Complexity, Complementarity, Consciousness

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Several modern scientific disciples arrive fast in exhausting the one-sided mechanical and reductionistic thinking that were established upon. Biological Evolution is discussed as such an example here. When confronted with the complexities of reality, our ideas about biological evolution had to change tenets and seek new grounds for its foundations. The complementarity of function and structure, as principle and as phenomenon, is elaborated further to help us discover how unity sustains dualities and why complexity arises unavoidably from polarities. Complementarity and Complexity, ubiquitous as they are, point to the need of a new kind of scientific endeavor that simultaneously brings forth and is brought from a deeper understanding of the workings of Consciousness. From the example of the science of evolution we can see the next turn of the evolution of science. To this end we trace some novel realizations about the role of complementarity and complexity in logic, neurosciences, psychology, and philosophy. They all point to that need of a new kind of understanding and a new kind of science. This can only be a "science towards the origins." And as its origin is consciousness, we realize that for this new kind of science to emerge, a new kind of consciousness has also to emerge in parallel. So, we attempt to propose a coarse outline for their new alliance.

Prologue: Evolution is not what it used to be…

There was a time when the linear mechanistic view of evolution dominated the mind and practices of the academic and research communities all over the world. After the deciphering of the "alphabet of life," as the genetic code of Crick and Watson came to be known, the Central Dogma of molecular biology became just that! A powerful unquestionable dogma that dictated the program of biology. It blandly stated that the chain of command in life everywhere was going from the molecular level up. The official statement proclaimed by Crick was "DNA makes RNA and RNA

makes protein." The idea was that a linear flow of information establishes a strict hierarchy of functions totally dependent and subservient to the structure of the DNA macromolecules. Copying the dominant idea of determinism that shaped classical physics up to the last century, biology followed the dream of establishing a grand project of understanding and controlling life by understanding and controlling its structure: the omniscient and omnipotent molecule of DNA! The gene and the DNA became the elementary particles of biology. So, biology's final task was to discover the "alphabet, language and logic of life" by deploying the grand "Human Genome-project." The genes even took anthropomorphic qualities, like "selfish," "intelligent," and "virtuous." They were held responsible not only for our diseases but also for our careers, vices, virtues, and even religions and god. In a way, they were collectively considered as the new immortals ruling over humankind.

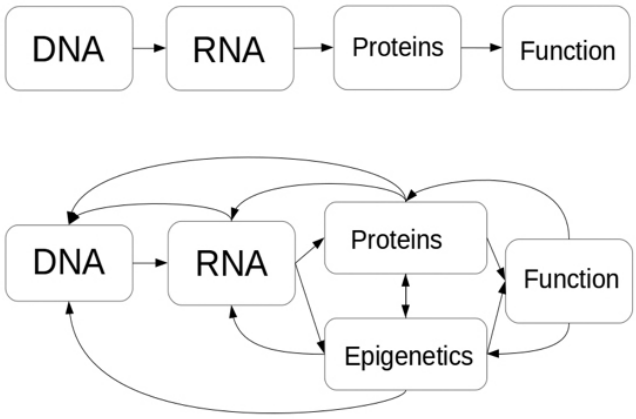


Figure 1 – Life's complications…information flow is non-linear

Alas for the central dogma, eventually the complexities of life took over. The idea that the DNA drives evolution only through random mutation was deflated and abandoned. We now know that the number of genes do not reflect the differences between humans and other organisms. The verdict was out with a funny surprise for the naive mechanistic/reductionist mind. The human genome was found to consist of only about twice the number needed to make a fruit fly, worm, or plant![1] Phenomena like "alternative splicing" and other complicated feedback processes finally drew the attention that was lacking under the spell of the "central

dogma" (for example and quite interestingly, prions, the notorious protein pathogens of "mad-cow" disease, have been recently discovered to be genetic elements that store and transmit information in various organisms).[2] It has now been established that are many more ways in which a gene's protein-coding sections (exons) can be joined together to eventually create a functional protein. Indeed, now "we cannot escape the conclusion that physical and behavioural differences between species are not related in any simple way to gene number."[1] The complexity of the evolutionary processes cannot be reduced to simple molecular mechanisms driven by pure randomness.

To his credit, the great developmental biologist Richard Strohman had predicted these surprises well in advance of the "Human Genome Project" completion. He foresaw the important functional role in evolution of the various feedback processes to genome from epigenetic factors. He brilliantly argued about the need to contain the paradigm of the gene, and for that matter of all paradigms, to its rightful place. He warned us, as early as 1997, about the unscientific slippery road of "Big Science." As he provocatively put it, "according to all media reports, genetic determinism is a paradigm whose time is here and now: everyone will get better as their biotherapists become richer."[3] His prediction for the then upcoming limits of the genetic paradigm and his brilliant deconstructing of the "myth of the gene" that aids the prevailing naive ideas of evolution lead him to consider alternatives to understanding evolution processes in the light of ideas close to Waddington and Wallace. Ideas that call for understanding the inter-woven phenomena of genetic-epigenetic interactions in the light of complexity, self-organization, adaptive systems, and emerging patterns and processes.[3,4]

It is customary to attribute to Darwinism the foundation of molecular biology and to use genetics to "prove" Darwinism. But actually, Darwin himself was not an anti-Lamarckian. With his friend and co-founder of the idea of evolution through adaptation, the lesser-known pioneer Alfred Russel Wallace, he left the possibility of adaptation due to environmental interactions open. Although Darwinists managed to prove Lamarckians wrong, contemporary developments towards the "extended evolutionary synthesis" bring back again the ideas of the two protagonists as they were at the time when they were jointly proposing their theory of the origins of

the species. Wallace, one of the most talented and potent intellectuals of the late nineteenth century, went even further than Darwin in proposing the intervention of "a mind of the species" as a leading factor of evolution. No wonder why the original "Wallace-Darwin Theory" changed to the "Darwin-Wallace Theory" and then just morphed down to what now is known as "Darwin's Theory." (A detailed account of the erasing from the collective academic memory of Wallace's name as well as his brilliant life and legacy can be found in endnote 5.)

Although Wallace was punished for his "radical" socioeconomic ideas and his fondness for spiritualism, other prominent proposals about a not-so-random, even guided, evolution were preparing the "extended evolutionary synthesis." A modern synthesis leads us one step closer to revisiting Bergson's ideas of "Creative Evolution."[6] His criticism equally of both the mechanistic approach of genetic determinism as well as teleological finalism (i.e. that everything is "designed" to evolve as it evolves) still holds true as a valid ground of understanding change and emergence as a self-organizing process: Life equals creativity. Bergson's "vital impulse" puts the "telos" of life at the very origin, the "initial conditions" in today's terminology. Equally important is the phenomenon of life's "complexification." This is the fact that life goes on creating and evolving from the simpler to the more complex organisms. Simple procaryotic cells will give rise to eukaryotes, eukaryotes make more complex cells and even form big cellular cooperatives as they give rise to fungi and plants, and as life goes on it differentiates the species so that they are made of more and more complex individuals in more and more complex interrelationships. In fact, it is worth observing that as life evolves and complexifies the degrees of freedom thus afforded increase. The cells diffuse and are swept away, the plants grow, the animals move, the more developed animals acquire complex brains that think and control their environment. If we want to put humans on the apex evolution we can even dare say they control completely their environment, albeit they still have to demonstrate that they can do that in a sustainable way.

If we follow Bergson's lead, life must be equated with creation. The coexistence of automated instinct, mostly "unconscious," and purposeful intelligence, mostly "conscious," are two complementary poles and not mutually exclusive states. They both stem from what informs life itself:

change and becoming. In that sense, we have to think again of what we mean by the dualities chance (randomness) and order (law). As Bergson asks "order is certainly contingent, but in relation to what?" to answer that it is not a matter of order versus disorder, but rather of one order, or pattern, in relation to another.

Structure & Function, Objects & Processes: Complementarity is Life's Force

From the "one-way only" idea that genetic material's (DNA) molecular structure and random mutations would explain in a grand scheme the totality of biological function, life, and its evolution we have now arrived in the inescapable conclusion that life's function itself equally determines its own genetic structure. Through the vicissitudes of modern times, the complexities of gene expression, epigenetic regulations, environmental/ecological pressures, and a plethora of other factors we have come to understand that structure and function cannot each work independently and in separation. More and more we now seek their harmonious coexistence. The point which offers us an understanding is a point at the correct place in the continuum these contraries define. Complementarity is the key idea here.

Complementarity usually brings forth the ideas of its primary advocate and one of the founders of quantum physics, Niels Bohr. His dictum, which he also chose for his coat of arms, "*contraria sunt complementa*" (opposites are complementary) along with his chosen picture of Tao's yin-yang poles has been stirring up excitement and controversy since the early days of quantum mechanics. Complementarity a la Bohr has been hailed as a great revolution in modern thinking, a daring transcendence, which allows understanding of the wave-particle nature of light and every other elementary particle thereafter discovered.

Bohr's coat of arms

For physics, complementarity is a theoretical principle as well as an established experimental fact. The Complementarity principle states that properties that cannot all be observed or measured simultaneously, coexist in a

complementary fashion. Bohr considered as complementary dualities the fundamental, mutually exclusive quantum properties. In particular, "position and momentum," "energy and duration," "spin on different axes," "wave and particle," even the value of a field and its local change and the equally celebrated ever since, key properties of quantum systems: the duality of "entanglement and coherence." The above quantum properties of matter are mutually exclusive due to the celebrated "uncertainty principle" put forth by Werner Heisenberg, whose uncertainty relations are the sine qua non characteristic of any quantum theory.

Concepts like "particle" and "wave," which are clearly borrowed from classical physics, make it impossible for an object to be particle and wave at the same time. So, Bohr argues, it is impossible to fully measure wave and particle aspects simultaneously. In quantum mechanics, intrinsic properties are dependent of their determination by a measuring device. This is a strong statement but also an indisputable experimental fact. In relatively recent times this theoretical statement, supported by the Kochen-Specker theorem and the violation of Bell's inequalities, has been extensively tested in determining the nonlocality of entangled/coherent quantum states. So the verdict of quantum theory has been confirmed again and again that "the type of measurement determines which property is shown."[26]

This is all quite well known and widely discussed. What is not so well known is that Niels Bohr, and many other pioneers of quantum mechanics, strongly believed that complementarity has a wider area of application than quantum physics.[7,9,23,24] As his life and work progressed he believed on the universality of his principle more and more strongly. Actually, the complementarity principle's roots lie deep in Biology.

It is reported that as early as 1929 Bohr briefly noted that "in the description of living organisms one might see a certain connection with the issues of the quantum theory."[7] In an international congress of light therapists (!) in Copenhagen, circa 1932, he addressed the audience with his lecture titled "*Life and Light*." There he posed the question of whether or not the analysis of living processes could be reduced and described in terms of pure physical-chemical mechanisms. Interestingly enough, in 1972, Kurt Goedel, the greatest logician since Aristotle, also raised the same question. No surprise here since this question bears the most critical

answer for the future development of science. Their common question was whether or not our physical and biochemical substratum permits a mechanical interpretation of all the functions of life and the mind. Bohr, although he emphasized the uniqueness of life in terms of organization (structure) and teleological purposefulness (function), he feared to be blamed as an old fashioned vitalist and did not give a clear answer. As he put it: "If we were able to push the analysis of the mechanism of living organisms as far as that of atomic phenomena, we should scarcely expect to find any features differing from the properties of inorganic matter." So, he left the scholars divided. Did he reduce life down to quantum mechanisms or did he push teleology and purpose down to the quantum level?

Kurt Goedel, on the other hand, touched upon on the nature of consciousness, life, and mind in a more explicit way.[8] Indeed, any possible answer to this question hinges upon how complexity emerges in quantum systems, the borderline between quantum theory and biochemistry, and in the application of algorithmic complexity theory to quantum information theory. What is at stake here requires an interdisciplinary effort of immense proportions, so we leave it for the present noting that, indeed, how we understand life and mind (whether these are cosmic phenomena or mere earthbound accidents) depends on the outcome of this question. But principally their outcome depends upon how we pose these questions.[8,23,24] Let us return then to the principle of complementarity beyond quantum physics.

Bohr extended his principle into biology by stating:

> The question at issue is whether some fundamental traits are still missing in the analysis of natural phenomena before we can reach an understanding of life on the basis of physical experience ... It must be kept in mind, however, that the conditions in biological and physical research are not directly comparable, since the necessity of keeping the object alive imposes a restriction on the former [i.e. living things] which finds no counterpart in the latter. Thus, we should doubtlessly kill an animal if we tried to carry the investigation of its organs so far that we could tell the part played by the single atoms in vital functions. In every experiment on living organisms there must remain some uncertainty as

> regards the physical conditions to which they are subjected, and the idea suggests itself that the minimal freedom we must allow the organism will be just large enough to permit it, so to say, to hide its ultimate secrets from us. On this view, the very existence of life must in biology be considered as an elementary fact, just as in atomic physics the existence of the quantum of action has to be taken as a basic fact that cannot be derived from ordinary mechanical physics. Indeed, the essential non-analyzability of atomic stability in mechanical terms presents a close analogy to the impossibility of a physical or chemical explanation of the peculiar functions characteristic of life.[27]

And Bohr continues:

> "[there is an]…obvious exclusiveness between such aspects of life as the self-preservation and self-generation of individuals on the one hand, and the subdivision necessary for any physical analysis on the other hand. Due just to this essential feature of complementarity, the concept of purpose which is foreign to mechanical analysis finds a certain application in biology."

As his biographer Abraham Pais reports, "later Bohr expressed his views most succinctly like this: 'Mechanistic and vitalistic arguments are used in a typically complementary manner.'"[7] Of course, such a statement ran counter to the current of ideas prevailing in biology at that time, no wonder that Bohr's lecture "Light and Life" was considered almost scandalous and its fate in citations was set from dim to obscure.

Is life's force behind the principle of complementarity, or is complementarity as a real phenomenon behind the concept of life's force? Or maybe this recurrent question simply occurs in unison? Let us keep our minds and questions open. It is remarkable that contemporary research on the history of the development of the idea of complementarity provides evidence that the principle of complementarity is not just a loan of biology from physics but that their inter-penetration is deeper than we thought. Niels Bohr's father, Christian Bohr, an eminent professor of physiology, took part of the debate whether the exchange of oxygen and

carbon dioxide in the lungs (an important problem after the First World War's use of poisonous gas as weapons) could be explained as a diffusion process. His conclusion was that there are other regulatory processes and feedbacks that are governed by he needs of the organism to be sustained as a whole. Young Niels Bohr's mind was definitely influenced by these heated debates that he witnessed about the preeminence of structure or function between vitalists and mechanists,[9] and sparked his life-long interest in biology.

As physicist Basil Hiley never ceases to advocate, "For Bohr, this was an indication that the principle of complementarity, a principle that he had previously known to appear extensively in other intellectual disciplines but which did not appear in classical physics, should be adopted as a universal principle."[10] Hiley, an erudite scholar of quantum physics, mathematics and philosophy has followed the ideas of complementarity outside Bohr's Copenhagen interpretation of quantum mechanics. Hiley's work with David Bohm on the implicate/explicate order, or as they call it, "undivided wholeness," and the concept of "holomovement" exceed also the boundaries of physics to include matter and cosmos, life and consciousness.[11] Besides the brilliant development of the mathematical framework of the "holomovement," their ideas are grounded in a deep philosophical background that can be traced back to Baruch Spinoza, Gottfried Wilhelm Leibniz, Giordano Bruno, and Nicholas of Cusa (or Cusanus).[12]

When discussing the enfolding-unfolding processes in the universe and consciousness, David Bohm elaborated further on the need for new notions of order in physics and in science in general. According to Bohm and Hiley, totalities are continually forming and dissolving out of the universal flux, the holomovement. The different poles of dualities here are seen as not only as complementary, but as identical, stemming from a deeper undivided source. The implicate order unfolds to the explicate order of phenomena "in a state of unending flux of enfoldment and unfoldment, with laws most of which are only vaguely known." Although unobservable or even unspeakable, the implicate order is felt and real. It is indirectly detected in the emerging, explicate processes, in the phenomenal world. Bohm concludes: "All of these [matter, life, cosmos, and consciousness] have been considered to be projections of a common ground.

This we may call the ground of all that is." Others call it "The Source," "The Force," "The Godhead," or "Tao".

Both Bohm and Bohr, although the founders of different interpretations of quantum mechanics see complementarity as the unifying, ubiquitous (both as a principle and as a phenomenon), common ground of all that is. They were both aware of the Hermetic-Alchemical intellectual tradition's idea of "*coniunctio*," meaning conjunction, is the (al)chemical process where two chemical substances "marry" to produce a third, different chemical substance. Carl Gustav Jung used also this term in his psychoanalytical work to describe an unconscious experience (e.g. instinct) that is combined with consciousness and becomes a new different experience (e.g. desire). Wholeness requires a "*coniunctio oppositorum*" (conjunction of opposites), an alchemical marriage. Here contradictory aspects are not just complementary, they are identical under conjunction. The ends of any polarity meet in the implicate and appear as separate aspects in the explicate. The whole, total flux is all what is all around.

Linear and Non-linear Logics: Similar but Different, Different but Similar

May you be able to find the similarities in difference and the differences in similarity.
— The Master of the Diamond (by Emilios Bouratinos)

In tristitia hilaris in hilaritate tristis (in sadness joyful, in joyfulness sad)
— Giordano Bruno,"Il Candelaio"(the candleholder)

Complementarity leads us to the strange logic of quantum physics with its seemingly contradictory, counterintuitive and sometimes upsetting conclusions for our everyday, classical, mindset. These "quantum paradoxes" caused John von Neumann and Garett Birkhoff to examine the logical foundations of Quantum Physics. And so they offered to the word another genuine surprise: quantum physics cannot be cast in a standard Aristotelean, or Boolean, framework. We need to extend our logical framework to accommodate complementarity and the weirdness of the quantum world. So, they proceeded in doing exactly that. It generated a

wide array of studies and now we understand that the logic of quantum physics can be formulated as a modified version of the standard propositional logic. There are many names and versions of "quantum logics" in our days, non-commutative logic, many-valued logic, no-associative logic and the list can go on.

Self-reflecting Taijitu.
Yin in Yang in Yin…

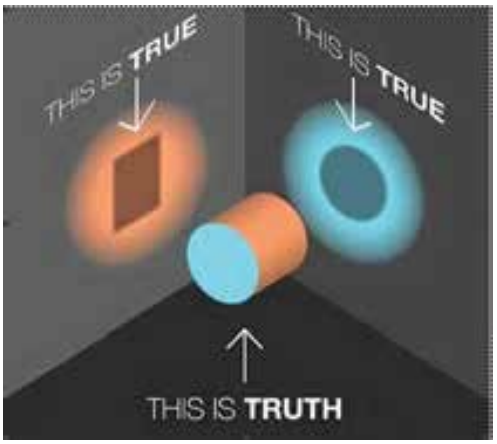
Quantum logic is a new kind of logic; that is, a formal way to reach conclusions from premises (or presumptions). It has certain properties that differentiate it from classical (Aristotelean/ Boolean) logic. The most crucial distinction from classical logic, is that the "distributive law" does not hold. In Aristotelean logic, as formulated in mathematical language by George Boole, if we have three propositions (say, A, B, C) their logical operations of conjunction ("and") and disjunction ("or") can be combined as: *"A and (B or C)" is equivalent to "(A and B) or (A and C)."* So, if one reads the menu that offers "eggs and bacon or sausages," if the restaurant honors Aristotelean logic one can safely order "eggs and bacon" or "eggs and sausages…unless the restaurant's waiters are quantum physicists! Because in a quantum restaurant that prides itself of its non-classical, quantum, logic if you see offered "eggs and bacon or sausages" and request "eggs and bacon" it will be entirely logical for them to inform you that they cannot serve you either "eggs and bacon" nor "eggs and sausages", because their "distributive law" is broken. However, you can have "eggs and (sausage or bacon)" where "(sausage or bacon)" will be a concoction of processed meat that resembles bacon and sausages at once…*

When the distributive law is not observed the three tenets of classical, Aristotelian, logic also cannot hold unconditionally. These are, as Bertrand Russell defined them: *The law of identity*: "Whatever is, is." *The law of contradiction*: "Nothing can both be and not be." And *The law of excluded*

* This illustration of quantum logic appears in endnote 13 from where I modified it and transferred it here. Another friend, David Lorimer, when discussing the logic of quantum observables offers another instance: "A client asked for tea or coffee has just been served a brown beverage. After tasting it, horrified, asks the quantum waiter 'Oh, jees! Is this tea or coffee?' only to get the answer 'if you can't tell the difference why does it matter?' … uncertainty and complementarity principles at work in quantum restaurants!"

middle: "Everything must either be or not be." Hence one can rightfully ask, what is the use of logic and what is reasonable in logic? Here one has to contemplate before rejecting any non-classical logic that, as in ordinary life, usually arise in situations in need of understanding, and requiring some reasoning that is far too complex and far too non-linear than the clear "yes-no" universe of classical Boolean/Aristotelean strict logic, that we demand from a good restaurant, and on which the "Boolean lattice of propositions" our computers and machines are built upon.

As far as quantum physics is concerned, however, the obstacles to conventional logic are the uncertainty principle, the nature of entanglement, and the complementarity issues of incompatible measurements. Uncertainties can play an equally obstructing role to complex systems' descriptive logical attempts. As complexity aspects are malleable due to their multi-faceted nature and/or adaptable under different conditions, during the process of observation we expect that complexity would raise equally disconcerting questions about their "unreasonable" extended logic as viewed through our classical mindset.



…what is true and what is truth?
(cc) by Leigh Blackall

Computers and machines do work based on Boolean logic, for sure. But it is exactly these severe limitations imposed by Boolean logic that ignited the search for extensions of classical logics in order for our machines to deal with the surrounding complexities of real world problem solving. Many models of alternative logics have been and continue to be proposed, sometimes inspired by quantum logic. The names of these logics are as innovative as their creators: we have Fuzzy logic, Rough-set logic, paraconsistent (or deviant) logics, many-valued logics, intuitionistic logic, and temporal logics, to name a few. Evidently, not all of them are directly related to quantum logic. Yet, context dependent logics and temporal logics, logics that change as time or information flow goes by are extremely close and relevant to quantum logic.[13,23,24]

It has been understood that Aristotelean/Boolean logic is based on language and on object-mediated perception. Then these other fancy logics could be based on another kind of language, accessible and manipulable through their strict formalism and even special machine coding. Then the problem of truth arises. And this problem is as old as philosophy itself. The problem of truth took a major decisive turn after Socrates rebelled against sophists for their use of logic that could prove whatever they liked whenever it seemed profitable to their petty interests. Are we now witnessing a similar major shift in understanding of the problem of truth as then? What will guide us to truth now that proof can lead us potentially anywhere?

If logic can create monsters what can guide logic to truth? Henri Poincare, the father of modern chaos theory, insisted that "it is by logic that we prove, but by intuition that we discover;" and that "Logic teaches us that on such and such a road we are sure of not meeting an obstacle; it does not tell us which is the road that leads to the desired end. For this, it is necessary to see the end from afar, and the faculty which teaches us to see is intuition." It is exactly what the contemporary Greek philosopher and essayist Emilios Bouratinos has been advocating all along; a return to "Logos" as a guide to escape the inevitable irrationalities of any system of logic that traps our mind to any particular paradigmatic thinking. As he puts it,

> One of the important things modern science has revealed is that when we objectify things, there is a price to pay. Objectifications always end up with something less than the real thing itself. They lead to a conceptual crystallisation of entities which in fact have acquired only temporary form and structure. So we cannot know with absolute certainty what will and what will not change in them, when it will change and to what extent they will not change. The origins of strange attractors in the non-detectable initial circumstances of chaos theory, plus Goedel's incompleteness theorem and Heisenberg's uncertainty principle, render any sweeping generalisation about patterns, transformations, methods or outcomes unreliable.[19]

Socrates would have readily agreed with Poincare and Bouratinos, as many contemporary thinkers agree in trusting, and leading us in trusting too, the forgotten organ of intuition anew. This is the only hope in navigating out of the labyrinth our collective mindset traps us in. Such realizations escape from the confines of academic thinking; nowadays many think along the same lines. Mainly due to the increasing complexities that our modern civilization faces and its inability to resolve crucial issues that fast become matters of life and death, more and more institutions, thinkers and common folks aspire for another way of understanding and doing things. Robert Jahn and Brenda Dunne in their book *Consciousness and the Source of Reality*14 quote a wonderful proverb carried forth from perennial wisdom by the Sufis, it goes: "You think that because you understand ONE you understand TWO, because one and one makes two. But you must understand AND!" It cannot be made more succinct or lucid than that. It stands so true that when dealing with logical reasoning we cannot be led blindly by assumptions, consciously or unconsciously given. We have to turn to honest introspection and be able to see the context in which our reasoning operates. It is not only a question of how, but of why, and from where, what is given arises. And of course, it is imperative to be able to discern the given from the real, in each and every case, at each and every time.

The One Behind the Two

There are powers and thoughts within us, that we know not till they rise
Through the stream of conscious action from where the self in secret lies.
– James Clerk Maxwell, in
The Man Who Changed Everything[22]

The faculty of intuition is not something that speaks only to the poet or the artist. It is inherent in all of us even though latent, silent or unacknowledged. To be able to access it as the great scientists have always done might actually be easier than we think. As proof has to be guided by truth in order to be successful, intuition has to be guided by beauty and utility by what is pleasurable and good. Let us call Henri Poincare again on the stage, he says: "The scientist does not study nature because

it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. If nature were not beautiful it would not be worth knowing, and life would not be worth living.... What I mean is this more intimate beauty which comes from the harmonious order of its parts, and which a pure intelligence can grasp."[28]

There is where the self in secret lies, close to the source of beauty and truth. It is where the "coinsidentia oppositorum" (coincidence of opposites) of Nicholas of Cusa, the complementarity of Bohr, and the implicate order of Bohm meet with no paradox. We can see and feel that this is so for all dualities, either confronted or created. We can find endless examples. For one, the crux of understanding Complexity, which is the duality of parts and whole. We have come to understand—especially with the recent advent of chaos and complexity theory, nonlinear dynamics, self-organization and systems' science—that indeed "the whole is more than the sum its parts" or that "more is different." What remains to be kept in mind along with these often-quoted remarks is that indeed the whole is reflected in all the parts, that all things keep their own relationship to the whole as the whole interpenetrates its parts. So the dichotomies of parts/whole, reductionism/holism, or particulars/universals can easily dissolve and reappear according to our approach. We can reduce reality and systems to our hearts' satisfaction, provided we remember where and when we started reducing from. We can take the pieces apart as far as we desire, provided we keep track and recall how to put them back together again. A fuller understanding will always come from such a two-way process.

Somehow, the duality game appears to follow certain common, almost universal pathways. Finite and infinite, for example, relate to conscious and unconscious. The same with unfolding and enfolding, or non-living and living, artificial or natural mechanisms and so on. Leibniz, for example, famously maintained that a living thing is a kind of divine automaton. What makes a divine automaton, he would profess, is the fact that "machines of nature, that is, living bodies, are still machines in their smallest parts, to infinity. It is this which constitutes the difference between nature and art, that is, between divine art and ours." From this realization, we have arrived to the current prevailing thesis, actually hubris, of "artificial intelligence" that we are all machines or that machines can be us, if not now then one day. To the delight of the strict reductionist

molecular biologists this is a most welcome ally as it would render all life to be reduced to a big molecular machinery. But what they forgot while descending blindly into their one-way dark alley is *infinity*. Infinity that cannot be ignored any more, for example in the newly fast developing field of quantum biology. There infinity sneaks from the back door as quantum probabilities that necessarily have to take up the stage. Chasing the mind to the realm of the minuscule particles inside the brain even Richard Feynmann, had to proclaim that: "Mind must be a sort of dynamical pattern, not so much founded in a neurological substrate as floating above it, independent of it."[21] But as far as patterns are concerned, "it takes one to recognize one." As patterns are an infinitude, it follows that it takes a Mind to see the pattern that is mind.

Left-Right Brain, Upside-Down Mind: Self-Locking and Self-Releasing Objectifications

Logic merely sanctions the conquests of the intuition.
— Jacques Hadamard

Iain McGilchrist, the author of the monumental work *The Master and his Emissary: The Divided Brain and the Making of the Western World*, takes the most up-to-date and deepest study on a different duality.[15] This time the duality concerns anatomical as well as functional aspects of the brain and their reflection to the dual aspects, logical-vs-creative, of the mind. He reevaluates, in a deeply erudite "tour de force" the seminal experiments of split-brain research since the late 1950s and the immense literature that has been generated ever since.

Usually the left hemisphere is attributed by the logical, analytic faculties of "how" the world is, where the right hemisphere is providing the relational, contextual meaning of "why." These two ways of understanding project two seemingly incompatible versions of the world, with quite different priorities and values. McGilchrist, unlike most scientists since the 1950s, does not abandon the attempt to understand why this division of the brain into two hemispheres is essential to human existence. In the course of his studies, he brings forth a very important realization: the duality is not so clear cut! He demonstrates, by a wide array of supporting

experimental data and analyses, that every type of function is possible only due to the complementary concerted action of not only one but both of the hemispheres. The communication between the two major parts of the brain is what makes the whole brain serve its purpose for the benefit of the animal that possess it. He goes on to argue that the differences lie not, as has been assumed so far in the "what," but in the "how" the processes of each hemisphere play out their roles. More importantly, he emphasizes the not-so-well-known fact that the relationship between the two hemispheres is not symmetrical, either anatomically or functionally. To do that he utilizes in a wise way the perennial theme of the Emissary (the left hemisphere) and his Master (the right hemisphere). As the theme of the story goes, the master delegates, in good faith, valuable executive power to his emissary in order to carry out tasks that the right hemisphere cannot itself undertake. Yet, as the emissary has his own agenda, he can finally trap and betray its Master. The "How" becomes now more important and singularly so. The "Why" becomes secondary and of a lesser priority. Utility dominates value, usage oversteps beauty, the means disregard the ends. More or less these are the lines upon which the drama of our civilization unfolds. What the Emissary can never accept or realize is that by betraying the Master he also betrays himself.

The issues of brain plasticity, the complex role of the corpus callosum (the connecting bridge of the hemispheres), and the "inner sanctum" of the brain (the midbrain where the pineal gland and all the primitive functions reside) are also examined deeply and their interrelationships with the hemispheres are elucidated. The structure and function of the brain and its hemispheres are found to be determining factors, but not something that the mind can be reduced to. The hemispheres, we come to understand, are not mere machines with specific functions. These parts offer whole, self-consistent, versions of the world. If communication breakdown between the logical and relational parts persists, as our history of ideas testifies, in this "uneasy relationship" of theirs, we may unfortunately witness the final triumph of the left hemisphere: The Emissary's total control and the final dismissal of the Master, "at the expense of us all" as McGilchrist warns us.

Is it possible that these two modes of knowing and being, the analytical "left-brain" and the relational "right-brain" have their own reasoning?

But since the relational does not use any kind of representations—it only exists as sense and feeling—one expects the enterprise of deciphering it to be a futile, delusive one. To be more accurate, any attempt to analyze it in terms of logical structures would not reveal its "logic," it would just describe how the analytical logical structuring reflects on, and takes in, the relational. In other words, if there is any logic for the mostly unconscious processes of the relational "right brain" processes, it is a logic to the degree understood by the analytical, rational, mostly conscious "left brain."

Recently, with the proliferation and relative ease of formal logical systems implementations another body of work, undeservingly forgotten, emerges to the foreground. It is Matte Blanco's original theory and its latter variations, about the way the unconscious mind structures itself. The original work of Matte Blanco started to be known outside the academically closed psychoanalytic circles when he published his work "The Unconscious as Infinite Sets" around the end of the 1970s.[16] His discovery that emotions are "similar to mathematically infinite sets" opened new pathways and introduced a fresh new way of thinking about and in psychoanalysis. This work, which is difficult to find and follow, as it is quite esoteric yet not obscure, remained out of reach to wider audiences until the beginning of this century. With the renewed interest in non-classical logics, more and more introductory and explanatory texts emerge, using many vivid clinical examples and less complicated language.[13,17] So Matte Blanco's theories and ideas about "bi-logic" are re-emerging now, notably for their use in therapy. The "bi-logical" treatment asserts that there two (hence the prefix "bi" in "bi-logic") distinct modes of reaching conclusions—one the conventional logico-analytical mode, and the other the unconventional felt-relational logic of the unconscious.

The conventional logic is asymmetrical while the unconventional one is symmetrical. In asymmetrical logic a proposition, A, is different than its negation, not-A. In the symmetrical logic, A and not-A are identical! Though Matte Blanco makes a delicate distinction between the Freudian sub-conscious and the unconscious, let us refrain from details of psychoanalytic terms. The important idea here is that analytical, left-brain, explicate order all share asymmetric logics, while the relational, right-brain, implicate order all share symmetric logics. Matte Blanco acknowledged that symmetric logic can be really upsetting to the logician and he had

his share of polemics at the time. But the key is to understand that the symmetric logic works through *associations* rather than *propositions* and that it is *unquantified*. Properties have no degrees: they are all or nothing. It looks crazy but who said that the workings of the unconscious should look sane? Here is an example paraphrased from Mate Blanco's theory: The patient is bitten by a dog and hurries to the dentist. Why? Because the road of "explanatory deduction" revealed by the patient's prevailing symmetric logic is as follows: "– A dog has bitten me – It hurts – It is bad – The dog is bad – Dog's teeth are bad – I suffer from bad teeth – when suffering from bad teeth we go to the dentist"…QED!

As Eric Rayner, one of the key proponents of the theory and practice of Matte Blanco, puts it, "It illuminates the emotions behind thinking and the thoughts behind emotions."[17] The interplay between conscious and unconscious logics in bi-logic is for all those concerned with advanced psychoanalytic thinking and therapy, yet it sounds the familiar tone of the language of the Artist, the Poet and the Mystic. It has the trace and taste of "coinsidentia oppositorum" (coincidence of opposites). The avenues of research that it opens are very important to the study non-conventional logics. Especially for those logics where the observer creates context by his mere presence and choices for the observables. Oscar Wilde once said, through the mouth of the character Algernon Monchief in his theater play *The Importance of Being Earnest, A Trivial Comedy for Serious People*, (Act I), that "The pure and simple truth is rarely pure and never simple." … So much even so, if the pure and simple truth is witnessed by observers with the faculty of introspection.

McGilchrist's and Matte Blanco's voices join many others' in a theme frequently encountered in our times: The prevailing strict, dogmatic adherence to one-way delineated thinking is as if we are happy to achieve record speed in a direction but we chose to ignore where it leads. Emilios Bouratinos also has been advocating a fundamental similar duality that leads us down the same path due to one-way of dogmatisms. He considers through his deep philosophical analysis how we appreciate, apprehend, and comprehend the world. His take on Consciousness, Objectivity, and Science illuminates each through the light of the others.[19] As he observes, the fundamental workings of Consciousness shape the world and also our ideas about the world. Here the one pole is what he calls "self-locking

objectification" while the other is what he calls "self-releasing objectification." In between, or behind, this duality is the unifying substrate and at the same time the bridge in "Logos."

Logos originally meant ratio, proportion, analogy, as well as reason and relation, and all at the same time. As Bouratinos observes, reason or logos (originally derived from an understanding of the flexible relationship of things to one another) became "formal logic" and "scientific methodology."[19,25] Formalism overtook intuition, prediction overshadowed openness. Concepts became more rigid in the same way language adapted to this rigidity and perception filters selected and mapped everything in terms of objects, object-oriented, and object-mediated relations. This is the process of "self-locking" objectification where consciousness is trapped by its contents. It requires a return to a fresh communion with process, even in the sense of Whitehead, a daring opening to the forgotten flexibility of metaphor and analogy to unlock our consciousness from the grip of its own contents. This is the process of "self-releasing" objectification. Usually it comes with the familiar sense of the enlightenment due to context: by the descending of a vision of a "Why" on the "How" things are as they are. In science, this is related our familiar "Eureka!" moment. The moment of transcendence of an old paradigm by the discovery of a new one. Yet, this relation is just an instance of the faculty of our consciousness for "self-releasing" objectification. The overcoming of the need for paradigmatic thinking itself is the real boon of the interplay between the "self-releasing"/"self-locking" game of objectification. This does not mean that we shall abandon paradigms altogether. To the contrary, we shall embrace them as what they really are: yet another emissary of their master, Logos.

One might dismiss all this as just a romantic tendency or a return to philosophizing "as it used to be," before analytic philosophy and positivism put philosophy in the straight-jacket of exact formalism and precise definitions. It might well be. But what is philosophy other than the love of wisdom? Asking Science to rediscover Her origins, the beauty and light that comes from an understanding of both how things are and why things are is, after all, primarily an act of Love. An act that the Master cannot delegate anymore to his Emissary. An act that can unlock the shackles

we self-imposed on our consciousness. Since "Love is introduced without any parent at all" as Francis Bacon (one of the founding fathers of modern science) put it, reintroducing it in the kingdom of Science might be easier than it seems. Emilios Bouratinos advocates and leads this reintroduction through his approach. This enterprise he is inviting us into is has to be equally precise as science in its means and joyful as art in its end: The regeneration of Science comes from a regeneration of Consciousness.

The suggestion he puts forward is an initiative to be undertaken for gradually creating a consciousness-informed science. As he says,

> …for such an enterprise to succeed, it must be carried out in the light of the major scientific breakthroughs of the 20th century as they contain precious clues about how object-mediated thinking operates. Researchers and philosophers must be encouraged to examine their own personal understanding of how consciousness works and what are the conditions necessary for science to explore it.

An important input form 20th century Complexity Science, the understanding of the phenomenon of Self-organization, can secure the effectiveness of such questioning. The people and institutions involved in such an initiative should consider their task, assess their findings and grow organically in the light of inter-personal dialogue. Like David Bohm, who also advocated a form of dialogue that explores personal and group introspection, similar forms of dialogue, which Bouratinos calls "Inter-personal dialogue," can be found and harvested from "techniques practised by pre-literate societies throughout the globe before the advent of individualism. These techniques contain and channel 'the ego explosion' aiming at getting collectively to the bottom of any important issue to the 'tribe.' Inter-personal dialogue is effective as it creates a common conceptual and ontological ground among discussants." As he puts it, "How a conclusion is reached matters as much (if not more) as what the conclusion itself stipulates."

Evolving Science, Extending Science

Theories are nets: only he who casts will catch.
— Novalis

The subtlety of understanding depends on the understanding of subtlety.
— Emilios Bouratinos

We have seen that even the idea of evolution has evolved and the prevailing "molecular machine" paradigm was exhausted by reaching its limits. A common theme for many areas of modern science, as well as modern thinking even in the more formal of formal sciences is Logic. As we observed, logic has evolved to embrace realms of reasoning far and wide. From the principle of complementarity we learned that no matter how much a pole of a duality grows it cannot engulf the other pole in its entirety. Behind every complementary duality there is a coincidence of opposites lurking at its deepest level behind the complementary phenomena. Theory and experience notwithstanding, they also both point to a deeper level where their coexistence is based. We need theory to bring forth more data as we need more data to bring forth new theories.

De bètacanon by Fokke & Sukke
J. Reid, B. Geleijns , J.-M. van Tol

There is a Dutch comic strip (created by writer and illustrator Jean-Marc van Tol, and writers John Reid and Bastiaan Geleijnse called "Fokke & Sukke") where a dismissive, austere, professor exclaims when his student has just demonstrated an experiment: "Very impressive, dear colleague, but does it also work in theory?" As always, there will be facts and givens of experience that no theory can entirely explain. Denial is the first reaction and it is humanly so. The barrier for any understanding needs energy to overcome, it also needs patience and persistence. In contemporary cosmology, the issues of "dark matter and "dark energy" fuel fiery debates and open many discussions. But also in science at large it seems that we have a rapid accumulation of "dark matters" and "dark energies." Moreover, as the crises of our times keep dragging on we see

an increasing polarization among cultures. The conflict between "the two cultures" (sciences and humanities) as famously delineated by C. P. Snow some decades ago, now has become a chaotic "meta-modern" battleground aiding a continuous proliferation of sub-cultures.[29] Numerous "mainstream" established fortifications prevent genuine dialogue, and on the other hand certain "new-age" misinformed groups create confusion about several very important issues. Signs and symptoms of a phase transition as they are, they nevertheless call for a deeper approach in thinking beyond mere paradigms. It is about time that we must concern ourselves not only with the study of nature but also by the nature of this study. Self-reflection and a quest for a new kind of validation of experience can be the only trusted peacemakers in resolving these contemporary conflicts.

We might be in just that instant of our collective evolution where we clearly see now the limitations of fortified self-interests and doctrinal ways of scientific thinking in society, the environment, the economy, politics, and education. The overarching theme in mainstream thinking is the seeking out of the "mechanism" as the core of any desired explanation. Although such mechanistic linear thinking ceased to be the prevailing one in physics since the beginning of the last century, other sciences are yet to catch up, still trying to fathom their practice in the mechanistic, naively reductionistic paradigm. They unquestioningly take their mode of understanding as only by means of reducing any operation to a mechanical process. They seek more and more the utility of the machine than the understanding of the process as a systemic whole. Hence crises ensue. And in our day when crises are met it is custom to throw up our hands and proclaim "Oh, this is complex" (end of discussion, thinking stops here!). I would propose instead to engage and encounter these complexities. Observe our limitations and navigate through them. Participate during our observations. Engage with systems and concepts. Be able to re-equip and re-inform our science by allowing it to reflect on its own foundations.

Arthur Koestler has remarked that the "decisive advances in the history of scientific thought can be described in terms of mental cross-fertilisation between different disciplines."[30] Complementary spirit is the key here. We shall be inspired by Socrates' "science of sciences." Such a "science of sciences" demands that we are not bound by paradigmatic

thinking or doctrine. We must turn the investigative powers of "science-as-we-know-it" onto itself, then onto the scientists, and finally onto the major expressions of social life. This is the true meaning of the founding spirit of modern science, endangered by the one-way, solely utilitarian, version of science demanded today. Science as its prerequisite has the underlying principle of "Libre Examen" (The Freedom to Examine). This is a basic human right demanded by the early humanists for honest research and study, free of any chains that bind the mind. It remains our privilege today to turn this human right to our human responsibility. It is our responsibility and right to allow and to seek by reaching, and observing, our limits of investigation. Moreover, there is another dimension to it: by becoming aware of what limits our own thinking, we can become aware of what justifies the thinking of others. Moderation is not just a moral issue, it is what will reveal the ultimate complementarity of the opinions and methods of others. Inverting the parable: If we have a little mote in our eye, our neighbor can still see it clearly even if he has not cast the beam out his own eye! The complementarity of freedom and compassion always performed miracles—this time it can only be for the benefit of all.

Last but not least, we have to keep vividly in our mind that research is most useful when it is driven by the desire to satisfy curiosity. There is a tendency that when new knowledge is furnished there arises the need for its immediate applications. But the furnishing of new knowledge is not primarily due to the demand of applications. If Faraday and Maxwell were constrained to discover a better and stronger candle they would never discover electricity.[22] It took almost a century to fully illuminate and run our cities with electricity, but it would never have happened due to the results of applied candle science. We manage to discover important applications (the transistor, the laser, superconductivity) when we are driven by curiosity and desire to understand.[18] Creativity, like Evolution, is a playful activity. So this call for a new kind of science informed by a new kind of consciousness is also a call to bring back the fun in doing research for its own sake. This new science will offer themes for exploration and research not driven by an egocentric or institutionalized agenda, but from the mere pleasure of doing so for its own sake and making ends and means a complimentary unity rather than an antagonistic duality.

Epilogue: A Modest Proposal

Thought must never be subjected either to a dogma,
to a party, to a passion, to an interest,
to a preconceived idea, or to anything.
For, to submit to it, would be to cease to be.
— Henri Poincaré

The burden of industrial-driven research is drowning modern research. The diminishing support for basic research has already become a matter of concern not only for the academic world but also for societal bodies at large. More and more the old ways of supporting basic research are weakening, funds are disappearing, and young people are discouraged from pursuing research-related careers. If the dismissal of research and education as useless activities with no immediate profitable turnover continues at this rate, very soon they will cease to exist as realistic or even legitimate occupations.

Yet, as any crisis is pregnant with opportunities, novel organizational schemes appear strong and fast. Closing on a much more practical and utilitarian mode, it is worth adding that research and educational activities find new fertile and nourishing ground through the recent, and by now well established, activities of "crowd funding," "crowd sourcing," and what is called "participatory research." Interestingly, all these new forms of support relate to ideas from modern physics and complexity science, the first coming from the idea of self-organization in micro-economics while the second and third stem from self-organization in physics, biology, algorithmics, and distributed computing. They are all inspired, basically, by the self-organization and spontaneous division of labour theories dealing with hyper-organisms such as beehives and ant colonies. Actually, in recent years these novel fund-raising and resource-management ideas, operating via ad hoc assembled "crowds" interested in specific science projects small or large, drew the attention even of the "mainstream" scientific and research community, to the extent that the well-respected journals "Nature" and "Science" keep running special editorials to cover it.

Evidently, such actions liberate the scientific workforce from contractual, ordered research and the constraints of "Big-Science," "Big-Pharma,"

and other "Big-Money" strictly utilitarian guidelines. Most importantly, by actively engaging every interested party they promote and nurture, in the most efficient way, public awareness via public participation. One hopes that new creative forces also will be released towards a new kind of science as has been the case for any innovative breakthrough since the beginning.[18]

Moreover, and quite surprisingly, certain modern-day politicians, science policy advisers, activists, and CEOs use extensively the insights from Complexity Science, Chaos Theory, and Nonlinear Dynamics to elaborate on the theme of emergence as a new framework of understanding for the dynamics of "the workplace." One key issue that draws their attention is how coherence is established in an organism or organization, naturally born or human made. On the basis of organic coherence lies the phenomenon of "entrainment," where the alignment of a system's period and phase to the period and phase of one of its own subsystems is responsible for the emergence of collective modes of behaviour that might surpass and guide the dynamics of the whole organism. A coordinated small group of individuals will influence the motion of a much bigger crowd. A few coordinated and well- informed bee-scouts help the whole swarm to make decisions by safely reaching consensus. A system of interconnected hubs determines the robustness and effectiveness of the World Wide Web and many other networks. A lively interacting team of scholars can provide access to more knowledge than a whole group of universities.

Complexity science, like system science before it, have developed the necessary tools and concepts to deal with such emerging self-organization. The call, the imperative, is the formation of polycentric networks where projects and ideas are shared and circulated among a network of organizations, laboratories, and individuals. Self-organized and engaged in dialogue along a polycentric scheme, projects and ideas can be developed and are developing through such "commoners' science." Yet we cannot but notice the absence of cooperative research projects aimed at basic and applied research activities with a long-term horizon. I think it is within our reach to encourage and support the formation of multi-state and multi-stake cooperatives of individuals and labs for pure basic research within an interdisciplinary spirit and a self-reflecting attitude. Imagine this new kind of network as an evolving village, or even better,

as an evolving organism like a "mycelium." Flexible, self-organized, exchanging energy, ideas, and nutrients with its environment. Open to societal changes and needs, yet resilient and growing, where it can grow, or keeping its ground and prepare to grow where it cannot grow. We can give birth to a live and resonant network of people, ideas, and projects. We can definitely envision it and organize it in such a fashion.

There is hope in considering an extended science, as sketched above. Contributing, cooperating, and sharing among numerous workers and thinkers, many unanswered questions will resurface allowing us to be able to move beyond accepted unquestioned answers. Many will be the questions, large and small, that will find new frameworks for investigation. For example, the question of information, memory, and knowledge-dynamics and their role in evolution, biological or not; or, what are the plausible frameworks where we can ask whether or not Nature has a mind of her own? What are the substrata that awareness/cognition/intelligence requires to express themselves, as Richard Feynmann anticipated? Can there be any observables associated with it, and what type of observations can be expected? In what sense can these observables be measurable or felt? Or even; How to verify reality? Of course, the big questions about Consciousness will also ask for accommodation. And that is where all the difference will be made, and the greatest, deeply satisfactory and soul-nourishing fun will be found!

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