Prime Matter: Its Unlimited Suppleness and Incorporeality and their Bearing on Emergence and Evolution

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The insight that there must be some primordial stuff or ultimate substrate that is the origin of all that is observable in the physical world came long ago to gifted individuals in different parts of the world, including what today are China, India, Egypt and the lands that border the Aegean Sea. There are some indications that the insight might even have appeared in those different lands at roughly the same time. If this turns out to be the case, whatever explanation gains our consensus must not gloss over the universality of the insight, for the questions regarding the existence and definition of the ultimate substratum have remained with us ever since and continue to garner the interest of many among the philosophically or metaphysically inclined. This has been heightened by many of the surprises sprung by recent and contemporary scientific work and thought.

But even at the level of such introductory remarks, there already is a danger that we might fall victim to one of the following two misconceptions: first, that the ancients were looking for what we would call a physical account of the origin of material reality; and, second, that when a philosopher like Thales asserted that water was the origin of all things, he was giving primacy to one of the four physical elements recognized by the Presocratics. On the contrary, the ancients did not distinguish between material and spiritual reality, nor between themselves and nature as a whole. As is well known, the world viewed mythopoetically teems with life, so that natural phenomena such as floods, volcanoes and droughts are seen as manifestations of more encompassing divine or quasidivine presences. The ancients did not reason from observed events to their gods, but rather saw in the former confirmation of the latter. Hence they could only conceive the ultimate substrate in divine terms.

When we turn to Thales, we must not therefore take his proclamation that water is the origin of all things too literally. As the Frankforts wrote in the conclusion to the book *The Intellectual Adventure of Ancient Man*,

> [w]hen Thales proclaims water to be the first cause [and some other Presocratics made analogous proclamations], . . . then we need not be astonished that commentators in a positivistic age unwittingly read familiar connotations into the quasi-materialist doctrines of the Ionians and regarded these earliest philosophers as the first scientists. No bias could more insidiously disfigure the greatness of the Ionian achievement. The materialist interpretation of their teachings takes for granted what was to be discovered only as a result of the labors of these ancient thinkers - the distinction between the objective and the subjective. And only on the basis of this distinction is scientific thought possible.
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> In actual fact the Ionians moved in a curious borderland. They forefelt the possibility of establishing an intelligible coherence in the phenomenal world; yet they were still under the spell of an undissolved relationship between man and nature.[1]

This spell seems well on the way to casting itself over us once more. For the objective is curiously merging with the subjective at many of the borderlands of contemporary natural science. This has also cast aside any lingering doubt that the "positivistic age" has passed. Not only are we

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free to look at nature with a freshness that echoes Presocratic naïvité, but the emergent scientific picture forces us to do so, albeit with the hindsight of a vastly enriched knowledge of natural minutae, their interrelationships and the laws that govern them. A spiral of scientific progress has led us right back to contemplate the same plateau that enchanted the Presocratics, but from a higher vantage point and with far more powerful eyes - at least in the literal sense.

But let us briefly return to Thales and his immediate successor Anaximander. It is sometimes said that whereas Thales appears to have limited himself to choosing one from amongst the four basic elements that were commonly taken to be the fundamental material base in ancient Greek thought, Anaximander argued that this could not be the case. Anaximander reasoned that since the four elements change into one another, there has to be something more primary underlying them. He reached the startling conclusion that the substrate from which all matter is formed must itself be without limit, boundless, indefinite or infinite (all of which are acceptable translations for the Greek word *apeiron*).

We have just seen that it is wrong to think of Thales as just having "chosen" one of the four *material* elements as the originating force. It follows that it is mistaken to think of Anaximander as having *deduced* the *apeiron* from argument against any such choice. Now there is no doubt that Anaximander thought in radically new terms compared to any of his predecessors. However, the idea of an originating force that transcended any particular phenomenon or element was latent in the mythology and protophilosophy that he had inherited. There was already the belief in *Okeanos*, a cosmic ocean that surrounded the world and flowed back into itself, hence without beginning and without end, and the source of all rivers and seas, all emergent dry land, and the sun that must traverse it in the night before it rises again. While Okeanos is a body of water, it was not seen by anyone, nor could it be seen given that it encompasses the world. It always lay over the horizon. Thales transformed *Okeanos* from a god without cult to "water", a more abstract but still quasidivine substance that inherently possessed originating powers. Anaximander was to push that abstraction further, detaching the originating power from any image or other positive representation. It was the boundless or infinite pure and simple, without beginning or end, from which all things come and into which they all pass, which rules and encompasses them all. The *apeiron* lay *beyond* any horizon.[2]

From then on, ideas about the ultimate substrate swung to and fro between one or more of the four elements and more abstract conceptions that would not have been possible without Anaximander. Among the latter, Pythagoras, Parmenides and Plato respectively mentioned number, Being and Forms as being the origin of all observable phenomena. Given its materialistic grounding, one of the most unexpected outcomes of modern natural science is that those abstract and *transcendent* ancient ideas seem more relevant and accurate than their materialistic counterparts, if we interpret them with an open mind and a little imagination.

But provided that we interpret what follows with the greatest care and keep in mind that something of great importance is being deliberately left out for the moment, it is with Aristotle that thought about the ultimate substratum reached its peak in ancient Greece, a development that would only be matched by Plotinus when the Roman empire was at its zenith. Aristotle, like Anaximander *conveniently reduced to his (namely Aristotle's) framework*, reasoned that if we continue to analyze matter in the direction of the most fundamental level, we would have to reach something called "prime matter" that underlies all things and is not underlain by any. So that prime matter may become anything observable, it may not have any of the particular qualities that we encounter in the phenomena. As Aristotle put it:

> By [prime] matter I mean that which in itself is neither a particular thing nor of a certain quality nor assigned to any other of the categories by which being is determined. For there is something of which each of these is predicated, [namely a substance], [whose] being is different from that of each of the predicates; [and it is the] predicates other than substance that are predicated of substance, while substance is predicated of matter. Therefore the ultimate substratum is of itself neither a particular thing nor of a particular quantity nor otherwise positively characterized.[3]

While we can not dwell on such things here, what distinguishes Aristotle's account from Anaximander is the introduction of the concept "substance" and the grouping of the various things that can be predicated of substances into the other nine categories of being (of which substance is the most important). It is against this backdrop that one can further appreciate the need for the ultimate substrate to be non-material, an abstract latency that is modified according to an infinite variety of natural conditions. Furthermore, Aristotle introduced the distinction between potentiality and actuality, having observed that all substances must have definite constituents and causes for them to become what they are rather than something else. An acorn is potentially an oak tree, a dolphin embryo an adult dolphin and bricks, wood and cement a house.[4] Noting that acorns, dolphin embryos and houses must themselves have been respectively brought into being by oak trees, adult dolphins and a combination of the idea of a house and the skills of a builder, Aristotle concluded that the actuality must somehow be there along with what is mere potentiality from the very beginning so that the potential may be actualized. He states clearly in the *Metaphysics* that actuality is both logically and chronologically prior to potentiality.[5] In still more abstract terms, form is prior to matter, and in general, form must be there along with the material substratum so that the latter is transformed into the physical and biological phenomena of the observable universe.

While the potentiality/actuality and matter/form dynamic will subsequently prove to be an ingenious intellectual device for a more complete metaphysical grasp of the world, Aristotle's framework helped separate matter from form and unwittingly made it easier for modern thinkers to become materialists (despite the total lack of support that materialism would find in his philosophy).[6] Besides, to return to something that was left hanging in the comparison between Aristotle and his Presocratic predecessors, his framework made him fail to see that whilst the Presocratics *seemed* to be talking about a material substratum, they were not talking about matter in the Aristotelian sense at all, for the simple reason that they did not have a concept of matter to work with, nor one of form. In philosophers like Anaximander, matter and form, to speak anachronistically, were combined. The positivistic misreading of the Presocratics began with Aristotle!

We shall presently see that in order to properly assess the conception of matter that best fits the contemporary scientific outlook, what is needed is an approach that combines the analytical sophistication of an Aristotle with the dynamism and comprehensiveness of an Anaximander. We need to think of an abstract material substratum in combination with some notion of form, yet somehow the two sides must not be kept too far apart.

It should be clear from the foregoing that the ancient Greek discussion of the ultimate substratum and how it relates to all that exists in the universe was so intense and sophisticated that one could devote a large book-length work to it. But it is now time to turn to some of what natural science has recently brought to our attention and then see just how evocative it is of the ideas of Anaximander, Pythagoras, Plato, Aristotle and Plotinus (of whom more will be said later). That twentieth century science has yielded a legitimate vantage point for a fundamental metaphysical question posed by the ancient Greeks has been recognized by Heisenberg in a lecture delivered to a Greek audience on the third of June in 1964:

> If I endeavor today to take up some of the old problems concerning the structure of matter and the concept of natural law, it is because the development of atomic physics in our own day has radically altered our whole outlook on nature and the structure of matter. It is perhaps not an improper exaggeration to maintain that some of the old problems have quite recently found a clear and final solution. So it is permissible today to speak about this new and perhaps conclusive answer to questions that were formulated here thousands of years ago.[7]

It is perhaps an exaggeration to declare the solution physics has found to the problem of what matter is to be final. But physics provides strong evidence in favour of what Aristotle had in mind when he used the expression "prime matter." A great many observations of what happens when collisions take place between elementary particles at sufficiently high levels of energy shows that all such particles at some point will either change into other particles or be annihilated, leaving only radiation behind. These changes are observed whatever the particles, however small. But logic dictates that there must be a substratum underlying those changes. Moreover, since all kinds of matter can be converted into or annihilate one another, the substratum itself cannot be a kind of matter. If the substratum is not itself made up of any particles, what could it be? The most economical answer is that the substratum must be something that potentially assumes all forms of matter. The substratum in itself can not yet be anything that is definitely ascribed to matter. It can not have any of the properties that matter has. In short, it must be pure potentiality.[8] Heisenberg expressed this as follows, based on his famously intimate knowledge of the study of collisions between particles:

> We can say that all particles are made of the same fundamental substance, which can be designated energy or matter; or we can put things as follows: the basic substance "energy" becomes "matter" by assuming the form of an elementary particle.[9]

We shall return to the idea of describing the substratum as "energy". For the moment, let us consider some other ways that the study of matter forces us to posit the existence of a substratum that can not be described in familiar material terms and may resist any material characterization whatsoever. In the course of a lecture delivered at the Smithsonian, Phillip Anderson gave a vivid example of an ambiguity that is not resolved unless the number of particles involved is computationally infinite.[10] The ambiguity concerns whether a solid turns out to be a conductor or an insulator. Nothing tells us that a "lump" of matter, if it is composed of relatively small number of atoms, will be one or the other. Only when a huge number are available will there be the possibility of the formation of what is known as a "free Fermi liquid", which consists of electrons freed when matter condenses into a solid under certain specified conditions. A mechanism that entirely obeys the laws of quantum mechanics, including the Pauli exclusion principle, would then dictate that the electrons have a high kinetic energy. Since their mass is minimal, this means that they move very quickly. We thus have a conductor. On the other hand, another kind of condensation process may trap those electrons, so that thermal energy is needed to free them. In this case, we have an insulator.

The idea that there is nothing inherent in matter that causes a material to be either a conductor or an insulator is an old one. It goes back to Michael Faraday, who was always willing to defy conventional wisdom in his efforts to unify physical phenomena and back up his claims with cleverly designed experiments. Faraday thought that the only thing that determines whether a material is a conductor or an insulator is the force that is needed to discharge current. The more closely-packed the "particles", the greater the force, the closer we are to the range of insulators. He asserted that any material could be turned into a conductor if the particles packed within it were subjected to a force of sufficient strength and that conduction and insulation were therefore located along the same property continuum.[11] Although we now know that there is one condition under which insulators can not be turned into conductors, namely at 0°K, Faraday's reasoning is esssentially sound. It shows how macroscopically different phenomena, when analyzed microscopically, fall under the same continuum.

The reasoning of Faraday and the experimental evidence adduced by Anderson demonstrate that matter in itself is neither a conductor nor an insulator. The ambiguity between the two is only resolved when a great many particles are condensed into a solid, so many that their number is what Anderson terms "computationally infinite." Even then, the process of condensation must cross a certain thermodynamic threshold so that we end up with either a conductor or an insulator.

The question now presents itself: What is matter before it turns into a conductor or an insulator? Clearly it must be something that can potentially become both. We have just seen the broad outlines of what decides the issue; but note that all along, matter was endowed with the suppleness that would permit it to sway with the developmental winds. In general, for a substratum to take on emergent properties, it must be such that it can potentially acquire all of those properties. Moreover, it must have that potential *from the beginning*. No doubt the "matter" of conductors and insulators is not the same as the "matter" of the elementary particles; the latter is more fundamental and forms the former. But we can derive our definition of the "matter" of the elementary particles by analogy. Whatever the ultimate substratum may be, it must have the suppleness to become all elementary particles known to us. Furthermore it must, *from the very beginning*, be the kind of thing that can form materials such as conductors or insulators.

The same reasoning applies for other macroscopic properties of metals, such as malleability, ductility, luster or hardness. Gold and quicksilver are both metals composed of exactly the same kinds of elementary particles following exactly the same physiochemical combinatory principles, with only the number of particles differing for each. Moreover, the number could hardly differ less since they occur consecutively in the periodic table of elements (respectively numbered 79 and 80). Yet one shines far more brightly than the other and can be drawn into thin wires, whilst mercury is a poisonous fluid at room temparature. Such a marked difference in properties can not be accounted for by their different crystal structures (gold is cubic whereas mercury is rhombohedral); for other elements possess similar crystal structures but again have markedly different properties (neon for example has a cubic crystal structure).

Clearly the elementary particles can not be identical in the manner that their usual presentation suggests, nor can they be seen in simple aggregate terms when they combine to form heavy metals such as gold and mercury. There must be something about them, *or underlying them*, that the periodic table fails to represent, which allows for the emergence of two levels of otherwise inexplicable macroscopic differentiation: first, the more general level of crystal structure, of which there are nine; and second, the more particular level at which neighbouring elements display characteristic individual properties that may be in sharp contrast.

Back in the third century, Plotinus was struck with the problem of how to explain such macroscopic differences. In the course of criticizing the atomic theory of matter, he asserted that

> [t]here are no atoms; all body is divisible endlessly; besides, neither the continuity nor the ductility of corporeal things is explicable apart from Mind . . . which cannot be made up of atoms; and, again, out of atoms creation would produce nothing but atoms: a creative power could produce nothing from a material devoid of continuity.[12]

Plotinus' terminology might seem arcane to us, but that ought not diminish our recognition of the stunning depth of his thought. His whole body of work serves, among many other things, as a reminder that an honest look at nature can not be compatible with the dogma that there are basic constituents which, left to their own devices, somehow come together to form larger entities that manifest greatly varying properties. Our theoretical and experimental apparatus presently allow us an even more honest look at nature. And we can see, if we are free to do so, that gold and mercury can not simply become what they are through the fortuitous combination of a fixed number of sets of identical constituent parts. We need not worry about what Plotinus meant by 'Mind', nor by his introduction of creation. Instead, we can concentrate on what he said about "continuity" and transpose it to our discussion: Something about matter that eventually makes it ductile or dull must already be there given that these can never be attained additively. There must be something *actively present* in the substratum to serve as a vehicle for the breathtaking variety of emergent properties that we actually encounter amongst the elements (a vehicle without which we are forced to posit a transcendent agency that acts on that substratum in archetypal ways). Metaphysical clarity about this problem may be impossible to come by, but it is helpful at this point to keep in mind the idea of a substratum that *as such* has no definite properties yet possesses a kind of dynamic suppleness and an almost boundless potential to assume a great diversity of material forms. In this spirit, let us consider some more material metamorphoses.

On the surface, it looks as though the macromolecules that are the backbone of biological phenomena can be reduced to complex combinations of a few atoms such as carbon, oxygen, hydrogen and nitrogen. In this sense, one is tempted to claim that such atoms, and a very few others (like sulfur, phosphorus and iron), are the building blocks of life. They are the "matter" of life. But observe what happens when we follow those "building blocks" through the different stages of molecular complexity:

- A methane molecule consists of four hydrogen atoms bonded with a central carbon atom to form a tetrahedral structure that is familiar to all those who have taken an introductory course in college chemistry. The symbols of the formula CH_4 suggest that the hydrogen atom in a methane molecule is exactly the same as a hydrogen atom on its own (or in a hydrogen molecule). It is not. The charge distribution is different according to whether the atom is on its own or in a methane molecule. In the latter case, it experiences the field influences of the other three hydrogen atoms and that of carbon. The geometry of the structure is due to the mutual influences of five atomic fields subject to the relevant quantum mechanical laws that determine the tetrahedral configuration of minimum energy.

A similar argument can be made for the symbol C that is used for carbon as we proceed upwards through the methane (or alkane) series of hydrocarbons. Consider the first five alkanes, namely methane, ethane, propane, butane and pentane, for which the respective formulae are CH_4, C_2H_6, C_3H_8, C_4H_{10}, and C_5H_{12}. The laws governing the formation of these molecules dictate that the carbon atoms always be in the center, usually forming a chain such that the carbon atom at either end is surrounded by three hydrogen atoms while those carbon atoms in between are surrounded by only two. This is so because all the bonds in those molecules are single covalent bonds: One pair of electrons is shared by neighbouring atoms, each of which provides one atom for sharing. The physics of hydrogen and carbon atoms respectively rules that they reach stability when two or eight electrons surround their nuclei.[13] If we were to compare ethane with propane, we would notice that the first has two carbon atoms at the center whilst the second has three. Thus propane has one carbon atom at the very center that is under the field influence of two neighbouring carbon atoms, one to each side. This is not the case for ethane, where each carbon atom has just one more to one side. Even within the propane molecule, the two "side" carbons have only one carbon atom neighbouring them whereas they both neighbour the central carbon atom. In each of these three cases, whether inter- or intramolecular, the carbon atom is not exactly the same, because the field influences of the neighbouring carbon atoms are different depending on how many there are and the geometry of their arrangement. Thus the symbol C does not mean exactly the same thing when applied to carbon in all alkanes and even within the same alkane whenever the molecule in question conatins three or more carbon atoms (a similar argument can be constructed for all other series of hydrocarbons, and so on).

It gets worse. If we were to consider butane or pentane, we must not only worry about the symmetry relations that cover the carbon atoms, but also the manner in which the structure of the molecule could be changed considerably without any alteration to the atomic composition with regard to number or kind. Those new molecules are called isomers. For instance, instead of the standard butane molecule in which the four carbon atoms are arranged in a chain, we could have one in which there is a central carbon atom surrounded by a hydrogen atom and three carbon atoms, each of which is in turn surrounded by three hydrogen atoms. One can readily see how symmtery relations render that central carbon atom subject to quite different field influences than those of the other three carbon atoms and those that it itself had in the original configuration. An isomer of pentane illustrates this change more neatly still, for in it, the carbon atom becomes entirely surrounded with (four) carbon atoms each of which is surrounded with three of the twelve hydrogen atoms that compose the molecule. As it happens, pentane is amenable to two different kinds of perfect structural symmetries, each of which gives rise to different cumulative field influences on the various carbon atoms involved. Morerover, the changes mentioned here are significant, for although the number and kind of atoms remain the same for either butane or pentane and their respective isomers, the properties change. For instance, butane and isobutane do not have the same boiling point or ignition threshold (in the case of esters, an easily observable property like smell changes). All this is glossed over when the same symbol is used for carbon throughout and again when the same symbol is used for a molecule throughout all the isomeric transformations that are possible for it (although different names are used for those compounds, which is unavoidable given that important properties are not the same).

To complete our inspection of the transformations experienced by the simple components of the alkane series as we advance towards the higher members, something must be said about the carbon-carbon bond itself. Leaving the isomers aside for now, we may consider ethane, propane, butane and pentane as follows: Ethane has one carbon-carbon bond, propane has two, butane three with one in the middle, and pentane four with two on the inside and another two on the outside. If we think in terms of a "stretch" for each of these bonds and reflect on the same symmetry considerations that helped us above to notice different field influences on different carbon atoms, we will conclude that the "stretch" is also different for each of the four compounds and that from butane onwards, there is more than one kind of carbon-carbon "stretch" *within* each molecule (one has but to observe the "pull" of neighbouring carbon atoms on one another and notice how it changes through all the structural transformartions that have been mentioned). Thus the bond itself, also represented by the same symbol (C-C for a single covalent carbon-carbon bond, C=C for double), is not exactly the same either. The notion of "stretch" will figure again as we further analyze the subtle tranformations of matter that remain hidden from the standard symbolic representation.

- There are other kinds of structural transformations that preserve the number and kind of atoms in a molecule. These transformations add another dimension to our analysis of the discrepancy between symbols that remain constant and that which the symbol signifies. The latter, as we have seen, is not always the same. Suppose we were to consider the case of cysteine, an amino acid that is a component of nearly all proteins. The chemical formula for cysteine is $HSCH_2CH(NH_2)COOH$, which may be compressed into $C_3H_7NSO_2$. When represented in two dimensions, the geometry of this molecule appears as a sequence of atoms linked in a chain, in a sequence that repeats the sequence of the symbols given in the extended formula above. As can be observed, there is a sulfur atom near one end of the chain, and a hydrogen atom at the other. Sulfur is negatively charged whilst hydrogen is positive. Opposites attract, and so a weak hydrogen bond can form between the two ends of the chain. The structure then waxes cyclical. The chemical reactivity of cysteine changes substantially depending on whether the structure is chain-like or cyclical. Yet the elemental symbols for both structures are exactly the same. These are not the only possibilities for cysteine. As it happens, there are many other geometrical possibilities for it intermediate between the fully stretched-out chain and the cyclical form. This is so because all but one of the thirteen bonds in a cysteine molecule are single bonds that have a rotational freedom of 360 degrees. In effect, this allows the formation of any intermediate structure along a continuum between the two extremes that have been considered. The continuum of geometric possibilities provides the cysteine molecule as a whole with the adaptability that allows it to attain a variety of stability points.

To appreciate the complexity of the computations involved in measuring the suppleness of a cysteine molecule, one must be able to simultaneuosly track the manner in which energy varies relative to the angle of rotation for each of the twelve single covalent bonds. Moreover, in order to measure the influences on the individual atoms that compose cysteine, for example hydrogen or carbon, each "stretch" between two neighbouring atoms must be imagined as a spring-like mechanism with a constant analogous to the proprotionality constant in Hooke's law (which states that the stress on a solid substance is directly proportional to the strain applied, provided the stress is less than the elastic limit of the substance). The mechanics of the molecule are then studied as a 14-body problem! From a mechanical point of view, the complexity of the molecule therefore increases at a staggering rate. A great many approximations are necessary in order to obtain results that agree with those of spectroscopy or quantum mechanics. Only with such results do we have a quantitative assessment of the peculiarities of hydrogen, carbon, nitrogen, oxygen and sulfur in the context of a cysteine molecule.

- The mechanical study of a cysteine molecule allows us to visualize it as an entity composed of fourteen elements vibrating at thirteen different frequencies (because of the "springs" that represent the bonds) with its sections free to rotate in countless different ways. The overall patterns of motion can thus be pictured as an elaborate dance. Yet this dance is quite simple when contrasted with that of the much larger molecules of which amino acids like cysteine are but the constituent parts. Such a larger molecule could be a protein or RNA or DNA. The movement of cysteine becomes a dance within a dance, and so there is a higher order of complexity relative to which atoms like hydrogen or carbon are again different from what they would be by themselves or within a relatively simple compound such as an alkane or amino acid. This defines yet another level of subtle transformations for those atoms, another way that the symbols we use to represent them are misleading.

The macromolecular "dance", for its part, takes on the aspect of time-relationships that form the basis for cellular behaviour. By the time we get to the level of a cell, the molecular mechanics are for all intents and purposes infinitely complicated. We have enetered the domain where the dance becomes life. The levels of complexity from amino acid to cell have been compressed here for simplicity's sake. For example, nothing has been said about the nucleic acid bases that compose RNA or DNA, and which themselves are *measurably* different in this context from what they are on their own. But we should have a clear idea by now of the many ways that the atoms that compose the macromolecules that are the backbone of life diverge from what they are on their own on the way towards increasingly complex contexts, of how little the symbols we use for them suggest those divergences, and some of the latter's significance on the physical, chemical and biochemical planes.[14]

Some of the foregoing constitutes a partial view of the range of physical and chemical states that we refer to by the symbol H or C. The metamorphoses that have been illustrated show that it is misleading for us to think of the hydrogen or carbon atom as a building block, for this popular metaphor conjures images of unchanging elements aggregated into ever more complex structures. Some have modified that metaphor by emphasizing the relational component of the so-called building blocks. This is not good enough. There is something *within* the atoms that changes along with their molecular context. If we are to persist with the metaphor of building blocks, then these must have a suppleness that is in flagrant contradiction with the logic of the word "block". We need a new metaphor, one that captures the sense in which an atom like hydrogen has the sort of structural elasticity that would allow it to change according to its molecular context. Hydrogen *already* is potentially all that it becomes throughout its various metamorphoses. It already has whatever it takes to take on a physical, chemical or biochemical aspect. In some non-trivial sense, those aspects must be incorporated into the definition of hydrogen. In that definition, the physical, the chemical and the biochemical are intertwined. We do not then have an element, certainly not in a strict sense, but an *envelope of possibilities* whose realization is determined by several kinds of molecular configurations.

With the concept "envelope of possibilities" and the illustrations that brought it forth, we are able to go further than we could following the discussion of macroscopic properties such as conduction, insulation, ductility and luster. There we were able to extract a preliminary sense of the suppleness of whatever it is that gives rise to material phenomena, or the substratum. We could at least claim that there had to be something other than seemingly identical particles, either along or interwoven with them, which accounts for marked macroscopic differences. But here, in our examination of the metamorphoses of atoms like hydrogen or carbon, we have in our possession a detailed example of that "something extra" *changing* according to its molecular context. We can actually "see" the envelope of possibilities unfold as the molecular configuration gains in complexity in the transition towards the biological domain. This establishes the existence of something akin to the continuity that Plotinus thought ought to be at work in matter in the first place to account for the fact of unity despite great complexity (the various constituents are integrated into a whole and do not simply fall apart as they must if we confined ourselves to the mechanistic picture of aggregation). The preexisting envelope allows the particles to shape themselves in a manner that makes greater complexity (or higher unity) possible. This envelope is revealed as we observe the changes that the particles undergo on the way to the biological. It could also be said that there are layers of information packed into particles and made manifest in the extraordinary morphological elasticity elicited by many kinds and levels of molecular configurations. We shall presently come across some more examples that will explode the notion of a particle altogether and strongly suggest that as an envelope of possibility, a particle is better thought of as a virtual slice of a seamless informational continuum. To anticipate a little, we may call up the quantum mechanical image of a particle such as a photon or electron as existing in a range of infinite pathways. For it seems that the geometric "haze" surrounding particles contains part of the secret of their morphological elasticity. But only a part, for there is another side to the story.

And so we turn to the molecular configurations themselves. Is there any other point of view from which we can consider the various levels of molecular complexity such that their configurations play yet another role in our efforts to define matter? It turns out that there is. The answer suggests itself as we examine how many configurations there are to choose from at a given level. If we return to our example and once more begin with the case of methane, it turns out that there is only one configuration to choose from given the five atomic fields and the relevant quantum mechanical laws. But as we move deeper into the domain of macromolecules, the determinations for their configurations are far from such simplicity. The choices of configuration for a given number of atoms that are to form larger macromolecules can be so numerous as to be continuous. Already for cysteine, a relatively simple molecule, we saw that there is a continuum of possible configurations between the chain-like or cyclical structures. Even a set configuration may not have a determined function, for a chain of nucleic acid bases (adenine, guanine, cytosine and thymine/uracil) means different things according to the context. How are the configurations for macromolecules then chosen when there are so many possibilities? If we are talking about cells, then we must introduce three extraneous notions: form, the historical selection of forms up to that point, and the environment specific to the cell, which we may call an "ecoment."[15] Form, history and ecoment combine to choose an appropriate configuration for a cellular macromolecule.

In the language that we have been using here, the "matter" of a macromolecule must somehow be so supple that it is susceptible to being shaped by forms that do not yet exist according to its specific future surroundings and the history leading up to that future event (which narrows down the pool of possibilities). This is not just true of the molecular components, nor even of the atoms that form them, but of whatever underlies those atoms. For the substratum itself must be able to form atoms that would later conform with the requirements for highly complex forms to function appropriately in an ecoment that has its own history. If we take this insight to its logical conclusion, we may assert that the substratum from the very beginning must be such that it can acquire the form of human beings and all derivative forms, indeed the form of the entire universe. Relative to all forms that it would acquire, the substratum or "prime matter" must have unlimited suppleness. It must, as Anaximander thought, be boundless or infinite; and remembering that he, unlike Aristotle, did not have the conceptual distinction between matter and form at his fingertips, it turns out that Anaximander's thought is more suitable for our purposes. For according to the foregoing illustration, it will not do to speak of prime matter in isolation from form, since the two turn out to be intermingled. In some sense, matter (prime or otherwise) already "knows" the form that it would acquire, and such reasoning can be carried through every level of complexity right up to that of human beings and the universe as a whole.

We have stumbled upon the foundation for the age-old doctrine that holds the macrocosm to be contained or reflected in the microcosm. A late development of that doctrine was laid out in the philosophy of Leibniz. What concerns us here can be sketched as follows: The world primarily consists of incorporeal, indestructible, indivisible substances called monads. Since Leibniz believed the world to be a plenum, he thought that all monads act on one another, indeed that everything in the world is interconnected. Each monad represents its point of view of the whole universe.[16] In the *Monadology*, he makes the distinction between an object and knowledge of an object and then asserts that monads are only limited with regard to the latter. They do have a non-trivial representation of and relation to the whole nevertheless.[17] In the *Discourse on Metaphysics*, Leibniz makes the more abstract claim that every substance (or monad) "is like an entire world" and that "the universe is multiplied in some sort as many times as there are substances."[18]

Leibniz' vision does not seem quite so laughable when sketched in the company of recent scientific thinking. Such thinking does not permit us to literally assert that the macrocosm is contained in the microcosm (and it is doubtful that Leibniz meant this literally anyway). But it does permit us to posit a nontrivial link between the macrocosm and the microcosm: The humblest speck of matter, to the extent that prime matter underlies it, and in that prime matter is in a state amenable to the assumption of all possible forms, including those of human beings and the entire universe, must in some non-trivial sense be informed by the totality of forms - else how does it have such boundless morphological suppleness *from the outset*? How can prime matter fail to have (or be interwoven with or receptive to) some kind of prescience of the entire panorama of evolutionary emergences if it would acquire all the forms it has actually assumed throughout the ages and shape the tiniest constituents accordingly?

These last remarks can not be interpreted to mean that the forms of all things and of the universe as a whole are *literally* present in the substratum before they come into being. No homunculus theory is being reproduced for the entire universe.[19] What has been proposed so far is the following: (1) There is a lot more to material "constituents" than what is captured by the metaphor "building blocks". (2) This "something extra" renders the constituents morphologically elastic with regard to a great many different material situations and must for that very reason be dynamic (otherwise how it can it have the *simultaneous* potential to become many things?). (3) The examples that have been given suggest that the constituents are best seen as envelopes of possibilities that are open to a seamless informational continuum. (4) These envelopes contain the "seeds" for the various configurations that matter would assume as well as for the environments (or ecoments) that would determine those configurations.[20] (5) The entire process must be driven by what I have elsewhere described in terms of an infinite gradient in combination with an infinite coherence that seem present in nature (the gradient accounting for the limitless energetic and/or other differences that are available for the generation of higher levels of organization the potential coherence of which again seems limitless, thus suggesting that there is no limit to the coherence that can be drawn out of nature in the process of complex unfoldings).[21]

Let us leave such abstract questions for the moment and return to what some contemporary physicists have been saying. It may be possible to represent the suppleness of matter to a certain degree, even though prime matter might have to remain elusive. We have earlier spoken in terms of an "envelope of possibilities." This concept was intended to capture the fact that particles have turned out not to be elements in the strict sense, nor building blocks in any logical sense of the term, but envelop intertwined physical, chemical and biochemical possibilities that are realized according to the ultimate molecular configuration and in the proper surroundings. We can now illustrate the concept "envelope of possibilities" at the level of physics through the use of some well known theories and experimental findings. Moreover, we will be able to concretize to a certain degree what was mentioned earlier about particles as "virtual slices of a seamless informational continuum."

At the turn of the century, the atom was thought to have a structure that repeats that of the solar system in miniature: electrons in fixed orbits around a nucleus that was later found to consist of protons and neutrons (which, crucially, are bound together by mesic fields, yet another indication that at no level do we find matter constituted as a mere aggregate).[22] But electromagnetic theory predicted that in such a structure, the electrons would rapidly lose the energy that they must radiate when in orbit and would consequently spiral into the nucleus. The discovery of quantized energy levels simply affirmed that no such losses occurred, but did not really explain the phenomenon. It was finally put forward that those levels are quantized and electrons are free to move within them without loss because of the wave nature of particles. This causes standing wave patterns to form around the nucleus, into which the electron wave happens to fit. The transition of electrons from one energy level to another then corresponds with a shift in that pattern.[23]

The new model of the atom presents us with a complex of waves that prescribes an internal quantum dynamics for which the phenomenon of resonance in music seems to be an appropriate metaphor. We no longer have before us a structure in the "hard" sense, but a far more fluid envelope that, precisely because of its fluidity, allows not only fixed patterns to emerge that define the characteristics that have been made manifest in the arrangement known as the periodic table of elements, but also exceptions that are the basis of, for instance, the macroscopic behaviour of metals.

Thomas Young's famous two-slit experiment has served as a model for analogous experiments performed on electrons or photons. These have led to results that have deepened our conception of the suppleness of matter, for it bears on the identity of elementary particles smaller than atoms. Three sets of results concern us here and will be briefly recapitulated. First, if a beam of electrons or photons is fired from a source towards a screen in which two slits have been opened, and they continue towards a second parallel screen that registers their impact, an interference pattern appears that confirms the wave-like nature of matter. Second, if the intensity of the beam is reduced such that only a single electron or photon is fired at a time, the second screen naturally registers a series of specks that seem to be random at first, but with time reveals those fragments to be part of none other than the same kind of interference pattern that was witnessed when a far more intense beam was fired at it. Third, if one slit is blocked but the same process is otherwise maintained, the interference pattern is destroyed. How is this possible?

It looks as though each electron or photon "knows" whether one or both slits are open and depending on this either forms what turns out to be part of the interference pattern characteristic of waves or fails to do so. But how could something like that have knowledge? The uncertainty principle provides a clue, for it has helped reveal that electrons and like entities do not move along a distinct path in space. They can not be said to travel along a path that continuously joins the points at which they are detected as would be the case with macroscopic bodies. Thus it is thought that each electron or photon is in possession of an infinite number of (virtual) paths all of which contribute to its behaviour. Each is an envelope of countless possible movements, so that it is able to detect the shape of the relevant region of space, however large (It could be the size of the whole universe). Hence it will have the capacity to detect how many slits are open and will behave accordingly.[24] We thus come to see an electron or photon as an envelope of (quantum) dynamical possibilities that, as a bundle of infinite virtual movements, is able to measure out its (spatial) domain and reflect the latter's features in its own shape or aspect. Hence the particle carries information about the whole region of space that affects it.

Just as one can think of an electron or photon in terms of the totality of movements that are possible for it, so can one think of the wave function for such an entity as a totality of parts into which it splits depending on the circumstances. One of these parts represents the entity in its particle aspect and enables us to speak of an independent reality. All parts together are called the *quantum potential* for that entity. Mechanics can thus be seen as an abstraction from the quantum potential, whereby it is collapsed into a single component, namely that which represents the corresponding entity as a particle. As we have seen in the foregoing analysis of the results of the two-slit experiment, the wave function must carry information about the whole region of space that affects the particle. Since several particles may occupy that space, say a gram-mole, then the quantum potential within that region is the sum of all the parts of the wave functions for 10^{23} particles in three dimensions. Within that same region, we may then define a *quantum field*, so that quantum mechanics becomes a study of the diverse quantizations of that field.

With the introduction of the quantum potential and quantum field into our discussion, we are offered another glimpse at the substratum. Its measurable face is given in the quantum potential, itself of an unimaginable order of complexity even for a small region of space (such as that occupied by a gram-mole of particles). And we have yet to include such phenomena as non-locality (or non-separability) and non-linearity. The quantum potential allows quantized matter to form such a fine and sophisticated dynamic mesh that the minutest features of the surrounding space can be detected, reflected in the consequent behaviour of matter, and presumably transmitted as information. And yet we remain at least one degree removed from the real suppleness of matter since the quantum field *underlies* the quantum potential and the latter reflects only the measurable features of the former according to increasingly clever mathematical analogies that have been contrived to wring out those minutae and discover that they are sometimes governed by symmetries, which has in turn paved the way for further discoveries.[25]

David Bohm has called the substratum that some take to be the quantum field *the implicate order*.[26] Given that the gravitational field is one of the four known manifestations of the substrate field, and that it extends throughout the universe, Bohm has seen it fit to extend the notions of quantum potential and quantum field to the universe as a whole. The observable material universe is then a collapsible component of the universal quantum potential, itself the measurable aspect of the underlying universal quantum field or implicate order. He has pictured the universe as "ripples on top of a vast sea of fiery energy." Photons, electrons and the whole of matter unfold from and fold back into that "sea." The fundamental or implicate order, he continues, then stands related to matter as meaning to words.[27]

Eminent physicists like Bernard d'Espagnat have criticized Bohm because the latter's theory does not accommodate the phenomenon of consciousness adequately,[28] and provides for an infinity of potentially measurable events that have not been accounted for.[29] However, one must bear in mind that d'Espagnat is certainly not averse to characterizing the substratum in non-material and even non-physical terms.[30] He goes so far as to say that the esoteric language typical of poetry and myth is more promising in our efforts to portray what he calls *veiled reality*.[31] But like Bohm, he believes that there is a sea of immateriality that underlies all measurable phenomena. George Farre is more understated in his choice of expression for the substratum, which he calls *radiant energy*.[32] In his view, radiant energy condenses into the quantum phenomena such as charge that compose the intrinsic properties of matter.[33]

We may beg to differ with one or more of those physicists on one or more counts. But there seems to be no escape from two emergent ideas: the extraordinary suppleness of matter, and the ineffable nature of the substratum that Aristotle called "prime matter." If the substratum is indeed one, and many respectable hypotheses converge at such an insight, and if it can be said to encompass the meaning of measurable phenomena, then there is some non-trivial sense in which the meaning of the whole is present in the smallest measurable part.[34] This sense becomes manifest as we track cascades of emergent matter up the ladder of complexity and find out that from the very beginning, the smallest entities had the potential to enter certain molecular configurations and later perform certain functions and still later find out what these are.

Meanwhile, what we have gained is a partial and provisional concrete representation of the "seamless continuum of information" that was mentioned earlier, and how what we call particles are related to it. We may now think in terms of envelopes of countless quantum dynamical possibilities (or "paths" of virtual motion) on the surface of and underlain by a universal quantum field or a still more abstract "implicate order." A simpler picture is provided by Farre's portrait of radiant energy condensing into quantum phenomena such as charge. But even with the more ambitious Bohmian vision, d'Espagnat's criticism notwithstanding, we would still fail to account for something that is manifestly there as we saw in our earlier examples. Were we to accept the idea of an implicate order and the claim that it stands related to matter as meaning to words, we would still be at a loss to account for the macroscopic properties of things such as metals and even less able to explain the kind of information that becomes embodied in macromolecules and living organisms. We need to go beyond an all-purpose claim that the meaning of material phenomena is contained in the ultimate substrate and produce a more *active* principle that accounts for matter's morphological elasticity and the coherence of the structures and surroundings into which it metamorphoses.

Our first hint comes from the physicists themselves, for they tell us that something latent in the substratum becomes manifest first as abstract symmetries (on the assumption that these themselves do not constitute the most primitive level) and then in various geometric configurations. Thus there are latent forms within the implicate order some of which at least can be described by higher order geometries. Some physicists suggest that the substratum also condenses into strings that have the structural regularities that allow them to be carriers of information and thus shape increasingly elaborate forms to generate more complex phenomena such as cells.[35] In a similar spirit, the metaphor of indestructible humps traversing the universe called "solitons" is put forward to account for the relationship between the (smallest) parts and the whole as well as the structural regularity of the parts.[36]

Those geometrical or quasigeometrical approaches to the substratum that many contemporary physicists favour have an appealing crystalline aspect. They also happen to vindicate the Platonic vision to an amazing degree as they place it within an entirely new perspective. For it was Plato, following the Pythagoreans, who saw ultimate reality in geometric terms and thus produced his theory of Forms. According to this traditional interpretation of Platonism, the key to all visibile phenomena lies in some higher geometrical order that transcends them. But is that what he really believed?

A few contemporary scholars are at last beginning to interpret the theory of Forms in a manner more faithful to what might have inspired it. For surely Plato's gifts were such that he could not have founded his whole philosophy on something that later generations would so easily regard as ridiculous. For one thing, the Forms could not have been archetypes in the literal sense. To render them in abstract mathematical terms is a step in the right direction. But geometry alone, at whatever level, rings hollow. It does not even account adequately for the quantum dynamical suppleness of matter. We are still lacking an active principle compatible with the genesis and formation of observable phenomena (all the more so in our day now that morphological suppleness and organizational coherence have become so richly illustrated). Thus, argues John Dillon,

> [i]t seems to me possible that what [Plato] envisaged, but was not prepared to be specific about, was not so much a series of discrete Forms, whether of abstract ethical or mathematical concepts, natural kinds, or anything alse, but rather a matrix of formulae, of a mathematical nature, which, when projected on the Receptacle (however we are to understand that - perhaps the principle of extension), will produce, primarily the basic triangles, and secondarily physical objects of all sorts.[37]

We may notice the striking similarity between Plato's metaphysics and the worldview of many contemporary physicists, who think in terms of a substratum defined in highly abstract mathematical terms which condenses into particles that then form the physical objects that we actually encounter. However, we need to go further than this picture allows, and Plato sets us on our way. The idea of a *matrix* of formulae, especially if the meaning of 'formula' were not collapsed into its mathematical dimension, helps us; but not enough. Dillon's interpretation is given in the course of an essay on Plotinus, and it is in the latter's work that an active principle truly comes to light. Plotinus, we may recall, demanded an explanation for the continuity observed in the world (and connected this with the continuity underlying it). We may transpose this into a demand for a more holistic conception of form that is consistent with the latent capacity of nature to form beings such as cells and higher organisms, especially that these require increasingly elaborate ecoments to shape and sustain them. If the "matrix of formulae" of which Dillon speaks were seen to include holistic segments, it can then inform the long condensation path of the substratum (or evolutionary history), and of course it would have the potential to do so from the outset. For we have seen that some of the milestones along that path are in some sense laid out before the process of material unfolding is underway. The unfolding then heads inexorably towards providing constituents shaped such that they might be gathered into beings striking in their complexity and coherence. In a process that must begin with the holistic segments within the "matrix of formulae", we have the rudiments for an active principle as well as a contemporary understanding of what must have spurred Plato and Plotinus to speak of "archetypes". The continuity and wholeness of the universe itself would then suggest that the entire matrix must be regarded holistically. This would render Plotinus' Mind not quite so outlandish to our minds.

Whatever slant we choose to put on what has just been said, something in its spirit would be necessary to provide the active principle without which the substratum would remain frozen in a web of highly abstract geometries (which some imagine to be the absolute zero state of the universe). And so, with the archetypal metaphysics of Plato and Plotinus recast in suitable contemporary terms and its dynamic potential fully brought out, the seamless informational continuum is seen for what it is, as truly inFORMational, enfolding the key, mathematical or otherwise, to emergent forms.

NOTES

1.Henri Frankfort, H. A. Frankfort, et al, *The Intellectual Adventure of Ancient Man: An Essay on Speculative Thought in the Ancient Near East* (Chicago: The Univ. of Chicago Press, 1977), 377.

2. The emergence of metaphysics in the context of an intellectual evolutionary framework is marvelously presented, convincingly argued and very well documented in Paul Seligman's *THE APEIRON OF ANAXIMANDER: A Study in the Origin and Function of Metaphysical Ideas* (London: Univ. of London/The Athlone Press, 1962), for example 130-148, but the whole book should be read to appreciate the momentous development embodied in Anaximander's idea of the *apeiron.*

3. Aristotle, *Metaphysics* 1029a: 20-5, reprinted for example in *A New Aristotle Reader*, ed. by J. L. Ackrill (Princeton: Princeton Univ. Press, 1987), 286-7. I have inserted the words in brackets for the sake of clarity since there is no room here for an exegesis of this passge.

4. Aristotle might have observed that whereas an acorn or a dolphin embryo depend on their respective surroundings in order to develop into adult beings, and that they do so in their own time and *grow* and *change* along the way, the materials that go into building a house are *already* enough to build the whole house and the timeframe in which it is built is very flexible . . .

5. Ibid., 1049b: 1 to 1050a: 23, for example in Ackrill 329-331.

6. It is true that Plato also separated matter from form, and if anything did so in starker terms than Aristotle. But Plato did not develop a sophisticated theory of matter that the materialistically inclined could later work with.

7. Werner Heisenberg, "Natural Law and the Structure of Matter," in *Across the Frontiers* (New York: Harper and Row, 1974), 104.

8. See Patrick Suppes, "Aristotle's Concept of Matter," *Synthese 28* (1974), 46-7.

9. Heisenberg, 115.

10. The lecture was delivered on December 13, 1994, as part of a series given by physicists who have been awarded the Nobel Prize and who were asked to speak about recent developments in their respective fields.

11. William Berkson, *Fields of Force* (London: Routledge and Kegan Paul, 1974), 91-2.

12. Plotinus, *The Enneads* II.4:7, trans. Stephen MacKenna (Burdett, NY: Larson Publications, 1992), 123-4.

13. Why this is so is itself reason for wonder, for the physical properties that determine how many electrons are required for an atom to become stable in a molecule are themselves derived from the Pauli Exclusion Principle, which states that no two electrons can have the same quantum state if they are to be at the same energy level, has been entirely borne out by what we know about all the elements in the periodic table, and can not be attributed to any force. The Pauli Exclusion Principle is a rule that deeply determines the structure of the periodic table of elements and yet there is no way to account for it physically. At a seminar at the Krasnow Institute at George Mason University on March 24, 1997, Harold Morowitz called it a "noetic principle." The implications of his reflections deserve lengthy consideration in a separate work.

14. I owe much of the information conveyed in this section to Jerry LR Chandler, a professional chemist who patiently pointed out the distinctions that I have emphasized in a conversation on January 11, 1997, and further refined them in another long meeting on March 20, 1997. While Chandler's interest in those distinctions is centered on the need to find a more adequate symbolic representation for atoms and molecules so that the subtle transformations that they undergo in different contexts are made manifest, it is clear that they also present a wonderful display of the suppleness of matter.
15. Again, I am grateful to Jerry LR Chandler for making me aware of these important findings and ideas. The term "ecoment" has also been coined by Chandler. It is etymologically related to 'economy', which meant 'home' in ancient Greek. 'Ecoment' is therefore intended to convey the notion of a *home* for things. It implies the inclusion of the immediate surroundings *even in the representation of an element*. There are different "neighbourhoods" for the different states of hydrogen or carbon. This in turn suggests that the elementary constituents of matter can not be represented as points. In the remainder of this paper, I shall develop my own account of the (implicit) ways that matter is inadequately represented when thought of as an aggregate of points.
16. Gottfried Wilhelm Freiherr von Leibniz, *The Principles of Nature and of Grace, Based on Reason* (1714), § 1-3. Reprinted in *Leibniz: Selections*, ed. by Philip P. Wiener (New York: Charles Scribner's Sons, 1951), 522-3.
17. Leibniz, *Monadology* (1714), § 60-1. Reprinted in Wiener, 545-5.
18. Leibniz, *Discourse on Metaphysics* (1686), § IX. Reprinted in Wiener, 301.
19. The clarifications in this paragraph were inspired by the intervention of Stanley Palombo after I presented parts of this paper at a scientific symposium on February 15, 1997. As ever, he is concerned that no homunculus theory find its way through one of the many backdoors of science.
20. Why this does not mean that the configurations are literally contained in the packets will hopefully become clear in the course of my concluding remarks.
21. See Richard K. Khuri, "A philosophical examination of the idea of emergence," in *Actes du Symposium ECHO: Emergence-Complexité Hiérarchique-Organisation: Modèles de la boucle évolutive*, edited by Andrée C. Ehresmann, George L. Farre and Jean-Paul Vanbremeersch (Amiens: Univ. de Picardie Jules Verne, 1996), 108-114.
22. Similarly, the quarks that compose nucleons are bound together by gluon fields. There is simply no escape from a binding agency over and above the constituent parts that have been discovered in such abundance in our century.
23. See *The Ghost in the Atom*, ed. P. C. W. Davies and J. R. Brown (Cambridge, UK: Cambridge Univ. Press, 1986), 2-3.
24. Ibid., 7-9.
25. See for example Mark Steiner, "The Application of Mathematics to Natural Science," *The Journal of Philosophy LXXXVI* (Sept. 1989), no. 9, 449-480.
26. David Bohm, *Wholeness and the Implicate Order* (London: Routledge, 1980).
27. Some of what is said here was communicted by Bohm at a lecture he gave in Berkeley on April 22nd, 1983. And some of that agrees with what is mentioned in an unpublished paper by George L. Farre entitled "Cosmic Evolution and Symmetry", the second draft of which he kindly passed on to me.
28. Bohm's theory would not be able to account for even more primitive biological phenomena such as nutrition and perception.
29. Bernard d'Espagnat, *In Search of Reality* (New York: Springer-Verlag, 1983), 90-92.
30. See for example d'Espagnat, 94 and 96-7.
31. Ibid., 105-6.
32. See Farre, *passim*.
33. Ibid., 7.
34. As has been mentioned earlier, this makes Anaximander's conception of the *apeiron* more pregnant with contemporary interpretational possibilities than Aristotle's prime matter.
35. Phillip W. Anderson, "More Is Different: Broken symmetry and the nature of the hierarchical structure of science," Science 177 (Aug. 4, 1972), no. 4047, 395.

36. Paul Davies and John Gribbin, *The Matter Myth* (New York: Simon & Schuster[Touchstone], 1992), 47-62.
37. Dillon, "The Mind of Plotinus," from *Proceedings of the Boston Area Colloqium in Ancient Philosophy*, ed. John J. Cleary (Lanham, MD: Univ. Press of America, 1986), 1:336-7.