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Beyond Descartes and Newton: Recovering Life and Humanity

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Abstract

Attempts to 'naturalize' phenomenology challenge both traditional phenomenology and traditional approaches to cognitive science. They challenge Edmund Husserl's rejection of naturalism and his attempt to establish phenomenology as a foundational transcendental discipline, and they challenge efforts to explain cognition through mainstream science. While appearing to be a retreat from the bold claims made for phenomenology, it is really its triumph. Naturalized phenomenology is spearheading a successful challenge to the heritage of Cartesian dualism. This converges with the reaction against Cartesian thought within science itself. Descartes divided the universe between *res cogitans*, thinking substances, and *res extensa*, the mechanical world. The latter won with Newton and we have, in most of objective science since, literally lost our mind, hence our humanity. Despite Darwin, biologists remain children of Newton, and dream of a grand theory that is epistemologically complete and would allow lawful entailment of the evolution of the biosphere. This dream is no longer tenable. We now have to recognize that science and scientists are within and part of the world we are striving to comprehend, as proponents of endophysics have argued, and that physics, biology and mathematics have to be reconceived accordingly. Interpreting quantum mechanics from this perspective is shown to both illuminate conscious experience and reveal new paths for its further development. In biology we must now justify the use of the word "function". As we shall see, we cannot prestate the ever new biological functions that arise and constitute the very phase space of evolution. Hence, we cannot mathematize the detailed becoming of the biosphere, nor write differential equations for functional variables we do not know ahead of time, nor integrate those equations, so no laws "entail" evolution. The dream of a grand theory fails. In place of entailing laws, a post-entailing law explanatory framework is proposed in which Actuals arise in evolution that constitute new boundary conditions that are enabling constraints that create new, typically unprestatable, Adjacent Possible opportunities for further evolution, in which new Actuals arise, in a persistent becoming. Evolution flows into a typically unprestatable succession of Adjacent Possibles. Given the concept of function, the concept of functional closure of an organism making a living in its world, becomes central. Implications for patterns in evolution include historical reconstruction, and statistical laws such as the distribution of extinction events, or species per genus, and the use of formal cause, not efficient cause, laws.

Key Words: Phenomenology; endophysics; quantum mechanics; measurement; functional closure; adjacent possibles; enabling constraints; purposeless teleology; statistical laws

Recent efforts to naturalize phenomenology have both opened new directions in cognitive science and revived interest in phenomenology. While inspiring major work in the area, this revival raises questions about what is phenomenology, whether phenomenology can be naturalized, and what is the significance of a naturalized phenomenology. Edmund Husserl, the founder of the phenomenology movement, was clearly hostile to naturalistic approaches to consciousness, logic and mathematics. As he wrote in 'Philosophy as a Rigorous Science', criticizing Ernst Häckel and Wilhelm Ostwald in particular:

> Characteristic of all forms of extreme and consistent naturalism, from popular naturalism to the most recent forms of sensation-monism and energism, is on one hand the naturalizing of consciousness, including all intentionally immanent data of consciousness, and on the other the naturalizing of ideas and consequently of all absolute ideals and norms. From the latter point of view, without realizing it, naturalism refutes itself' (Husserl, 1965, 80).

For Husserl, the naturalistic attitude was something that had to be accounted for from a transcendental perspective. As he put it in one of his most important series of lectures, *Cartesian Meditations:*

> Natural being is a realm whose existential status [*Seinsgeltung*] is secondary; it continually presupposes the realm of transcendental being …. The Objective world, the world that exists for me, that always has and always will exist for me, the only world that ever can exist for me – this world, with all its Objects … derives its whole sense and its existential status, which it has from me, from me myself, from me as the transcendental Ego' (Husserl, 1973, 21, 26).

This rigorous form of Idealism, arrived at in part through radicalizing Descartes method to arrive at the transcendental ego as the foundation and starting point for all philosophy, provoked a reaction. A branch of the phenomenological movement inspired by Husserl rejected his Idealism and developed a profound critique of Cartesian dualism. They rejected Descartes' claim that mind, *res cogitans,* and matter, *res extensa,* are totally different kinds of being. Those taking this path concluded that consciousness is socio-historically situated and incarnate, part of and participating in nature, and both consciousness and nature must be reconceived accordingly.

The development of endophysics has also challenged Cartesian dualism, but from the opposite direction. As articulated by Max Planck, objectivity in physics involves 'the complete separation of the world from the individuality of the structuring mind; i.e. the emancipation of anthropomorphic elements. This means: it is the task of physics to build a world which is foreign to consciousness and in which consciousness is obliterated' (H. Bergman, quoted by Rosen, 1999, 82). Biologists embraced this idea of science and sought to explain life in terms of chemistry and physics. The consensus view was summed up in the preface to a committee report to the National Academy of Sciences in 1970: 'Life can be understood in terms of the laws that govern and the phenomena that characterize the inanimate, physical universe, and indeed, at its essence, life can be understood only in the language of chemistry' (Philip Handler, quoted by Rosen, 1999, 82). This conception of objectivity was underpinned and reinforced by conceiving mathematics as totally objective and impersonal. It was this very quest for complete objectivity has forced physicists and mathematicians to recognize the necessity of including the observer inside this supposedly objective reality of nature and mathematics, both facilitating and limiting what can be observed and known. This became evident in relativity theory where the observer's reference frame has to be incorporated into the theory. It also became evident in mathematics where Hilbert's program of reducing mathematics to objectively describable syntactical relations foundered on the recognition that what is modeled in this way is always more than the model is able to prove. However, it was quantum theory that brought home most completely the inescapability of acknowledging that the observer is part of what is being observed. As David Finkelstein, who coined the term 'endophysics' put it: 'In quantum theory, physics at last recovers from Descartes' fever. Its Nature cannot be completely described. Its language does not picture being but records deeds, including input-output operations that we have done' (Finkelstein, 1993, 5).

It is the convergence of post-Idealist phenomenological philosophy and post-reductionist science that has enabled researchers to link the two together to develop a post-Cartesian conception of cognition.

However, this is only a starting point, bringing into sharp focus the problems and challenges that lie ahead in acknowledging that nature is not merely a mental or cultural construct but has engendered mental and cultural constructs, requiring the development of a conception of nature that does not commit its adherents to explaining away the reality of life, mind and culture. Addressing these problems and embracing these challenges should illuminate all aspects of biology, both in terms of what it is being investigated and how life should be examined and understood. This should open up new questions about what consciousness is, what is scientific inquiry, what it is to understand anything, what mathematics is, what is its relation to physical existence, life, sentience and consciousness, and what its role should be in scientific inquiry and explanation. A start can be made in this by examining the confluence engendered by the logical unfolding of inquiry that drove phenomenologists to embrace naturalism and drove scientists and mathematicians to endophysics, and the insights generated by this confluence, revealing the assumptions that have to be overcome and what new paths are opened up by transcending these assumptions.

From Transcendendal Phenomenology to Naturalized Phenomenology

While transcendental phenomenology is one of the most rigorously formulated Idealisms ever developed, characterizing it, and then showing why phenomenologists rejected it and came to embrace naturalism, is anything but simple. Husserl attempted to clarify what he meant by phenomenology in his essays, and the sequence of essays reveal the trajectory of his thought. However, there were a number of strands to his thought. Originally he was more aligned with realism than Idealism, and many of his followers never embraced Idealism, rejecting his transcendental turn and developing their own original approaches to phenomenology. While Husserl criticized these, he himself was influenced by their work, an influence manifest in his late interest in the historicity of human subjectivity and the life-world. To fully understand what is at issue in the opposition between Idealism and naturalism in phenomenology, and the significance of this for developing a post-Cartesian, post-Newtonian naturalism, it is necessary to understand the original ambition of Husserl in developing phenomenology.

Husserl was originally a mathematician who turned to philosophy to account for the certainty, absoluteness and universality of mathematics and logic given that these are the products of particular human minds, and to oppose a tendency in philosophy towards relativism and skepticism, not only about knowledge, but also about ideals. There were two questions that had to be answered by a philosophy of mathematics: How do mathematical and logical concepts originate? and then What is the nature of the formal patterns within which these concepts function? That is, what is their relation to the world. Husserl found the beginnings of the philosophy that he was looking for in the work of the Aristotelian philosopher, Franz Brentano. From Brentano he embraced the concept of the intentionality of consciousness according to which consciousness is always directed to some 'object' that is other than consciousness; whether a perceived physical existent or an abstract mathematical concept. Acts of consciousness and objects constituted by these acts are inseparable correlates. Whatever these objects are, they have an ideational component and are seen in relation to generals and their possibilities and the relations between these. Husserl's first efforts to characterize mathematics were severely criticized by Gottlob Frege for confusing cognitive acts and the objects of knowledge; therefore not adequately acknowledging the objective nature of logical and mathematical truths. It is these problems that led him to study logic as the formal aspect of deductive argument, and as such, the necessary condition for any enquiry that claims to be scientific. In Husserl's first major work, *Logical Investigations* (1970a), there were two avenues of approach to these topics; reflection on psychic life, particularly perception, and reflection on logic. Neither of these avenues was ever abandoned. Although perception was always investigated in relation to the problem of ideality, to begin with, Husserl assumed it could be investigated in the context of belief in the natural world. However, a third avenue into phenomenology was investigated, a reflection on self in which belief in the natural world was brought into question and transcendental phenomenology, a form of Idealism, defended. This began with the published *Ideas* and continued with the unpublished *Ideas II* and *Ideas III* and was defended in its most extreme form in *Cartesian Meditations*. Then in *The Crisis of European Science and Transcendental Phenomenology* Husserl introduced a fourth avenue into phenomenology - analysis of a primordial ‘life-world’ (*Lebenswelt)* as the foundation and condition of all abstract thinking (Husserl, 1970b). While designed to support transcendental phenomenology, it weakened its claim to achieving apodictic (i.e. incontestable because demonstrably true) knowledge.

For Husserl (as for Charles Sanders Peirce, another proponent of phenomenology), phenomenology begins with a presuppositionless description of phenomena (although he later saw this as more complex). In carrying this out Husserl was concerned to avoid assuming the ‘natural attitude’ according to which appearances are of a physical world structured by space, time and causation. He also wanted to make explicit the hidden presuppositions concerning reference to the world implicit in the meaning of current formal logic, disguised by claiming that the realm of logic is radically distinct from matters of fact (Tito, 1990, 2f.). Free of such assumptions and presuppositions, it is possible to recognize the descriptively valid status of general meanings and a mode of consciousness that directs itself to these general meanings. This is what Husserl referred to as the ‘intuition of essences’. The intuition of essences, or ‘the eidetic reduction’, involved free imaginative variation of each ‘eidos’ (idea, essence or concept) without radically changing the object-meaning; to reveal what elements are necessary to these and thereby to clarify eidetic structures. Following this, the essential relation between essences could then be revealed. Husserl’s characterization of this intuition of essences reveals the influence on him of his work in mathematics in which such imaginative variation is essential to understanding and developing mathematical concepts and relations between them, and his notion of the intuition of essences is really a generalization of this to grasping the meaning of all objects of experience. The aim of Husserl’s phenomenology, as Ronald Bruzina put it, was ‘a presuppositionless clarification of the essential structure of consciousness as capable of having essential structures as its object; or, in other words, as eidetic clarification of consciousness in all its forms, including its summit activity, grasp of eidetic structures – essence-intuition’ (Bruzina, 44).

Transcendental Phenomenology

In his quest to achieve greater clarification, Husserl in *Ideas* introduced a further reduction, the ‘phenomenological reduction’. This involved ‘bracketing’ (*epoché*) all assumptions concerning both transcendental being and physical existence, leaving only pure consciousness with its acts and correlates of these acts. A further ‘bracketing’ excluded intentional activities associated directly or indirectly with other subjectivities (Husserl, 1982, 60ff., 113). These ‘bracketings’ were designed to reveal a realm of primordial transcendence in which only those actual and potential intentionalities remain in which the ego is constituted in its proper sphere. For Husserl, this was seen to provide the ultimate foundation from which it would be possible to examine the constitution of the empirical subject, other subjects, the existing life-word, values and ideal objects such as those of logic, mathematics and the sciences. Achieving this, Husserl believed, would make phenomenology into a rigorous science able to explicate the possibility of and foundations for all other domains of inquiry; including, logic, mathematics and science and the ideals of ethics, showing their limitations and their relations to each other. This is phenomenology as transcendental Idealism.

Many of Husserl’s erstwhile followers not only refused to take the path that led to this transcendental Idealism, but offered searching critiques of Husserl’s work and reformulated what they took to be the project of phenomenology, in the process making major contributions to phenomenology, philosophy and science. Even some of his most loyal interpreters, for instance Alfred Schutz, complained that in the development of Husserl’s work ‘the idea of constitution had changed from a clarification of sense-structure, from an explication of the sense of being, into the foundation of the structure of being; it had changed from explication into creation’ (Schutz, 1970, 83). More radical critics rejected the whole idea of making philosophy into a rigorous science that would provide apodictic knowledge foundational to every other science, arguing in different ways that this is an impossible project (Watkin, 2009, 1-12). The claim to have provided certain knowledge through a presuppositionless description of a realm of pure consciousness, it was argued, is marred by presupposing and imposing old concepts and categories on experience, deploying the concepts of ego, the subject, and even the notion of consciousness itself, rather than examining experience to reveal whether these concepts do have a valid place, and if so, what place.

While in the case of Jacques Derrida and his epigone, this led to the complete rejection of phenomenology; alternatives to the Idealist transcendental form of phenomenology were developed as philosophical anthropology, hermeneutic phenomenology and existential phenomenology. While deploying Husserl's phenomenological method, these approaches revived ideas from the past that had been sidelined and almost forgotten. To begin with, Friedrich Schelling's argument that there is an unprethinkable being preceding all thought that cannot seriously be doubted was revived by Heidegger to reject Husserl's claim that all claims to existence could be bracketed out. Fichte and Schelling's argument that concepts are developed in practice before they can be reflected upon as concepts was defended by Heidegger, and following him by the existentialists, and then by Husserl himself. The argument of Fichte, Schelling and Hegel that the ego presupposes other egos was also revived, leading to the rejection of Husserl's effort to account for the constitution of intersubjectivity through the operations of the transcendental ego. Intersubjectivity and the 'we' relationship are the foundational categories of human existence, argued Stephen Strasser (1969) and Schutz, and this was later accepted by Husserl. Husserl tried to accommodate these claims in embracing and developing the concept of the life-world, but his effort to reveal structures beyond history through transcendental phenomenology was clearly in tension with his acknowledgement of the historicity of the life-world. This was seen, even by his defenders, to have been unsuccessful (Carr, 1974), and in a fragment, Husserl himself acknowledged his quest for an apodictically rigorous scientific philosophy had failed. As he put it, '*the dream is over*' (Husserl, 1979, 389). What these developments show is how difficult it is to free oneself from presuppositions when examining experience, and how engagement with thinkers, particularly thinkers from the past, can facilitate this.

Such work was not a rejection of Husserl's philosophy, however, but was a rigorous continuation of his phenomenological approach, with the same concern to acknowledge the reality of idealizations in the world. Husserl's transcendental Idealism was questioned and rejected by building on his insights, and Husserl himself appears to have moved away from Idealism. Husserl's work had been embraced because it had liberated philosophers from various forms of scientism, whether materialist, positivist or neo-Kantian, bringing into question the assumptions and categories of mainstream science that had come to dominate people's understanding of the world and themselves. His slogan 'back to things themselves', extending William James' radical empiricism, and his revival of Aristotelian philosophy with its concern with essences, had led philosophers to look again at what is life and what are humans, inspiring the development of philosophical biology and philosophical anthropology in terms free from and challenging the prevailing Newtonian framework of concepts (Gare, 2008, 55ff.).

These divisions among phenomenologists revealed the tension in Husserl's work between his concern to describe conscious experience, which is essentially temporal, and Frege's ahistorical objectivism. Throughout his career, Husserl was centrally concerned with time and temporality, a theme that had been placed at the centre of psychology by James and even more emphatically by Henri Bergson. Bergson had argued against the spatialized, geometrized conception of time assumed by mainstream science on the grounds that it is inconsistent with the immediately given experience of temporality as durational becoming (Capek, 1971). Clearly influenced by James and Bergson, Husserl from his early work had grappled with the experience of temporality (specifically, inner-time consciousness) in his study of experience and his characterization of consciousness (Husserl, 1991). Experience was characterized as integrated at a 'pre-predicative' (i.e. unreflective) level by a hierarchy of 'protentions' and 'retentions' whereby a partially open future is seen to be largely anticipated before it becomes present, carrying with it a pre-predicative awareness of what had been present. Space was then reconceived accordingly as lived space. This theme was taken up by Heidegger who edited Husserl's work on time and focused on temporality in his early lectures (Heidegger, 2009). Time was central to his first major work, *Being and Time,* and to his characterization of human existence as 'being-in-the-world (Heidegger, 1985). Almost all later phenomenologists, and all those who rejected Husserl's Idealist turn, were pre-occupied with lived temporality and spatiality. Such work on time, space and embodiment greatly influenced the development of philosophical biology along with philosophical anthropology where it was used to develop Jacob von Uexküll's argument that to understand living organisms, including humans, it is necessary to understand their worlds and how these are constituted (Buchanan, 2008, Gare, 2009, 269). A number of phenomenologists have continued this project (Tymieniecka, 2007).

This appreciation of temporality did not sit easily with Husserl's early characterization of the constitution of objects. However, as he developed his philosophy, Husserl moved from an essentially static to a genetic conception of constitution in which he examined the origins of intentionalities, thereby opening up phenomenology to investigate how consciousness develops from more basic experiences of objects of the life-world to synthesise and constitute more abstract and more complex objects and relations (Bruzina, 116-138). After making this transition to genetic phenomenology, Husserl consistently referred to consciousness as a life (Bruzina, 129). He emphasized that the transcendental ego was the formal ego postulated by Kant, but only existed as 'lived'; involving a living body (Husserl, 1970b, 104ff.). This not only allowed for the development of a phenomenological psychology, but also for the study of the development of such concepts and the corresponding development of consciousness through history. It justified treating the life-world and its relation to mathematics and science themselves as historical, leading him to examine how idealities emerge and are sedimented into historical traditions and instituted as traditions. Geometry, and the tradition of research on it, exemplified this (Husserl, 1970b, 354).

Merleau-Ponty's Naturalized Phenomenology

The philosopher who took up and developed phenomenology in this direction most fully was Maurice Merleau-Ponty. Merleau-Ponty's first major work, *The Structure of Behaviour* (1967) was heavily influenced by the philosophical biologists and philosophical anthropologists inspired by phenomenology, and offered a severe critique from a phenomenological perspective of objectifying approaches to psychology that excluded any place for experience and consciousness. Subsequently, he gained access to Husserl's unpublished work, most importantly, Husserl's later works on the life-world and perceptual consciousness, and all his work on temporality (Bruzina, 86). His next major work, *The Primacy of Perception,* in which he conceived being human as being-to-the-world and consistently deployed a genetic approach to constitution, was the product of his engagement with this later work. The theme most fully developed in this work was that of embodiment. Totally rejecting Cartesian dualism and all philosophies influenced by it, including both empiricism and neo-Kantian intellectualism, Merleau-Ponty argued that the body is neither an objective function nor a pure intellect but is first and foremost a lived body. Expression similarly cannot be grasped as an object nor as an intellectual thought, but is a structuring of experience and modulation of existence whereby the senses of the lived body come to be known, made explicit and decided. The focus on the lived body was not seen to imply an acceptance of Husserl's effort to establish philosophy as a foundational discipline through a rigorous science of the experience of the individual. Merleau-Ponty, like Strasser and Schutz, argued that we are essentially social, and developed this view by embracing and further developing Husserl's notion of the life-world. In doing so, he rejected not only the approach of Husserl's *Cartesian Meditations* in which he had embraced and attempted to radicalize Descartes' focus on the thinking subject, but also the claim that phenomenology could serve as a foundational discipline providing certain knowledge superior to that of the natural sciences. Having been acquainted with the very last works of Husserl where, reflecting on the importance of history, he had acknowledged the failure of the quest for an apodictically rigorous scientific philosophy, and living in an intellectual environment saturated with Hegelian scholarship, Merleau-Ponty argued that human existence is not only social but essentially historical. Interpreting the life-world on this basis precluded the current life-world being taken as an absolute reference point.

Merleau-Ponty, instead, redefined the goal of phenomenology and its relation to the sciences. While he was equally critical of claims made within the sciences that their objective knowledge of humans grasped the true nature of humanity, and its tendency to dismiss conscious experience in all its complexity as illusory, he did not regard such claims to objective knowledge as completely wrong or argue that scientific knowledge has to be totally subordinated to phenomenology. He argued that such knowledge has to be made sense of, incorporated into the life-world and into our experience of the world through phenomenology. As he put it in a study of sociology and its relation to philosophy:

> Philosophy is indeed, and always, a break with objectivism and return from *constructa* to lived experience, from the world to ourselves. It is just that this indispensible and characteristic step no longer transports it into the rarified atmosphere of introspection or into a realm numerically distinct from that of science. It no longer makes philosophy the rival of scientific knowledge, now that we have recognized the "interior" it brings us back to is not a "private life" but an intersubjectivity that gradually connects us ever closer to the whole of history (Merleau-Ponty, 1964, 112).

What this involved is illustrated by Merleau-Ponty's engagement with the findings of the neuroscientist, Kurt Goldstein. This engagement initially was mediated by Ernst Cassirer's study of this work, and in the process, Merleau-Ponty incorporated insights from Kant on the productive imagination (Matherne 2014). Goldstein was looking at what was then called aphasia, the loss of the ability to use words. An example is a person who could not name a knife as such, but could call it an 'apple-parer'. This could be regarded as nothing but bad memory, but looked at closely as Merleau-Ponty did, it suggests the loss of an abstract attitude to the world, or the ability to constitute more abstract objects of perception, to use Husserl's terminology. Merleau-Ponty did not leave it there but showed the correlation between a whole range of deficiencies, thereby revealing global features of our normal perception that we are so used to that it is difficult to be aware of, and would not have been revealed by the mechanical exercise of a phenomenological method. For instance, this same person could not knock on an imaginary door, revealing how bound he was to his immediate practical context. Looking at the implications of this, Merleau-Ponty pointed out that the normal capacity to identify something such as a knife is to see it not just as something there but as having a huge range of potential functions independent of the particular context in which it is perceived and identified as such. As he put it, 'The normal person reckons with the possible, which thus, without shifting from its position as a possibility, acquires a sort of actuality. In the patient's case, however, the field of actuality is limited to what is met with in the shape of a real contact or is related to these data by some explicit process of deduction' (Merleau-Ponty, 1962, 109). Not even chimpanzees abstract themselves from their particular context. Other living beings are bound to their contexts in a way that normal humans are not, and this is the basis of their freedom and their capacity for creativity.

No phenomenological study is final and complete, Merleau-Ponty argued. It can and should be challenged by historical developments, including advances in science. This was Merleau-Ponty's own approach, which while being phenomenological, made extensive use of scientific research. This makes all knowledge historically relative to some extent and brings into question the old idea and ideals of truth. This does not mean abandoning the quest for truth, but recognizing that these old ideas and ideals were always problematic. As Merleau-Ponty noted, 'As long as I cling to the ideal of an absolute spectator, of knowledge with no point of view, I can see my situation as nothing but a source of error' (1964, 109). Opposing this, and celebrating the embodied situatedness of individuals as the condition of there being any truth, Merleau-Ponty argued that phenomenology founds a new idea of truth in which historical developments and advances in science have to be made sense of by individuals in contact with their social milieu and in the finitude of their situations. These are revealed as 'the point of origin of all truth, including scientific truth' (1964, 109).

Merleau-Ponty was pre-occupied with the lived body and its ambiguous nature until the end of his life. He was writing a book, *The Visible and the Invisible*, which was unfinished at the time of his death, on this topic. Here he attempted to redefine and provide an ontology in terms of 'flesh', observing its peculiar reversibility as neither mere object of experience nor mere subject, and treating it as 'the concrete emblem of a general manner of being' (Merleau-Ponty, 1969, 147). 'Flesh' is exemplified by hands touching each other, simultaneously being touched and touching. Effectively, this ontology was Merleau-Ponty's alternative to Husserl's transcendental ego as the 'foundation' for philosophy. The role played by this 'foundation' in Merleau-Ponty's philosophy was very different, however. The ontology of the flesh resolved the subject-object question by pointing to a primordial realm that was more fundamental than, and the condition for, the subject-object opposition, containing this opposition within it. Flesh for Merleau-Ponty is not merely that of individuals, although it is this, but is also the matrix that underlies and gives rise to the perceiver and the perceived. As a landscape opens out from the flesh of each hand enveloping each other and interwoven with the landscapes opening from other flesh, and this is immediately understood from the particular flesh of the individual. As Merleau-Ponty put it:

> My body is made of the same flesh as the world (it is perceived), and moreover that this flesh of my body is shared by the world (the felt [*scenti*] at the same time the culminating of subjectivity and the culmination of materiality), they are in a relation of transgression or of overlapping --- This also means: my body is not only one perceived among others, it is the measurant (*mesrant*) of all, *Nullpunkt* of all the dimensions of the world (1969, 222).

Flesh is the world of life lived from within by the intelligent body which (or who) is part of the world he or she experiences.

The quest to naturalize phenomenology, explicitly conceived as such, emerged as part of the reaction to various reductionist forms of cognitive science. This reaction was provoked by efforts to extend reductionist science to the brain to eliminate the last vestiges of respect for the reality of life, mind and humanity. To begin with, opponents of such reductionism turned to Merleau-Ponty's work. Hubert Dreyfus had utilized Merleau-Ponty's phenomenological studies to expose the limitations of representational models of the mind and computational models of cognition (Dreyfus, 1992). Franscisco Varela turned to Merleau-Ponty in his efforts to overcome the deeply entrenched assumptions of mainstream science, influencing even those (including Varela himself) who were striving to overcome these assumptions. Having been involved with Maturana in developing the concept of autopoiesis, he came to see that even this concept, allowing that organisms are self-making, was still too mechanistic. Teaming up with Evan Thompson and Eleanor Tosch, Varela charted the path for an alliance between post-reductionist cognitive science and phenomenology through a naturalized phenomenology, a development that has not only advanced cognitive science, but psychology generally, including social psychology, psycholinguistics and psychopathology, and has given birth to the new discipline of neurophenomenology (Varela et. al. 1993; Petitot et.al. 1999; Gallagher and Schmicking, 2010). These phenomenologists have re-examined Husserl's work and defended Merleau-Ponty's claim to be developing Husserl's philosophy against conventional interpretations of his work. Dan Zahavi even questioned whether Husserl was ever an Idealist, claiming that his 'transcendental Idealism' was really a form of internal realism, as this had been defended by Hilary Putnam (Zahavi, 2003, 68ff.). What this evolution of ideas has revealed has not only been that the claims of phenomenology to be elucidating the primordial conditions for truth, including scientific truth, to emerge have to be respected by scientists as a form of truth, but that any claim to scientific knowledge inconsistent with these claims must be rejected as invalid, or at least defective beyond a limited domain of validity. This has engendered a growing body of research in which scientific research is guided by phenomenological studies of experience, while phenomenological research has attempted to take into account and learn from such scientific research.

Naturalized Phenomenology and the Philosophy of Nature

While working on *The Visible and the Invisible*, Merleau-Ponty was also giving a course of lectures on the philosophy of nature and tracing the history of the concept of nature. This should be seen in conjunction with and as complementary to his work on flesh. Echoing Schelling's claim that there is an unprethinkable being preceding all thought, Merleau-Ponty argued in this work that 'Nature is … an all-encompassing something, as a type of englobing being in which we discover ourselves already invested prior to all reflection' (Merleau-Ponty, 2003, 84). To develop this conception of nature he examined and engaged with the philosophies of Descartes, Kant, Schelling, Bergson, Husserl and Whitehead, and also examined developments in modern physics and revisited and further developed his earlier research on philosophical and theoretical biology. In this he focused in particular on Jacob von Üexkull and the concept of the *Umwelt* (surrounding world) of organisms. Essentially, Merleau-Ponty was extending his argument about the relation of the human sciences to phenomenology to the natural sciences generally. Far from supporting Idealism, phenomenology reveals to us that we as flesh are part not only of an intersubjective world but also part of nature in which there are diverse organisms with their surrounding worlds that intersect with our own. We are situated not only in human history but within the englobing being of nature in which other organisms are also situated. We know and can only know this history and develop our knowledge of nature through our bodily engagement in history and nature. Ultimately, we have to recognize that we are part of the world that we are striving to know, a world that is always open and unfinished, both for us and for other organisms. We are products/producers of history and products/producers of nature, and the goal of the natural sciences should be to situate us in and help connect us to the whole of nature and its history, not explain away our existence.

If Merleau-Ponty is right in his characterization of nature, all science, including mathematics, physics, chemistry and biology, must be judged according to whether it is consistent with the reality of humans as flesh, historically situated beings-to-the-world participating in an englobing nature. It was for this reason that Merleau-Ponty included work on recent physics in his lectures on nature. Obviously, Merleau-Ponty's naturalist phenomenology requires the rejection of traditional reductionism according to which consciousness and life are at best epiphenomena of chemical processes explicable through physics. However, proclaiming this does not provide answers to the most important problems that have to be addressed in the quest to naturalize phenomenology, the place accorded mathematics while accounting for the emergence of consciousness. Husserl has been opposed to the naturalistic attitude for a number of reasons. Naturalism appeared to provide no grounds for upholding ideals, it could not account for the objective necessity characteristic of mathematics, and it seemed incapable of accounting for consciousness. In order to defend Merleau-Ponty's naturalization of phenomenology, it is necessary to answer questions about the ontological status of mathematical objects that the proponents of this movement have not begun to address, and consider how living forms that can be studied objectively can at the same time be aware and conscious. While Merleau-Ponty pointed to work in physics and mathematics supporting his claims that this conception of the physical world has been overcome, with the exception of Steven Rosen and Fernando Zalemea, those inspired by Merleau-Ponty have not attempted to deal with these issues (S. Rosen, 2008; Zalemea, 2012). This has left major lacunae in their work. While it might not be regarded as equally important, it is also necessary to give a place to ideals, including the ideals that define science, the breakdown of which it could be argued are now threatening science, reducing it to nothing but an instrument for advancing profitable or militarily useful technology.

Since concern with mathematics was central to Husserl's thinking and central to his transcendental Idealism, the first issue that must be confronted by phenomenological naturalists is whether Husserl's view of mathematics does rule out naturalism, and if it does, can it be modified to fit a naturalized phenomenology. Husserl himself at the end of his career summed his views very briefly when he wrote that 'Mathematical method "constructs," out of intuitive representation, ideal objects and teaches how to deal with them operatively and systematically' (Husserl, 1970b, 348). The difficulty here is interpreting what he meant by intuitive representation and ideal objects. While Husserl was strongly influenced by Frege and corresponded with Hilbert and other leading mathematicians, both Gödel, a Platonist, and Hermann Weyl, an intuitionist, aligned themselves with Husserl's phenomenology, leaving interpreters struggling to understand how this was possible (Feist, 2003). Fortunately, Richard Tieszen has offered a coherent account of Husserl's views on mathematics and how these evolved, including his later genetic approach to the development of mathematical concepts (Tieszen, 2005). This does seem to be compatible with a form of naturalism if it can be formulated to make intelligible the practices described by Husserl, but to reconcile these it will be necessary to clarify and rethink both Husserl's characterizations of mathematics and naturalism.

The advantage of Husserl's philosophy of mathematics is that it acknowledges the objective status of mathematical knowledge central to the thinking of the Platonists, while avoiding elevating its metaphysical status so that knowledge of it becomes unintelligible. Husserl emphasized the role of imagination in exploring possibilities, and argues that it was only through such exploration that science became possible. As he put it, 'The science of pure possibilities must everywhere precede the science of real facts, and give it the guidance of its concrete logic' (Husserl, 1931, 7). When explained genetically, the development of consciousness and the development of the capacity to comprehend increasingly complex and abstract objects could be seen as correlative while still grounded in the embodied engagement by individuals in society and nature. However, there is still the problem of characterizing the ontological status of mathematical entities and relations (or 'idealizations') and how they can be conceived to be part of nature. Schelling, Bergson and Whitehead, the philosophers of nature turned to by Merleau-Ponty, do offer some guidance in answering this question. So also does C.S. Peirce, who characterized himself as a Schellingian of some stripe, transformed in the light of modern physics. It appears that Husserl's understanding of mathematics has much in common with the later philosophy of mathematics of Whitehead and both can usefully be interpreted through the work of Peirce. This could provide the conception of mathematics required to uphold Merleau-Ponty's conception of nature. What these philosophers defended in their later work could not be characterized as Platonism, formalism, logicism, intuititionism or quasi-empiricism, but a form of structuralism grounded in experience, avoiding the extreme formalism on which later structuralism foundered (Corry, 2004). In each case, what is acknowledged by these philosophers is the place of possibilities in nature that has little or no place in the reductionist forms of naturalism that have dominated since the overthrow of Aristotelian metaphysics. This is the naturalism that Husserl was so hostile to. By virtue of giving a place to possibilities, without treating these as Platonic forms, they validate Husserl's concern to recognize the role of ideation in experience, as appreciation of possibilities. This acknowledgement of possibilities in turn is based on conceiving nature as a creative process of becoming, rather than as a completely determined 'block' universe.

Husserl, Whitehead and Peirce on Mathematics

Whitehead's later philosophy was based on a careful study of experience, and for this reason alone it bears similar features to phenomenology. His overall philosophy is best understood as a naturalized form of Platonism, and for this reason also his understanding of mathematics has much in common with Husserl's mature philosophy of mathematics as characterized by Tieszen. In his speculative cosmology Whitehead characterized a realm of pure possibilities as 'eternal objects', or as he later referred to these, as 'potentialities for definiteness', inter-related in definite ways to every other potentiality for definiteness, and mathematics was characterized by him as the study of some aspects of this realm. Every potentiality for definiteness is also related to every 'actual occasion', the primary existents in Whitehead's ontology, and it is through the 'concrescence' (the process of self-formation) of actual occasions that these possibilities are realized as actual forms of definiteness in what exists (Code, 1985, 163ff.). Whitehead characterized mathematics as the study of objective forms of definiteness: forms, relations and most importantly, patterns and their transformations. He was highly critical of the excessive role accorded to number in mathematics. It is only in special branches of mathematics that quantity and number are the dominant themes, Whitehead argued, and quantity by itself only provides a very crude understanding of nature. '[B]eyond all questions of quantity there lie questions of pattern, which are essential for the understanding of nature' Whitehead wrote (Whitehead, 1968, 143). Elsewhere he proclaimed that mathematics is a 'general science' for the investigation of 'patterns of connectedness, in abstraction from the particular relata and the particular modes of connection' (Whitehead, 1933, 197), and that it is 'the most powerful technique for the understanding of pattern, and for the relationships between patterns' (Whitehead, 1951, 678). This should be seen to include the transformation of patterns to realize new patterns. When we say ‘twice three is six’, Whitehead proclaimed, ‘we are not saying that these two sides of the equation mean the same thing, but that two threes is a fluent process which become six as a completed pattern.’ So, for Whitehead, ‘mathematics is concerned with certain forms of process issuing into forms which are components of further process’ (Whitehead, 1968, 92).

While Whitehead lauded the achievements of mathematics, at the same time he argued that it could only deal with some aspects of reality. Mathematics involves abstraction. Abstraction as such is essential to life. According to Whitehead, ‘The growth of consciousness is the uprise of abstractions. It is the growth of emphasis. The totality is characterised by a selection from its details. … Thus a fortunate use of abstractions is of the essence of upward evolution’ (Whitehead, 1968, 123). When we abstract, ‘we necessarily introduce the notion of potentiality’ which ‘is fundamental for the understanding of existence, as soon as the notion of process is admitted. ... Hope and fear, joy and disillusion, obtain their meaning from the potentialities essential to the nature of things’ (Whitehead, 1968, 99f.). The highest form of abstraction grasps the ‘eternal objects’ such as colours, numbers, relations and patterns. However, grasping these in isolation from each other and then in their particular relations should always be understood as abstractions, and to fail to do this, to treat abstractions without acknowledging that they are abstractions, is to commit the ‘fallacy of misplaced concreteness’.

Peirce’s philosophy, which he characterized as ‘pragmaticism’, differs from Whitehead’s in crucial respects, but is not entirely incommensurable with it and deals with aspects of mathematics where Whitehead’s philosophy is silent, while Whitehead’s philosophy provides the ‘objects’ (possible patterns as forms of definiteness and their transformations) required by Peirce’s philosophy. Like Whitehead and Husserl, Peirce was concerned to do justice to all experience, and argued that philosophy must begin with phenomenology, the study of appearances at their face value, describing and classifying whatever appears before consciousness. This involved recognizing potentialities, existents, and lawfulness. As he put it: ‘My view is that there are three modes of being. I hold that we can directly observe them in elements of whatever is at any time before the mind in any way. They are the being of positive qualitative possibility, the being of actual fact, and the being of law that will govern facts in the future’ (CP 1.23). Through Peirce’s influence on William James, this commitment to the careful study of appearances also influenced Husserl.

However, like Whitehead, Peirce gave a major place in philosophy to speculation. Speculating, he suggested that the universe began as pure potentiality. or as he put it, in ‘the process of derivation, a process which extends from before time and from before logic, we cannot suppose that it began elsewhere than in the utter vagueness of completely undetermined and dimensionless potentiality’ (CP 6.193). This chaos eventually gave rise to self-reinforcing habits. With habits, nature was differentiated, leading to reactions. With dyadic relations, it became possible to interpret habits as signs, and on this basis, make predictions. Peirce characterized the sign most generally as that which ‘mediates between an object and an interpretant; since it is both determined by the object *relatively to the interpretant*, and determines the interpretant *in reference to the object*, in such wise as to cause the interpretant to be determined by the object through the mediation of the “sign”’ (EP II: 410). Sign activity is triadic, and thus lends itself to forming sequences and networks of semiosis, with interpretants, which can be original creations, becoming increasingly complex. This makes possible the development of ever more complex and creative forms of semiosis. Life is based on semiosis, and with humans, semiosis becomes more complex again. Mathematics is a form of semiosis. As one interpreter of Peirce, Susanna Marietti put it:

> Mathematics is, in Peirce’s, view, a semiotic activity. It is semiotic because it deals with signs, and it is an activity because ... it actively operates on them. Such a semiotic view of mathematics must be able to account, among other things, for three properties of mathematical knowledge, two of which are acknowledged by everybody and the third of which is in any case maintained by Peirce. Namely, such a view must account, first of all, for the universality of mathematical knowledge; secondly, for certainty of it; and thirdly, for its fertility, that is to say its ability to get – while applying its peculiar instruments of reasoning – knowledge which turns out to be authentically new (Marietti, 2010, 148).

It is this capacity to generate new knowledge that interpreters of Peirce have had difficulty accounting for since there appears to be no object or 'Secondness', the subject matter in the semiotic process resisting false beliefs (Cooke, 2010, 169). This is where Whitehead's notion of possible patterns as forms of definiteness and their transformations complements Peirce's semiotic interpretation of mathematics. Mathematics, Peirce argued, is the science which draws necessary conclusions from exclusively hypothetical states of things (Peirce, 1955, 140), where an hypothesis is 'a proposition imagined to be strictly true of an ideal state of things' (Peirce, 1955, 137). Necessary conclusions are drawn by mathematicians through the use of diagrams which function as analogies to such hypotheses. As Peirce put it:

> [Mathematical deduction consists in constructing an icon or diagram the relations of whose parts shall present a complete analogy with those of the parts of the object of reasoning, or experimenting upon this image in the imagination, and of observing the result so as to discover unnoticed and hidden relations among the parts. (Peirce, 1992, 227)

This includes algebra.

Peirce argued that with the development of mathematics as a system of iconic signs, nature can now be interpreted through mathematically expressible law (although even here actuality will involve an element of chance and so will not entirely conform to the necessity of mathematical deductions). However, again like Husserl and Whitehead, Peirce argued that it is impossible to grasp the whole of existence through mathematics because it is impossible through mathematics to account for the emergence of variety. The evolution of laws of nature that can be represented mathematically cannot be modelled mathematically. Like Whitehead, Peirce argued that potentialities and possibilities are a real part of what there is. He did not accept the view that an objective understanding of nature must be free of the constructive mind and any anthropomorphic elements. For Peirce, nature is more akin to mind than brute matter, and matter is effete mind hidebound by habits. The centrality of semiosis in nature is based on and is an extension of his understanding of human cognition, and as nature is perfused with signs, it is perfused with 'interpretants'. Peirce understood that experimental science involves active intervention in nature to enable it to respond to questions put to it, and that where-ever predictive laws could be found, these would be operative in particular conditions and would need to be explained. The place and importance of ideality and idealizations in nature were also recognized by Peirce.

While Peirce's philosophy is incomplete and not beyond criticism, through it, it is possible to more fully appreciate the convergence of naturalized phenomenology with post-mechanistic philosophies of nature exemplified by Schelling and Whitehead. Peirce situated mathematics and the efforts to understand nature through mathematics within nature and as a further development of nature's semiosis. He was implicitly opposed to the whole idea of abstract mathematical concepts as a universal language, arguing that mathematics can only complement other forms of semiosis that often utilize, and have to utilize, vague terms. It is only in specific contexts that mathematics can be applied, and then since there is always some element of chance in nature, its application will always involve some degree of idealization, as Ilya Prigogine (1997) has argued. It is not difficult to interpret Peirce's understanding of mathematics and the role of diagrams as the study of what Whitehead referred to as patterns or modes of togetherness, with necessary conclusions being the relations revealed through the study of these patterns. This is consistent with Husserl's later philosophy of mathematics, and illuminates it. All this is not only consistent with naturalized phenomenology. It has the added advantage that, through the place accorded to semiosis and its characterization, a means is provided for understanding the relationship between objectifying ways of grasping reality and non-objectifying appreciation of temporal becoming; for instance, through telling stories. This is consistent with Merleau-Ponty's view of flesh experiencing itself within the englobing being of nature.

Michael Polanyi and Hierarchy Theory

There have been advances in more recent work on the philosophy of nature, some of it directly or indirectly influenced by Husserl, Heidegger and Merleau-Ponty. Michael Polanyi's work, *Personal Knowledge* (1958) was probably influenced by Heidegger, while Polanyi acknowledged that Merleau-Ponty's phenomenology foreshadowed his own work (Polanyi, 1969, 222). Heidegger argued in 'The Question Concerning Technology' that experimental science is based on enframing nature, setting upon it to reveal itself as a coherence of forces calculable in advance and reducing reasoning to calculation (Heidegger, 1977, 21). Polanyi pointed out that scientific work generally involves setting up boundary conditions that allow particular processes to be studied by altering initial conditions and measuring outcomes at a later time, while ignoring the fact that such processes only occur as scientists portray them within the boundary conditions they have set in place, and measurements being made when the scientists choose to do so. No boundary conditions are set in place for the study of the solar system, but this is a highly unusual system with boundary conditions already in place. It is possible to set up boundary conditions because boundary conditions exist in nature, and it is these that provide the conditions for new levels of organization to develop. The properties and laws of structures produced by chemicals, for instance, are the boundary conditions for and are harnessed by higher level organization as living organisms constrained by semiotic processes. On this basis Polanyi defended what he called 'hierarchical ontology.' Polanyi's work in turn influenced Howard Pattee's hierarchy theory based on the notion of facilitative constraints, treating mathematically and generalizing the notion of boundary conditions as non-holonomic constraints to account for emergence of levels of control and the symbols required for these. Pattee's work was further developed by Timothy Allen and Thomas Starr, Robert Rosen, Stan Salthe and Alicia Juarrero, among others (Pattee, 2012, 91ff.; Umerez, 2001, 162f.; Allen & Starr, 1982; Rosen, 1988; Salthe, 1993; Juarrero 1998 & 2002).

Polanyi also pointed out the personal element in all knowledge, and in this he was influenced by, or at least aligned with Merleau-Ponty's argument, that scientific knowledge can only be made sense of by embodied, situated individuals. Polanyi pointed out that all knowledge involves 'indwelling' in the instruments and theories deployed in such investigation and in that which is being investigated, and it is only with the tacit knowledge of this background that is 'dwelt within' that what is focused on makes sense. This is the personal element in science. The 'from-to' structure of this indwelling is prone to blind reductionists, claiming totally objective knowledge, from acknowledging the boundary conditions that have been set up in experimental science, and the reality of higher levels of order they are investigating when they purport to explain these through their constituents. For instance, when examining life, they fail to notice that the chemical processes they investigate could not survive except in the environment created by the functioning organism and are being constrained to serve this functioning. They fail to appreciate this background tacit dimension of their own knowledge. This argument in turn influenced Thomas Kuhn in his characterization of science as socialization into disciplinary matrixes through the use of 'exemplars', the problem-solutions that have defined the success of past science, the mastery of which (along with the tacit knowledge gained through this mastery) is required for them to participate in the advance of science.

From Anti-Humanist Objectivism to Endophysics

The development of naturalized phenomenology and the philosophy of nature have exposed and brought into question deeply held assumptions that have defined science since the seventeenth century. The progress of these phenomenologists has been impressive. However, while phenomenological cognitive science and neurophenomenology are now major fields of research, they have only grappled with a small part of biology, let alone science generally. And it is still widely believed that the quest for objective knowledge has been most fully realized in physics, and that all scientific explanations must ultimately be reducible to chemistry, then physics. Briefly, we remain children of Newton, despite the vast transformation Darwin wrought. Newton, then more rigorously (and incoherently) Laplace, laid the foundations of modern "Reductive Materialism", which remains our model of science itself, including "Dreams of a Final Theory" (Weinberg, 1992). Defending naturalized phenomenology, an even more fundamental assumption (formulated explicitly by Max Planck), that objective scientific knowledge has to be totally independent of the structuring individual mind and emancipated from all anthropomorphic elements, has to be challenged. The first requirement of understanding the logic of this development is to work out what objectivism as characterized by Planck meant, and how it came to be embraced as an ideal by scientists in the first place. This involves understanding the ideal of science set up by Newton, but even more fundamentally, the ideal of scientific explanation privileging logic and mathematics that has led to the commitment to account for the whole universe through a set of mathematical equations. Why should objectivism be taken as excluding any role to the structuring mind or anthropomorphic elements?

The obvious answer to this question is that objectivism so conceived is the extension of a trajectory concerned to eliminate any subjective bias and to overcome the limitations of particular perspectives. This serves as a partial explanation. However, objectivism can be conceived as that which is intersubjectively valid without excluding the mind or anthropomorphic elements from knowing, and in fact it is impossible to exclude subjects from the objects that are known; as Brentano and Husserl pointed out. Furthermore, to claim to have knowledge that life and mind are mere appearances that can be fully explained through chemistry and physics is not an objective judgment. Since it involves scientists viewing their scientific judgments as merely the epiphenomena of deterministic chemical and physical processes, it is self-contradictory. Clearly, something more is involved.

Part of reason for such beliefs is, paradoxically, subjective. The flight to so-called objectivity continues a long tradition of flight from acknowledging the reality of temporal becoming characteristic of life and consciousness. As Lee Smolin wrote in his recent book *Time Reborn,* 'I used to believe in the essential unreality of time. Indeed, I went into physics because as an adolescent I yearned to exchange the time bound, human world, which I saw as ugly and inhospitable, for a world of pure, timeless truth' (Smolin, 2013, xii). There are deeper assumptions leading to these claims, however. One of these is that objective knowledge must be timelessly true, and along with this, that timeless truths are only possible in a world that in some fundamental sense is timeless. If nature can be represented through mathematical models, these provide the timeless objects of knowledge. As Smolin noted, physicists believe 'that the task of physics is the discovery of a timeless mathematical equation that captures every aspect of the universe.' (Smolin, 2013 xvi). This belief is rooted in the whole history of Western thought, beginning with Pythagoras' claim that all is number, the implications of which were spelt out dramatically in Parmenides claim, defended by Zeno, that the way of truth leads to the view that the universe is an undifferentiated, unchanging plenum, and that the appearances of diversity and change are illusions (Hintikka, 1974, 58ff.). Atomists accounted for the appearance of change by allowing that a large number of plenums or atoms could move in the void. The obvious implausibility of these views was overcome with the rise of modern science deploying new forms of mathematics. With developments in mathematics allowing for more complex spatial order, the apparent absurdity of Parmenides philosophy has been gradually diminished, allowing more recent scientists to claim that they are arriving at the kind of timeless knowledge of a timeless reality that was implicitly the ideal of knowledge from the Ancient Greeks onwards (Gare, 2005). Galileo had represented motion mathematically. Descartes' analytic geometry provided a means of representing all physical existence algebraically, and with Newton's and Leibniz's development of calculus, time was able to be represented by Lagrange as the fourth dimension of space.

We all know Newton's triumph, following Descartes and the failure of his *res cogitans,* Galileo, Copernicus, and Kepler. One mind invented the differential and integral calculus, three laws of motion, the law of universal gravitation and created the framework of "objective" classical physics.

Newton mathematized Aristotle's efficient cause. His laws of motion in differential equation form give the "forces" between the moving particles, say balls rolling on a billiard table. The balls have mass and energy due their motion or gravitational potential energy, so the laws of motion are efficient cause.

Given seven balls rolling on a billiard table, Newton tells us what to do: Write down the positions and momenta of all the balls. Write down the boundary conditions of the edge of the table. Write down the differential equations giving the forces among the colliding balls and balls and wall (via the third law). Then, to find out what will happen to the balls over time, integrate the differential equations to obtain the future trajectories of the balls (forever if we ignore friction). But to integrate the differential equations is to deduce the consequences of the differential equations for the trajectories of the balls. But deduction is “entailment”. “All men are mortal, Socrates is a man, therefore Socrates is mortal”. In this Greek syllogism, the truth of the conclusion is entailed by the truth of the two premises. Newton gave us a view of the world’s becoming as entirely entailed. Nothing not entailed could arise.

Laplace, somewhat over a century later, noted that were we to know the positions and momenta of all the particles in the universe, a vast calculating engine, Laplace’s demon, could use Newton’s laws to calculate the entire entailed, hence determined, becoming of the universe forward and backward in time - because Newton’s laws are time reversible.

Laplace gave us the birth of modern objective science Reductive Materialism, the belief that “down there” are laws which will entail the entire becoming of the universe, given initial and perhaps boundary conditions. This reductionism to laws “down there” is material because the laws are efficient cause laws with forces and matter and energy. This is the Pythagoran Dream of a set of laws outside the universe, fixed, immutable, that governs all. All questions stop at the foundational laws. More, in this view, nothing new and radically emergent can come into being. And perhaps most important, with the triumph of Classical Physics, objective science, we literally lost our minds, our subjective pole, our humanity and any legitimacy of phenomenology.

It is this that justifies the view that time as becoming is an illusion, a view that has continued to dominate science. As Einstein concluded, it is natural ‘to think of physical reality as a four-dimensional existence, instead of, as hitherto, the *evolution* of a three-dimensional existence’ (1961, 141).’ Hermann Weyl followed Einstein and simply asserted as fact that ‘The objective world simply *is*, it does not *happen’* (1949, 116).’ This view has been supported more recently by quantum cosmology uniting quantum theory with general relativity, where as Lee Smolin put it, ‘time is not just redundant, it disappears completely. The quantum cosmos doesn’t evolve or change, it doesn’t expand or contract, it simply is’ (Smolin, 2013, 77). The structuring mind and anthropic elements, which can only be comprehended as temporal becoming, therefore must be illusions explicable entirely through chemistry and physics.

From Exophysics to Endophysics

It is here that the ideas of the endophysicists bring into question the assumptions underlying this objectivism, and in doing so, converge with the work of the naturalist phenomenologists. Just as the rigorous formulation of Idealism by Husserl revealed most clearly the weakness of this philosophy and paved the way for his successors to develop a radically post-Cartesian understanding of humans as part of nature, so the very quest for a thoroughly objective knowledge of nature, understood as giving no place to the structuring mind or anthropomorphic elements, has forced scientists to acknowledge that while such an approach can be useful, ultimately it is necessary to acknowledge that we as conscious, active beings are part of what we are striving to understand, and this has to be incorporated into science.

To begin with, it should be noted that not all proponents of mathematical physics have been committed to this Pythagorean/Parmenidean objectivism. Descartes, appreciating that the mind could not be comprehended in terms of the conception of physical existence he was defending in his philosophy of nature and believing that minds do exist, famously defended dualism. He allowed that two totally different kinds of being could interact with each other, an incoherent position, as Spinoza pointed out. Even Einstein in his mature years, after having developed his general theory of relativity and interpreted it in accordance with a Pythagorean/Parmenidean view of the universe, was not satisfied that science could explain away the privileged place accorded to the experience of ‘Now’, clearly fundamentally different from the experience of the past and the future (Smolin, 91). While Immanuel Kant who defended the pre-eminent status of mathematics in science, understood the logic of the argument that this implied a deterministic block universe, observed that science takes as objective knowledge the answers to questions posed in terms of concepts that are brought to experience by a transcendental ego and by mathematics which, he argued, is a human construct. Consequently, it is only the world as it appears to us that science portrays, and not reality in itself. In each case, what has been recognized is that such objectivism implies a perspective to uphold it that is itself not comprehensible through this objectivism. Kant's whole philosophy was an effort to confront the problem that the apparently objective world is in some sense created by the knower, who transcends the known and appreciates there must be a reality beyond that which is constructed, the noumenal realm - which includes the knower, without this knower having the means to gain cognitive access to this realm of things in themselves. The objectivists, such as Bolzano and Frege, rejected Kant's questioning of objectivism, and attempted to rigorously defend objectivism. The outcome was an initial triumph of their objectivism in logic, mathematics and science, but it ended in a forced retreat from such claims. This led to the development of endophysics, resonating with and supporting the conclusions of those promoting naturalized phenomenology.

Endophysics deals with physical systems from within, 'allowing also observational processes as partial physical processes. This involves the phenomena of *self-reference,* and of *introspection'* (Löfren, 1993, 54). The term has a narrower sense as the study of any domain in which the observer is part of the observed, and a broader sense as modeling systems that include in the models 'observers'; that is, subsystems that interact with the rest of the system (Kampis, 1991, 192ff., Kampis, 1993, 20, Rössler, 1998, 29ff.). With this broader sense in mind, George Kampis emphasized that 'endophysics is not about observers, even though it has been formulated with reference to observer problems. *Endophysics is about the local and internal communication and interaction between processes*, observers or otherwise' (Kampis, 1993, 35). This suggests that endophysics could involve observing from outside a system that has local and internal communication and interaction between processes. However, the two senses of endophysics cannot be entirely separated, since in observing systems with internal communication and interaction, observations of these are inevitably part of what is being observed and so part of the system that they are striving to understand, and the system which includes them is an instance of a system with an internal observer. This is the case with a scientist studying the universe, or studying the global ecosystem, or studying language. It is also the case when examining an organism which requires us to take into into account that we are part of its world. This means that we have to acknowledge that we cannot transcend time and are observing the world at a particular time, and are subject to the same constraints as the system being studied. As Kampis put it, '"Now" is not a place in time, but an endophysical relation between an observer and a system' (Kampis, 1993, 21). Here the parallels and resonances with Merleau-Ponty's conclusion based on phenomenology, that we are only able to know the world through being embodied in a particular time and place, and in doing so find ourselves within an englobing nature in which there are other beings experiencing the same world, should be evident. However, to clarify these parallels we will begin by looking at the broader sense of endophysics and the implications of this, and because of its role in promoting an anti-humanist objectivism, it is first necessary to look at mathematics.

Once the primacy of endoscience has been appreciated, it becomes necessary to redefine the role of exoscience. Exoscience seeks to transcend the limits of endoscience by constructing models and using easy to handle representations rather than direct observations. Exoscience always involves abstraction, in practice and in theory, from a context that has boundary conditions that in most instances are controlled by the researcher. Once the subordinate status of exoscience to endoscience is recognized, it becomes necessary to redefine the goal of exoscience. Apart from providing the knowledge required to develop technology, which as Heidegger pointed out, is a goal it is oriented to fulfill, its goal should not be seen as explaining away the reality of life but as comprehending how the emergent realities brought into focus by endoscience (including phenomenology) are possible.

Endophysics and Mathematics

Central to Pythagorean/Parmenidean objectivism has been the status accorded to mathematics. The proponents of Pythagorean/Parmenidean objectivism are committed to denying the reality of temporal becoming, because they are committed to viewing mathematics, and later, logic along with it, as a purely objective language beyond any perspective on it, and they believe it is this language alone that can define what is true. This is an exophysical perspective.

Not all those who value mathematics draw these conclusions, however. Logicians and mathematicians have always been divided over whether they interpret what they are dealing with is a universal language (*lingua universalis*) or as a calculus (*calculus ratiocinator*). While Bolzano, Frege and Russell were logicians committed to the former view and were attempting to develop a universal language, De Morgan, Boole, Peirce and Schoeder were committed to the latter (Hintikka 1996). Johannes Lenhard and Michael Otte have pointed out that this same division occurs among mathematicians (some of whom are also logicians). As they characterized this opposition:

> One group, from Leibniz through Bolzano to the analytical philosophers of the Vienna Circle and their students today, believe in an analytic ideal of mathematics ruled by formal proof and logical necessity. … Others, from Descartes, Newton and Kant though Peirce and quite a number of modern mathematicians, value insight higher than proof and believe that evidence rules over rigor (Lenhard and Otte, 2010, 311)

Husserl, in opposition to Frege, viewed logic as a calculus, not a universal language (Kusch, 1989), and Whitehead also dissociated himself from the view of logic as a universal language (Whitehead, 1948, 104). Those who look upon mathematics as a calculus are interested in the insights it provides in particular domains, appreciating the limited nature of their insights, and have no reason to assume that objectivity implies a Pythagorean/Parmenidean view of the world. Nor is there any reason for them to deny the constructive role of thought in achieving what insight is gained, or to assume that nature must be devoid of anthropomorphic elements.

The quest to rigorously defend the view of mathematics and logic as a universal language evolved from Hilbert (who was relatively uninterested in logic) to Frege, who criticized Hilbert for being insufficiently rigorous. Frege strove to reduce arithmetic to logic. Russell (and at one time, Whitehead) attempted to reduce strove to reduce all mathematics to logic. Gödel's Incompleteness Theorem, directed against the formalism of Hilbert and logicism of Frege and Russell, was fatal to this quest for a universal language.

While Gödel himself was concerned to defend a Platonic view of mathematics, Robert Rosen in a conference on endophysics drew different conclusions from Gödel's work. Rosen was developing modeling theory through category theory (which, he argued, comprises within itself a general theory of modeling).

Category theory has been briefly characterized by Ehresmann and Vanbremeersch as 'a universal semantics of mathematical structures' (p.26). It enables us to see the universal components of a family of structures of a given kind, how the structures of different kinds are interrelated, and to examine the mutability and admissible transformations of precisely defined structures. Structures are 'lists of operations and their required properties, commonly given as axioms, and often so formulated as to be properties, shared by a number of possibly quite different specific mathematical objects' (Mac Lane, 1996, 174). A category has been defined as 'a composite item consisting of a graph and an internal law which associates an arrow of the graph to each path of the graph, called its composite, and which satisfies some axioms given further on' (Ehresmann and Vanbremeersch, 25f.). Category theory began with the observation that many properties of mathematical systems can be unified and simplified through a presentation with a diagram of arrows between 'objects' (which can be sets, groups or rings, or can be unspecified), where each arrow represents a function. The most important property of these arrows is that they can be 'composed', that is, arranged in a sequence to form a new arrow. The focus is then not on 'objects', but on the structure preserving mappings or 'morphisms' between these 'objects' (Rosen, 1991, 143ff.). These mappings, which reveal the possible transformations of structures, can themselves be studied in this way. If the structures are themselves categories so that the morphisms revealing possible transformations are between categories, these are referred to as 'functors', and are represented as arrows between the categories. There can also be a category of functors. The morphisms that transform one functor into another while respecting the internal structure of the categories involved, thereby bringing into focus their mutability, are 'natural transformations'.

Rosen's conception of mathematics and its relation to science, is based on his development of category theory as a general theory of modeling. He argued that in fact most mathematics has some referent to something external to the formalism itself, and so is 'applied' mathematics. Modeling is the judicious association of a formalism with these external referents (Rosen, 1993a, 359). However, category theory makes explicit and clarifies the nature of this modeling relation. Rosen characterized categories as formal systems, morphisms as entailment structures, and natural transformations as explicit modeling of one system by another (Rosen, 1991, 147). He then argued that from material systems we can abstract out 'natural systems' which can be modeled in the same way as formal systems are modeled. Modeling natural systems in this way is really hypothesizing via abstractions about their elements and entailment structures to establish congruence between formal systems and these natural systems. This involves carefully delineating observables and linkage relations of the natural systems. There can be no mechanical algorithm for doing this, it is inescapably an art. Once this congruence has been established successfully, we can learn about the modeled system by studying the model of it. This involves using encoding and decoding arrows, along with 'dictionaries', to translate back and forth between the two systems, with measurement being a form of encoding and tracing causal entailments being a form of decoding.

When examining the variety of entailment structures Rosen argued that modern science, under the influence of Newtonian science, has proscribed the kinds of observations, relations and models with complex forms of entailments characteristic of living organisms. Rosen's main concern was to develop mathematics and to reconceive the goal of science to do justice to the reality of life itself. This involved advancing a tradition of natural philosophy inspired by Kant's 'Critique of Judgment' and the work of Friedrich Schelling (Gare, 2011, Gare, 2013). Category theory as conceived by Rosen can be interpreted as a major development of the Whiteheadian/Peircian conception of mathematics - as the study through abstraction of possible patterns of connectedness and their transformations utilizing iconic signs or diagrams (Zalamea, 2010, 219ff.). Its potential has been tapped by Andrée Ehresmann and Jean-Paul Vanbremeersch in developing their model of *Memory Evolutive Systems* (2007). These systems are multi-scale, multi-agent and multi-temporal and analyse changes from an 'endo' perspective through a net of internal agents acting as co-regulators. Involving a family of categories indexed over time, these are able to model a complexification process internally selected by the net of co-regulators capable of creativity (Ehresmann and Vanbremeersh, 2007, and Ehresmann and Simeonov, 2012). Rosen's work has also been a source of inspiration for the development of non-reductionist biomathematics, or 'integral biomathics', exemplified in Simoenov (2010). A major anthology on integral biomathics has been published, edited by Simeonov, Smith and Ehresmann (2012) along with a previous edition of *Progress in Biophysics & Molecular Biology* edited by Simeonov, Matsuno and Root-Bernstein (2013).

Based on this way of understanding mathematics, Rosen argued that Gödel's theorem is just another foundation crisis for mathematics, due to it having taken a fateful wrong turn with Pythagoras (Rosen, 1993). Pythagoras had attempted to reduce geometry to arithmetic, equating effectiveness with an iteration procedure such as counting; that is, computation. It was this assumption that led to Zeno's paradoxes and the crippling of mathematics for millennia. The basic problem is assuming that the simple procedures adequate to simple domains of mathematics, which are adequate for modeling very limited domains of reality, are adequate to more complex domains and can define acceptable procedures. This underpins the quest for formalization, and over and over again, it has failed. More recent efforts in this direction involve efforts to eliminate semantics from mathematics and to reduce mathematics to syntactical operations without outside reference. Rosen noted the consequence of this: 'once inside such a universe … we cannot get out again, because all the original external *referents* have presumably been pulled inside with us. … Once inside, we can claim "objectivity"; we can claim independence from any external *context*, because there *is* no external context anymore' (Rosen, 1993b, 115).

Most mathematics is not formalizable through axioms as Hilbert called for. For Rosen, what Gödel showed was that the model of arithmetic, developed by Frege, Russell and Whitehead using set theory and logic, is less rich than arithmetic. Arithmetic is 'soft science' relative to the 'hard science' of set theory and logic, just as arithmetic is less rich than what is modeled by it, the richness of which is better captured by the 'soft' disciplines of the humanities and by the arts (Rosen, 1991, 9f.). With modeling, this will always be the case. The modeling relation, where something is learned about one system by studying another which is analogous to it, is ubiquitous and characteristic of everyday life as well as of both theoretical and experimental science (Rosen, 2012, 82). It is the failure to appreciate this that has led to the belief that objectivity implies the reduction of biology to chemistry and physics. As Rosen diagnosed the source of this problem:

> [T]hese ideas [that every model of a material process must be formalizable] have become confused with *objectivity* and hence with the very fabric of the scientific enterprise. Objectivity is supposed to mean observer independence, and more generally, context independence. Over the course of time this has come to mean only building from the smaller to the larger, and reducing the larger to the smaller. … In any large world, such as the one we inhabit, this kind of identification is in fact a mutilation, and it serves only to estrange most of what is interesting from the realm of science itself (1993, 118).

Once this is realized we can not only free ourselves from the spell of the Pythagorean/Parmenidean ideal of science, reveal further aspects of its incoherence and free science to acknowledge the reality of life and mind and to develop mathematics more adequate to life, but also recognize the limits of mathematics and the role and validity of non-mathematical conceptualizations and models that acknowledge some measure of indeterminacy in the present and openness to the future.

Reintroducing 'Possibilities' into Nature

One pathway beyond the Pythagorian dream concerns the question of what to make of Possibles. Can they be "ontologically real", as for example, Whitehead proposed in *Process and Reality*? And Peirce centered his views on what we will here call, "Possibles"and "Actuals", his "facticity", and, in his case "laws". We follow him, (Peirce 1902), and Whitehead concerning Possibles and Actuals, albeit on a somewhat different track.

A central feature of classical physics is that it takes itself to be discussing only "Actuals", i.e. events that do or do not actually happen. In this world view, that of Newton, or later, Einstein in Special and General Relaitivity, the becoming of the world is entirely determined and is what actually happens, Pierce's "facticity" our "Actuals". Were we to try to talk of what "might have happened", that talk is nonsense, for the world can only become in the specific way that it became given the initial and boundary conditions and Newton's laws, or Special Relativity and even General Relativity.

This framework denies the possibility of free will, let alone consciousness and qualia, hence phenomenology. Free will requires that "we could, contrary to fact, have "chosen hence done" otherwise". This means that "the present could have been different". But the specific becoming of the actual world in classical physics cannot have been otherwise given the initial and boundary conditions and laws of motion of the system.

But we have missed something subtle in classical physics. Possibles, unstated, are central to it: Consider the billiard table and the edges which constitute the boundary conditions we use to integrate Newton's equations. Now think of a modest number of rolling balls rolling for, say, a few minutes on the table, bouncing off the edges of the table. In *fact*, the balls will only touch the edges of the table at a small number of specific points and, by the third law, rebound. But in using the edge of the table as the "boundary conditions" we are asserting that "*were* the balls to hit at other places than they did hit, they *would have* behaved as predicted by Newton's laws. But "Were" and "Would Have" are what are called "conditionals contrary to fact". They are Modal logic terms about what Might happen or Might have happened. But modal terms like *were*, Would, Might, concern what is *possible*. The boundary conditions CREATE the very phase space of "all possible positions and momenta of the particles"!

In the case above, however, the Newtonian behavior of the particles is "causal", and General Relativity concerns causally linked events in space-time. However the famous Second Law of Thermodynamics in statistical mechanics, (Boltzmann), rest fundamentally on an even stronger appeal to The Possible". This appeal is the famous "Ergodic Hypothesis", for example for N particles in a liter box. Each can have its position and momenta defined by six numbers, thus there is a 6N dimensional phase space broken into tiny 6N dimensional "microstates". A "macrostate" consists in a set of microstates. Some macrostates have few microstates, others have many. The Ergodic Hypothesis entirely give up integrating Newton's laws of motion for the N particles and simply asserts: The system will spend "equal time in equal volumes of state space". But there are NO CAUSES in the Ergodic Hypothesis. But to spend "equal time in equal volumes" it must be POSSIBLE to spend equal time in equal volumes! Without the hypothesis, the second law cannot be deduced for it is: The system will tend to flow from macrostates with fewer microstates to those with more microstates. Taking the "entropy" of a macrostate to the logarithm of the number of its microstates, entropy "tends to increase", the very Second Law. Thus, without the non-causal Ergodic Hypothesis which must appeal to the "reality of possibles", there is no way to derive the Second Law! Classical physics, in its state spaces given boundary conditions and the Ergodic hypothesis depends upon the reality of Possibles.

What this shows is that the conditions for this form of science are the capacity to set up such boundary conditions and to envisage different possibilities. This in turn, implies that it is possible to set up boundary conditions and it is conceivable that different possibilities could be realized. Any physicist in fact believes that he/she could construct a billiard table with a different shape, hence boundary condition, and "could have done otherwise". Physicists assume responsible free will to act as exophysicists, then deny that assumption! Such science, the traditional approach of exophysics, is important, but limited.

As Smolin points out (2013), physicsits typically divide the universe into the system and the rest of the universe. Clearly the universe as a whole cannot be studied by setting up boundary conditions because we cannot get outside it to control its boundary conditions. We have to study it from the inside as part of it, and in fact, we cannot completely step outside what we are studying because we to some extent are involved with and partially create what we study, even in the "simple case" of building a billiard table. The study of systems from an internal perspective is endophysics. What can be observed as a participant within a system is different from what can be observed from an external perspective.

More, there is an inevitable "Subjective Pole" component to the "doing" of exophysics as in choosing the boundary conditions. Robert Rosen pointed out that science at its most basic level involves making discriminations, thereby creating dualisms. The most basic discrimination made by all scientists, Rosen argued, is between the self and everything else, which Rosen referred to as the *ambience* (Rosen, 1991, 40). Discriminating oneself from one's ambience, which is fundamentally phenomenological, the foundation on which all other discriminations are based, requires one to accept that this is a division within the world encompassing both oneself and the ambience. The proponents of endophysics have understood this, and as a consequence, regard endophysics as more basic to science than exophysics, although exophysics can reveal aspects of reality that those inside a system cannot possibly see. Newton's laws, the initial triumph of exophysics, describe the solar system very well, although done better in General Relativity.

The Confluence of Endophysics and Naturalized Phenomenology

In recognizing this, work on endophysics converges with, supports and clarifies Merleau-Ponty's conclusion that we as flesh are within and part of an englobing nature that is also flesh; more primordial than and the condition for the emergence of subjects and objects. This involves recognizing that nature is simultaneously observing and observed and in process of becoming. But to get to this view we must surpass classical physics in which the world of actuals happen whether or not observed. We will appeal to Quantum Mechanics below. If successful, we also converge with Polanyi's observation, further developed by Pattee and other hierarchy theorists, that not only does scientific investigation of nature involves setting up boundary conditions for studying particular phenomena, but that we are only able to do this because we ourselves are not outside the world free of the constraints governing what we are investigating. Our very existence involves a whole hierarchy of extra facilitative constraints. The constraints on cells maintaining bodily form are the basis of the freedom of action of the individual as a multi-celled organism. The constraints of language are what facilitate complex forms of communication. It is such constraints that make scientists and scientific inquiry possible.

The implications of this confluence of naturalized phenomenology and endophysics are most clearly manifest when the role of measurement in science is considered. Measurement cannot be treated in abstraction from other aspects of scientific activity, such as what is involved in recognition of patterns, discrimination and classification. However, given these other aspects, measurement is, as Rosen argued, 'both the basis for our concrete knowledge of the physical world and the point of departure for the formation of conceptual structures (models) which organize this knowledge and enable us to predict and control (Rosen, 1978, ix). In exophysics, as exemplified by Newtonian science, it is assumed that measurement is completely separate from what is being examined. As physics has advanced beyond Newtonian science, measurement has had to be taken into account as part of what is being examined. Measurement, recognition, discrimination and classification depend on the capacity of a system to induce dynamics (a change of state) in another system, and this relationship has to be acknowledged. For instance, in thermodynamics it had been suggested by Clark Maxwell that increased entropy could be avoided by a demon observing particles in motion and selectively choosing which particles to be allowed to pass through a door. What Maxwell had forgotten was the entropy generated by making observations and opening and closing a door, and observation is now recognized as something that has to be taken into account in the study of thermodynamics. While the general theory of relativity and quantum cosmology appear to be strongholds of anti-humanist objectivism, Einstein's initial concern had been with the problem of establishing simultaneity in OBSERVATIONS, essential to the experimental study of physical systems. He took the special theory of relativity to imply the primacy of becoming and the derivative place of space, as there is never any question about the direction of temporal becoming within any reference frame. And the theory is incompatible with determinism because the future of a particular reference system is affected by the variables 'elsewhere', outside the past light cone of the system of interest, that cannot be fully known but affects events in the later and future light cone of that system, (Bohm, 1965, 180ff, Bohm and Hiley, 1993, Popper, 1988.). Interpreted in this way, different perspectives can be seen to have an objective status, while a God's eye perspective is ruled out. It is possible to extend this way of interpreting the special theory of relativity theory to the general theory. Interpreting the geometry as a *mapping* of the events in the world, their potential for independence and interaction between reference frames and from there to more recent developments in quantum cosmology (Čapek, 1961, 175ff.). This is affirmed by Lee Smolin's efforts to reformulate cosmology in a way that privileges time and treats space as emergent (Smolin, 2013, 172ff.).

However, it is in quantum mechanics that the significance of quantum measurement has become central to science and which justifies a conception of being that is neither observer not observed, more primordial than either and the condition of both. Endophysics began with reflection on quantum theory, and has continued to develop through such reflection (Buccheri et.al., 2005). Here we will propose a new, perhaps the fifteenth, version of quantum theory, which both acknowledges the impossibility of construing reality independent of the measurement process, but then takes this measurement process to be an essential feature of what there is.

From Quantum Measurement to an Enveloping Nature of Creative Processes

In outline: we shall offer a new interpretation of quantum mechanics, then below a new view of the evolution of life, both, of which are entirely open-ended GENUINE EMERGENT BECOMING, in the spirit of Pierce above, but, unlike Pierce, entailed by no law, where radical emergence is real and where we regain our Subjective Pole in a participatory universe that ever becomes with a Subjective Pole "all the way down". What we shall say about quantum mechanics is a cousin of the position of Sir Roger Penrose and Stuart Hameroff, Orchestrated Objective Reduction (Orch OR) (Penrose 1989, 1994). We and they propose that whenever quantum measurement happens in the universe, bursts of consciousness and free will doings arise in that measurement, sometimes called "the collapse of the wave function". Penrose and Hameroff (ibid) propose that spacetime itself splits into two or more superpositions of "possible" structures of spacetime, then via self gravitational effects, measurement "happens at a time Eg =h/t, where h is Planck's constant, t is time and Eg is self gravitation We state in preliminary form an alternative view, "The Triad", in a moment, where conscious free willed "mind" itself acausally is both necessary and sufficient anywhere in the universe to carry out measurement. (There is preliminary evidence that distant human consciousness can mediate measurement, Radin (2012, 2103, described further below.) Radically, on either Orch OR or the Triad, the universe is vastly participatory, with some form of "cosmic consciousness", hence qualia and phenomenology, and something like protoresponsible free will "doings" every time measurement happens! If so, the universe, all of life, and we with life, are choosing, in part, what the universe and we are becoming.

The above pictures, Orch Or, (ibid) and "The Traid" also needs an account of the "classical world". If not we cannot be "embodied" Physics accepts quantum mechanic and quantum field theory and the classical physics of General Relativity, but has as yet no agreed upon account of what the classical world might be and how it may emerge from quantum mechanics.

We mention at least three ideas, among more, about what the classical world is, given Quantum Mechanics, decoherence (Zurek), the ideas of Henry Stapp (Stapp), and the possibility that the classical world rests on what is called the Quantum Zeno Effect, (Kauffman 2014, 2015b). These hypotheses are testable. Importantly, the "standard interpretation" of quantum mechanics, The Copenhagen interpretation largely crafted by Bohr, assumes the world "just is" both quantum and classical. von Neumann in his foundational book on quantum mechanics and measurement, (von Neumann 1933), struggles with these issues. General Relativity and Quantum Mechanics remain ununited since their discoveries in 1916 and 1927. String theory, and loop quantum gravity are two major attempts to quantize General Relativity. Neither has yet succeeded; but may yet.

The Triad

We shall here build towards a new view of quantum mechanics which may solve a number of problems at its foundations: Actuals that are ontologically real and defined as obeying Aristotle's law of the excluded middle, Possibles which are ontologically real and are defined as not obeying the law of the excluded middle, and Mind, consciousness with qualia, and free will doings at measurement. In short: *res potentia*, *res extensa* linked by "mind" at measurement.

Quantum superpositions do not obey the law of the excluded middle. This is captured in the Schrodinger Cat mystery in which the Cat is "simultaneously dead and alive" until we "look" in the box holding it to see if quantum random release of a particle has killed it. But "The cat is simultaneously dead and alive" is a contradiction, so does NOT obey Aristotle's law of the excluded middle. Pierce pointed out that actuals and probables do obey that law, but possibles do not. "The cat is simultaneously possibly dead and possibly alive" is not a contradiction. We will define ontologically real Possibles as "not obeying the law of the excluded middle" which characterize the wave behavior of quantum systems prior to measurement. Actuals, after measurement, DO obey the law of the excluded middle, for example the spot on the film in the two slit experiment. So measurement does convert from that which does not to that which does obey the law of the excluded middle. Our position is *res potentia* and *res extensa*, and measurement converts Possibles to Actuals.

But how does measurement happen? Von Neumann, (von Neumann), proposed that human consciousness could suffice for measurement. Radin has weak evidence for this, (2012, 2013). If confirmed human consciousness can be sufficient for measurement. If we come to believe or demonstrate that human consciousness can suffice for measurement, then we need to invent a way either classical devices, or such devices that are quantum at their base can measure. In a set of arguments based on Conway and Kochen's "Strong Free Will Theorem" (Conway and Kochen), and "The Quantum Enigma, (Rosenblum and Kuttner), the simplest hypothesis is that quantum variables can consciously and with free will, measure one another, (Kauffman 2014, 2015b), and whatever the classical world may be, it is quantum at base and those quantum variables can measure consciously, so classical devices can measure as well, as von Neumann and most physicists want. At present we see no way to test whether quantum variables can consciously measure. If that is true, then electrons measuring have free will (Conway and Kochen) and qualia, so have some form of phenomenology!

Now the "Triad" consisting of Actuals, Possibles, and Mind" In this view, Mind measuring Possibles yields unentailed, new Actuals in the universe. New Actuals instantaneously and acausally yield new Possibles for Mind to measure acausally, creating again new Actuals that again acausally create new Possibles for Mind to measure. This is a persistent emergent BECOMING. Nothing IS, all BECOMES, STATUS NASCENDI. Bergson's Duration is real (Bergson ref). Peirce's Possibles and Actuals = Facticity are real. Mind is real. A central hypothesis is that conscious mind can measure. As noted above, there is very preliminary evidence that this may be true. D. Radin (Radin et. al. 2012, 2013), has early evidence using the famous two slit experiment, described below, that distant participants by concentrating, but not when not concentrating, and not robots, can affect measurement in the two slit experiment slightly but strongly statistically significantly. The effects on measurement are to shift the famous interference patterns of dark and light bands that arise in the two slit experiment, altering the ratio of "brightness" of adjacent dark and light bands. Each spot in these bands, whether recorded by a film emulsion or a CCD, the present case, is a single measurement event. Thus, to alter the ratio of dark and light band intensities is to alter measurement events. Thus Radin, (ibid), has the first very tentative evidence that mind can affect measurement, or "mediate" measurement.

We have used Pierce to assert a new Dualism: *res potentia*, ontologically REAL possibiles that are defined as NOT obeying the law of the excluded middle, and *res extensa*, ontologically real Actuals, defined as obeying the law of the excluded middle, linked by measurement, in the Triad by mind measuring, converting Possibles to Actuals. Unlike Descartes' *res cogitans* and *res extensa*, a substance dualism, *res potentia* and *res extensa* is NOT a substance dualism, because possibilities are not substances for they do not obey the law of the excluded middle, hence are not Actuals.

Non Locality, Instantaneous Changes in Wave Functions, Which Way Information, and the Quantum Enigma.

The postulate of ontologically real possibles seems strongly to answer four deep puzzles about quantum mechanics that all interpretations of quantum mechanics face: Non-locality, Instantaneous changes in wave functions, "which way information", and aspects of the Quantum Enigma.

In 1933, Podolsky and Rosen (Einstein, Podolsky, Rosen), published a paper meant to show the incompleteness of quantum mechanics. In QM, two or more variables can be "entangled, and no longer two independent variables, but they are described by a single Schrodinger "wave function." Quantum Mechanics predicts that if two electrons are entangled and each, say, has by the Born rule, a 50% probability to be measured spin up or 50% probability to be measured spin down, then if one is measured "here" and found to be spin up, the other, WHICH MAY BE MILLIONS OF MILES AWAY, INSTANTANEOUSLY WILL BE MEASURED SPIN DOWN. But light travels at a finite speed, C, so this prediction of quantum mechanics violates special relativity. Einstein was apparently wrong. The experiment has been carried out many times, and the results are just what Quantum Mechanics predicts. But no information can travel faster than the speed of light, so no causal effects can account for the correlations of the two measurement outcomes. Non-locality has been demonstrated up to 190 kilometers at this point. The universe is NON LOCAL in the sense that no causal connection between the two entangled particles can account for the non-local observations. Physicists have no clear way to account for non-locality. Many struggle with "supraliminal acausal" influences.

ONTOLOGICALLY REAL NEW ACTUALS ACAUSALLY AND INSTANENSOUSLY YIELD NEW POSSIBLES.

We begin with classical physics and the two authors. We are going to meet at the store on J street tomorrow to buy orange juice. Today a sign goes up on the store on J street: "This store closed immediately!" What just happened to the possibility that we could meet at the store tomorrow? The possibility VANISHED, AND DID SO INSTANTEOUSLY AT THE MOMENT THE SIGN WENT UP, AND THE POSSIBLITY, GIVEN THIS NEW ACTUAL, VANISHED "ACAUSALLY". No billiard balls bounced on a billiard table as in Newton. If possibilities can be real, then a change in an Actual, if time is real up to Special Relativity, can acausally and instantaneously, change what is now possible.

In Quantum mechanics, if *res potentia* is real, and possibilities are outside of space but inside of time up to special relativity, or inside of space and time up to Special Relativity and propagate as "real possibles" with the Schrodinger equation, we easily account for non-locality. The measurement of the first electron as "spin up" is a new in the universe ACTUAL that obeys the law of the excluded middle and acausally and instantaneously, changes the outcome for the second entangled electron. The possibility that the second electron can be measured to be spin up has VANISHED with the measurement of the first electron. Thus the second electron can only be measured as the one remaining possibility, spin down. More precisely, by symmetry of two entangled electrons, if the spin of one is up, the other must be down. There are only two possibilities. When the first electron is measured UP, that possibility for the second electron vanishes and thus the second electron can only be measured spin down. If Possibles are outside of space but inside of time up to Special Relativity, and measurements must have outcomes, as Actuals, inside of space as well as time, we have an account of non-locality. If Possibles are inside of space and time up to Special Relativity and spread with the Schrodinger equation, we also have an explantion for non-locality: At time T the single wave function of the entangled particles propagates in space. At time T + tau the measurement of the first electron occurs. At time T + tau + e the measurement of the second electron occurs. But the interval, "e", between the first and the second measurement is too short for light to have traveled between the locations of the first and second measurement, so the correlations of the two measurements are non-local.

The view: *res potentia res extensa* linked by (mind) measurement accounts for three other puzzles in quantum mechanics beyond non-locality. In QM, given N entangled particles, measurement of the first, INSTANTEOUSLY ALTERS THE WAVE FUNCTION HENCE THE AMPLITUDES OF THE REMAINING N - 1 PARTICLES hence their Born probabilities of measurement outcomes. How can anything causal, with the speed of light finite, C, INSTANTANEOUSLY alter amplitudes of the N - 1 particles? Nothing causal can happen, (if measurement is real, hence not on Bohm, (Bohm).). But measurement of the first particle yields a new in the universe Actual that can instantaneously and acausally change what is now possible, hence change the possibles comprising the wave function.

A third puzzle in QM, an aspect of the quantum enigma, (Rosenblum and Kutter), discussed more fully below, is that if we prepare an electron to be in a superposition in box 1 and simultaneously in box 2, like the CAT, and we look in box 1 and do NOT find the electron in box 1, it is instantaenously "measured" to be in box 2, despite the fact that no one looked in box 2. How can that be? If possibles are real, there were two possibilities, the electron in box 1 and simultaneously in box 2. If I or we look in box 1 and it is via "my conscious observation of it, measured to be NOT there, that possibility is eliminated and the remaining possibility is that it now IS in box 2. Confirmed without conscious measurement.

A fourth puzzle, "which way information", is an aspect of the two slit experiment: In brief here, at last, is the two slit experiment, probably the central experiment for which QM was invented. A screen with two slits is erected, with a film emulsion or CCD behind it. One slit, the left, say, is covered. A flashlight shines light through the open right slit and the film or CCD records a bright spot behind the open right slit. Now cover the right slit, again shine the flashlight through the now open left slit, and a bright spot will be recorded on the film or CCD behind the now open left slit.

Now open both slits! What happens is the central mystery of QM. One does not get two bright spots, but a series of light and dark bands on the film or CCD, spanning between where the two bright spots would have been. This set of bands is the famous interference pattern. It is this pattern that Radin (Radin et. al. 2012, 2013) is finding, with still tentative evidence, can be slightly altered by distant people attending to the pattern and "trying" to alter the ratio intensity of adjacent light and dark bands.

Stunningly, if one tunes the flashlight now so one photon an hour passes through the two open slits and accumulates the spots, the same interference pattern is found! So the "weird behavior" is true of single photons. This mystery is that the photon behaves like a wave before being measured, and a particle when measured and a, say spot, arises on the film emulsion. To explain the "wave like" behavior picture parallel water waves approaches from seaward, a sea wall with two slits, passing through them and yielding semicircular waves propagating from each slit in the sea wall toward the beach. Let these wave trains overlap. Walk along the beach. At some points the crests of waves from the left and right slits in the sea wall arrive at the same point on the beach and the crests sum to a higher crest. This corresponds to a bright spot on the film. At other spots on the beach, two valleys from left and right slits in the wall arrive at the same spot on the beach and also correspond to bright spots. But between these spots, the crest of one wave, say from the left slit in the wall, arrives where the valley of a wave from the right slit arrives, and the crest and valley CANCEL out, corresponding to the dark bands on the film or CCD.

In the case of photons, or electrons or buckyballs, all showing the interference pattern, one says that the photon or electron or C60 Buckyball, simultaneously passes through both slits, in a "quantum coherent SUPERPOSITION", like the dead and alive cat. This quantum coherent behavior of two or many superpositions is the WAVE behavior of quantum variables. Importantly, no one ever SEES this quantum superposition, we see only the results of measurement, the particle behavior of the photon, electron, or buckyball. This is the famous wave/ particle duality of quantum mechanics.

Now as if that were not bad enough, if one mounts any instrument behind one of the two slits, say the left one, "recording" which way the photon passes, the interference pattern DISAPPEARS! THIS IS "WHICH WAY INFORMATION". How can which way information affect the interference pattern? ON *RES POTENTIA*, why does the interference pattern disappear? Because the measurement of the photon passing (or not) through the left slit, is a new Actual, that changes what is now possible instantaneously and acausally, hence removes one of the two (two slits) possibilities, and only one possibility remains, given this new Actual. If the photon Actually did go through the left slit, that removes the possibility that it went through the right slit. So the interference pattern disappears. If the photon did NOT go through the left slit, the only possibility left by that new actual, is that the photon went through the right slit.

In short, if possibles are real, we can account for four deep issues in quantum mechanics. On *res potentia*, for example superpositions, what is waving in the Schrodinger equation, are POSSIBILITIES. Heisenberg has much the same view long ago, (Heisenberg), as did Deiter Zeh more recently, (Zeh).

We know of no explanation for these four mysteries, that appear to be explained by ontologically real Possibles.

Von Neumann's Epistemic Cut

von Neumann (von Neumann) struggled with this: a quantum system is to be measured by a classical device, but the quantum system becomes entangled with classical system and the total entangled system remains QUANTUM. A further classical system now is to measure the first quantum system entangled with the first classical system, and this second measuring system also becomes entangled so remains quantum, in an infinite regress of measuring devices. To break this regress, von Neumann proposed that only consciousness can measure. Then he "waffled" and said maybe the classical instrument can measure, placing an "epistemic cut at consciousness for measurement or at the classical apparatus or anywhere in between. Almost all physicists hold that "classical" devices can "record" hence measure, for example a cosmic ray leaves a track on mica and is measured. Bohr, in conceiving of the Copenhagen interpretation, assumed both a quantum and a classical world, the latter somehow playing a role in measurement, as just noted.

One possible answer, the one is to propose (Kauffman 2014, 2015, 2015b), is that classical systems are quantum at base and the quantum variables can consciously observe one another and so measure, as Radin (Radin et. al. 2012, 2013), is tentatively finding human consciouness may do. This is a huge step: IF WE CONVINCE OURSELVES THAT HUMAN CONSCIOUSNESS CAN BE SUFFICIENT TO "MEDIATE" MEASUREMENT, AS RADIN'S RESULTS BEGIN TO SUGGEST, THEN EITHER WE INVENT SOME OTHER WAY THE CLASSICAL WORLD, WHATEVER IT IS, OR QUANTUM VARIABLES AT THE BASE OF THE QUANTUM WORLD CAN "MEDIATE MEASUREMENT BY CONSCIOUSLY OBSERVING ONE ANTOHER, SEE MORE BELOW, OR WE TRY THE IDEA THAT QUANTUM VARIABLES CAN CONSCIOUSLY MEASURE ONE ANOTHER, SAY BY FERMIONS EXCHANING BOSONS, (Kauffman 2014, 2015b).

This proposal solves the epistemic cut issue of von Neumann. Direct evidence that electrons are consciosus at measurement seems impossible at present.

The Quantum Enigma: We and Nature Jointly Co-Create Reality.

Rosenblum and Kuttner, (Rosenblum and Kuttner), wrote The quantum enigma in a simplified form. Here it is: We can choose to prepare a system such that a single electron is in a superposition in box 1 and box 2. Then we look in box 1 and it is either in box 1 or not, hence comes to be IN box 2. We have measured 1 by looking in box 1. But if the electron is not in Box 1 it is and measured be in box 2 even though we did not look. But critically, we COULD HAVE CHOSEN, FREE WILLED, TO DO A DIFFERENT EXPERIMENT, we could have examined boxes 1 and 2 simultaneously and inferred a superpositon just like life and dead cat, or the interference pattern in the two slit experiment. We, free willed, ask one of two questions of nature, but could have asked the other question: i. yes or no, in box 1 or two, ii. yes is there an interference pattern, and we confirm the interference pattern, hence questions I and ii yield a different reality! Thus, we by our choice of what experiment to do, what question to ask of Nature, but could contrary to fact, have asked the other question, and Nature's answer and our measurement or inference, CHANGE REALITY! THERE IS NO PREEXISTING REALITY, AND OUR FREE WILLED CHOICES AND CONSCIOUS OBSERVATIONS ALONG WITH NATURE, CHANGE WHAT "BECOMES REAL". SEE ALSO STAPP, (STAPP) . For the enigma to be real, it must be the case that we could have chosen to do the other experiment. Then the present could, contrary to fact, have been different. Ontologically, it is possible for the present to have been different if measurement is real and indeterminate, for the electron could now have been measured to be spin up or to be spin down, so the present could have been different.

One solution to the Enigma, (Kauffman 2014, 2015b), is to push it all the way from us to electrons and protons exchanging photons, and consciously measuring one another with free will. The Conway Kochen Strong Free Will Theorem, (Conway Kochen), seems to establish that if we have free will, so does the electron which decides non-randomly to be measured spin up or spin down.

Penrose and Hameroff, on different arguments, seem to want the same thing. As we understand their view, expressed in Penrose, (Penrose 1989, 1994), and Hameroff on line P.C to a discussion group, spacetime splits into two or more POSSIBILITIES, which by gravitational self interaction collapses at moment with a flash of consciousness and, it seems free will. On their view, like the Triad, consciousness and free will occurs whenever measurement happens. The Triad presumes free will happens on measurement too, so both, Orch OR, and Triad, have a vastly participatory universe with something like the start of : Cosmic mind and will whenever measurement happens!

Either the Triad, (Kauffman, 2015b) or Orch Or, give us a universe where at each measurement flashes of consciousness, qualia, and free will occur. We then have mind and phenomenology all the way down.

Then we have the start of our Subjective Pole in a vastly participatory universe in which mind and free will are part of the becoming of all. If so, reductive materialism fails, for free will is real. More, on either the Triad or Orch OR, all is a becoming, not being. The outcomes of measurement change the world which then becomes again, based on the unentailed outcomes of measurement. The world becomes. Bergson's Duree is real, (Bergson ref). So is Whitehead's, (Whitehead).

Human Mind-Body and Phenomenology

All this provides support for the way nature is actually experienced, as Merleau-Ponty claimed, nature that does not stand over against us but of which we are part and are participating within. It is not a mechanical world of matter occupying Euclidean space and governed by immutable laws, as Newtonians led us to believe, but is an enveloping world that is active, with some measure of openness to the future. If measurement even at the quantum level in whatever the classical world may be, is "mediated acausally" by mind, conscious and free willed, then life, on earth for 3.7 billion years, did not evolve mind ab initio, but made use of it and presumably elaborated it to achieve the remarkable human mind. What is the experiential content of the human mind? How complex! Phenomenology, as in Merleau-Ponte (Merleau-Ponty) and others back to William James (James), have studied this. Thomas Nagle famously wrote, "What is it like to be a bat?", (Nagel), trying to show that consciousness is real, there IS something that it is LIKE to be a bat,whose phenomenology is presumably different than ours given the bat's capacity for echolocation. But what, phenomenologically, what is it like to be E. coli, Stentor, Hydra, Anabena, yeast, a bush, tree, chimp or thee?

Answering Descartes

Descartes' *res cogitans* and *res extensa*, a substance dualism, failed, for given the classical world of *res extensa* and Newton, the current state of the classical brain suffices for the next state of the brain. Then there is nothing for mind to do and no way for mind to do it. We have been frozen in this stalemate since Descartes and Newton due to the "causal closure" of classical physics. We need to go to quantum mechanics to break the Stalemate. Kauffman and colleagues, S. Niiranen, G. Vattay have recently discovered The Poised Realm, (Kauffman et. al, 2014, Kauffman 2014, 2015, 2015b, Vattay et al, 2014, 2015, Vattay and Csabai 2015), which hovers reversibly between quantum coherence and "classical" worlds via ACAUSAL decoherence and recoherence, both acausal, and measurement. The poised realm seems VERY real, and may explain how a quantum coherent and poised realm and classical mind body allows the quantum and poised realm aspects to have ACAUSAL CONSEQUENCES, for whatever the classical "meat" of the brain / body may be. This breaks the causal closure of classical physics and is an answer to the Stalemate.

The poised realm seems real, (ibid), and quantum effects such as long lived quantum coherence that decoheres slowly, is real in light harvesting molecules, (Engles et al.) in bird migration and smell, where smell may not be classical receptor ligand lock and key binding, but in part due to quantum oscillations.(Get). Partial grounds exist to think life is partly in the poised realm. For example, theory suggests receptor ligand complexes work better if partially coherent, (Vattay and Csabai).

What is the Classical World?

We have no accepted account of the classical world. If Merleau-Ponty, contra Husserl, (Husserl), wants EMBODIED PHENENOLOGY, we need a classical enough world to have a body. So does evolution, otherwise advantageous mutations could not accumulate adaptations. We mention again decoherence (Zurek), Stapp (Stapp), and Kauffman's try, (Kauffman 2014, 2015b) based on the quantum Zeno effect. Here is the Quantum Zeno effect. Some quantum measurements yield a single wave function, hence an Actual, but not a stable spot (classical) of a film. Quantum theory says that the single wave function will flower slowly, quadratically, in time, new waves. Initially these will be of tiny amplitudes, while the initial wave function is still of very high amplitudes so the Born rule is very likely to be the one measured if the system is rapidly remeasured. This is confirmed and is the Quantum Zeno Effect. Were remeasurements infinitely rapid, which is not possible, the propagation of the Schrodinger wave would be halted. Now Linus Pauling famously proposed that a covalent chemical bond is a SINGLE WAVE FUNCTION, say between an electron in one atom and proton in another, exchanging virtual or real photons. But we can then ask, "WHY DOES THE SINGLE WAVE FUNCTION OF THE CHEMICAL BOND NOT FLOWER NEW AMPLITUDES? A tentative answer is that the exchange of photons allows the proton and electron to remeasure one another rapidly enough to induce the Quantum Zeno effect, thus "co-trapping the proton and electron in a single "stable" wave function that creates the chemical bond. Much of the classical world is made up of simple and complex molecules, from metals to Buckballs to lumps of coal to spots on film emulsion in the two slit experiment. The idea is that cross observation as the number of atoms in the "mass" increases, induces the Zeno effect ever more strongly, so a benzine molecule is less classical that a 50 kilogram lump of coal, which is a single molecule of many carbon atoms. This hypothesis seems testable. Can cross trapping by a Zeno effect for long times be confirmed? Maybe.

In short, the Triad is insufficient in itself. We need a classical world somehow, such as stable spots on film emulsions that last years. In quantum mechanics, the Schrodinger wave is set equal to a classical potential which is its boundary conditions and the waves must "fit" those boundary conditions. Change the boundary conditions and the quantum wave functions will change. Were there no stable classical enough world, evolution could not have worked. We advocate no refined idealism such as Berkeley or Hursserl (Husserl), but side with Merleau-Ponty, (Merleau-Ponty).

The "classical world" presumably bears on the phenomenology of bats with echolocation and us with highly evolved sight, smell and so forth. Our brain stems, amygdala, limbic system and forebrains are largely classical neural structures that evolved with respect to our emotions.

The views above suggest a naturalized phenomenology all the way down in a becoming universe. We turn next to the unprestatable, radical emergence of life and mind in the evolution of the biosphere; hence to an open ended becoming of an embodied naturalized phenomenology.

The Origin and Unprestatable Emergent Evolution of Life

Any human phenomenology rests on the emergence and evolution of life, here on earth, embodied life. If panpsychism is right on Orch Or, (Penrose 1989, 1994) or the Triad as two possibilities, then mind is in the furniture of the universe and life started with mind and mind evolved with life. Phenomenology has been with us for 3.7 billion years on earth and perhaps on some of the 10 to the 21st stars that have exoplanets and perhaps life.

No one knows how life originated. Briefly there are four views now contending, giving a primordial soup of organic molecules due to abiotic synthesis on earth, infall of comets and meteorites on the early earth, or both. The first view, the RNA world view, started with the observation that DNA is a double helix, and so is its cousin, RNA. The hope has been that one side of the double helix, say the Crick side, could, without enzymes, line up free building blocks called nucleotides, and link them into the second, Watson strand; the two melt apart and cycle, creating a replicating RNA or RNA like polymer. For many reasons, this has not worked for 40 years, but still may, (Orgel and Lohrman). A second view is that life started with budding hollow lipid vessicles called liposomes, which do occur, (Daemer and Barchfield). A third view is the spontaneous emergence of sets of molecules, say RNA or small proteins called peptides, or both, which mutually catalyze one antoher's formation from some outside building blocks, (Kauffman 1971, 1986, 1993, 1995, Hordijk et al, 2010, 2011, 2012). Call these collectively autocataltyic sets. This has succeeded to a substantial extent with DNA, RNA, and peptide CAS. Ashkenasy, (Wagner and Ashkensay), for example has a 9 peptide collectively autocatalytic set reproducing in his lab in Israel. The fourth view, the Chemotron (Ganti) by T Ganti, proposes a bounding membrane with a metabolism inside and some form or reproducing polymers, eg RNA world-like, inside. It seems likely that some form of protocell, perhaps a CAS inside a liposome that can bud, making the lipids needed to form more liposome, can be made in the next decades. If so we will have created some early protocell, and have good grounds to think that it can evolve, even before DNA encoded protein synthesis via the genetic code emerged. That code, a major issue, enabled wide exploration of DNA, RNA and protein space and thereby did not cause, but enabled enormously more rapid evolution. We can hope that we will have created protolife soon.

If the Triad or Orch OR are correct, mind is throughout the universe, hence was part of life from the outset. More the Poised Realm is real, and may be part of life from the outset. If so, qualia and mind and embodied phenomenology are all parts of the evolution of the biosphere. With this comes AGENCY, sensing the world, evaluating it as “good or bad for me”, and thence doing in the world. Hence emotion to evaluate, linked with some forms of “knowing and acting in the world”, (Peil), major issues in the emergence and evolution of phenomenology. The extent to which mind, via niche construction and more, has played a role in evolution is very poorly explored.

As we saw, the Pythagorean dream and Newton gave us Reductive Materialism where all that becomes is entailed. Does this view hold for the evolution of life? We claim No, for no law entails the becoming of the biosphere, (Kauffman, Longo et al. 2012, Kauffman 2015b).

We shall try to show that this view of an entailed becoming is profoundly wrong for the evolving biosphere. In place of an entailed becoming we shall find a new explanatory framework: The evolution of the biosphere is describable by *no* entailing laws at all. Nor is such evolution even mathematizable in any known way. Instead, new in the universe, and typically unprestatable, Actuals (the term defining the existing and not merely potential or possible) arise. These actuals constitute new in the universe, unprestatable boundary conditions that are “enabling constraints” that literally create new in the universe and unprestatable “Adjacent Possible Opportunities”, into which evolution “becomes” with the radical emergence of yet new Actuals. In turn these unprestatable Actuals create new unprestatable Adjacent Possibles into which evolution becomes creating yet new Actuals in a continuous, beyond entailing law, largely unprestatable becoming. Indeed we will find that evolution creates the very possibilities into which it becomes, without natural selection “acting” to achieve these new adjacent possibilities. Evolution *is* radical, ongoing, co-creativity.

What we shall say has many implications. First, we often cannot even know what *can* happen. Then we can form no statistical probability distributions for we do not know the sample spaces of the Adjacent Possibles. Harder, “sufficient reason” fails. We cannot reason about what we cannot know. Then Reason, the highest human virtue of the Greeks and our Enlightenment, is an insufficient guide for understanding, predicting, or living our lives forward. In turn, our model of the scientific method, based on physics: laws, deduction of new consequences given those laws, confirming or, with Popper, (Popper), falsifying those predictions, fails. We have no laws from which to make the predictions. We need new ways to “do science”, when we cannot know what can happen. In truth, we already do science when we do not know beforehand what *can* happen. We do this all the time in our historical approach to evolution, as in paleontology, where we reconstruct the past from “the Record”. We do history, and the patterns of evolution we seek are those revealed in a history that is entailed by no laws of motion.

Darwin hoped to be the Newton of biology. Kant said there will *be* no Newton of biology. Kant was right and Darwin and evolution is the end of the hegemony of Newton and Reductive Materialism in our understanding of science and the world at large, surely for the evolution of life, and for the universe as a whole on Orch Or, (Penrose 1989 1994) or the Triad.

Further, if no law entails the evolution of the universe with mind as part of it, or no law entails the evolution of the biosphere with mind as part of it, then the evolution of mind and phenomenology is governed by no entailing law! We must study this radical emergence retrospectively, rather like paleontology and history.

From Phenomenology and Endophysics to Endobiology: Patterns in the Evolution of Life

The convergence of naturalized phenomenology and endophysics not only transcends Cartesian dualism, it also transcends Idealism and more importantly, as far as science is concerned, the form of objectivism that identifies true knowledge with a logico-mathematical order that denies reality to temporality and emergence and thereby to life and mind. Exophysics, while having a major role in gaining knowledge where boundary conditions can be found or set up to allow predictions from one state of a system to another, cannot grasp the whole of nature and is necessarily limited. Ultimately, such systems and models of them should be regarded as abstractions that need to be contextualized, interpreted and made sense of by approaches that take as their starting point that scientists are products of, and active participants in nature and society, internal to the world composed of diverse and sometimes creative processes they are striving to understand. One of the most important aspects of this is the way time and temporality and space and spatiality are understood. Rather than temporality being regarded as an illusion and reduced to a dimension of space in General Relativity, temporality has to be taken as primary with spatiality as perhaps emergent, and space as normally conceptualized as an abstraction from such spatiality. 'Now', within which every observation is made and recorded, is centrally important, an issue that Smolin, (Smolin), reports bothered Einstein profoundly, for on General Relativity, in spacetime, time is a DIMENSION and there is no flowing time, thus NOW must be an illusion. Yet we LIVE an asymmetry between the relation of the present to the past and the present to the future. The future is to some extent open. Being situated in the present with a future to some extent open is a defining feature of life, including ourselves. The alliance of phenomenology and endophysics removes most of the obstacles to developing a rigorous non-reductive science of life.

Of course this does not mean that all past biology should be jettisoned. External perspectives on living organisms, or exobiology, advanced through anatomy, biochemistry and molecular biology, should be recognized as of enormous importance; it is just that their importance can only be properly appreciated when developed in conjunction with an endophysical approach to life characteristic of the study of physiology, embryology, epigenesist, biosemiotics, emotion, sensation, intuition, and cognition, hence mind and meaning. The integration of phenomenology and cognitive science illustrates how external and internal ways of studying living phenomena can and should be combined. It is possible to interpret their combination as claiming that first person accounts of experience can be useful to those studying the brain or developing abstract models of information processing, by guiding and refining their research and the models they develop to characterize these. However, if the endophysics perspective is privileged, as it is argued here that it should be, the primary concern is to comprehend the experience of people, utilizing diverse studies of the brain and abstract models to deepen our understanding of such experience and to account for its possibility. Merleau-Ponty's work illustrated this approach in using Goldstein's research to illuminate the way people affected by brain defects actually experienced the world, in the process deepening our understanding of the unique way in which normal humans experience the world and how this facilitates their unique abilities. Following Jacob von Üexkull, who had argued that to fully understand organisms it is necessary to understand their surrounding worlds, physiological research should serve to explain the possibility of organisms being able to constitute their environments as surrounding worlds the way they do.

To do full justice to life requires phenomenology and endophysics in both the broad and narrow senses. Viewing animals from an internalist perspective, attempting to understand their worlds as systems observed from the inside to understand their behavior, clearly cannot be achieved by taking an externalist perspective. But it is also necessary to take into account that the worlds of organisms encompass other organisms and their worlds, or in formal terms, the models organisms have of themselves and their environments must also contain the models other organisms have of themselves and their environments. That is, ecological systems studied by scientists consist of active components with their own interpretations of these systems interacting with each other. This includes the scientists studying these organisms and their ecosystems. The essential point here is, understanding organisms in ecosystems involves appreciating that it is through one's own experience and being embodied in and a product of the same world as the organisms being studied, appreciating that one's own world is different from, but also in some ways similar to and intersecting the worlds of the life forms being investigated, human or otherwise, and that the worlds of other organisms can be comprehended. Such an approach, integrating phenomenology and the broad and narrow senses of endophysics, with a specific focus on life itself, can be characterized as 'endobiology'. Von Üexkull's work can be regarded as an exemplary contribution to this.

Endobiology raises new issues and problems of how to integrate diverse approaches to the study of life. One of the most important of these is considering what role mathematics can play in biology. Once the view of mathematics as a universal language has been abandoned and the goal of mathematics in science is seen to be identifying and studying patterns that have been actualized in nature, then clearly there is no reason why the potential of mathematics in biology to study the patterns associated with life should not be recognized, with the critical caveat that the EVOLUTION OF LIFE is entailed by no law, and probably is not even mathematizable, (Longo et al,2012, Kauffman 2015). The work of Robert Rosen illustrates the role mathematics can play in modeling forms of life once they have evolved. Having rejected the Pythagorean/Parmenidean conception of physical existence and criticized the assumptions that led to it, Rosen's main concern was to develop forms of mathematics adequate to model life. While initially being closely aligned with Howard Pattee and concerned to explain living process through nonholonomic constraints that define structure (1988), his later work in biomathematics involved developing mathematical models of anticipatory systems in which final causes could be modeled along with material, formal and efficient causes. Rosen's primary objection to Newtonian forms of explanation was that the forms of entailment allowed in its mechanistic mathematical models were too impoverished to model all these forms of causation. A feature of these anticipatory systems, which Rosen argued is the defining feature of genuine complexity, is that they require a number of mathematical models to describe them, none of which is the largest model from which the others can be derived, while each model is a component of the other models.

Rosen's work has stimulated other mathematicians to utilize category theory to develop mathematical models that can deal with scalar hierarchies, emergence and cognition. Notable is the work of Ehresmann and Vanbremeersch and those influenced by them on memory evolutive systems. Important as Rosen's work is, it avoids the question how such anticipatory systems could emerge in the first place, or consider how their internal models could change with changing environments rendering their models of themselves defective. Furthermore, it only captures part of what von Üexkull, and following him, Merleau-Ponty dealt with, although work on memory evolutive systems has gone further in this regard. Models of systems that have models of themselves must also take into account how these systems model other systems with models of themselves. These issues, associated with evolution, are an added challenge to efforts to comprehend life. The study of evolution itself, concerned with temporal development of forms of life and ecosystems, further highlights the inescapable reality of temporal becoming in nature and the limits this places on how far life can be understood through mathematics. It highlights why it is necessary to give priority to endobiology over exophysics and exobiology, in both senses. It is only by acknowledging the priority of internalist over externalist perspectives that the distinguishing characteristics of life and their most important dynamics can be understood. It is said that normal humans have theories of the mind of the other, as do many animals, but we can get to the sixth order. Shakespeare seems to have gotten to the seventh order.

Classic neo-Darwinian models of evolution are exobiological and assume that the selection forces are somehow given in a well defined form, independently of the temporality of the process of evolution. This assumes a complete description of the system in terms of a unique set of conditions and, consequently, that there is a unique and invariant history to explain (Kampis, 1998). It is impossible to fully explain evolution in this way. As George Kampis pointed out, it is only from an endobiological perspective that the constantly changing conditions associated with co-evolution and the transformation and even replacement of whole ecosystems, along with innovative responses of organisms to such changes, can properly be taken into account (Kampis, 1994). Endobiology in the narrow sense is also required. It is in the environments produced by ecosystems that each organism can exist and interact with other organisms, and those who study these, are themselves the products of evolution and share this environment which is a facilitative or “enabling” constraint on their research. The observer is part of what is being observed, and this should be acknowledged. Ultimately the study of the evolution of ecosystems is the study of the origins and continued existence of the global ecosystem and its current regime that generated and sustains human life and its civilizations, including the scientific enterprise, which is now a component of this regime of the global ecosystem. While Rosen was developing a form of mathematics that could capture the complexity of entailments in living organisms, in evolution the problem is that many of the developments that do occur are not entailed, and this has to be acknowledged. As Stuart Kauffmann pointed out in an earlier work, ‘Emergence and Story: Beyond Newton, Einstein and Bohr?, it is impossible to prestate the configuration space of all future evolutionary possibilities. Stories are required to deal with such open-ended and creative complexity. This will now be looked at in more depth.

In physics there are only happenings. Balls roll down hills. In biology we speak of “functions”. Thus, the function of the heart is to pump blood. But the heart makes heart sounds and jiggles water in the pericardial sac. Were we to ask Darwin why pumping blood is the function of my heart, he would say “It was selectively advantageous to your ancestors to have a heart that pumped blood”. Darwin would give a selective explanation most of us would accept. Note that the function of my heart is a subset of its causal consequences, pumping blood, not jiggling water in my pericardial sac. In physics there is no way to make distinctions like this among causal consequences; all are just happenings.

We need now to try to show that the use of the term, “function” is fully legitimate in biology. To do so takes a few steps.

First, the universe has created all possible stable atoms. But has the universe created all possible proteins length 200 amino acids? Well, no. There are 20 kinds of amino acids and for proteins length 200 amino acids there are 20 to the 200th power or about 10 to the 260th power, number of possible proteins length 200. There are 10 to the 80th particles in the known universe, which is 13.7 billion years old. Were all these particles making proteins length 200 on the Planck time scale of 10 to the -43 seconds, it would take about 10 to the 39th power times the lifetime of the universe to make all these possible proteins *once*.

This fact is deep and physical. Above the level of atoms, the universe is vastly non-ergodic. It will not make most complex things, molecules, organisms, civilizations, or even rocks.

Then “getting to exist” above the level of atoms, where the universe is non-ergodic is ‘a big deal’, (Kauffman 2015b). One way to exist above the level of atoms is to be a Kantian Whole, in which the parts exist for and by means of the whole (Kant, 1914). A simple example that can be seen as a Kantian whole is a 9 peptide collectively autocatalytic set created by Wagner and Ashkenasy (Wagner and Ashkenasy). In this real chemical system, no peptide catalyzes its own formation. Rather, each peptide catalyses the formation of a second copy of the next peptide from two of that peptide’s fragments, around a catalyzed circle of the 9 peptides. The set is “collectively autocatalytic”. Here, as Kant would want, no part, i.e. peptide, catalyzes its own formation, rather each part exists, i.e. its formation is catalyzed, due to the 9 peptide collective whole. The whole exists, due to the interacting peptide parts. The collectively autocatalytic set is comparable to a Kantian Whole.

Note in passing that this peptide reproducing set proves that molecular reproduction does *not* require template reproduction of something like single stranded RNA or DNA. There is now a large literature on such collectively autocatalytic sets and their hoped for spontaneous emergence as one theory for the origin of molecular reproduction (Kauffman, 1971, 1986, 1993; Ballivet and Kauffman, 1989, 1998; Hordijk et al., 2012). We hold high hopes for this theory.

Given a collectively autocatalytic set, say peptides, in the non-ergodic universe above the level of atoms, we claim that we can *define* the function of a peptide as its role in catalyzing the formation of the next peptide, so its function is its “role” in sustaining the collectively autocatalytic Kantian whole. In turn, if the peptide jiggles water in the petri plate, that causal consequence is a side effect and is not the function of the peptide. So we now can distinguish between functions and causal irrelevant side effects.

Our next point is also important and not well stated in biology. If we consider catalyzing a reaction as a catalytic task, or function, the collectively autocatalytic set achieves *functional closure*. All the functions or tasks that must be accomplished for the Kantian whole to persist existing in the universe above the level of atoms do get performed. An important part is missing: The set achieves functional closure, or “sufficiency”, “in its world”. That world beyond the, e.g. peptides, constitutes the “niche” of the Kantian Whole. We discuss below that we cannot define the niche independently of the collectively autocatalytic set, the set in its world finds functional closure and gets to exist in the universe. Functional closure is central in biology but usually not explicitly stated. Some discussions can be found in Moreno et al. (2008), Bich (2010), etc. An organism, say *E. coli*, is a functional whole with functional closure in its world, so gets to exist. We claim this is central. It is the organism as a whole in its world that undergoes selection. Thus, many organisms are made of DNA genes transcribed into RNA, translated into proteins, but the organism, say bacterium, achieves a vast functional closure of tasks in its world, by which closure it gets to exist in the universe above the level of atoms. Nor, we note briefly, is it easy to say what the functional closure is in a mixed microbial community, with lots of functional cross effects, perhaps “functional sufficiency” a more “open” concept, is better than “functional closure”. Indeed, what if anything is the functional closure of the biosphere as a whole, or diverse parts of it such as in mixed microbial communities? It is this functional closure or sufficiency of the organism in its niche, of the set of organisms in a mixed microbial community, and the entire functionally coupled set of organisms in the biosphere that is evolving. We emphasize that if mind is part of the universe, and life from the start, then the world of any organism is partly phenomenological.

Now let us consider just one dividing bacterium, say *E. coli*. It completes some vast task or functional closure in its world to get to divide and perhaps survive.

We want now, (Longo et. al. 2012, Kauffman 2015b), to show that we cannot prestate the emergence of new functions in biological evolution. We begin in an odd way: “Here is a screw driver. Tell us all the uses of a screw driver.”. Try it: screw in a screw, open a can of paint, stab an assailant, scrape putty off a window, tie to a stick and spear a fish, rent the spear to locals and make 5% of the catch.... Do we agree that: i. the number of uses of a screw driver is *indefinite*. Next, the integers, 1,2,3, are orderable. Are the uses of the screw driver I just listed orderable in any natural way? No, they are just “names” of different uses, a nominal scale only. But if we accept these two premises, indefinite and unorderable, then no algorithm, or “effective procedure”, can propositionally list all the uses of a screw driver or find the next use. We have just shown that uses of a screw driver are not to be found algorithmically.

Now consider an evolving bacterium, say in a new environment. All that has to happen is that some molecular screw driver in or on the cell “find a use” that enhances the fitness of the organism in its world, and with heritable variation, that new use will probably be selected by selection operating, not at the level of the new use of the screw driver, but at the level of the whole organism in its world, and a new function or use, will emerge in the evolution of the biosphere. But we cannot “prestate” this new use, or function. Thus, this *is* the arrival of the fitter, never solved by Darwin, and is also unprestatable in general.

Such adaptations occur all the time, and are called Darwinian preadaptations such as the proposed evolution of feathers from thermoregulation to flight (Regal, 1975). More on such Darwinian preadaptations below.

It is here that it is necessary to appreciate the significance of an internalist perspective on organisms to understand how adjacent possibles are sometimes explored and realized behaviorially. This involves exploratory behavior on the part of organisms concerned with their own survival. An instance of this was described by A.C. Hardy, of blue tits in Britain that discovered they could peck through the tops of milk-bottles and devour cream. Other blue tits imitated this behavior, and manufacturers of milk-bottles produced thicker lids. Those blue-tits with the potential to develop stronger beaks had a competitive advantage, leading to blue-tits with specialist milk-bottle top penetrating beaks. What this example shows, as Hardy pointed out, is that evolution depends in part on the restless, exploring and perceiving animal that discovers new ways of living, new sources of food, just as the tits have discovered the value of the milk bottles. It is adaptations which are due to the animal's behaviour, to its restless exploration of its surroundings, to its initiative, and inventiveness that distinguishes the main diverging lines of evolution; it is these dynamic qualities which led to the different roles of life that open up to a newly emerging group of animals in that phase of their expansion technically known as adaptive radiation - giving the lines of runners, climbers, burrowers, swimmers, and conquerors of the air. (Hardy, 1965, 192). Presumably the blue tits were conscious, had some form of free will, and had rich phenomenology. What is it LIKE to be a blue tit, after all.

But the same evolution that cannot be prestated and gives rise to new functions also includes morphological evolution; hence in part the classical physics of embodied organisms, as in the evolution of the swim bladder in some fish, where the ratio of air to water in the bladder tunes neutral buoyance in the water column. Paleontologists think the swim bladder evolved from the lungs of lung fish, some of which became partly filled with water and were poised to evolve into swim bladders. Neutral buoyancy is a NEW FUNCTION in the biosphere that we could not have prestated. We cannot prestate the ever new functionalities, hence the ever changing phase space of the evolution of the biosphere. If we cannot prestate the relevant new functionalities that constitute the ever changing phase space of evolution we cannot write differential equations for that evolution: We do not know the relevant functional variables beforehand! Thus we cannot integrate the differential equations we do not have to obtain entailing laws for the evolution of the biosphere. Thus no law entails this evolution, (Longo eg al 2012, Kauffman 2015b).

Furthermore, if the niche is the boundary condition on evolution, we cannot define the niche non-circularly from the organism which "in its niche" it achieves functional closure and gets to exist in the universe above the level of atoms. Thus we have no laws of motion in differential form, and even if we did, we have no boundary conditions by which to integrate the laws we do not have anyway; therefore *no laws entail* the evolution of the biosphere (Longo et al., 2012, Kauffman 2015b).

This is a major negative result. Negative results drive science. Thus, the failure to show that denying Euclid's parallel postulate led to non-Euclidian geometry used later by Einstein in General Relativity. The failure to find an analytic solution to the problem of three gravitating objects by Poincare' led to chaos theory and destroyed Laplace's claim that determinism meant predictability. Gödel's famous undecidability theorem showed that mathematics is not complete. Any sufficiently complex axiom set generates formally undecidable statements. The negative result above, if it survives criticism, is major; it claims that we cannot even MATHEMATIZE the specific evolution of the biosphere. We do not know the functional variables that will become relevant beforehand! But the biosphere is the most or one of the most complex systems we know of. It seems to have become without entailing laws. If no entailing laws, then there can be no final theory "down there" that entails the entire becoming of the universe of which the biosphere is part. Sufficient reason fails, for not only do we not know what will happen, we do not even know what *can* happen. This seems true of economic life as well, where we cannot prestate innovations (Felin et al., 2014); hence we can have no mathematical theory of the detailed evolution of the economy.

An explanatory framework beyond entailing laws: Actuals creating Adjacent Possibles allowing new Actuals that create new Adjacent Possibles…

We saw that in classical physics, the boundary conditions literally create the phase space of the classical system, e.g. all the possible positions and momenta of the balls on the table, or N particles in a litre box in statistical mechanics.

Now we have grounds to believe that no laws entail the evolution of the biosphere, and that new Actuals, such as the new use of the screw driver, emerge all the time in evolution. We want now to show that new actuals literally are new, typically unprestatable, boundary condtions, that are "enabling constraints" that literally create a new in the universe, hence radically emergent, Adjacent Possible phase space of typically unprestatable evolutionary opportunities, in which new Actuals arise, creating yet new adjacent possibles. This involves phenotypes ranging from morphological to behavioral, we can suppose, phenomenological.

We begin with Darwinian preadaptations. Darwin noted that a causal consequence of a part of an organism of no selective use in the present environment might find a use in a different environment so be selected for a new use. This is the new use of the screw driver. A case is a possible evolution of swim bladders from the lungs of lung fish (Perry et al., 2001). Thus feathers, evolved for thermoregulation, were co-opted for flight, and hearing via the three middle ear bones that transmit sound, arose from the jaw bone of an early fish. The swim bladder, as just above, has water and air in it, whose ratio tunes neutral buoyancy in the water column. Paleontologists think the swim bladder evolved from the lungs of lung fish. Water got into some lungs, now a sac with air and water poised to evolve into a swim bladder. Suppose this is correct. Did a new function arise in the biosphere? Yes, neutral buoyancy in the water column. Did this change the evolution of the biosphere? Yes, new species with swim bladders, new proteins. Could we prestate the evolution of the swim bladder? NO, it is the screw driver problem. And: Once the swim bladder exits as an Actual in the biosphere, it constitutes a New *Empty* Niche that *creates* a new but unprestatable set of adjacent possible opportunities for evolution. For example a worm or bacterium but not a giraffe or large fish could evolve to live in the swim bladder. That is, the adjacent possible has some possibilities but not *all* possibilities. The next point is stunning: Presumably natural selection "acted" on a population of evolving lung fish to "craft" a well-functioning swim bladder. But did selection in any sense "act" to create the swim bladder *as a new empty niche that creates new adjacent possibilities in evolution*? *No!* So without selection acting to 'achieve it' the evolving biosphere creates its own possibilities for further evolution! We are beyond Darwin. Evolution creates, without selection achieving it, the very possibilities into which it becomes. If true of morphological organs such as the swim bladder, so almost sure is it true of behavior and "mind"; thus of the evolution of mind with evolved sense organs, such as the bat's echolocation, the eagle's sight and the dog's smell, 2000 times as powerful as ours. So mind, and with it phenomenology has evolved, and done so with no entailing law, becoming into the possibilities that evolution created without selection achieving those possibilities. All is a radically emergent becoming.

Furthermore, the swim bladder does not *cause* the evolution of the bacterium or worm to live in the swim bladder. Rather the swim bladder *enables* that evolution which is driven by quantum acausal mutations, then selection acting at the level of the whole functional closure of the organism in its world. Thus the swim bladder is an Actual that constitutes a boundary condition that literally, like the billiard table, creates a new adjacent possible phase space for evolution. But unlike the classical table boundary, the swim bladder is not causal, but enabling. And selection did not achieve the new adjacent possible.

More, we do not know what is "in" the unprestatable adjacent possible in the evolution of the biosphere, so we do not know what *can* happen, and can have no measure of probability for we do not know the sample space. We do not know the next use of the screw driver. Sufficient reason fails.

Our post-Newtonian entailing law explanatory framework becomes: Actuals emerge, typically unprestatably and are new in the universe, unentailed by any law, boundary conditions that enable a new adjacent possible, but unprestatable, "set" of opportunities into which evolution "flows", creating new actuals that create ever new adjacent possibles. This is, the emergent, creative, unentailed, becoming of the evolving biosphere, beyond law.

In the evolution of the biosphere, probably we do not always need to consider conscious behavior. But we claim the same kind of becoming is true of the becoming of human life and culture and economy and art and civilization and history. New actuals create adjacent possible opportunities in which new Actuals arise in a continuous unprestatable co-creation. Consider the metaphor of improvisational comedy. The first rule is: Each member must accept the line given to her by the earlier member and build on it in a comedically appropriate way in the comedic adjacent possible. Here is the first line: "Jack, here is a silver platter with a steaming pile of horse…" Jack cannot say, "Take the platter back!" He can say "Oh! Where did you hide my cookie cutter?" This improvisation continues until the troupe creates a skit that none could have prestated. In the improvisational comedy case each line is an enabling constraint that creates the comedic next adjacent possible.

We claim biological evolution is the same sort of unprestatable co-creation, so is economic evolution, and much of cultural evolution, all beyond entailing law. So too for the becoming of emboded phenomenology.

What is the ontological status of the Possible in Adjacent Possible?

We have already seen that even classical physics in its boundary conditions appeals to the reality of counterfactual conditionals, hence to a Possible in some sense. In quantum mechanics, Heisenberg describes quantum coherent behavior as *Potentia*, (Heisenberg) and Zeh thought its possibles are real, (Zeh). Penrose and Hameroff, (Penrose 1989, 1994) and the Triad (Kauffman 2015b) support the ontological reality of the Possible. Penrose's OR (ibid) and the Triad, (ibid), lead to a vastly participatory universe with consciousness and free will at each measurement event. Then there is no entailing law for the becoming of the universe itself, for consciousness and free will are parts of the universe. This panpsychism IS Endophysics and Endobiology. If Spinoza sought a monism, a single "stuff" with mental and physical aspects, but not causal connections between them, save God, he worked with a 17^{th} century notion of matter. Quantum Mechanics opens a new door to Spinoza's panpsychism.

What is Science In this new Explanatory Framework?

In a word, part of this science is historical reconstruction of what did happen in the non-ergodic universe above the level of atoms, e.g. paleontology and the patterns of evolution, discussed further below, economic history of innovations by which the economy grew from 10,000 goods and production functions 50,000 years ago to 10 billion goods and production functions now. If and when we can, the evolution of embodied phenomenology, perhaps of mind, from the origin of life to E. coli, Stentor, Hydra, jelly fish, bats, and us.

Before attempting to discuss further the implications of this post entailing law explanatory framework for the study of evolution, we want to raise further new issues, hard to state at present. If evolution is the becoming via actuals that constitute enabling constraints that create ever new adjacent possibles into which evolution "becomes", we need to begin to formulate what enabling constraints are, and "how" they create "wide" or "narrow" adjacent possibles. Moreover, evolution is co-evolution and enabling constraints include co-creation of enabling constraints which together create new adjacent possibles into which evolution becomes. We have not thought about this. Even harder, if the claims above are right, we do not know ahead of time what the new actuals are, or the unprestatable adjacent possibles that come into existence and into which evolution becomes. Post factum, the history we reconstruct, say in paleontology, is the history of this becoming.

Roughly then, what kinds of single and sets of enabling constraints create what kinds of adjacent possibles, with lots or few possibilities, even if unprestatable? Take three prestatable cases: Tic tac toe, chess and Go. These are statable, because each is finite and has a finite set of legal, hence perfectly defined, next moves which are the adjacent possibles from each position. Clearly, tic tac toe has an impoverished set of adjacent possibles compared to chess and chess compared to Go. This suggests that even when the adjacent possible is not prestatable, some enabling constraints are richer in what they enable as possibilities even though at present we do not know how to "count them". Now, organisms co-evolve and co-create co-meshed enabling constraints in their morphological, behavioral, phenomenological and other evolution. In ways we do not yet understand, it seems that the explosion of diversity of biological species in the past 3.5 billion years and of economic goods and production capacities in the past 50,000 years, reflects something terribly important. In "Mind and Cosmos", Thomas Nagel (2012) seeks a purposeless (having no explicit aim or goal) teleology by which "things or systems" tend to get more complex. The biosphere, economy and culture all exhibit this. Why?

Formal Cause, Beyond Formal Statable Laws, and Purposeless Teleology

We want now to introduce the concept of formal cause. Newton mathematized Aristotle's efficient cause in his laws of motion in differential equation form. If we may borrow from one of us, (Kauffman, 1971, 1986, 1993), in 1971 Kauffman wondered about the origin of life, and did not like the idea that it depended on DNA or RNA template replication. What if the laws of chemistry were a bit different and there was no carbon with 4 bonds or nitrogen with 5 bonds, but still atoms and chemicals? Would life be impossible? Kauffman wanted to believe that, "of course not". So he tried the idea that molecular reproduction was a collectively autocatalytic set. He made simple, mathematically formal, models of binary strings as model polymers, undergoing cleavage and ligation reactions, and in which each molecule had a probability to catalyze each reaction. Simple proofs and simulations showed that over a vast ensemble of reaction "graphs", typically, as the diversity of molecules increased, the diversity of reactions increased even more rapidly and with some fixed probability that any molecule catalyzed any given reaction, at some point a collectively autocatalytic set, (CAS), would emerge spontaneously as a phase transition. Better theorems are now available (Hordijk et. al., 2010, 2011,2012). And we now have the spontaneous formation of collectively autocatalytic sets (CASs) from libraries of halved ribozymes (Vaidya et al., 2012). But what is this theory? First there are no efficient causes. Second it is about objects, transformations among objects, and objects helping or harming those transformations. So the theory is independent of the material stuff and energy, and even applies to the evolution of the economy, where input goods and output goods are the analogues of substrates and products, the production function is the analogue of the reaction, and the tool that carries out the production function is the analogue of the catalyst.

We want to call such a theory that is independent of the specific "stuff", a Formal Cause Law. Here, moreover, it is 'generic" in a vast ensemble of systems of objects, transformations of objects and objects helping or hindering those transformations that "collectively autocatalytic sets" arise. This spontaneous emergence at a sufficient diversity of objects, transformations among objects and objects mediating the transformations, is a form of Nagel's concept of purposeless teleology by which complexity increases, but without a guiding purpose (Nagel, 2012). Complexity begets more complexity (Hanel et al., 2005). But as stated, the "enabling constraints" are not stated. Well in classical chemistry, the enabling constraints are the allowed reactions among the set of molecules, and the probability of catalysis. In the economy, the constraints are enabling in a related sense, but seem not to be formalizable! What can this screw driver and that hammer *be together used for* that may be of value? To return to the screw driver: A fine use of the screw driver is to prop it against a wall, sharp edge perpendicular to wall, prop a piece of plywood on top of the screw driver and place a wet oil painting under the plywood to keep it out of the rain. One might even sell this silly contraption creating a new business. This example makes the point and puzzle. Somehow the screw driver is an enabling constraint on what it can be used for alone or with other things or processes, for some function in an organism, or purpose or function in our personal or economic lives. But we cannot "say" ahead of time what a given "object" or "process", alone or with others, enables. This means that a hoped for formal cause law, such as the theory of the spontaneous emergence of collectively autocatalytic sets or new sectors of an economy, cannot really be formalized for we cannot even "count" the number of uses of a screw driver alone or with other things, such what can we use in a formal theory of e.g. nodes and arrows, where the arrows each point out from a node and depict what the node "enables", when we cannot say how many arrows should point outward from each node?! What exists, the Actuals, find unprestatable uses that constitute, if "selected" in evolution, or acted upon by the innovating entrepreneur, new morphologies, new ways organisms "make a living" in their worlds, and new businesses. We have more even than the phase transition in formalizable models (Hanel et al., 2005) of the purposeless teleology Nagel (2012) seeks. We cannot even count the "connectivity" of the enablement graph, at least once we consider all the parts of organisms, organisms, ecosystems, the biosphere, economies, legal laws, and culture.

We need a theory beyond formal causes, beyond that which is stateable, and hence is not obviously formalizable mathematically, as far as we can see, in the uses and richness of webs of enabling constraints and that enable poor or rich adjacent possibles into which life becomes. Nagel's intuited purposeless teleology (Nagel, 2012) seems right: more complexity of things and processes and laws and behaviors enable ever new and yet richer adjacent possibles into which the biosphere and human life become. We do not yet recognize the potentially enormous power of this often unstatable emerging adjacent possibles, the very opportunities evolution creates morphologically and behaviorally for itself, the very opportunities the evolving economy, governmental structures, laws, regulations and enabled behaviors, strategies, that create yet new adjacent possible opportunities into which we become. If so, and for human life if we cannot know what we enable, how do we do so wisely? How in human life do we garden the partially unprestatable and unintended adjacent possibles into which we become, flowering or metastasizing? As for embodied phenomenology, is not the discovery of a new use of a screw driver in a context in some sense phenomenological? The becoming of mathematics, number to calculus to topology are emergent crystals of pure creativity, part of our phenomenology. If so, there is no fixed content to human phenomenology.

Patterns of Evolution of Life and Mind

If we can have no entailing laws for the detailed evolution of the biosphere, life and mind, can we use the ideas above to help look for patterns in evolution? We hope so. We mention only a few cases. 1) The distribution of species per genus, genera per family, up the higher taxa, can and has been studied. The statistical features of these distributions tell us what the exploration and exploitation of the enabled adjacent possibles have been in real evolution. Given this branching history, it seems very worthwhile to attempt now to examine each case and try to tease out what were the actuals in one or many interacting species in their joint world(s) that enabled each new species to arise at the morphological and behavioral level. 2) If Nagel's purposeless teleology (Nagel), is right (Bickhard, 2001), as complexity and diversity of processes and "stuffs", grow, it becomes easier to both create richer adjacent possibles and "discover" new ways to enter these enriched adjacent possibles at morphological and behavioral levels. In the economy, for example, was it easier to invent something new 50,000 years ago or today? Obviously, today. Why? We now have so many goods and production capacities that it is easy to find new uses for these, and new combinations of existing goods and production functions that can be put to new uses. The economic history of technologies is a fine case in point. We can reconstruct what happened. The printing press put the wine press to a new use. Behind this invention is human phenomenology. Complexity is itself autocatalytic, but unprestatable, at and after the origin of life and its becoming. 3) The distribution of extinction events is, statistically a power law. Theories such as self-organized criticality are one formal cause attempt to explain this (Longo et al., 2012). So too are Schumpeterian gales of creative destruction in the economy apparently a power law, perhaps explained by formal cause analogues to self-organized criticality (Hanel et al., 2007). If so, criticality may be an emergent unentailed law for functional organization across scales in the evolving biosphere and economy, morphological, technological, mind and phenomenology welded together.

Conclusion

In a sense, what is written here is known-in-the-bones by working evolutionary biologists and in many senses; we intuitively feel that Darwinian evolution is not derivable from entailing laws and carry out our evolutionary studies with confidence, without seeking such entailing laws. We cannot derive what selection, acting at the level of the whole organism in its world, will "select" among the possible but unprestatable "uses of screw drivers" that may happen to be new uses that enhance the fitness of the organism in its world, so heritable variation may be selected. If we cannot close evolutionary theory, the world, at least living world, is vastly different from the dreams of a final entailing theory of the cosmos, as Weinberg hoped. The biosphere is part of the universe, and if its becoming is not logically entailed, then neither is that of the universe. This accords with the interpretation of quantum theory offered here, in which the measurement process involving some degree of freedom to choose what is measured, is recognized to influence what is measured, and this is seen as only a particular instance in the 'choices' that are ubiquitous in nature. The future is to some degree open, and in choosing what to measure, systems are participating and influencing what possibilities will be realized.

If the biosphere and the cosmos are creative in this way, the faith of biologists that ultimately, reductionist explanations that reduce organisms to chemistry and physics must eventually succeed, is completely misplaced. There is no reason to assume this at all; on the contrary, there is every reason to accord proper recognition of the unique features of life that have emerged in the creative becoming of nature, and to recognize that it is essential to acknowledge the openness of this becoming. Not only is it necessary to appreciate that each organism, including protozoa and plants, have worlds that have meaning for them to which they respond accordingly. It is necessary to recognize that these worlds are to some extent open and that organisms to survive have to confront and deal with this openness. In doing so they can realize new possibilities that had never before been realized, or even envisaged. This is evident in Hardy's observation and insight that evolution depends on the restless exploring activity of animals which discovered new uses for what was available to them in their struggle for life.

But the same is true in economic evolution as seen in the evolution of our technologies which emerge into the very adjacent possibilities they and we, often unknowingly, co-create. The Turing machine led to the von Neumann universal computer, to IBM main frames, then with the chip to personal computers that led to word processing, sharing files, thence the WEB, and selling on the web and social media, that played a role in the Arabic Spring and the metastasis of Eisenhower's Military Industrial Complex to the US's NSA spying on its and many global citizens. We too become, for better or worse and must learn to garden the adjacent possibles we co-create but cannot fully prestate.

Endophysics and endobiology (endoscience with life and mind), have to be recognized as more basic than exophysics and exobiology (exoscience), and must be given far larger precedence in defining scientific truth. What the above analyses of quantum theory and evolutionary theory show is that we are participants in the phenomena being studied. That we as conscious, embodied beings are part of what we are studying means that such research is reflection upon ourselves and the conditions of our existence. It is in a sense, introspection. Apart from measurement, the boundary conditions used in exophysics setting constraints are also part of nature, and only a very small number of the constraints that are operative in making science possible. There are also the constraints of being a living organism that has evolved and grown into a human form able to participate in society, culture and the enterprise of science. The 'interpolation' of new constraints is central both to evolution and the development of particular organisms, and are not entailed by their antecedent conditions (Salthe, 1985, 145; 1993, ch.2; 2012). Among the most important of these are the various facilitative constraints that transform physical structures or events into signs through which organisms are able to remember and anticipate, and communicate. It is through these that organisms constitute and interpret their environments as their surrounding worlds, and explore their possibilities. This makes the study of the evolution of the biosphere endoscientific in another sense. It is the study of a system with components that are themselves agents interpreting the system of which they are part and acting on the basis of their interpretations. Since as we have seen, this can involve identifying new possibilities, putting objects to new uses or establishing new relations (for instance, symbiotic relations involving further emergent constraints and possibilities) this also makes it impossible to produce a predictive model of evolution. Any predictive model will only be an approximation of some limited domain of evolution with limited applicability.

It is in endobiology that endophysics converges and unites with naturalized phenomenology. Endophysics examines systems with active participants in which the future is not entirely determined by the past. Phenomenology, on the other hand, is primarily concerned to elucidate the nature of human being-to-the-world, as Merleau-Ponty characterized human being. In doing so phenomenologists are clarifying all dimensions of this, including the experience of embodiment in nature and society, the temporality and spatiality of the experienced world, relations to others of various kinds, human and non-human, the different domains of experience and their relationship to each other, what is involved in using language, being involved in various forms of communication and expressing oneself, the nature of emotional engagement and detachment, the sense of an identity and the loss of it, the experience of meaning in our lives and loss of meaning, in thinking practically and theoretically and what is involved in making decisions, acting individually and collectively, and facing up to our mortality. Phenomenology is relevant to understanding the highest cultural achievements of humanity and their significance, including art, mathematics and science. Such work almost inevitably led to investigations into the experience of others and efforts to understand their experience, particularly when these others are very different to ourselves. Phenomenology has proved immensely fruitful in psychology and psychiatry, making sense of the behavior of people who appear to be acting irrationally and unpredictably (Spiegelberg, 1972). Despite Husserl’s concerns, phenomenology lends itself to the development of philosophical biology and the study of non-human organisms to elucidate their worlds. Through such studies, taken for granted assumptions, embedded in most people’s experience, have been exposed and brought into question, revealing new possibilities of experience.

However, there are many aspects of nature that cannot be understood through phenomenology, and as Merleau-Ponty and the naturalized phenomenologists have argued, phenomenology should be conjoined with other forms of enquiry. With endoscience, this can be work very similar to that of the phenomenologists, such as that of the biosemioticians developing the ideas of Peirce, von Uexküll, Saussure and Cassirer. Some theories of cognition are similar to phenomenological studies of perception without being influenced by them, and each can illuminate the other. Mathematical models of life or cognition cannot capture the experience of being alive (stories are far better for evoking appreciation of this), but are important for illuminating some aspects of life. With exoscience, for instance the study of chemical reactions in the brain, what is isolated and studied can appear to have nothing in common with lived experience, and yet still be important for understanding human consciousness. In all instances, what is required is a dialect between exoscience, endophysics and phenomenology, using each to correct or challenge the others. It should be borne in mind that modern chemistry is based on the notion of valence, with chemicals seen as existing as balances between opposing forces, an idea put forward at the end of the eighteenth century by Friedrich Schelling who argued that given the reality of life and mind, nature could not possibly be made up of inert bits of matter.

Ultimately, as Merleau-Ponty argued, this dialect should illuminate what it is to be engaged in scientific work and developing such knowledge. Here the experience and consciousness of the scientist is absolutely central. Every scientific inquiry, every theory and model and every bit of evidence, no matter how distant from directly comprehending experience and consciousness, has to be made sense of by scientists. They themselves have to appreciate that they are conscious beings embodied and socially situated, participating in the process of becoming of science, and it is only by virtue of this that they can advance knowledge. In turn, their work is part of the process by which humans are coming to understand themselves and their place in nature, and the immense significance this could have for the becoming of society and of nature. Emotion, (Peil), which, as the phenomenologists have argued, is an aspect of living beings appreciating the significance of their own and others’ existence, the openness of the future and the potential of their decisions to affect the future, is also central to the restless exploring and drive for comprehension of scientists. Its reality and importance also should be understood by them as aspect of their self knowledge and knowledge of nature.

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