of logic, a rational framework that seems most apt for the situation at hand. Not cast in stone, such a logic can and will continuously change in major and minor ways, as long as scientific research is alive and active. Not tied to any *a priori* assumptions, an open rationality is the ideal vehicle for science.

It is interesting, and not a little ironic, that many of the so-called 'softer' sciences, such as psychology and sociology, have tried to borrow what they considered to be hard-nosed physics type approaches to research — only to find that many of those techniques had either been superseded in physics itself, when new data required new forms of explanation, or were actually never used as advertised.

What happened earlier this century, was that many sociologists, psychologists, economists, and others tried to incorporate elements of the 'method of physics' into their own research. The problem here was that many social scientists really believed the polished positivistic stories about the alleged way physicists work, in their systematic way of defining first principles, strict rules, and neatly organized step-by-step approaches to as-yet unsolved problem areas. They were not alone in being fooled. In fact, most beginning students in physics are fooled as well by text book accounts of how progress has been made over the last few centuries.

To some extent, it is perhaps unavoidable to fool students this way, at the start of their training. It would be rather impractical if one had to go through the details of the few hits and many misses of the historic process of building up physics, through the politicking and personal rivalries, the many emotional reactions that either helped or hindered progress at certain times, etc. And also, it is in practice not very harmful, as long as the teacher presents the text book material as what it is: encyclopedic in nature, and not at all a fair account of how this knowledge has been arrived at.

In any case, when physics students begin to do their own research, the message is quickly driven home to them that actual research is far messier and much less systematic a process of induction and deduction, than the text books had led them to believe. The real victims of the myth of 'the scientific method' are therefore not the students inside physics, but researchers in completely different fields, wanting to actually apply this mythical animal.

The moral of the story is that each field and subfield needs its own formalism. And while there sometimes are unsuspected parallels between seemingly unrelated fields, such surprises are more the exception than the rule. What is needed is a form of pluralism, an approach to science that lets a thousand flowers bloom, each in its own way.

Role Playing

A pluralistic world view does not automatically exclude any and all forms of unity. To talk about plurality and about different forms of logic presupposes the possibility of comparing them, at least to some extent. Some form of middle ground has to be present, as the condition of possibility for such a discourse. No matter how incompatible the logics and fields of investigation may seem, some form of connection, however tenuous, must be present.

At the same time, it is important to be aware of the trap of positing facile universal features, ironing out differences that seem less important. Such 'flattening' of 'uninteresting' details almost always stems from the use of a particular political agenda, often tacit, and perhaps completely unconsciously present, handed down as received wisdom through education. Whatever the origins are of particular attempts to cut the world down to size, in order to fit within a pregiven unified view, such attempts almost always imply forms of violence.

Unity thus implies responsibility. We cannot avoid talking about unity, since it would be utterly naive to try to treat any single event completely on its own, as if nothing connected with anything else. We have to choose dots to connect, and we have to acknowledge patterns we see within the plurality that we encounter in our life. And any form of connecting carries with it a responsibility for the consequences of the connecting activity. This, then, brings us to the question of ethics.

Science that does not have any ethical implication can be useful, but cannot claim in any way to describe all of reality, since clearly some form of ethics is part of our world of experience. On the other hand, ethics as a set of arbitrary commands, either ascribed to a superhuman source or to a biologically useful set of general rules, is not satisfactory either.

Spinoza may have come up with the best suggestion so far: that a deep understanding of reality automatically gives a deep understanding of ethics. His main work was entitled 'Ethica'. And, significantly, he came up with an organic view of the world, a form of panpsychism if you want, very far removed in spirit from his main source of inspiration: Descartes. Spinoza is much closer in spirit to our modern sense of ecology than Descartes, the vivisectionist who regarded even mammals as mere mechanisms, as clockworks that could be freely taken apart in order to study their mechanism.

The particular view Spinoza came up with may not be too attractive, perhaps, and can strike us in some sense as outdated. His lack of emphasis on the historical dimension of life, for example, is something that does not appeal to most of us anymore. However, his open-mindedness is still remarkable: avoiding the dualism of Descartes, he combined a non-dualist monism of substance with a form of infinitism of attributes.

The notion of ethics seems to be tied up with the notion of role playing. A play can have both the connotation of something serious as well as something frivolous. In order to play a good play, one has to be quite serious. But taking a play or a game too seriously may not necessarily be the best strategy. A somewhat more detached view may actually a better player make.

Starting from a no-boundaries hypothesis, and seeing everything as a play, as an interplay of forms of software, everything is questionable. There is no hardware and there are no hard limits. All experience, in principle, is equally 'valid', and equally material for a radical form of questioning reality. Poetry is neither more or less 'real' than physics, for example. Feelings and reason are equiprimordial [11].

What is this world we are living in, and who are we? In order to come to terms with such questions, we can switch from an inquiry as to 'what' to a more revealing inquiry as to 'how'. How does this whole world arise in the way it does, in the way it appears to us? And how does our notion of who we are arise in that same experience in which the world appears as well?

Asking such questions, we can find a tentative answer to what it means to say that something 'is'. There 'is' a cup, there 'is' joy, there 'is' form and function and value. Whatever appears, it has to make some form of sense to us, in order to qualify as something that 'is'. Even utter chaos or non-sense presents a form of sense (namely: chaos, nonsense). So, for us, 'what is' is the direct result of identifications we have made.

In a very real sense, the world we find ourselves in as well as what we believe ourselves to be are the result of ideologies, of identifications that are, in an ultimate sense, highly questionable. This is not to say that there is not a practical value to our usual interpretations. Of course there is. Of course we need a large amount of knowledge about the world in order to be able to function in it. It is only when we forget the role-play character of all that we consider to be 'real' that we get into trouble. Having labeled something as 'real', we make it more difficult to delve deeper, below the roles that have been labeled as 'real'. The concept of reality is like a terminal station, whereas the notion of role playing beckons to continue the ride to the next station stop, and the next, and the next . . . , in a dynamic unfolding that sees no need to freeze and tie down what appears to a flat level of a single, unique, and absolute reality [12].

As long as we avoid the habitual identification with the roles that are being played, the answer to the question of 'what is' retains its multi-layered character. At each moment, the question of 'what is' can be answered from within the play in which something takes significance, as well as from within a larger play that embraces the framework of the more specialized 'play within the play', or an even larger play, and so on.

For example, a pawn within a game of chess has to obey certain strict rules and consequently is caught in a situation with severe limitations. But when seen as just a piece of wood, it literally can be moved anywhere on the board at any time, or it can even be moved off the board altogether. And as a piece of wood, it can be again be viewed in many ways. If it were carved in an unusually intricate way, it could be deemed worthy to be exhibited as a piece of art, even though its role within the chess game would not be changed at all. Or it could be seen as 'just a piece of wood' and perhaps thrown in the fire as a consequence of being denigrated to a piece of firewood. Clearly, the question of 'what is' is highly contextual.

Freedom from Identification

Earlier I mentioned that each barrier can be seen as an invitation to freedom. Freedom here means this: a freedom from identification. When all barriers are seen to be relative, contingent upon the framework we choose to adopt, the barrier-nature of barriers is recognized as resulting from identification with the corresponding framework. Letting go of this identification does not mean a destruction of the barriers, rather it means a breaking free from previously unquestioned identification. Recognizing a movie to be 'unreal' does not imply that we have to walk out of the movie theater. On the contrary, it is through a recognition of a play as a play that we can fully appreciate the drama being played out.

In a nutshell, this is my motivation: using the no-boundary working hypothesis as a starting point, my goal is to explore the possibility of a freedom from identification.

Here identification is any form of barrier building in which the barriers are considered to be absolute. Other terms can be used, instead of 'barrier', depending on the circumstances, such as edge, or border, limit, frontier, horizon, boundary, wall, or skin. In all cases, however, a barrier does have a relative function. Just as a cell wall or a human skin has both a protective and a communicative function, each boundary can be explored in these two modes.

Boundaries can turn into bridges, the moment we acknowledge the context dependency of the limiting role that boundaries play. And as I argued before, I see role playing as that what allows boundaries to be transcended.

Freedom from identification is the immediate result of seeing through the propaganda attached to the role playing, the propaganda that suggests that the roles are 'real,' more than relative to their contextual situations. Freed from the massiveness of a given outside reality, ethical questions of what 'ought to be' can then be seen in a new light. In a very practical way, questions of change can be dealt with in a fluid way. From a contextual viewpoint, we can be responsive to the situation at hand, without the need to recite ideological or religious scriptures or other codified systems of problem solving.

At any time, we can view anything in its 'being' aspect, as the role that is being played, as that 'what it is'. But we can equally well view it in its 'non-being' aspect, in its aspect of openness or emptiness. From the point of view of the play, the player underneath the role being played is simply not there. In a drama, there 'is' a king. The actor 'is not' within the rules of the play. Within the play the actor steps aside, disappears, to let the king show through. But when we step outside the play, the king has vanished, has completely lost his base, his foundation of existence. We then see that, at bottom, the 'king' has been an empty notion all along. something being played but not ultimately 'real' in any sense.

It would seem that, instead, the actor is the real person, rather than the king. But what if the actor unexpectedly gets fired, soon after the play? Then the next layer drops. The actor disappears as well, and a jobless person appears instead. Is there a core that remains unchanged? Flesh and bones, or molecules, or a life history constructed as a vast web of connected past events and relationships between events? Or are any and all of these in turn the results of further attempts at role playing and play interpretations? I suspect the latter. Let me try to sketch what that may mean.

Stated in the most radical way, each subject or object, human or physical object or abstract idea or whatever, is playing a role. And what we identify as playing the role is itself playing a role. We are part of a great drama of role playing, with roles within roles within roles — without anybody or anything 'home' underneath; without any stable and final foundation to bolt things down upon.

This emptiness is what allows anything to appear in the first place. The notion of emptiness is truly the most positive notion we can come up with, the one notion that is least notion-like, if we can resist the temptation to conceptualize it [13]. Only emptiness can provide full openness. And this openness is fully accessible as soon as we look through the layers of role playing that tend to obscure the underlying openness.

The funny thing is, though, that the obscuration has never happened in the first place. Within a play a king can be a powerful person, but once we look from a vantage point outside the play, what is left of the power of the king? Even if we would try to strip the king of his power, to rebel against him in order to overthrow him, we would not find any handle. There would be nothing to fight against. Emptiness and openness do not offer a place for a sword to cut into.

Freedom from identification is something extremely paradoxical. Each time we gain an extra measure of authentic freedom, we realize that we have been free all along, that we have not found anything new at all. Take the example of a moth flying around a lamp. Physically, the insect is completely free to fly away, any moment it wants. But the problem is, it doesn't 'want' to. And while we may consider moths to be programmed biologically, we cannot maintain the same excuse for ourselves. From within the play (of being obsessed with flying in circles), there is no freedom. From outside the play, there never have been any prison walls.

And this is not just a fancy form of wishful thinking. It applies to anything in daily life. Once we wake up to the tentativeness of the world, and to the contingency of being, the massiveness of the world can drop away, gradually or suddenly. A lightness of Being can make itself felt, even in the marrow of our bones, as attested by so many pieces of world literature; not to mention many of the great mythologies of various cultures. All this may sound mystic (a label and verdict that is very suspect in scientific circles). Be that as it may. If an appreciation for appearance as such, before any form of interpretation or reduction, is classified as a form of mysticism, then my view should indeed be labeled as mystic. But I rather prefer to label it as a form of empirical philosophy, or more accurately: radical empiricism [14].

There are interesting parallels with mysticism, though. If a scientist looks at the claims of a traditional religion, he or she is likely to be rather skeptical at the seemingly arbitrary boundaries that are acknowledged by the true believers of that religion. To take one example, the believer may claim that a particular temple ground is 'holy', and that there is a clear distinction in sacredness between what lies within the perimeter of the temple area and what lies outside. The scientist may object that the molecules inside the temple are the same as those outside, and that no scientific analysis is likely to yield any measurable distinction that could justify the presence of a definitive limit, separating the sacred from the non-sacred.

Such a scientific attitude would be very reductionist, and would probably not convince the believer. The scientist in turn might well be ready to concede a contextual value to the notion of sacredness. But it is interesting to take up the reductionist conclusion, and turn the tables. The first, naive, interpretation of the absence of a distinction between temple and non-temple would suggest that nothing is sacred. But this is only one way to react to the dropping away of a limit. There is an alternative: we may equally well conclude that everything is sacred. Rather than limiting appreciation to a particular spot, we can follow the examples of mystics of all ages, who have never tired telling us that there is no such thing as ordinary, finite, non-sacred things and events. Anything can be viewed in its proper aspect, as an open gateway to a boundless reality. It is here that science and mysticism meet, in an outlook that is literally limitless.

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Notes

[1] A note about philosophy here: granting knowledge the same ontological status as space and time, and a more fundamental status than matter, may label me as an idealist, as opposed to a realist. However, I am not happy with these categories. If anything, I would prefer to classify myself as an radical empiricist, along the lines of William James's *Essays in Radical Empiricism* (1912), reprinted in *Essays in Radical Empiricism & A Pluralistic Universe*, by W. James [1967, Peter Smith]. Within twentieth-century Western philosophy, I feel most attracted to Husserl's ideas (*cf.* Husserl, E. 1913, *Ideas for a Pure Phenomenology*), but I am also sympathetic to many non-European systems of thought that approach knowledge in a less derived way than we normally do (*cf.* Nishida, K., 1911, *An Inquiry into the Good* [1990, Yale Univ. Pr.]). Specifically, the notion of viewing knowledge on a par with space and time has been suggested by Tarthang Tulku (1977, *Time, Space, and Knowledge* [Berkeley: Dharma Publ.])

[2] For a vivid description, refreshingly unsophisticated and down-to-earth, see Harding, Douglas E. 1961, 1988 *On Having No Head* [London: Arkana].

[3] Husserl, E., *The Crisis of European Sciences*, 1970, Northwestern Univ. Pr., p. 137.

[4] Harvey, C.W., *Husserl's Phenomenology and the Foundations of Natural Science*, 1989 [Athens: Ohio University Press], p. 233.

[5] Nishida, K. *op. cit.*, p. xxx.

[6] For a view from across both sides of the fence, by someone who has received full training in both Eastern and Western philosophy, see Mohanty, J. N., 1992: *Reason and Tradition in Indian Thought* [Oxford: Clarendon Press], pp. 282-299.

[7] Romanyshyn, R. D. 1989, *Technology as Symptom and Dream* [New York: Routledge].

[8] Anderson, P.W. 1972, *Science* **177**, 393.

[9] Polanyi, M., 1962, *Personal Knowledge* [Univ. of Chicago Pr.], p. 382.

[10] Rota, G.-C. 1989, The Monist **72**, 70.

[11] *cf.* Rota, G.-C., *op. cit.*

[12] There are various approaches in robotics that reflect this active type of reality construction; for a recent introduction and overview, *cf.* Franklin, S. 1995, *Artificial Minds* [M.I.T. Press].

[13] Among the recent explosion of books on emptiness, one place to start would be *Emptiness of Emptiness*, 1989, by C.W. Huntington [Honolulu: Univ. of Hawaii Pr.].

[14] This term was introduced by James, W. 1912, *op. cit.*