On Scanning Scientific Discovering: Plastic Control, Substitutionality and the Bootstrap Problematic

By

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Discovery and Discovering

There are indeed two sides to a scientific discovery: the process of discovering and the very product of discovery. Like a day, the former is the 'night' of day and the latter, the 'light' of day. The studies of L. Chawla (1981) reveals distinct reactions to this metaphor by scientists and artists.[1] She records the observation after making a series of interviews with the celebrated artists and scientists that "The scientists express an acute consciousness of the darkness. . . the artists may be described as being dazzled by the brightness. The scientists have pitted the power of analytic observation against the darkness of the unknown. Artists on the other hand, busy themselves immortalizing life. They pit their ability to synthesize experience against the grimness of analysis."

The day-night metaphor may obviously give rise to a chicken-egg bootstrap dilemma between discovering and discovery.[2] But we are

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[1]L. Chawla, "Past Place/Present Time: An Exploration of Environmental Autobiography." Paper Prepared for the Development of Environmental Psychology, City University, Graduate Center for Human Environments, Graduate Center of CUNY. 1981. p.81.

[2]Gerard Vollmer, "On Supposed Circularities in an Empirically Oriented Epistemology," in *Evolutionary Epistemology*. Radnitzky & Bartley (eds.), (Ill. Open Court, 1987). He writes, "If the hen - from which egg did it crawl? If the egg - by which hen was it laid? This venerable puzzle of evolution or rather of evolutionary theory has been solved only recently. As evolution did not start with birds, it will be legitimate to translate "hen" into "function," represented by proteins, and "egg" into "information," represented by nucleic acids. Which then was first, function or information? If function - how was it encoded? If information - how was it decoded and duplicated? The answer is this. Life started with macromolecules (RNA molecules) representing, at the same

confident that the fertility of our day-metaphor will prove itself to be quite convenient and helpful and not otherwise self-destruct in the process. The metaphor at this point in time will serve to illustrate quite simply that, a) discovering and discovery are quite distinct stages, b) discovering and discovery are distinct, yet constituting an integral whole, and, c) the discovery will have to play the role of the "first," over and above the 'discovering' process, regardless of whether that role is to be either that of the chicken or the egg.

It is to be expected that Einstein should earn so much attention and accolade from the world at large, that his autograph becomes a common fixture and a *necessary* inclusion in pertinent science books and periodicals. He had written volumes, and still a hundredfold have been written about him and his work. Like Moses, Einstein was both enthroned and enshrined for his scientific discovery of the theory of relativity. Like the sun in the solar system, Einstein's work became a source of heat and energy in the world of science and of society at large.

The creative product 'by' an Einstein, have made him 'the' Einstein, the celebrity. Any study made of Einstein, e.g., the 'reasons' for his success, must obviously start and emanate from the *success referent* of the theory as an accredited and therefore, valued discovery. It is on the basis of the credibility of the creative product that will obviously make any such 'reason' to be taken as a credible reason which could be validly accepted for the 'success' of what became a successful consensually accredited theory. The intuitions of Einstein as a patent office employee may have been considered brilliant, but they will never formally possess the same spectral caliber *a priori* which the Einstein of relativity possessed. The former may have been formative and developmental in the process, but this statement can only be annexed with certainty in the light of the latter, *a fortiori*. At best, given the *success referent* which we now possess, Einstein's earlier career as a patent processor, may be taken with greater plausibility as being contributively seminal and prophetically accessory, to Einstein's *post accreditum* status. The confirmation of the theory of relativity have, in effect, 'validated' and 'legitimized' all seemingly puerile baptisms, whether they be of fire, of water, or of blood.

The 'presence-factor' of an accredited creative product assumes all the presentiments of the processes, disjunctive they may have been, into a

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time function and information. Those first self-replicating molecules, which started molecular evolution, were folded chains of nucleotides. Their information was the sequence of their elementary building blocks, being duplicated without enzymes, therefore not in need of being decoded. Their function was to replicate as fast, as faithfully, and as durably as possible. And because different sequences (i.e., have different functions), those first self-replicative unites must have met with different success in multiplications (or with a well-known, though highly misleading, phrase: in the struggle for life). Thus biological evolution could take off from those first self-replicating systems, leading, in due time and course, to more and more complexity and, finally, to cognitive systems, pondering over this baffling non-vicious circle." pp. 181-182.

conjunctive and intelligible whole; disparate as the attempts may appear, but quite naturally, into full responsibility and accountability; imparting on the creator and the process, the original sense of being justly creative. The implication is already showing its slip at this very moment with its 'parousiac' excitement. Canonicity spells standard valuation and universal enthronement. A kind of juridical sentence have been meted on a scientific discovery by the recognized and proper bodies that such scientific work merits a universal scepter of acquired authority. The very elite circle of the community of scholars have decreed that such work is truly a work of competence. The accredited discovery thereon subsumes its personal character into the whole matrix of the firmament of the solar system of the rest of accredited scientific discoveries, subject to further and possible bifurcations. Done the other way around, we may encounter a serious fault of presumption, no less than the fallacy of *post hoc, ergo propter hoc.*[3] In simple analogy, it is a way of arguing by placing the cart before the horse.

The ontological demand asserts the *a posteriori* necessity of positing the creative product before one can at all explore any assumption of a creative person or a creative process. Such ontological position is also at once, a logical priority. It follows then, not only that discovery is distinct from discovering; the discovery as a success-referent makes the 'backward-direction' analysis of discovering less fraught of aimless tentativities.

It is the view that this does not necessarily make the 'discovery of discoverings' follow the rigor of the logic of justification even if granted, a framework and success-referent point exists. The return flashback to the 'darkness' of discovering is deemed as a world in itself as we will see as we progress in our study.

If this mode of treating the person and the process, which are deemed as creative by virtue of the referent canonical product leads on to conclude that the study of 'discoverings' is a necessary consequent of the logic of justification to serve the long range needs of accountabilities, so much the better for us. It must be affirmed though, that it 'need not' follow as a necessary consequent too, that the discovering analysis follow the same logic of justification. We take this as a proof of our contention, that while the genetic and the evolutive mode must carry on a process-to-product manner, and the justification of the process requires a vicarious through-product route, both process and product constitute one continuum of seeming discontinuities. On this point, some opinions are of the position that there being no sharp division between science in the making and science in the textbook, the canonical act stamped on the product 'im-

[3] I am taking the major thesis of Larry Briskman in his "Creative Product and Creative Process in Science and Art," Dutton and Krauz. (The Hague: Martinus Nijhoff Publ., 1981), pp. 129-155.

plicitly' subsumes the processes that were 'imputed' into it, and imparts the same character. This position is within the ambit of what we hope to illustrate, though the antecedent is an issue that must be resolved. At the bottomline of what we have been trying to explicate above, both 'chicken and egg' should ultimately refer to each other in the most natural way, e.g., the spiral process mode.

This mutuality of referencing will have to be clarified. Science as a task is not anonymous. It is in fact a polygamy of peerdom and a network of ontic and epistemic enterprises. In the absence of an achieved discovery, the success-referent position is preoccupied with something else, e.g., the current 'toast' which is always a candidate to be succeeded, and later assume the historic title of being a 'prior' product, in concert with the background milieu, and the problem. The most recent achieved discovery either extends, or improves on the prior product, or it veritably transcends and replaces the position of the prior product with its own background and problem, when it "rightfully" assumes for itself, such a niche in the world of science by virtue of the consensual permits.[4] In these varying degrees of distantiations, the 'revolutionary' kind of paradigm shift is construed as illustrative of a manner of a radical rupture that is extended to a position which conjures the 'new' paradigm as an entirely new creature. The implication leads to a denial of a connective tissue to a prior product.

The point of an ultimate mutual-referencing explicates that the justified product *cum-process-to-be-discovered,* will only operate on a priority of what-is-in-act, or better, an accredited act, will be in more solid foundations of epistemological adequacy and ontic capacity to liberate affective experience from its aggregate 'darkness' into the effective leaps onto the 'light of day.' In this sense, whatever is more stable and thereby more perfect, is able to stabilize and perfect the less stable; and the fully given is able to command and share the splendor of its unique and enviolable status.

We have mentioned the relationship of the achieved discovery to the prior products to emphasize the cardinal highlight of the achieved discov-

[4]See Richard Blackwell's *Discovery in the Physical Sciences.* (Notre Dame: University of Notre Dame Press, 1969). Though he does not necessarily explicitate what Briskman is so passionate about, he discusses certain ideas on the modes of change or growth of knowledge which a new 'discovery' may effect on what will be relegated to a position of a 'prior product.' Hence, what he terms as the 'epistemological' approach for example, is meant as "an examination of the process of discovery from the point of view of the meaning content of the knowledge involved... A statement expressing the result of experimental observation is considered at a different epistemological level than a statement expressing empirical law... (p. 86). How are these properties of generality and necessity grounded in experience? How do they emerge in the process of discovering an empirical law, and what do they reveal about the act of discovery itself? At a higher level, there are other epistemological differences between a statement of an empirical law and the statement of a theoretical explanation of that law. The creative scientist freely introduces non-observable entities and events as explanations of empirical laws. pp. 87-88.

ery's rightful *claim-to-creativity,* a fact which otherwise may 'difficulty' keep the candidate product to remain as a private matter if the motions and rigors of the canonical processes are not channeled through. In such state of affairs, it remains in the status of a personal and private 'vision,' no matter how grand such vision may have been, or pretend to be. But as a conviction, we take it here as a form of universal accreditation of what otherwise a vision may never graduate to such status, if it fails to meet consensual criteria.

There is no doubt that clinical experimenters may have delved extensively up to the present, with much profit and as a consequence generating so much interest no doubt, into the exciting studies of 'candidate' creative personalities and traits in various fields of endeavors. But these factorial studies may amount to being no more than being "hypotheticals of a hypothesis," bereft of the accredited fact and foundational credibility of an accredited discovery, and their 'discoverings' in the same train of an amorphous epistemological analysis. The study being made by clinicians, on one hand, suffers the same philosophic widowhood of what we have been trying to point out all this time. By the qualifier creative, there is a demand of both an authoritative and a competent body armed with the consequent standards/criteria which declares and pronounces such processes as the emotive ingredients of the accepted product. In this sense, the mere correlation of just about any psychological process or trait, which are deemed to be developmentally creative, are just that, they are possible correlates. These correlates so to say, does not bestow, and much less enshrine a person who may manifest such traits, as made evident by clinical testing and analysis, as creative in the sense in which we are interested in, e.g., in scientific discoveries, and indeed, more so, in its corresponding 'scientific discoverings.'

No doubt, the product was obtained through a series of processes. That is as obvious as the 'day' which must too, be thankful to the 'night.' But it is the final say of the accredited product to declare which of the multifarious procedures have finally become a part of the canonical whole.

Creativity in creative scientific discovery is a historical process of trials and errors, of silence and communing, of voids and space, of light and shadow, of chaos and order, of evolutions and devolutions. Certainly, we would not like any misconception to develop that we are not giving the 'silent heroes' of errors, mishaps, or even failures their due import. Common sense dictates that footstools, humanly inevitable as they are, and indeed so profitably chargeable to experience, are just as necessary as some other evils are. There are more themata that could be conjured illustrating that a scientific discovery exemplifies the transcendence of the human spirit in such unique obsessions.

The figure of the feedback loop perhaps, could effectively illustrate these apparent contradictions within a contradiction so called.

The process toward creativity is a series of actions and reactions of preliminaries, of which everything is of yet, no immediate bearing or consequence until such product is canonized creative. Such preliminaries we are referring to here, is the scientist's interaction with the current and prevailing creative product within the greater milieu of society, the discovery's potential consumers, in general.

The Epistemological Rupture

It was the same Einstein who is quoted to have said that, "In the light of the knowledge attained, the happy achievement seems almost a matter of course, and any intelligent student can grasp it without too much trouble. . . But the years of anxious searching in the dark, with their intense longing, their alternation of confidence and exhaustion, and the final emergence into the light – only those who have themselves experienced it can understand that."[5] How humbling indeed is the experience to be reminded that it takes an accredited product to accredit its process; in a similar vein, it is equally humbling to realize that it is at best an accredited discoverer to talk about canonical discoveries.

There are two sides contained in Einstein's statements. One side refers to the obviousness of the intelligibility of the scientific discovery which caps the search, though of course, given Einstein's pre-requisite standards of 'intelligence,' which anteriorly, in the case of the scientific discoverer, prompted him to burst out into a supreme expression of elation signaling the untangling of a problem which deemed to encase the solution itself. Elation is recognition, as recognition speaks of intellection.

The other side it seems, is the darkness phase of the discovery which is that of 'discovering,' the intensity of human emotional expenditure spent on the 'roller coaster' of rise and falls, of bewilderment on one hand and the unflagging tenacity on the other hand. Einstein's statements aptly describes the transformation of the dark of night to the light of day mutually sharing a common benediction.

There is however one more point which bears notice and observation after our lengthy, almost redundant sets of explications.

If creative products are explicitly canonized on account of their originality and problem-solving factor, they are literally devolved upon evaluation, shifts, and departures, and from/for which reasons, the prior products held the 'crown' for, previously. The question of criteria is obviously in question here. And this is one issue that can easily muddle

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[5]As quoted by Banesh Hoffman and Helen Dukas, *Albert Einstein: Creator and Rebel.* (NY: Viking, 1972). p. 124.

our confidence in the 'success-referent' position. In the case of a revolutionary science it seems, regarding its point of reference which has led some to argue that there is, in fact, no objective criteria with which to back up some cardinal choice and the most we can do to explain such choice is by means of psychological and sociological factors. This objection is especially highlighted when the "leap" occurs from the 'grim' experience to the flights of an hypothesis. In the apparent absence of a referent, the whole brunt of judgment is left to subjective pontifications. It seems that what is at issue here, is the nature of the epistemological rupture created by such 'leap' as a discontinuity. Understandably, the difficulty lies in the fact that there is absolutely no rational justification for inductive inference, and the grounds for which a hypothesis is accepted cannot be explained in the rational connective terms either.

It is implicit in the objection raised that the theory is accepted, forgetting the inescapable fact that such theory was also conjured within the bounds and framework of the scientific method with all its attendant background paraphernalia, and on which basis such theory is taken as an acceptable worldview representation. Such ontic reference as naturally inescapable is an epistemic necessity and consequent.

Even the 'theory-laden' nature of the experimental fact as such, is shown to be problematic. The fact is alleged to be circumscribed within a perceptual organization which is made up of assumptions and previous knowledge. Ergo, this system of background explanations enter into our encounter and recognition of the facts. And within this background is included the use of some device or instruments! What is sought for is a fact which connotes a 'purity' of 'objectivity.'

While we must admit that there is no such thing as the 'one' single scientific method which connotes a strict procedure or technique, we must admit to the fact of a scientific method which argues along the general lines of appraisal and a rigorous commitment to the need of the evaluation of candidate theories within the parameters of such principles and evidential 'support.' It goes without saying certainly that these principles do vary at specific instantiations as needs arise to the better judgment of the experimenter.

The implications of the discussions we have just gone through are quite crucial and far-reaching. The reasons for which objections are raised and grounded on, seem quite tenable. The *a priori* set of factors and conditioning elements are inevitable as we have shown. They will always be present and we will have to contend with them, for better, or for worse. This means that when we take the phenomena of 'discontinuous' and 'revolutionary' in science in the strict sense of their substance and meaning, the creative scientist has gone beyond being *formed* by the community of scientists. He has *formed* his own community.

Lawlike, Not Lawful

Carl Hausman writes that ". . . though I want to show that creativity cannot be reduced to a system of laws, I also wish to avoid reducing creativity to a mystery that defies speech and all forms of understanding."[6]

Any attempt to reduce the creative act according to lawfulness, *vis-a-vis,* according to systems and algorithms, is nothing short of an unwarranted reductionism, which is a death sentence to the very act itself, *ipso facto.* Briskman illustrates this fatal act as follows.

> . . . take the specific creative scientific or artistic achievement C, and assume that we had some general theory of creativity, or of the creative process, T according to which C was necessary. This would mean that given T, and a description of some relevant set of prior circumstances or initial conditions P, we could actually deduce the attainment of C. But this implies that in possession of T, and given the description P, would ipso fact been in a position to himself create C; and would, moreover be able in principle to simulate the actual creative process of the creator C..."[7]

The dire consequences of such a scenario are as horrifying as they appear to be absurd. Given such picture, we are caught in at least two manholes. Either creativity taken in the sense of our discussions entirely becomes an arena for general patronage public right, of which it is, in all its pedestrian and latent peripathetic forms; to the effect that anyone of goodwill, or everyone in masse, could lay claim to; or that, creativity entirely disappears with its most precious value, that of being a unique event. Along the lines of T, C is divested of any creative possibility since P would be a consumeristic merchandise. Or else, the public availability of T would lead to the achievement of Cs' *ad infinitum* for otherwise T would not have any reason for its being. The whole edifice crumbles, either way. Creativity is strangulated and gets nipped in the bud at its germinal stage.

The other position runs at the other extreme of the pole. Randomness or pure chance lies at the very eye of the storm out of which emerges the creative product when bifurcation subsides. Randomness is taken as a factor which runs in 'complete abandon' and as such, assumes a stance which does not owe any specific determination or guiding inspiration at all. The achievement of a scientific discovery as decidedly and intrinsically human in nature belies the thumbmarks of being a human product, even if granted that it is an achievement, for any intent or purpose. This

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[6]Carl Hausman, *A Discourse on Novelty and Creation* (The Hague: Martinus Nijhoff, 1975). Preface, vii.

[7]Larry Briskman, Op. cit., p.131.

is psychologism and is no different from clinical experimentations which takes 'creativity' on the terms *qua* creative psychological processes. While creativity may decidedly conjure some degree of "free play" on account of the human act of freedom and liberty, the essence of deliberation amounts to a license without being licentious.

Another position admits of some factorial guidance no matter how incoherent or hazy that guide may appear to be. Briskman finds this model as an attempt that tends to explain "too much" since it assumes the fact of being drawn or magnetized by a future product. He raises the issue: "how can he ever fail to recognize it once he has reached It?," apparently whining the same problem which Yukawa' encountered. The issue which Briskman raises no doubt, concedes to an assumption of quasi-mechanical strains present in this model.

It may take some time, we do not know how long, but the scientist will be 'there.' The problem lies in his consciousness or awareness to recognize that he has 'arrived'! There seems to be an inference that inspirations of scientists are rare in coming and once they come, there it goes. The trial and error method made crucial in Blind Variation and Selective Retention may indeed save this position from an intellectual adultery with mechanism.

An exegesis of the synoptic discoveries will bear this alternative as plausible. In this manner, randomness gives way to a concentrative chance or blindness circumscribed by selective retention. Control is not ruled out, for that is not possible to the advantage of scientific discovery as we have seen. But neither should the situation allow that it be 'ruling-in.' Briskman fittingly calls this via media as "the plastic control of the creative job specification."[8] Zeroing in on the creator, he continues,

> . . . to see the creator as a) critically interacting with prior products, with a tradition, so as to put himself "in touch" with problems and standards for acceptable solutions: b) generating blindly, but not randomly, a hopefully potential solution or fragments of such a solution - blindly, because these are generated without foreknowledge of success; but randomly, because the generation is itself already under the plastic control of the relevant problem, the background of prior products, and the relevant standards; c) critically interacting with this initial, fragmentary product so as to select or reject it, either in part or in its entirety, such a selection procedure being again under the plastic control of the problem, the background, and the relevant standards; d) generating blindly but not randomly, further hopefully potential solutions or fragments, this time under the plastic control not only of the initial problem, the background, and the relevant standards, but also under the plastic control of what has already been done, of his initial effort; e) repeat step c (i.e., critical selection); f)

[8]Ibid., p. 147.

> repeat step d (i.e. blind but not random generation);, etc., ... until hopefully, one has managed to generate or assemble a product which either meets the initial job specification or else meets some improved job specification - this improved job specification being itself the outcome of the above process.[9]

The plastic nurturing is fundamental to the whole framework owing to the very plastic nature of the process itself. If we have made our stand clear, that any attempt at the analysis of the discoverings must definitely start from an accredited product; it seems to follow, though for an altogether distinct reason, as the conviction is commonly held, that the rigors of the logic of justification as applied to the creative product's juridical criticism ceases, and does not similarly apply to and when the inquiry into the discovering zone begins. Blackwell elaborates some reasons for this when he writes,

> ". . . First, the main tools of contemporary philosophy of science have been the methods of linguistic and logical analysis. Indeed these tools have proven to be very helpful. But their use is limited to the already articulated results of science. The act of discovery which is science at the moment of genesis, is too amorphous and non-formalized to provide subject matter for the method of formal analysis. The initial formation of scientific meaning is almost always based on content-centered, rather than rule-centered, thought processes, and to this degree is resistant to all attempts at formal analysis.[10]

What Blackwell wishes to remind us regarding the mode of treatment of the subject matter of discoverings is the matter of the principle of congruence. There is the need of a congruent method of analysis that is apt to the subject matter of study. Quite definitely, he is of the conviction that such methods of linguistic and logical analysis while they are methods which have been proven effective and successful in the justification process, are definitely not the methods that should be used in the treatment of discoverings. This would occasion some kind of an overkill. As yet, the data provided by the 'discoverings' are by their very nature in a flux and amorphous, that is to say, discontinuous, disparate aggregates. As 'science at the moment of genesis," they are acts which are experimental in nature which have not yet scaled the level of the dematerialized and idealized states so to say.

The Case of Cases

Experience in the long run gives way to an incontrovertible admission that the correct formulation of the question itself is the answer already half answered. Crucial croosroads in life have been triggered by

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[9]Ibid. pp. 147-148.

[10]R. Blackwell, Op. cit., p. 89.

'leading' questions as we have witnessed in the lives of some great thinkers, e.g., the ancient naturalists' "What is change?", a question which is not by any means simple to comprehend even if the question appears to be formulated in its starkest simplicity. It appears now that the genuinely simple questions are indeed the most difficult to comprehend, and more so to respond to. Transcendence is a property of such types of questions which outlives generations of mankind and epochs of age. They challenge the very soul of the best minds in various periods of history, to an intellectual swordplay, the highlights of which, the very same history cannot fully record in human color. Indeed, it takes the right question to incise, or to mold; to excavate, or to scale the human intellect.

In a battery of overarching questions of such nature, which appear to transcend all sorts of scientific events, G. Holton mentions a series of them constituting the second half of the total number of which he had enumerated, which implies the order of precedence of treatment, but no less of importance. To wit, the second set reads as follows:

> Why do scientists privately not acknowledge a dichotomy between the context of verification and that of discovery, and yet publicly accept it? If it is true as Einstein believed, that the process of formulating laws purely by deduction is far "beyond the capacity of human thinking," what may be guiding the leap across the chasm between experience and basic principle? What is behind the obviously quasi-aesthetic choices that some scientists make for example, in rejecting as merely ad hoc a hypothesis that to other scientists may appear to be a necessary doctrine? Are the grounds from which such choices spring confined to the scientific imagination, or do they extend beyond it?[11]

We have purposely left out the first half of those mentioned by Holton, not because we will not be dealing with them, but because they are not our immediate concern at the moment. Our concern here is to analyze the creative act as a recombinant feature of a creative product and for which reason, certain appropriate measures or approaches, or 'logics of discoverability' will bear out, if at all that is possible. Thomas Nickles (1990) insists that there is no single logic of discovery, but there exists many logics of discovery which are local in nature and content-specific. While the term logic have itself met vociferous objections, we grant the term, without conceding, some tolerance for the moment.[12] Such being the case, it must be clear at the outset that such logics are not to be treated as causal, or as constitutive explanations of the corresponding discovery, but simply a methodological, rational reconstruction worked out by critical reflection on how solutions were arrived, streamlined, or

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[11]G. Holton, *The Scientific Imagination. Case Studies.* (Cambridge, Mass.: Cambridge University Press, 1978), p. 7.

[12]Thomas Nickles, "Discovery Logics," PHILOSOPHICA, v. 45, 1990. pp. 7-32.

improved, etc. Discovery includes justification in "a sense," so that the original problem solution and the solution space mutually "justify" each other, not only by consequential testing but more so, on the grounds of generative justification. The so called logic of discovery as misnomer, or better still (or worse), is a semantic tragedy, if it means a routinary algorithmic approach as we have seen above, and loses out quite easily, when a recourse to the alternative case studies inevitable comes to the fore. Letters, interviews, autobiographics, and even the very scientific texts themselves when possible, must be treated exegetically and only then can they possibly disclose and discourse a multiple varia of diversities, "a fact which implies the improbability of finding a strong logic of research that fits them all, even when (or especially when) "logic" is weakened to include heuristics."[13] Indeed, this sounds close to homebase as Nancy Nernessian (1990) claims that "examination of actual cases of concept formation in science, establish that concepts do not emerge fully grown from the heads of scientists, but are constructs in attempts to solve the scientific problems by utilizing specific procedures." "Central among these procedures are analogical reasoning, imagistic reasoning and idealization, such as though experiment and limiting case analysis."[14]

But as it is, the issue with the case study method is left with simple hypothesis testing and scientific prudence cautions the formulation of generalization. This is a ground of concern if indeed the case study method is applied, *vis-a-vis,* in scientific discoveries, and allegedly, will produce nothing but short-lived adventure in hypothesis testing. If this were so, of what use then is an induction with only 10 samples? The kind of hypotheses which a case study method introduces is of such nature that the empirical content in time trajectory over an extended parameter, tends to pull with it a tendency for a larger context toward whole properties. Conditional statements replace that of the empirical universality since a serious consideration of contexts exacts a serious toll on the price of truth. And such is the price of truth one may expect as one shifts from a systematic manipulation of *in vitro* constants and variables to an in vivo situation where the creative person works (and works best) within a climate of freedom and liberty. Under such climate, uniqueness is the rule.

The view of the extremist scientific rationality circumscribes the totality of the scientific enterprise (both discovery and discovering) within the strictly quantitative and semantic-logic processes.[15] To a degree, this is the luck of discovery itself. Within such framework, discovering is deemed irrational and metaphysics in the sense which the Vienna Circle

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[13]Ibid. p. 9.

[14]Nancy Nernessian, "Methods of Conceptual Change in Science: Imagistic and Analogical Reasoning," *Philosophica*, Vol. 45, 1, 1990. pp. 33-52.

[15]G. Holton, "Dionysians and Apollonians," Op. cit., p. 100.

had considered mortal, is an absolute anaethema. Science is the synagogue where the scientist as its own demagogue, he reigns supreme. His decalogue consists of continuum-progressivism, avoidance of the carnal delights of sociobiology, psychology or history of science, contexts of discovery; for all these are spurious.[16] Stranger than fiction indeed, since the more vehement of the protagonists of this kind of view is Karl Popper who considers Einstein as a very strong influence on his thinking. The rationality principle in the rational reconstruction of events works through the whole fabric of his position even when he attempts to express himself in more subdued tones:

> Admittedly, no creative action can ever be fully explained. Nevertheless, we can try, conjecturally, to give an idealized reconstruction of the problem situation in which the agent found himself, and to that extent, make the action understandable, that is to say adequate to the situation as he saw it. This method of situation analysis may be described as an application of the rationality principle.[17]

Eleven pages later, he sounds conciliatory without necessarily giving up: "a theory of understanding which aims at combining an intuitive understanding of reality with the objectivity of rational criticism."[18]

I. Lakatos, his student, disciple and successor, propagates a similar stance. He writes thus,

> In writing a historical case study, one should, I think, adopt the following procedure: (1) one gives a rational reconstruction; (2) one tries to compare this rational reconstruction with actual history and to criticize both one's rational reconstruction for lack of historicity and the actual history for the lack of rationality.[19]

Thus goes the irrationality of actual historic cases of achievements in science for a preferred Popperian card for their concept of methodology and scientific progress idea.

Themata in Casibus

It is precisely on the account of the uniqueness of every creative product that equally posits a unique creator and a unique process that has gone into the product of imputs. Creativity as originality signals uniqueness. We may as well premise the fact that no two creative products are

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[16]K. Popper, "Normal Science and Its Dangers" in *Criticism and the Growth of Knowledge*, Imre Lakatos and A. Musgrave (eds.), (Cambridge University Press, 1970). pp. 56-58. See also Popper's opus, *Objective Knowledge*. (Oxford: Clarendon Press, 1974) p. 114.

[17]Ibid., p. 179.

[18]Ibid., 190.

[19]Imre Lakatos, "Falsification and Methodology of Scientific Research Programmes," Op. cit., p. 138.

the same and so goes well with the creator and the process. If it is not at all discouraging, let it at least be a siren of fair warning when Peter Medawar (1967) prophesied in his opus, *The Art of the Soluble:*

> What scientists do has never been the subject of a scientific, that is, an ethological inquiry... It is no use looking to scientific papers, for they do not merely conceal but actively misrepresent the reasoning that goes into the work they describe... Only unstudied evidence will do — and that means listening at a keyhole.[20]

Grmek, M., Cohen, R., and Cimino, G., (1980), introduced their edited anthology *On Scientific Discovery* as a case of "broad *denotans* with imprecise *connotatum* ranging from a broad hypothesis to a specific transcript which aptly requires the interfacing of several spheres of interdisciplinary approaches of study.[21] The *personal* 'touch' is emphasized and imprinted on the scientific discovery as an expression of what the discoverer *himself* thinks as it passes from a personal perception to a *personal* affirmation.

Michael Polanyi (1983), is most rabid in his opus *Personal Knowledge,* with the intensity of personalism involved whether it be a contribution, a responsibility, a commitment, an obligation, or indeed, as it will never be less than, that of being a *passion.*[22]

Natalie Angier (1988), presents a more contemporary scene and of certainly a more recent vintage. Still yet, it seems that the climb to the Temple of Science has not changed substantially in its essential physiognomy over the centuries. In the Foreword written by Lewis Thomas, M.D., to an aptly titled, *Unique Obsessions,* he writes:

> "Method has the sound of an orderly, preordained, step-by-step process; one maneuver leading sensibly and logically to the next; a beginning, a middle, and then an ending. I do not believe it really works that way most of the time, and surely, it doesn't in the first hand anecdotes that abound in this book. . . . But then, more often than not, the step-by-step process began to come apart because of what most always seemed a piece of luck, or of bad, for the scientist: something unprecedented and surprising turned up, forcing the work to veer off in a different direction. Surprise is what scientists live for, and the ability to capitalize on moments of surprise, opens the gift, amounting to something rather like good taste, of distinguishing an

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[20]Peter Medawar, *The Art of the Soluble.* (London: Methuen & Co., Ltd., 1967) pp. 151-157.

[21]Grmek, M. et al. (eds.), *On Scientific Discovery.* BSPS 34. (Dordrecht, Holland: D. Reidel Publ. Co., 1980).

[22]Michael Polanyi, *Personal Knowledge, Towards a Post-Critical Philosophy.* (London: Routledge & Kegan Paul, 1983). For example, he uses the following terms very profusely, e.g., personal participation, a responsible act, fusion, a passionate contribution, personal obligation to universal standards, etc.

> important surprise from a trivial one, are the marks of a good investigator. Others, less gifted, cannot endure bewilderment and find other ways of making a living.[23]

The ideal of the scientific discovery being best described as they are best understood by "only those who have themselves experienced" the victorious process is, it seems, quite approximated by the perusal of first hand texts, so called. Indeed, backgrounds can spell a marked difference as, e.g., a philosopher, or a scientist, in dealing with smudges, bloodstains, footprints and thumbmarks of a scientific research. The controversy on the rationality of science, re: Popper and Lakatos, is a case in point on issues between: how do scientists actually go about gaining knowledge, *versus* how should they. . . ?[24] There is no doubt that the creative product experience serves as the material object while various anatomic procedures may be introduced. It is a personal case of a discovery requiring a "consortium of talents: psychologists, biologists, philosophers, computer scientists, artists and poets" having something to say.[25] This is inevitable to happen to what initially is a "private science," but which nonetheless must be subjected to public scrutiny on account of its universal intent. In the light of the personal-universal fusion and function of a scientific discovering, Holton developed the so called thematic analysis which distills a tool for discerning commonalities and stable structures that endures best, and shines its brightest luster, especially so in moments of paradigm-shifts, revolutions and incommensurabilities. With this kind of thematic analysis, the narratives of the history of science are linked to some overarching general ideas and processes which are deemed to thread through the individual case presentations. Thus, "couplings antithetical dyads such as atomicity-continuum, simplicity-complexity, analysis-synthesis, or triads of constancy-evolution-catastrophic changes;" facilitates mapping operations for a subject which is dramatically a human concern. At one time or another, these themata could be perceived as working in the inner dynamics of the creator, and for better or for worse, works toward either as their source of charism, or atrophy.

Since scientific themata are *per se* neither verifiable or falsifiable, Holton suggests some eight approaches or so, by which such themata underline and underpin the scientific event.[26] These are:

First, the understanding of the scientific content of the event at a given time, both in contemporaneous terms and, separately, in terms of

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[23]Natalie Angiers. *Natural Obsessions.* (Boston: Houghton Mifflin & Co., 1988). Foreword by Lewis Thomas, M.D., xvii.

[24]G. Holton, Op. cit., p. 108.

[25]Peter Medawar, *Induction and Intuition.* (Philadelphia: American Philsophical Society, 1969). p. 57.

[26]Op. cit., p. 4 et passim.

what we now believe to be the case. The original issue and his attendant awareness of the prevailing scientific knowledge, world views and exemplars are brought to the fore. Let me term this as the Recall approach.

Second, the scientific 'event' is subjected to a time trajectory of the state of shared and public scientific knowledge that led up to and perhaps beyond the time chosen for the event. The event serves as a point along which the World Line of the idea is traced. As components of the "context of justification," antecedents, parallel developments, continuities, and shifts are monitored, traced and through out, analyzed. I call this the *Historical-Developmental* approach.

Third, the private and personal 'discovering' aspect in which the event is embedded and nascent, serve as the focus of study. This is an area which is an obvious mine field for a host of reasons, e.g., it is a 'record' (if at all records exist) of the 'personal struggle' and hence deemed by the justificationists as illogical and irrational. This is the *discovering* approach, §'1.

Fourth, is the application of the tool enunciated in the second approach, that of a time trajectory as applied to the "personal struggle" of the scientific 'discovering.' The historico-developmental process takes place in a fashion which is ultimately autocatalytic and autosuggestive. It is a pantomime concentration and dialogic, a personal evolution which is both an involution and an immanence. Let this approach be represented with the symbol St-1.

Fifth, the psychobiographical development of the creative person is monitored and traced: the intimate relationship between the creative product and the personal style is made to intersect and examined. this approach is symbolized by St-1/§2.

Sixth, the sociological setting, conditions, or influences which arise colleagueship, peerdom, professionalism, funding, evaluation and acceptance, and quantitative trends are dealt with.

Seventh, the cultural developments which are not properly of its field, but which mutually interact with science in some sort of a positive-negative transference of feedback loop fashion. An illustrative example would be the interaction of science with society, technology, ethics and literature.

Eighth, a logical analysis which involves the validation of the scientific work under study preceding that of any historical analysis.

Consequently, it now appears that while the eightfold historical approaches appear streamlined bands of their own possible areas of concen-

tration, they are all, in actual usage converging in the mainstream of applied instances. While the evidence of so much study is easily obtainable in the eighth approach, a comprehensive attempt at the anatomy of 'discoverings' may involve the orchestration of approaches taking the first to the seventh, that is assuming, that our point of departure is a validated, consensually accredited creative product. The possibility is not ruled out at all that a particular study may have utilized all of the above, at one time or another.

Holton, in addition to all of the above mentioned approaches, submits a ninth mode which zeroes-in on the use of a *themata* and these elements function by way of "constraining or motivating the individual and sometimes guiding (normalizing) or polarizing the scientific community."[27] In a mode which hardly expresses the involved themata in explicit terms, the thematic identity can only be deduced by way of the "workings" of the "meaningfulness." Thus, as Holton suggests, that the logical suppositions involved in the repeatable phenomena, e.g., the empirical and the analytical content, be identified as the x-y coordinates of a plane; the themata can be located as something like the z-axis, as lying in an orthogonal dimension to both coordinates where verification and falsification process lie. This orthogonally positioned z-axis may function diversely, vis-a-vis, as a thematic concept, or component of a concept, as the concept of symmetry and continuum; as a methodological thema as the expression of laws of science possibly in terms of extrema, or constancies; as a thematic proposition or hypothesis such as Newton's hypothesis concerning the immobility of the center of the world, or the two principles of special relativity theory. Holton admits that thematic elements in scientific discussions are to some degree analogous to the folkloristic or anthropologistic grasp for the underlying structure and recurrence which may appear intelligible in epic stories. The particular case of the attachment to the old electromagnetic view by Lorentz, Poincare' and Abraham, is a case in point since ether is thought as an embodiment of the thematic concepts of the absolute plenum.

The obituary for Abraham written by von Laue and Born is very explicit on these attachments:

> [Abraham] found the abstraction of Einstein disgusting in his very heart. He loved his absolute ether, his field equations, his rigid electron, as a youth loves his first passions whose memory cannot be erased by later experience. . . His opposition was grounded in physical, fundamental persuasions to which he, purely in accord with his feelings, held on as long as possible. . . [As Abraham himself once said] against the logical coherences he had no counterarguments; he recognized and admitted them as the only possible conclusion of the

[27]Ibid.

> plan of general relativity. But his plan was to him thoroughly unsympathetic, and he hoped that the astronomical observation would disconfirm it and bring the old, absolute ether again into honor.[28]

The obituary did not only illustrate the fundamental differences and ideological distance between Abraham and Einstein. More than that, the obituary perceived the root cause and reason behind such cleavage. Einstein, to be sure, had his thema to which he passionately held on to during his physicist's life, which was life for him, and which he spent his life in. Such a behavior, as far as both parties are concerned, is both a behavior of personal choice and vice versa. It is a commitment to a chosen thema.

In the age of antiquity, the thema may range from an interrogative form as we have earlier seen, to a thematic methodology available and prevalent during those times e.g., observation and speculation, to a thematic commitment to Thales' water, Democritus' atoms and void, Heraclitus' river paradigm, or Pythagoras' cultic number. Perhaps, this is more evident with Plato's theory of forms or Aristotle's matter-and-form. What I believe should be emphasized is the point that behind an ideology is a bundle of inscrutable psychological forces which like Cornford's "memory of a race," shape and impel the ideological content in a particular slant and perspective. The fundamental limitation of a verbal expression, or a paradigmatic construct, or even a mathematical economy retroducts the corresponding fertility of such instruments. It seems therefore, that the most salvific attitude to adopt at the moment, is that more than the public icon of discovery, it is more so in the case of 'discoverings' where the creative product extracts its derivative concealments, formulating the symbols for its signals, spelling out the pregnant mental conjurations, and integrating the seemingly discontinuous determinations into what must be an intelligible whole. Strangely though, that while it is this `discoverings' that a discovery assumes its constitutions, it is in the nationhood of the discovery that discoverings realize their statehood. But such procedure of priority of the creative product over person and process is analogous to that of the role of a whole over its constituent parts, and the supreme analogue of the creative product thereby specifies which of the 'jobs' that were undertaken, assuming that they would be vivid and expressible to a certain extent to the discoverer, would be deemed positively productive and canonical towards the identity and function of the intelligible whole. Parts *qua* parts are bereft of meaning of wholeness and it is only in their being parts *of* or *in* the whole that participative significance and the impact of the relational truth begin. It is only on the basis of this 'pieced' whole so to say, that the inner thread is monitored and becomes intelligible with varying degrees of determinations and

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[28] *Physikalische Zeitschrift* 24, (1923):52., quoted by G. Holton, Ibid. p. 10.

definiteness. This is so since the 'wholeness' of a scientific discovery is historically a progressive process interconnective of developments of growth and evolving identity. A historicizing whole works on the assumption too, that the whole is possibly computable, a construed ideal which must ultimately endow as a property of the whole's actual status in real of objective reality.

Discovering That and Discovering Why

From the above discussion, we have laid down the non-negotiable assertion that any 'legitimate' inquiry into the 'discovering' process must inevitably emanate from a discovered product, vis-a-vis, a product to which the honorific valuation is tendered as a bona fide scientific discovery. Accreditation processes may vary, as such process may tend to be relative in criteria set applications. But evidently, some criteria as those which have been mentioned previously, to wit, novelty, valuation, and problem-solving, may always have to be present, for obvious reasons, in varying degrees. Such criteria are generatively necessary to the very existence of that which maycan only be considered a canonical product.

Given a canonical creative product, one can further possibly distinguish distinct types of discovering on the basis of the kind of creative product. The Copernican revolution for example, was not a case of an additional set of observations which put the observations of, say, of which Aristarchus of Samos advanced centuries earlier, wrong. Thus, for example, with the human observer also in motion, a dimension in astronomy is configured. The Copernican revolution for example was basically interpretive in nature. Interpretive discoveries involve a higher cruising height of conceptual ramifications and coagitations on a fundamentally the same observational given. Tycho Brahe's insistence on the geocentric astronomy was occasioned by the tremendous epistemological obstacle created by the Aristotelian mechanics which then was the accepted paradigm of his time. Anything new formulated had to integrate into the existing grand conceptual scheme, if the 'new entry' was not 'grander' enough to displace the current dispensation. Kepler's discoveries of the elliptical orbits of the planets was based on Tycho Brahe's observations. In the Keplerian orbit, the radius vector from the sun to the planet engulfs equal times for equal areas and squares of the periods of two planets are proportional to the cubes of their mean distances from the sun. Such laws are seen as statements of patterns and regularities existing in nature.

Kepler discovered that planets moved in a certain way but he did not discover why the planets move in this way. That had to wait for Newton's principle of universal gravitation and central force laws which are deducible from Kepler's discovering 'thats.'

Discovering 'that' refers to an additional datum to existing ones and discovering 'why' tends to the reason or rationalia behind such described behavior.

Explanans and Explicandum

When Peter Medawar described the pathetic state of "doing science" as having "never been the subject of a scientific, that is, an ethological inquiry...", neither did the other option of "looking to scientific 'papers' for they not merely conceal but actively misrepresent the reasoning that goes into the work they describe. . ." The fears of Medawar are not entirely without basis for the strictly methodic scientist can veritably rule out any 'fantasy' towards the inching into the 'darkness' of discovering. Holton marshalls some of these reasons which we find worthwhile quoting:[29]

> 1. "The scientist typically insists that in written reports of work from students' laboratory write-ups to the papers we referee and the textbooks we write — the individual traces of the personal self be attenuated as far as that can be done. Hence the impersonal style of the scientist, for which there are only a few counterexamples. The aim is to make one's work seem 'objective,' repeatable by anyone. . . This is part of the scientist's value of 'other-orientation,'. . . of transcending the world of personal experience.
>
> 2. "This eradication of individualistic elements from publication is of course exceedingly functional insofar as it helps to minimize personal disputes of the unresolvable kind and removes interpersonal obstacles to consensus. But it is also seen as responding to the epistemological demands of science itself."
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> 3. "The second, related commandment of the scientific ethos, as commonly understood, is to be logical, not emotional. Statements that fall into areas with a large component of not easily verifiable or of falsifiable content are frowned upon, and issues dealing with ethical conflict, responsibility, or even long-range prediction of the technological applications of scientific findings are therefore not expected to be raised in scientific meetings. Mere opinions, preferences, emotions, and instincts must be repressed, and even the exhilarating flights of intuitive imagination must be recast in deductive style to be respectable."
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> 4. "The desired outcome is the simple, not complex. One aspires to economy of thought and uses Occam's Razor to help achieve it. Therefore, in most cases, and for most scientists, the reductionist strategy is far safer that a synthesis-seeking one. the main charm of work in a physical or biological science is that it ideally permits one to formulate statements of simple lawfulness that is very opposite of the complexity characterizing most social questions and interactions."

[29]Op. cit., pp. 237-238.

> 5. "As with the content of science itself, the setting in which one does one's science is ideally as removed from interpersonal disputes as possible. . . As the psychologist David C. McClelland put it with ample research determination, 'Scientists avoid interpersonal contact' and 'scientists avoid and are disturbed by complex human emotions, perhaps particularly interpersonal aggression."

The awesome difficulty encountered in probing into the "behind the scenes" situation, given a canonical creative product, has its genetic and originative 'terminus' *a quo,* from the very nature of the 'accepted' mold of the scientist and his pursuits. In addition to what we have explicitated before in our discussion of 'Genetic Opacity' via Prigogine's diagnoses (PHIL. SACRA. Vol. XXVI, N. 76, pp. 51-65), at this point we are brought into the finer details of the probable cause of such attitudes which seem to be inherent in the very profession of the scientist.

The pedagogic and formative strategies seem to swing between two major points, that of the intellective, e.g., the theoretic phase; and the psychomotor, namely, the experimental phase. These accepted formal distinctions are indeed to be taken as such, and no more than what they ought to represent. It is not farfetched that these layers actually are interfacing each other! Seemingly, the affective state is either assumed or presumed, or with a "boxed-in" connotation that may hardly be as tangible or as explicit as the other two centers. While affective descriptions do not enter into the recorded in he sense of being measurable domains of the scientific method properly speaking, it is safe to assert without fear of contradiction, that as an essential part of the whole man, the affectivities play a significant role, if we may now safely assume, in this conscious act. This is quite understandable too, since experimentation and observation on one hand, and justification on the other hand, are equipped with tools and instruments which inherently facilitate a recording and registration of 'deeds.' No doubt, the 'praxis' lent by the psychomotor and intellective faculties does not intently reveal factors as "commitment," "personal struggle," and other emotive elements. This seems to be one of the reasons for the emergent bracketing orbit within the laboratory recording of pure numerals and similar other usages of figures; to the exclusion of the essay of an 'autobiographical' style. The logic of the pedagogy of science and the nature of the climate fomented by public science will have to undertake a rethinking on this matter and take a hard look on those particular areas where the emotive space can positively configure for the benefit of the budding scientist, and, ultimately, contribute to a better future of scientific undertakings conscious of its inevitable accountabilities.

There is a need for a more considered affirmation of the affective elements in pedagogy in general, and science education in particular. Very likely, such well ensconced discernment of these 'neglected' parameters in science may as well be the resultant feature of science as a pursuit

which, akin to every human act, is not exempt from, and is unavoidably an ethical concern too. But such concerns will have its proper locus later. What we are trying to establish at this point in time, is that the role of the affectivity in scientific discoveries deserves, and to our mind, truly merits recall and plumbing, if this is at all possible. Understandably, while the stereotype scientist will waste no time and raise vehement objections on such 'adolescent stuff,' as it would likely augur the same objections in other spheres of the nature of exact sciences and professions; it is not easy to undermine such inherent qualities demanded of every serious scientist whose obvious dream is "to make good" and succeed in one's profession. Indeed, the bottomline characteristics may share fundamental commonalities as universally required, regardless of pursuits. But all know that this is only half of the whole story of the inevitable specificities that uniqueness and specializations demand.

It is not therefore surprising that a scientific ethos so called, did evolve, and indeed, must evolve *a posteriori* which reaches out to idealized forms filtered from paradigmatic heroes of the likes of Einstein and company. It is the misfortune of future scientists indeed, if I may be granted such observation, that pedagogy of science and definitely — public science, are presented in bookkeeping style, and the factive qualities which ignited and sustained the emergence of the product as a human enterprise which a scientific pursuit is rootedly, to the heights of heroism and suprahuman bullheadedness, are sucked into an incongruous anonymity in the finished canonical product. The structured form shorthands the ingredients and constituent elemental parts.

It is the very system that is in question here, through we must admit that the job specified the coming up of results that would solve the problem at hand and would assume a degree of 'maturity' which would need a certain degree of emotive orchestration. Such system in fact should remind us that it did not perdure in its stable form without the trial-fire and the 'blessings' of a series of historical passage into what is now its most enduring 'package' form. But it is to be admitted too, that the very system of pedagogic practice is a situation that will probably wait for the resurrection of the kind of another Socrates in science, to emerge and break the bondage that masks the human face in a creative canonical product from scientific discoverings. We might be surprised to find out that the dilemma could be trickier than a bootstrap. Like the original Socrates, he may have to frame a problem which is altogether different, both in substance and in style.

With some outstanding exceptions such as Kepler, Einstein, and Darwin, to name a few, indeed what we are left with, are the 'faceless' scientific papers so called which Hanson, with a sigh of resignation admits that "by the time a law has been fixed into an H-D (hypothetic-deductive) system, really *original* physical thinking is over."[30] But such 'original'

[30]N.R. Hanson, *Patterns of Discovery*. (London: Cambridge University Press, 1969), p. 70.

physical thinking even in its conjectural and tacit mode as the "initial suggestion of an hypothesis is very often a reasonable affair."[31] He continues that "it is not so often affected by intuition, insight, hunches, or other imponderables as biographies of scientists suggest."[32] The conception and formulation of a hypothesis is a situation which is "logic-laden"; a 'reasonable affair.' Hence, does a 'logic of discovering' exist? The question will continue to bug us. Or any other similar transaction of the same import that we are faced with? With reasons backed by analogous and formal symmetries, and even by appeals to authority, considerations may possibly suggest hypothesis. The transfiguration of data to their hypothetical status constitutes the exciting parameters of discovering, a study without which H-D, Hanson insists, will be incomplete without, and for Souriau, remains unaccountable. The suggested hypothesis works in function of a background theory, or a set of theories, and is not, and will never be a result of any enumerative induction of sorts.

Selectivity and Specificity

The intuitive talent in man is perhaps the greatest endosomatic component inherent in the gift of Self as far as scientists should equally be concerned about. It has attracted so much interest from scholars of both related and conflicting concerns alike, that shades of meanings border on both dilemma and presumption. If at all, this may at least signify the generality of such talent and the difference that exists among us is concretely, a matter of degrees and resourcefulness. It conjures the emotives of both hope and remembrance.

The old English intuycion (contemplation), the old French intuition (view, contemplation), the Latin intueri (to look at or toward, contemplate), and the hypothesized proto-Indo-European form teri (to pay attention to, turn to), constitute some of the primitive origins of the word.[33] If the phenomenon of contemplation is intuition's broad interface, then, we find ourselves close to what Campbell calls as analytic tautology.[34]

M.R. Westcott provides a summative review of intuition from the scientific and philosophic positions.[35] M. Bunge represents the extremist school which belittles the importance of intuition as no more than a case of change association and that scientists would be better off not discussing the subject in formal company.[36] The classical school of thought, on the other extreme of the intuition rainbow, considers it as the only way by

[31]Ibid.

[32]Ibid., p. 71.

[33]Vorhees & Royce, Op. cit., p. 31.

[34]Donald T. Campbell, "Blind Variation and Selctive Retention in Creative Thought as in other Knowledge Processes" in *Evolutionary Epistemology, Rationality and the Sociology of Knowledge.* Radnitzky and Bartley (eds.) (Illinois: Open Court, 1987). p. 109.

[35]Westcott, M., *Toward a Psychology of Intuition.* (NY: Holt, Rinehart, and Winston, 1968).

[36]M. Bunge, *Intuition and Science.* (NJ: Prentice- Hall, 1962).

which truth and beauty are approximated, as in the case of the positions of thinkers of Spinoza, Bergson, and Croce. The moderate position so called, do not hold intuition as the only factor and it may be incorrect indeed, so that checks may be installed to verify its "truth-claims."

While Bunge alludes dogmatism and authoritarianism to philosophic intuition, he fails to eliminate the role of intuition in scientific thinking and we realize that his categories which he suggests, can be feasibly incorporated in Royce's scheme which is as follows:

ASPECTS OF SCIENTIFIC INTUITION[37]

	Empirical Intuition	Rational Intuition	Metaphoric Intuition
Perceptual Aspect	Quick Identification	Common Sense, Good Judgment	Representative Ability
Conceptual Aspect	Clear Understanding	Catalytic Inference	Skill in Forming Metaphors
Symbolic Aspect	Interpretation Ability	Power of Synthesis	Creative Imagination

Thus Bunge's 'quick identification' is Royce's 'perceptual aspect' of 'empirical intuition.' The 'metaphoric intuition' in the table matches with Bunge's skill in forming 'metaphors,' and his power of 'synthesis' jibes with the table's 'symbolic aspect' of 'rational intuition.'

'Empirical intuition' serves as the initial cognizance, involving a perceptual "quick identification" of forms and characteristics. The conceptual grasp of the relationships of identified sensations, promotes "clear understanding." The symbolic process of the assignment of meaning serves as the interpretation ability. Horizontally, the perceptual aspect of intuition assumes the passage from "quick identification," to "common sense," taken from experiences and stored in the memory, until the representational ability evolves.

Intuition is basically not an act but a potency which a stimulus ignites to act and respond in a kind of awareness of a potential meaning. We are talking about real intuitions in the present tense, when it is in

[37]Royce, J.R., "Three Ways of Knowing and the Scientific Worldview," *Methodology and Science*. 11 (1978): pp. 146-164.

motion towards an accelerated sense of signification and landscape. Its functional mystery lies in what Karl Popper describes as a "blind man who searches in a dark room for a black hat which – is perhaps – not there."[38] Gremek describes this situation as a "winding path in a straight-lined road, an iter mentis in veritatem." [39] The symbolism strikes a metaphor of an amalgam of both reason and a depth which is unfathomable, of both logic and irrationality, and of both intelligibility and mystery. The light of day will always have some clouds of shadow, like wrinkles of the residues of a previous experience of the pangs of birth, even as the radiance of the innocence of a new birth exudes deliverance and victory.

In the context of a problematic, there is always a ray which the persistent scientist tentatively hangs on to as a conjecture of the conditions and/or constituent elements required of by the solution which needs invention. Everything is fuzzy and foggy in both the mind and the senses. This bit of information is made up of what Briskman identified as the prior products, the problem, the background, etc. We are aware of the past 'givens,' and we are facing the current problem. There is a conjecture of how the past 'givens' should necessarily participate in working out a new mandate with the present problem, but we are not certain of the way that may possibly lead to that point, and neither are we at all certain of the how, such end could be attained. The problem of how the new set of components would be essayed into the desired and the desirable symmetry or mosaic, is perhaps made more dilemmatic by the more fundamental problem of how to begin, or, where to start anew. Starting points seem to be very crucial as a vital issue towards any hope for the possibility of any success in scientific endeavors, no different in fact, from other transactions. Except perhaps of a few cases of which John Dalton's Atomic Theory serves as the more classic example, the need of a proper discernment of the starting point is anchored on the 'common sense' that it is highly improbable that something rational will ever result from what appears at the start to be 'irrational' and untenable. This is not a dogmatic principle for ever and for always especially so when we deal with the empirical. Dalton's case, even if considered a 'rare accident,' lends us to the moral lesson that though not unilaterally, the philosopher must be prepared to learn from science, for science has its own unique ways of formulating its own philosophy. Seemingly, the worst kind of attitude a philosopher could adopt when he ventures into a philosophizing of science is to try to fit science and scientific thought into his antecedent metaphysical frameworks.

The novelty of the creative product depends to a large degree on the substance of the starting point so called, which determines the direction

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[38]K. Popper, "Campbell on the Evolutionary Theory of Knowledge," in Radnitzky & Bartley, Op. cit., p. 117.

[39]M. Gremek, "A Plea for Freeing the History of Scientific Discovery from Myth," Op. cit., pp. 15-17.

and accent of the succeeding building up of the relational parts. In this sense is the 'learning-how-to-walk' stage of a somewhat random character. False starts are inevitable, and we should never be surprised at all about their occurrence. But we will never know how many, or we might not even care to know how many. The crucial thing is, that we know that the start presently employed does not work, and convinced, we are forced to retrace our steps and start anew. As this process of elimination continues, a process which is basically inherent in the scientific enterprise as such; options are whittled down and the chance at arriving at the best probable, never mind if it happens very belatedly, becomes clearer. Selection of the more possible options is slimmed down to fewer and fewer alternatives as our thoughts become more adept at sizing up the various nuances of the past 'givens' and the urgent naggings of the present 'whys.' Familiarity of the situation enables the mind to have a better grasp and control of the emergent, in both the substance and style of the solution called for by problem. There is no doubt that familiarity with the problem occasioned by a longer reaction time and dialogic transfers enables the mind to develop a greater spontaneity, a sharper incisiveness, and a clearer view of his anticipations what should come about. The perceptual anticipatory component assumes a better definition of the various facets of the problem such as, "what is its 'now' status"; "what should its new status be"; and "how will this new status be managed and confronted." The increased definition and precision of the situation at large connotes an increased preponderance of a sharper discernment of the depth and breadth of the architectone that is, still yet, unborn; but already in the process of fetal development. Obviously, this stage would also call for a more facile usage of logical patterns than it was before. This is probably the sense by which we should take the statement of scientific discovery commentators that discoverers are wont to believe first, and only then do they come to task of proving (or disproving) their convictions. The statement is of course similar to the effect, that the fundamental equation that exists between discovery and discovering is that of an inverse proportion.

This implication is inevitable, and indeed to be expected as more light is getting to be more available to the scientist, what with the heightened 'familiarity' so to say. In the same manner, we must mention the fact that as choices were made on the basis of a value, this component correspondingly gets to be more intensified. It is very evident that values ought to play a significant role in scientific endeavors, and that definitely, there are such things as scientific values working through in the life and thought of scientist and his world. Scientific judgments and decisions were made by him in the past and will continue to be made by him in the future, between for example what is likely or unlikely chance configuration, between what is frivolous and what otherwise is substantial in a scientific construct.

If we allude that intuition is not something permanently active but that of a discontinuous facility which depends on certain conditions and

climate which incite and nourish it, and for it to react to its "proper object"; then, we are similarly alluding to the premise that, in a clearer sense, both the faculty and its object, bear the same fate of tentativity and suppositional operation.

Presentationalism versus Representationalism

Intuition as the radar of the scientist, I tend to espouse, is representationalist in both in its operation as well as in its objective. Representationalism maintains that the world as the object of study has a separate existence and the sense data need further anatomy to seek out the most probable set of 'reasons' behind and beneath such observational data. In a certain sense, the immediate observational data available are taken as aids, leads, or means, leading to something else; and these data are not ends by themselves, and much less for themselves in the sense of a centrifugal circumscription as Ernst Mach and his logical positivistic colleagues would insistently maintain.

Presentationalism as a position, antedates Mach, Berkeley, or the church apologist, Pierre Duhem. The Galilean controversy figured an ecclesiastical celebrity in the person of Robert Bellarmino who pontificated for scientists, that science must not go beyond the stark presentations of the senses. In the short and long of such view, the ecclesiastical Prince considered the task of scientists as nothing more than that of being an heir apparent.

In his book, the *Analysis of Sensations,* Ernst Mach qualifies his previous convictions with, "colors, sounds, spaces, times... are provisionally the ultimate elements, whose given connexion it is our business to investigate. It is precisely in this that the exploration of reality consists."[40] It was then the set parameters for the scientist within which he could orbit: to be in a sense, for sense, and with sense; that Mach had condemned the future of the scientist to a presentationalist destiny.

In a presentationalist career, all that the scientist would achieve would be an information about the world for being in the world of nature would be a trespass. This implication becomes evident in the mind of Cardinal Bellarmino wherein Nature is held sacrosanct and any attempt at the exploration of the secrets of Nature simply becomes a serious offence which I term as a sin 'against Nature,' and therefore unnatural. Since whatever is unnatural is immoral, hell's greatest population is made up of scientists. The implication is quite comic as it is tragic. But this is again a classic example of what we have mentioned above regarding the extreme caution when we posit our premisses. The scientific transaction is basically a human act and it therefore cannot escape the consequentials

[40](NY: Dover, 1959). pp. 29-30.

of responsibility and accountabilities. The scientist is a moral being who is never exempt from the moral evaluations of his actions. It is a sheer waste of time to allude to the dictum of "just doing (or undoing) one's job," unless, of course, we put an aplatonic sign outside our laboratories to the effect that: "He who does not accept his moral responsibilities, will be allowed to enter," which again, is incongruous. It now appears, that, whichever turn we make, we end up in a sting of fallacies simply because we started with one. Belatedly, we realize the cogent experience that falsehood will never amount to any grain of truth.

The other implication that becomes inevitable also refers to the so called metaphysical entities such as the atoms, forces, and the molecules. These entities would be denied of even their kind of existence since there is nothing, or there should be nothing else beyond the sense prescription of its greatest commandment: Thou shalt not have other entities other than me. It was precisely on this concatenated linkages of sensations in fact, that Mach is led to deny Einstein's contention of the velocity of light in a vacuum as independent of other phenomena, in the framework of the Special Theory of Relativity. If Bunge thought that intuitions are dangerously dogmatic, Mach considered his pet sensations taken as such, as both venerable and infallible.

Indeed, Mach's fame and fortune had its own destiny too. In the scientific world as it was too, in the world of nature, the survival of the fittest principle works mysteriously and no less effectively. The Atomic Theory was steadily getting attention between 1860 and 1920, a period when Mach was precisely basking prominently in his presentationalist designs. In 1811, Avogadro published his Law of Gases which asserted that: Equal volumes of gases contain equal number of molecules under the same conditions of pressure and temperature. Like the soup of the day, the Atomic Theory became quite a popular choice itself and became rather a celebrated polygamous companion of just about every sort of scientific problem there was. Scientific discoveries somehow, without intending it perhaps develop this terrible habit in both scientists and non-scientists, which tries to use the latest finding, like a master key to pry open the doors of other mysteries. It is never difficult it seems, for a winner to find company, and scientific discoverers must relish this sign of acceptance in both their work and their person.

Boltzmann (1841-1906) who was a physicist working in the area of thermodynamics, was no exception. Mach was no different either. The increase in entropy in the second law of thermodynamics posed a serious problem of irreversibility which Boltzmann was working out the statistical solution under the aegis of the atomic theory. It was a case between presentationalist and representationalist thermodynamics.

In 1927, Robert Brown, an English botanist, formulated the phenomenon of what is now known as the Brownian movement. Small

particles in a liquid medium travel incessantly in a zigzag motion due to a constant collision between the small particles and the liquid particles. The predictive potential of the Kinetic Theory of Gases had prophesied this phenomenon. This scientific implicative which was now successfully 'extracted,' was corroborated by Einstein. The so called molecular bombardment was affirmed by him in 1905 during which Mach was served the certificate of a 'fatal' bifurcation to his scientific conviction. But while Boltzmann won the war for the representationalists, he lost the battle for his own probabilistic derivation of the second law of thermodynamics. Unfortunately for Mach, he suffered continuous reversals, another coming from Planck in 1908, and another from Oswald Kulpe who is famous for his "imageless thought" and ultimately grandfathered the Gestalt physchology.

Intuition or not, the presentationalist-representationalist controversy highlights some 'moral lessons.' the 'primacy' of contact with experience without limiting oneself to experience per se is an attitude which is promotive of a kind 'objectivity' which liberates the investigator from the tyranny of "isms" and suffocating fixations. D. Campbell refreshes our minds with the nurture of the scientific endeavor which breeds on a rational selectivity when he writes:

> What is characteristic of science is that the selective system which weeds out among the variety of conjectures involves deliberate contact with the environment through experiment and quantified precondition, designed so that outcomes quite independent of the preferences of the investigator are possible. It is preeminently this feature that gives science its greater objectivity and its claim to a cumulative increase in the accuracy with which it describes the world.[41]

Objectivity blends with selectivity as the researcher intuits the motive and tactiles the directive which impels and imbues his efforts from the personal preference being subsumed into the universal plane, from the private right to a public responsibility. Objectivity is objectification. It is the act of choice and selection. Objectification is selecting as selecting discriminates and zeroes-in on its re-cognition. It is not an entirely subjective act since the choice is historically discerned and developed in contact with the emergent not-fully-known objective. Neither is it a straight jacket objectivity, if this phenomenon is at all possible, since the choice is made with both internal and external referent sources. The subjective element as constituted by the discoverer' intellective-affective-psychomotor responses and commitments, become integrated into the historical emergent process of the object. As Yukawa observes, this is "The development of man's intelligence (which) can be looked upon as a

[41]D. Campbell in "Evolutionary Epistemology," in Radnitzky & Bartley, Op. cit., p. 7.

kind of evolution of the process of identification."[42] There is, it seems, an evolving development of the clarifying "connections" and a deepening emergence of "coherence" from the 'darkness' of the inexhaustible, the unpredictable, and the indeterminate. What before then were complex aggregate of clues now turn into more definitive parts of a new meaning and organization. As the analogue hovers over the digital, sense is extracted out of chaos and contours are carved out of what before was an indistinct canvas. This situation also implies that the researcher is led so to say, persuasively now, because he is now better convinced of an emergent reality independent of 'what he may want otherwise,' because he was intimately privy to its conception, delivery and maturation. The indeterminate vision and outline of the clouded reality slowly firms up its hold on the beholder. This is the dynamic force of the imagination guided by intuition. And equally so, this is the dynamic force of aesthetics on the discoverer's affectivities.

The researcher reaches out and aggrandizes as 'his own' an 'object' which appeals to him in the level familiarity on account of identity. The law of *pragnanz* effects the perceptual tendency towards "as good a figure." The eyeful symmetry does not, again, 'force' itself on the discoverer's mind, but it is in itself the 'best persuasive argument' ever. Views differ on whether it is because of such symmetry that the discoverer realizes near endpoint of his work, or such symmetry comes 'post factum' the discovery as a kind of a secondary and after-taste transcendental. Ultimately, the issue is whether such symmetry is cerebral, or glandular, or both! We can only guess, for even the texts authored by the discoverers themselves do not go as far as this problem which appears like one of those questions found in codified textbooks responsible for the freezing of such human delights.

I can probably venture to distinguish this integrating process into three phase-leaps in very general frames, namely, the *envisioning* process, the *invisioning* process, and the convisioning process.

The *envisioning* stage is a fuzzy, opaque situation where the current problematic offers no other referent other than the prior products, background, etc., so that such entry into the envision occurs in a scenario of blindness and darkness. Exploratory and random, possibilities are sorted out in a quite broad 'nodding' acquaintance, almost detached as yet to any commitment. It is similar to parade and review of events though we must accept the fact that the mere presence at such an event as a parade and review connotes a purpose, no matter how routinely and trivial such 'entry' may have been.

The *invisioning* phase-leap conjures a marked improvement over the mere sorting out and reviewing of events. It begins to see 'in,' and begins

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[42]Yukawa', "The Conception and Experience of Creativity," *Creativity and Intuition*. Trans. John Bester. (Kodansha Intl. Ltd., 1973), p. 121.

to rest 'in' *some* of the details, characteristics, qualities, etc., apart and separate from each other, but attention is beginning to grow in reaction time and reflexivity. A level of direction and connection begins to form.

When the *convision* phase-leap occurs, a scientific discovery is formalized according to a certain form and according to the requirement of a consensual permits. The process is now in the level of being 'seen' with, and canonized in the presence of and together with the intersubjective standards and canons. As the most plausible conjecture, the object has been subjected to the stiff collisional and falsificatory processes. The stiffer the standards, the better for both the product and the product perusers. The strict quality controls lend a protection on all parties concerned. As such the canonical convisioned product is treated with a kind of an heirloom respect until such time that it 'self-destructs' on the basis of factors and elements which we have mentioned before. What initially was an aggregate of experiences by a singular or a group's commitment now becomes a conviction of the congregation of scientists, leap-frogged from an *ad hoc* to a *post hoc* excellence.

It is now becoming clearer to us that intuition works as an integrating factor of the 'likely' elements and clues in what may be construed initially as an act of an ordinary simple perception. It is in this sense that scientific discoveries are viewed as an extension of simple perceptions which have been turned by an extraordinary stroke of 'conversion' into something out of the ordinary. In this sense too is the view that there is in fact no sharp division between science in the making and codified science. In which case, the vision which have led to such a discovery lives on as 'impregnated' in codified form. Verification and falsification as a result, are actually formally indeterminate procedures.[43] Surely, these observations could lead to more serious and far-reaching implications.

Within the scenario of indeterminacies encountered in the facts, intellective process and more so in its outcomes, lie the unpredictables which the scientific imagination and intuition play. As we have noted earlier, Yukawa' was more certain on the 'how' rather than on the 'when.' But by and large, both Einstein and Yukawa' have the common observation on the human least common denominator: it would depend on individual styles.

The mosaic of the 'Lure of the Temple' assumes more light at this point. It is within the background of the celebrated problem of Meno brought up by Plato. Obviously, it all starts with a problem, which means that we are in need of a solution. Ignorant of a solution, we do not know what we are looking for. And we cannot expect to find anything. The solution to this circuitous problem is typically Plato's thema of recollection

[43]M. Polanyi, "The Creative Imagination" in *Creativity in Science and Art* (1981), p. 96.

and remembering. It lies in the dynamic intuiting of the past incarnations, which serves to perform a Solomonic assundering by the Platonic deliverance.

The problem itself encases the solution, we have mentioned this. But for the problem to turn into a solution means an historical inching process into the awareness of the emergent coherence manifested by the hidden reality of nature. It is in this sense that P. Souriau not only considers a well posed problem as already half answered, but more so as the locus of true invention itself.[44] And aside from their fortuitous nature if creative, genuine scientific questions are endowed with valuation, fruitfulness and prognostic properties. We feel obliged to emphasize at this point once again that the problem formulation as a genuine basis of the creative process is not immune to the psychophysical and sociobiological trappings of a problem of reality.

The scientific transaction is in itself a cathartic and a very humbling experience. Obstacles come mainly from within the inner self of the scientist when fixations, as they are perniciously omnipresent, cease to be flexible, and create, what otherwise could be a pernicious type of omniscience, "which needs breaking down within ourselves."[45] This certainly sounds too personal and moralistic, which, in the context of science, may appear a bit too juvenile. But this is precisely the point which must never be overlooked even if it is presumed! Only when this ordinary type of inner conflict that must extraordinarily be controlled, that the transempirical world of the unobservables be possibly "observed" and incarnate its own rightful position in the firmament of scientific truth-claims.

As evidenced by Einstein's 1905 experiment and confirmation of the Brownian movement, the proof *postdated* what the atomic theory probed by intuition, a practice which we have been enthused eons of years ago, as established by Epicurus, Lucretius, and even by Democritus, based on sheer contemplation and speculation. Yet, the "independence of the preferences of the investigator" also came into play and focus with R. Carnap whose group gravitated around Moritz Schlick in the celebrated Vienna Circle which group was also known as the "Ernst Mach Society." There too was the Copenhagen School of thought of Bohr, Pauli, and Heisenberg. The principle of uncertainty figured the impossibility and meaninglessness, of a particle's having both position and momentum. In parallel lines, it is similarly impossible and meaningless to conjure of an existence at a distance from observation. Atoms cannot be observed, thus, they do not exist. In the second law of thermodynamics, less and less is

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[44]"Theorie de l'Invention," (Paris:Hachette, 1881) p. 43, as quoted by D. Campbell, "Blind Variation and Selective Retention" Radnitzky & Bartley. Op. cit., p. 98.

[45]A. Einstein, Letter to P.A. Schilpp, quoted by the latter in his "The Abdication of Philosophy," *Kant Studien* (51, 1959-60), pp. 490-1, taken from Bartley's "Philosophy of Biology Versus Philosophy of Physics" Op. cit.

known of entropy as entropy increases. This is often termed as the "subjectivist theory" of entropy. The irreversible direction of time in its arrow, is also considered subjectively as an illusion.

Karl Popper witnessing all these, writes in his *Conjectures and Refutations* that the problem of demarcation between science and non-science serves as the "key to the most of the fundamental problems of the philosophy of science."[46] And within the demarcated science at large is the intuitive process of scientific discovery. Meanwhile, the presentationalist phenomenalism pursues its conviction under different cloaks, e.g., operationalism, positivism, instrumentalism, etc.

In a letter to P.A. Schilpp's invitation to contribute to the volume celebrating the works of R. Carnap, Einstein writes with wit and imagery, no doubt, unfailing to describe his unequivocal position regarding the encomium expected of his contribution:

> I cannot accede to your request. For I have dealt with this slippery material only whenever my own problems made it absolutely necessary. . . I would not be able to do justice to this swarm of incessantly twittering positivistic birdies. . . *Entre nous* I think that the positivistic nag, which originally appeared so frisky, after the refinements which it had of necessity to undergo, has become a somewhat miserable skeleton and has become addicted to a fairly dried-up petty foggery. In its useful days it nourished itself on the weakness of its opponents. Now it has become respectable and finds itself in the difficult position of having to make a go of its existence under its own power, the poor thing. . .[47]

Surely, we owe this big favor of making available a private communication of Einstein, to P.A. Schilpp, and we are certainly enthused and regaled. Bereft of formalities, a private communication makes available to its perusers an insight into the feelings and attitudes of the writer in a no holds barred arrangement. The style and the choice of words would expectedly connote a meaning and message which would be 'closer to homebase,' in a very personal, very frank voice. As a private communication, the text would obviously be more revealing over than that of a packaged official communication.

From Collisions to Collusions

It is becoming clearer that intuition as a mental process as posted in the illustrated table above, does not force itself 'upon,' but works itself 'into' an approximation of the most likely configuration which best "fits' into the intuited prefiguration. It is a strange development of a vision into a conviction, which does not supply knowledge as certain of reality.

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[46]Ibid., p. 42.

[47]A. Einstein, Op. cit.

It is a strange interplay of the conscious and the subconscious, of sets and subsets, of hunches and of pairs. We see this in the autobiographic chronicle of Poincare' which he writes so vividly that we quote it extensively.

> One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination.[48]
>
> What happens then? Among the great numbers of combination, blindly formed by the subliminal self, almost all are without interest and utility; but just for that reason that they are also without effect upon the esthetic sensibility. Consciousness will never know them; only certain ones are harmonious, and consequently, at once useful and beautiful.
>
> . . .Perhaps we ought to seek the explanation in the reliminary period of conscious work which always precedes all fruitful unconscious labor.
>
> Permit me a rough comparison. Figure the future elements of our combinations as something like the hooked atoms of Epicurus. During the complete repose of the mind, these atoms are motionless, they are, so to speak, hooked to the wall; so this complete rest may be indefinitely prolonged without the atoms meeting; and consequently without any combination between them.[49]
>
> On the other hand, during the period of apparent rest and unconscious work, certain of them are detached from the wall and put in motion. They flash in every direction in space (I was about to say room) where they are enclosed, as would for example, a swarm of gnats, or if you prefer a more learned comparison, like the molecules of gas in the Kinematic theory of gases. then their mutual impacts may produce new combinations.[50]
>
> . . .In the subliminal self, on the contrary, reigns what I should call liberty, if we might give this name to the simple absence of discipline and to the disorder born of chance. Only this disorder itself permits unexpected combinations.[51]

Poincare's mathematical inventions find ideal analogies in scientific discoveries and his autobiographical accounts puts us in a better light towards the understanding of this phenomena. Yet, in spite of what seems to be quite a rare graphic account, we realize that coursing through

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[48]See Henri Poincare', "Mathematical Creation" in his *The Foundations of Science*. (NY: Science Press, 1913). p. 387.

[49]Ibid. p. 392.

[50]Ibid. p. 393.

[51]Ibid. p. 394.

the accounts of Poincare' requires that we cautiously tread our steps and thread the extremely fine and delicate ware of his description of the event. As a first hand personal record, the rewinding of the event in order to capture the highlights of the discoverer's recollection, and 'reproduce' a copy from the 'original' by the man who had experienced the 'personal' encounter, will be by far, the 'closest' account of 'what' actually took place.

We also hope to secure references to the 'how' circumstances under which conditions the discoverer experienced and found himself during the discovery. There are different opinions regarding the importance of the value of such data for we realize, they are in a state of what precisely Blackwell had observed as being in an 'amorphous' state.

Other observations caution us on the time span factor which intervenes between the event as it happened, and the actual recording of the event that 'it happened'; an important element to consider but definitely and not to be taken lightly. But obviously, these are factors which are more easily described than measured. A plus factor we believe that is available to us, is the seeming spontaneity of the quoted text which does not portray any ground or basis that would intimate to us of a studied and calculated recording with prepared answers to a previously posed questions. Indeed, what the text lacks in terms of an algorithmic coherence as we would expect to find some kind of a general-to-particulars framework, or vice versa, is a decisive advantage of this material. On this score, alone among many others available to us, it appears that the record is a 'faithful' account of the event which, as we are cautioned, are events which not only that they do not follow such predetermined rules; such predeterminations are actually defied. We get a fair assurance that even if we do not get what is a considered exegesis of the autobiographical account, we have a substantive source at 'hand.'

Poincare's insistence on the *sine-qua-non* need of the *preliminary period of conscious work,* is an emphasis which, needless to say, we have seen quite universally in similar first hand and personal accounts. This point of emphasis as an obvious 'predetermination' galvanizes our concept of creations and inventions as events which must follow a previous event, or more realistically, a set of 'building-up' events. 'Discovering' as a processive historical act is a 'concrete' act, with its own demands and requirements, and therefore quite uniquely though, possessive of certain 'here-and-nows.' The *ante hocs* of conscious preliminaries recalls previous works, efforts, interests with their attendant peripherals. The relationship that resultantly dwells between the *preliminary period of conscious work* and the intricate workings of what is yet not fully known creature, is illustrated by Poincare'.

Several combinations or options are incubated and gestated in pairs. It is quite a curious matter how and why nature tends to dyadic and binary systems to start with, in most complexes. There exists, it seems, a

natural diatomic requirement out of which, then and only then can a possible entitative construct be formed and consequently be epistemically conjured. Nature is so rich in this type of bonding and interlocking affinities. The pair concept seems to be a more common objectification of stability as early as the times of the Greeks.

But then, we realize that not all pairs are fit and fair. collisions are necessary to test the survival of the fittest. The collisional chaos serves as the testing arena for the most beautiful and most useful if the leap from chaos to harmony is going to be achieved. Why a particular combination is the 'most,' or the 'mostest,' "consciousness will never know them." And perhaps, consciousness will be at a loss too, how the dyadics tend to a unitive form of One.

The discoverer gropes, and is at a loss. Analogical thinking comes very handy to him as he proposes to 'figure' a 'something like' referent image of the hooked atoms of Epicurus. Poincare' at this point too, invokes a 'rest time' which is actually a sustained activity in the guise of a different mode. During this 'apparent rest,' some events may possibly take place which may be crucial as a 'beginning.' 'Unconscious work' though unconscious, is by all means, still work. But this unconscious phenomenon probably cannot be entirely avoided, or helped, with the onset of the *preliminary period of conscious work,* of the *kind* which "always precedes all fruitful unconscious labor."

Collisions which are impactive of 'new combinations' trigger into what we might call the flashpoint signals of the positive equivalent of selective chance. Then, we have enough reason to term such entity which survives this game of combinations and chance, the chance-combinatory-configuration.

It should be pointed out too, that what happened to Poincare as he provides the account, is a case in point of what we might call an epistemological 'shifting' process employed in the solution of what appeared to him as an insoluble problem. In such case, the creative solution of a problem involves also, to a large degree, the creative 'handling' of the problem vis-a-vis, reformulating, relocating and the indwelling of the "disorder born of chance."

We were constrained to quote Poincare' quite lengthily for reasons we have just articulated. For a vivid, and blow-by-blow scintillating autobiographicality, scientists and artists will find this mathematician's account homely and interesting, elucidating a similar commonality for the metaphoric propensity for elegance, beauty, economy and simplicity of constructs. Quite strikingly, we notice close parallels in the Einsteinian descriptive verbiage, with such descriptions as "combination, blindly, subliminal self, esthetic sensibility, consciousness (and unconsciousness), harmonious, useful and beautiful, preliminary period of conscious work, chance and disorder," of Poincare'.

Summarizing, we may express the following:

1. There seems to be a mutuality and interfacing of the conscious and the unconscious preoccupations, a kind of a permuting circularity of feedback loops. The preliminary period of conscious work in its broad acceptation, provides the initial input into the system. There is a direct proportionality of the resulting depth and intensities that may possibly occur between the conscious and the unconscious work.

2. The "givens" constitute a fertile multitude of possibilities, an abundant crowd in disorder, without any definite design.

3. 'Blind' pairing combinations are set into motion in the subliminal, unconscious state.

4. Some of the selection criteria are the impactive emanations of the 'splendor' of esthetics, of harmony and usefulness. Usefulness is taken into account because of the problem background and truth-claims. Beauty and harmony are tokens of truth. Truth and usefulness in a scientific work must go hand in hand; for which reason, we encounter the 'functional' truth as a very appropriate term.

5. The system is open to a continuing coagitation so that new combinations are obtained. The openness of the system revolves around the 'liberty' factor, a liberty that is prompted by a problem and is sustained by responsibility.

The Analogous Referent

Yukawa's equally vivid autobiographical account with allusions to the combinatory analogical similarities and pattern recognition reads in the following familiar context:

> "How can a man determine the kind of similarity between things that enable analogical thinking to be creative and fruitful?" In order to answer this question, we have to take a further step. When we notice that something is similar to another, we admit that they are the same in some sense. . . It seems to me that the process of identification not only is the starting point of analogical reasoning but also prevails in all kinds of mental activity, so that the analysis of this process may lead us to *the understanding of the secret of creative thinking.*
>
> Let us go back to a very simple, but nevertheless a very fundamental, born of identification, that is, what we call pattern recognition. Man acquires the ability in childhood to recognize such patterns as squares, circles and triangles. Such an acquirement is prerequisite for the understanding of Euclidean geometry. It is often overemphasized that the Euclidean geometry we learn in school is a system of

> statements which are linked with each other through the procedures of formal or deductive logic. . .[52]
>
> I would like to point out that man acquires an amazing capacity for pattern recognition without being taught in school, whereas man has to learn formal logic in school. I would like to repeat that we come to comprehend formal logic because we had been unconciously aquiring beforehand the ability to recognize patterns in childhood as exemplified in the case of learning Euclidean geometry.[53]

The fundamental equations of Yukawa's autobiographical account are the following:

> 1. There is in man an almost innate potential virtue to experience a sense of similarity and dissimilarity. This is called the process of analogical reasoning.
>
> 2. The process of analogical reasoning is anchored on the identification and recognition of patterns.
>
> 3. The identificatory and recognitive ability are built on an 'informal, homegrown' type of inductive logic or reasoning.
>
> 4. The ease with which this 'informal and homegrown' type of inductive logic and reasoning is directly proportional to the ease with which formal logic or deductive logic are comprehended.
>
> 5. Analogical reasoning as a creative process delves on relations, arrangements, shapes, etc.

The achievement of the 'connecting' process of relations, arrangements, shapes, etc., with their root experience , Einstein calls intuitive, and never of the logical nature, and therefore, creative. He writes thus,

> I see on one side the totality of sense experience, and on the other, the totality of concepts and propositions. The relations of the concepts and propositions among themselves and each other are of logical nature and the business of logical thinking is strictly limited to the achievement of the connection between concepts and propositions among each other according to the firmly laid rules, which are the concern of logic. The concepts and propositions get "meaning," viz., "content" only through their connection with sense experience. The connection of the latter with the former is purely intuitive, not itself of a logical nature. The degree of certainty with which this connection, viz., intuitive combination, can be undertaken, and nothing else, differentiates empty fantasy from scientific truth.[54]

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[52]Yukawa', "Creative Thinking in Science," Op. cit., p. 117.

[53]Ibid. p. 117

[54]A. Einstein, "Autobiographical Notes" in *Albert Einstein: Philosopher-Scientist*, vol. 1, ed. by P.A. Schilpp. (NY: Harper & Row, 1949) pp. 11-13.

Here Einstein asserts the crucial importance of experience which should be stage-managed by the logic of concepts and propositions, which propositions so called, gain their being for 'being such,' on the basis of their reference with experience. This is one canon which Einstein is quite emphatic about. And rightly so. In this sense, any form of philosophizing about science, and purports to be a philosophy of science, cannot, on very fundamental terms, be separable from science itself. Ultimately, any account that is purported to be an explanation, will necessarily be assessed on the terms of this crucial referent point. This is just a minute dosage of the total matrix of cross-referencings that we will continue to witness in the pursuits of science, philosophy of science, and the underlying ontics and epistemics which work in a substantially critical-reflexive mode. If by any chance, however, reflexivity as a pattern of a circularity is deemed as a manifestation of an incompatibility with rationality, then we find ourselves in a very odd, indeed, not to say a chimeric situation of our own making, for having denied the very natures on which human thought operates.

The crucial event occurs in the linking process between the two components which ceases to be a phenomenon of logical nature but more so, as that of the nature of an intuitive operation. The connecting 'fit,' so to say, having been set and done by intuition, and not by logic, cannot be explained or justified by the rigors of logical reasoning. Correspondingly, such being the case, any explanation or justification of the process which achieved the combination which "clicked," which is a radical departure from the very process itself, vis-a-vis, the heuristically programmed problem-solving computers and other similar models of creative thought, will end up succeeding in their 'own way' and not solve the issues at hand.

Substitution and Subsidiarity

The level developed thus far accrues to an 'orientation to" or "a perspective on" creative thought processes, rather than a "theory of."[55] For the most part, it is essentially a phenomenon of conditions which favor the process to continue until details which are essentially unpredictable are grasped. This is basically the reason why the whole process is getting acceptance as fundamentally akin to that of what we know and term as a process of blind variation and selective retention phenomena. some of its themes are outlined by Campbell who is one of its major proponent.[56]

1. A blind-variation-and-selective retention process is fundamental to all inductive achievements, to all genuine increases in knowledge, to all increases fit of the system to environment.

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[55]A. Bain, "The Senses and the Intellect." (NY: Appleton, 1874) 3rd ed., pp. 594-598, as quoted by D.T. Campbell, *Blind Variation and Selective Retention*. Op. cit. p. 97. Thomas Nickles, Op. cit. p. 25.

[56]D. T. Campbell, ibid.

2. The many processes which shortcut a more full blind-variation-and-selective-retention process are in themselves inductive achievements containing wisdom about the environment achieved originally by blind variation and selective retention.

3. In addition, such shortcut processes contain in their own operation a blind-variation-and-selective-retention process at some level, substituting for overt locomotor exploration of life-and-death winnowing of organic evolution.

The Principle of Substitution so called, which works out in the creative thought level is described as a "substitute" exploration of a substitute representation of the environment, the "solution being selected from the multifarious thought trials according to a criterion which is in itself 'substituting' for an external state of affairs."[57] 'Intelligent' behavior which evolves out of the multifariouss trial-and-error method and the "forays into the unknown," marshals these three-prong "substitutions" so that the solution in overt locomotion becomes adaptive. Blindness therefore connotes at its core the singular 'lead' of the analogical comparisons as the process which installs the 'substitutes,' nay, including that of its own insights.

It behooves on the status of ideas and frames already existing in the discoverer's mind that thus inevitably predetermines to a large degree of modal specificities whatever new and incoming fact or observation that is taken into consideration. The posture and accent of these 'praenotamina,' e.g., the scientist's memory, training and knowledge, lie the future so to say, of these facts' manner and style of intelligibility and subsequent possible assimilation to his conceptual framework. With these previous experiences hovering at the back of our heads, we discern, we delineate, we conjure, we hypothesize, and we theorize. The principle of selectivity comes into use and operation according to the signatorial nuances of a personal style.

If an anomaly is taken to be as so perplexing a data or situation which can only respond to a kind of retroductive analysis which seeks for the explanatory premises rather than seek what the premises at hand will bear unto; quite clearly, the hypothetico-deductive framework follows the set and formulaic rules of logical analysis and patterned exposition of the

[57]Vollmer, Op. cit. p. 181. And he continues, "When does this process end? It is a continuous interplay, a perpetual give and take, a never-ending critical cooperation, an endless mutual connection. This process is not circular. This spiral structure obtains both historically and systematically: New knowledge has necessitated new epistemologies, and the understanding of scientific theories. Many epistemological systems, meant to be unshakeable and final, turned out to mirror the respective knowledge of their times (or even worse, the nescience of their creators). Cases in questions are Francis Bacon, John Locke, Rene Descartes, David Hume, Immanuel Kant, Herman

solution from say, hypotheses and laws. the treatment of an 'anomaly' does it in the reverse manner, or in any manner altogether different from the established modalities.

Within this framework, it is then the view that neither logical reconstruction nor psycho factorial analysis, alone and independently will suffice to operate in this unique situation. Perhaps a different kind of philosophical brew and concoction is called for. Quite definitely, the 'must be' attitude of H-D is not made for this kind of role. If the discoverer is 'born' and skilled to see what others fail to see, obviously his methods should be no less.

In the Piagetian tradition, it is a conviction that knowledge as change does not occur unless we act on them. This personal stimulus involves a totality and an organization of a series so much so that qualities such as volatility or say, roughness, are not merely considered as local impressions. These qualities are subsumed on the basis of their translocal potentials and field attributes within a spectrum of a larger matrix. It means a decisive treatment of the datum of observation and is rather taken more than a simple fact but as a 'fact-for' and a 'fact-of.' Its relational and contextual meanings are deployed. This calls for an innovative amalgamation of a myriad of the life, exact, and sociological sciences, in what seems to be a cyclic pattern. It starts up with the logico-mathematics, physics-chemistry, biology, psycho-sociology and back to the logico-mathematicals. If we examine through this 'curriculum,' one can easily construct a close parallel with the emerging structure of our study. We have insisted on the initial referent of the canonical product. From this point on, the perusal of the history of science or even that of codified science will provide us with their theoretics, e.g., physics, chemistry, and biology. What we have discussed in this paper at length is the penultimate factor of psycho-sociology, which of course merits its locus in lieu of the logico-mathematics of the theoretics. And we are back into the same cyclic pattern.

Hence the mere grammatical view taken of these data does not augur much for the future, e.g., towards a better understanding of nature. Otherwise it will be a case of a very unfortunate loss of a rare syntactical opportunity to have failed to input our intellectual contribution to these bare sense impressions. Science, in this case have hardly started at all. This is the cataractic darkness which I was referring to earlier with that rather odd caricature, and here we realize it to be an emptiness caused by a strange case of an 'infinite series of absurdities.'

We must realize, therefore, that observing is not a mere phenomenal act of seeing or watching, and hypotheses are not happy unconscious guesses pure and simple. The personal inputs of arranging and representing are not mere statements of facts. They are already in a different cruising altitude of 'showing' the facts. This means that the conceptual

organization arrived at, is absolutely not the same as a visual picture and presentation of nature. One does not need to be creative for this sort of thing. It is rather a representation of the way nature was visually apprehended, and the prefix lends to what would be an ordinary presentational copy, an entirely different perspective. These are entirely two different and distinct situations, and the differences that lie between them are non-negotiably eons apart. It is the creative elements which are personally 'inputed' on a representation that cannot be replicated. Thus the human and personal aspects so called, constitute the 'bloody' version of the logical frames hidden in, and which must be distilled from reality. In this sense, we can say that to 'see' is to know more, and better.

The Iconic Referent

This mental advancement of 'knowing more and better' involves another component which appears at the very vortex of every genuine scientific activity. At the outset, it initially serves as an intermediary, a bridge of some sort which helps to forge some very leading clues between the unknown and the 'reality' which is not fully known. It is viewed as the referent *Icon.*

Icons in science are representations of reality which sheds some kind of a scanning ray or light of vital explanatory intelligibilities on facts which by themselves would be mere discordant notes in the overall orchestrated hymn of nature. They appear to be the 'prototypes,' or the mother hypothesis of 'the' theory of nature which may work either for or against any incoming data and observation. As some sort of master plans or blueprints or natural processes, they are explicative of the multifarious varying data projections and enables the discoverer to come up with a 'worldview' that is more representational as a coherent and holistic concept. Such insight and overview makes the classificatory experience more feasible, for example. From the standpoint then of the yet unexperienced, they function on both the prognostic and the transcendental. It should be noted perhaps that this Icon mentality is a 'talent' which is acquired through years of evolutive knowledge akin to what Yukawa' referred to as some sort of stable intellective configurations which enables the scientist to lead and to inspire by his very witnessing of his lived commitments. Hence, his imagination reaches a singular point and value of being both fertile and reproductive, yes; including that of being reproductive of possible natures and realities of which the inner dynamics are yet unknown to him. The Icon then is a constitution that is predictive of the possible nature and performs the role of the referent analogatum to the object in question.

Judging from the train of our discussion, it is very likely that we would be starting to form the conclusion that we are referring to the laws

of nature. An Icon as a product of the reproductive imagination is a conception of the very natures of actual objects existing independent of the mind. In a similar fashion, we have to take an Icon in its *perseity* as reflective and a representation of, e.g., its operative and functional mode; and its genetic and originative considerations. It is obvious that some form of analogy again works between the former mode as it transcends actual experience, and the Icon. It belongs to the creative act therefore to reproduce this sort of Icon which is depictive of an unknown mechanisms in the outside world and, at the same time be accepted for its intelligible suggestiveness of possible structures of mechanisms and processes which makes up the problem. This is a clarification of what seems to be an a priori emanation of the 'generative' mechanisms of how an Icon functions.

We must never lose sight thus, of the role of our experience of actually existing objects as the source from which Icons are modeled on. The metaphysics of science demands that given possible choices of sources, those which are of more stable configurations are to be preferred over those which are otherwise of less stable natures. Thus Rom Harre' (1981) notes the preferences of gases over imponderable fluids, of material atoms over atmospheres of heat, of neural networks over that of mental substance. The requirement of coherence suggests a protocol of a degree of 'material endurance and stamina' in the framework of space and time. And in the context of possible experience, a version of experienced reality is reproduced. Such limiting factors and constraints must obviously work to avoid what Einstein warns us about the dangers of what may turn into a factless set of 'fantasies.' This appears to be the vital strand which keeps the discoverer on the ground even as he ruminates on the lures of the Temple of Science.

This is what precisely connects so to say the world of the real and the world of the possibles, between 'seeing as' and 'seeing that' distinction of Hanson, between the pictorial and the reproduced representation. Thanks to underlying structures and mathematical tools, Icons are made to transcend even more beyond the world of the possibles onto the more abstract confines of such inexhaustible real estate of nature. The Icon speaks a different tongue this time, the language of metaphors which confronts meaning at its transcendent best.

Yet, inspite of what seems to be an awesome and overwhelming altitude that can confront the potentials of science, we must again affirm the intimate connection that underlies between the most mind boggling Icon to its historical roots of time, people and place. Science is like a cascading landscape of plateaus, hills, mountains, forests and valleys. The Icons constitute one of these Everests,' awesome, imposing, and guiding. The factors of intelligibility and fruitfulness demand that for Icons to be the bearers of 'possibles' and meaningfulness, they should ultimately find their way to their source and origins, the concrete world of nature.

Roots is one term which indeed is quite evocative of our logico-societal conviction that underpins the cross-referencing of such a complex human act as the scientific creativity. In more simple terms, this seems to be a more existential way of what the ancients understood what they meant by saying that knowledge proceeds from the known to the unknown, and thereby positing some kind of a 'previous knowledge.' The discoverer's motivations and problem orientation will always be set against the background of his previously accepted and established knowledge.

It is precisely on account of this precondition that relations and connections, adaptations and identifications, analogies and images, and even of the new forms of language that emerges out of this transaction, of which are spoken of and used in science' beyond-phenomenal seeing, that they are made to be possible. Pictures then, made out of simple organic retinal reactions are 'retouched,' or they might even need a retake, within what may be termed as the discoverer's conformational analysis.

Thus, in such context, the phenomenon of substitution works in a split-level type of operation. The discoverer is on one hand aware of the hazy contours of the 'object' he is searching for, while at the same time, he is also aware at a different level, in a more fuzzy scenario of the various clues which are candidates to be integrated into the 'object.' In an almost parallel fashion, we have our focus on the main 'object' while at the same time we are also 'subconsciously ' and subsidiarily aware of those clues as could possibly point and lead us to a more coherent knowledge of our 'object.' Notice that there are two functions and operations taking place at different levels at the same time, and at different specificities. The knowledge of what to look for is not the same as the power to find it. This power is usually termed imagination. It involves the conjurations of things which are not as yet present, or will never be present as the acts of imagination. The duality of intentionality between that which is better known as up against what is less known is bridged by this gift of imagination. At this stage, between harbored intention as the 'object' and performance as the clues, we are dealing with an 'act' as pertaining to the former, and potency to the latter. It is up to the power of the imagination to incite and evoke the 'helpful' clues and succour to the filling up of missing gaps in a more coherent 'object.' Keeping the gears of the imagination at a sense of wholeness and globality induces the powers of the senses and the intellective faculties to be able to shift and perform the act of substitution. But despite this, or perhaps because of this bifocality, is reintegration and innovation feasible and possible. In this sense, a 'feeling of direction towards something definite' is maintained.

What the imagination proposes, intuition disposes by its integrative powers. It seems incumbent on intuition too, to say that a more definite assessment of the 'when' the discovery is made. The splendor of coherence is detected and sanctioned by intuition. It is a discovery of a 'reality,' even if we must realize that history suggests that there is no universal

standard for coherence. The winds of change on the standards of varying historicities can best be braved and/or appreciated from an existential and value-clarification praxis maneuverings.

The Circulus Virtuosus

Two years before Darwin's publication of his idea of Natural Selection, A. Bain provided an information which appears to have used the phrase "trial and error" for the first time. He wrote thus,

> Possessing thus the material of the construction and a clear sense of fitness or unfitness of each new tentative, the operator proceeds to ply the third requisite of constructiveness – trial and error – to attain the desired results... the number of trials necessary at a new construction is commonly so great that *without something of an affection* or fascination for the subject, one grows weary of the task. This emotional condition of originality of mind...
>
> In the process of deduction. . . the same constructive process has often to be introduced. The mind being prepared beforehand with the principles most likely for the purpose. . . incubates in patient thought over the problem, trying and rejecting, until at last the proper elements come together in the view, and fall into their places in a fitting combination.
>
> With reference to originality... whether in science, practice, or fine art, there is a point of character that deserves notice... I mean an Active turn, or a profuseness of energy, put forth in trials of all kinds on the chance of making lucky hits. . . Nothing less than a fanaticism of experimentation could have given birth to some of our grandest practical combinations. The great discovery of Daguerre. . . The discovery is unaccountable, until we learn that the author. . . got deeply involved in trials and operation far removed from the beaten paths of inquiry.[58]

More than mere historical interests, the quotation from A. Bain strikes our fancy for many cogent reasons which obviously we have witnessed in the accounts of Yukawa', Einstein and Poincare'. The text transports us to the depths of the "Active Turn," the fanaticism for experimentation, the endlessness of the pursuit which is scaled with unflinching tenacity. This we are veritably forced to account for, otherwise, "the discovery is unaccountable." The emphasis is made, this time, for unique "historical reasons," if we take by being historical, that human factor underlying all human achievements, scientific discoveries included. The affectivity and emotionality involved in originality has quite often been swept under the rug for many reasons some of which we have already mentioned, and more of which we still are likely to encounter.

[58]Ibid. pp. 171-174.

Such pursuits are nothing short of being "irrational," and therefore an illegitimate knowledge as far as a philosopher or a scientist is concerned.

A presumed fact belabors the question on 'accountability,' as Bain opines, and accountability denotes the parameters and scope of the 'wholeness' of accountabilities.

As a consequence, we have always kept the extended but considered view of science as an inquiry made of nature *by* man, and redounding to the benefit *of* man and for man. The epistemic evolutive process by which this science asumes its position in the whole treasury of knowledge is certainly scientific both by nature and indeed by nurture. What we might seem to be positing at this point may appear rather anthropomorphic. Science by implication will lose its coveted autonomy with the sciences of the humanities breathing over its shoulders. And to think that it was many hundred years past that science have assundered its umbilicals from the humanities!

The inner dynamics of science is all its own and inviolable. It is in fact man's greatest discovery, as Yukawa' believes. Its autonomy will always be present so long as its fundamental methodologies are sustained. But as what we have seen earlier, the scientist's figure is becoming more and more distant from his undertaking. Theories are being constructed and deconstructed for their own sakes, independent of the proposer and the user. It is thus a process of the dehumanization of a hallmark of a human discovery which science is. The epistemology of such an independent science proceeds in the absence of the knowing subject.

What greater science can we have than that of the science by man creating the science of man, and vice versa! Of course, it is all too obvious that the absence of man in such an epistemology is unrecognizable and anonymous without its subject. It was the indefatigable student of scientific discovery, Thomas Nickles (1990) who said that since "discovery is an achievement, discovery includes justification."[59] This must extend to the subject-form 'justification.'

What he is trying to say here, I believe, is that discovery as a process is an area for analysis and anatomy, and thence would lead to its level of 'justification.' If what he meant by 'justification' alludes to the 'logic of justification,' Nickles would be orbiting in the same firmament of conviction as Polanyi whose thesis on this matter we have seen earlier. Discovery and the canonical justification are deemed as extensions of the normal simple apprehension, and differs only in terms of degrees and intensities.

Understandably, justification will 'normally' proceed onto many pathways, mostly unbeaten, since, as Gruber (1980) realizes, "creative proc-

[59]Thomas Nickles, Op. cit., p. 25.

esses may have certain similarities when looked at from the 'outside' view, but there is no a priori reason to presuppose that in the essentials of their inner systematic functioning, any two creative processes are alike."[60] Since this undertaking lends to the use of materials of case studies, the philosopher is forced to declare, "Pass!" Unless of course, he cares to join the likes of Polanyi in 'Post-Critical Philosophy.'

These observations reflect the transport from what is deemed as a broad hypothesis to something which is more specific, from the "reasons"4 of fact referring to the affective and emotive components. The autobiographical makeup are laid bare after starting off from the consensual biographics and certificates. This is a reflection of the cardinal value of the history of science in the advancement of science itself. We did not mean to explain thought as a mere re-enactment of earlier experiences. This procedure is farthest from creative act even in its broadest spectrum of tolerance. It seems more positively suggestive to posit the possibility of the immense virtualities a person is capable of, given the proper milieu in the dynamics of the understanding of scientists of the experimental and theoretical practices of science which enables them to pursue advances in their fields, e.g., the processes of accepting, correcting or creating theories. This is more than the statics of the process of logical gymnastics of the deductive interplay of a set of statements.

In this case, which is the *explanans* and which is the *explanandum?*

To a certain extent, we have explicitated on the issue that the human acts forged by the discoverers constitute the explanans and creativity as the explanandum.

The persistence of interest in the study of discoverings despite its avowed 'illegitimacies' on account of the myriad of cross-referencing embroideries, sets off one of the clear offshoots of the revolution taking place in the natural sciences at the end of the last and in the beginning of the present century. This phenomenon can perhaps be momentarily termed as the process of differentiation. It is a result of a collusive equilibrium that takes place after a tenuous bifurcation occurs between the necessities of social development and indeed, the internal systemics and character of scientific knowledge as such. For one thing, new subdivisions continue to germinate and appear, and finer differentiations of sciences are nurtured. This phenomenal differentiation is viewed as a reflection of the swing of knowledge emphases from the abstract to the more detailed erudition, a situation which by now, we must already be forewarned as being part of the whole pendular swing.

We realize that this too, is but another phase of the phenomenon of intersecting multidisciplinarities. The atomary divisions and further suba-

[60]Gruber, Op. cit.

tomic subdivisions taking place in intellectual pursuits equilibrate in a mutual penetration and coherence into a revised and unified whole. It is observed that the strict and narrow specialization of the discoverer's intellectual life actually consist a small fraction compared to the worldview they later embrace and champion. There comes a point, another Active turn so to say in their career paths, wherein they cross the Great Divide' to an integration of general causality and interconnectivity of various forms.

Perhaps, we can explain this dialectical differentiation and integration of the form and matter, of the substance and style, taking place in the natural sciences, as its own concrete manifestation of the macroscopic thema-antithema polarities which we have seen Holton illustrate.

If the formal systems of natural science behave the way as they do, is the inner dynamics of nature's behavior substantially different? Does the question tacitly encourage a kind of metaphysics? The figure of the cyclic pattern of our environment was a commonly held conviction by the earliest naturalists and physicists. This construct they glued from mere observational clues.

But within this overall framework, the premises are still held and must therefore be clear that as no two creative acts would exactly operate in the same way, no two creative products which are similar in nature would be accredited as canonical at the same time. Then, are case studies, e.g., of the discoverers, condemned to cases as such, *sui generis*? Then too, are the discoveries evolving out of such eventual cases to be taken in a similar atomary fashion and epistemics?

When we mentioned earlier about the bottomline mutual referencing between discovering and discoveries, about the chicken-egg 'dilemma; we were encountering an 'expected and inevitable' situation, which we now can tern after undergoing through the winding but necessary process. This is called the 'bootstrap' problematics. Vollmer describes this situation in the following manner,

> In its broadest sense, the bootstrap idea says that nature is as it is because that is the only way for nature to be consistent with itself. To describe nature correctly would mean to recognize all its traits as necessary; no arbitrary fundamental constants or laws could be tolerated. Elementary particles would not consist of even smaller particles, but would constitute dynamic structures which owe their existence to the same forces by which they interact with each other.
>
> A familiar picture, developed by Hideki Yukawa', qualitatively describes a pair of nucleons (protons or neutrons) as being held together by the exchange of mesons. Now, what are mesons? A

> meson would be, in turn, a bound state of two nucleons, namely just the state it helps to build up. The mass of the meson would then have to be mass of the two-nucleon system bound by the meson. This chain of inclusions would continue indefinitely: mesons are pairs of nucleons which are pairs of mesons which are pairs of nucleons, etc. . .[61]

With a systemic picture of nature working in the manner which the meson theory of Yukawa' illustrates, we raise a similar parallel question: could the study of the process of 'discovering' from 'discovery' be far from behind? Does this systemic approach and framework not strike a familiar cord in our minds? We have witnessed, to cite an example, the ancient problem of 'change' how it evoked the enduring thema of the cyclic figure of the Icon of reversibility of nature to nature hovered over every change conjured.

Or even with the Platonic world of Forms. Vollmer pursues this analysis with the following,

> If there is, indeed, a circle, it is not a vicious circle, not a fatal blind alley, not a sterile trap of self-contradiction. It is rather a virtuous circle, a *circulus virtuousus,* a fruitful self-correcting feedback-loop, a system with new properties which one of its parts possessed at the outset, and with effects which neither of its individual elements could have produced. . .[62]

The argument assumes an altogether different dimension when one shifts from a logico-theoretical type of reasoning, to a logico-historical approach of which an empirical epistemology is what is all about. As such, it "relies heavily on empirical facts – on the existence of knowledge, of subjective cognitive structures, of impressions, sensations, recollections, thoughts, inferences of communication, language and understanding, on the partial fit between subjective and objective structures, on facts of science in general, and of evolution in particular, on the fact that there are structurally different cognitive devices culminating in man's central nervous system."[63]

The profound involvement, the fanaticism for experimentation, the prolonged and patient incubation of thought by patterns of the 'how and why,' yet while they are experienced, they require awesome efforts to elucidate. P. Souriau describes this 'moment' in this manner,

> Even genius has need of patience. It is after hours and years of meditation that the sought-after idea presents itself to the inventor. He does not succeed without going astray many times; and if he thinks himself to have succeeded without effort, it is only

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[61]Thomas Nickles, Op., cit., p. 25

[62]Ibid.

[63]Ibid.

> because the joy of having succeeded has made him forget all fatigues, all of the false leads, all of the agonies, with which he has paid for his success.[64]

Einstein's mainframe of "stubbornness" flashbacks. And so too, his inexplicable joy and release, reverberates. To describe the agony and ecstasy that sustains a scientific discovery must be a discovery itself as far as the discoverers are concerned. It is an ambivalent emotion to relive and reenact an overpowering enterprise which the discoverer will never be able to understand even by himself, why he took it upon himself to assume such a vocation, and much less, explain why. The magnet which the problem pulled his whole life of time and dedication will forever be incomprehensible to those who have the least inkling of the fiber which runs though the skin of these immortalized mortals.

Replications

Selectivities and specificities are grounded on values. Man assumes his position in this world and leads the kind of life he makes for himself, on account of his concepts of values, the valuation he imbues on both his ideal and praxis. The humanity of scientists are not immune from these value systems. Values cannot be defined by themselves. They are defined by people who composed them as they are lived. Values are more affectively caught than intellectively taught. They refer to the overall ecology and geography which pulsates and beats in man's interiority and environs.

1. We have seen that determinations made of the objects of scientific knowledge undergo the scrutiny of scientific epistemological values. The overall conceptual pattern made out of a set of empirical data reveals a large degree of imposed structures, norms, standards of objectivity and of epistemological values. They are interfaces of rational, technical and social forms of objectivities. It is one of the tasks of a genuine philosopher of science to sift into these forms of interfacings to determine the finer contours and confines of a given theoretic and value orientation. Throughout our discussions, we have developed the theme that the empirical content as object of science can never be conceived without their attendant epistemic and ontic frameworks, and therefore, the scientist's fingerprints and signature can "possibly" be quarried from the theoretic. Somehow, this leads to the implication, *ceteris paribus*, that there is no, or, there ought not to be, a sharp separation between the scientific undertaking as such, and the philosophy of science that goes with it as its interpretive and critical component. Science, akin to its empiric materials, possesses in its very grooves and fibers, an equally unique philosophic disposition. It follows then, that the historicities that science must undergo, must reverberate a corresponding epistemic and ontic restructuring in its

[64]Ibid.

philosophy of science. Thus, we have observed the radical shifts in frameworks for example, to the non-Cartesian, non-Euclidean, and non-Baconian modes of theoretic frames. It is precisely in these evolutive frames together with their empiric contents that historic references are tracked. And within these historic references do we find the "subjective" components of the discovery, e.g., the processes of discoverings.

2. Indeed, scientific discoverers are no less human and as such, are no less immune from the matter and form of values. It is in terms of the values that they harbor, that they have invested their whole lives in scientific pursuits in general; it is too, in terms of their treasured values that they have limited their concentrations on very special problems which intrigued them most. Values constitute the center of gravity of problem-choices. And values are personal contraptions of man, the scientist. In this seemingly psychological pursuit lies and lurks what may surprisingly be metaphysical postulates.

3. Furthermore, this instrumentation and coinage of metaphors by scientists, as we have seen in Einstein and Yukawa', to cite just a few, bears a lot of meaningful implications from its primitive value origins. If we accept the fact that theories are crystallizations of people's attitudes, views and values, as Jose Agassi (1986) bluntly adverts to in his opus *Science and the Interpersonal,* metaphor use in scientific discoveries can justifiably lead to the scientist's personal and societal digital information. The 'quantum leap' styled by the scientist from the set of sense data and information to the hypothesis and theoretic level is by the ordinary means of 'justification' unbridgeable. We have seen this mortality affirmed on several occasions earlier. A creative process known as the *"autopoesis"* or the *"poetikon,"* succours the scientist 'of facts,' and fashions him into a role which leaves those extra baggages behind, and handcarries the essentials or other lightweight 'substitutes.' Does this mean that he no longer plays the role of a scientist or a discoverer at this point?

The answer is both yes and no. The scientist cruises at an enormous height distant from his primitive materials without losing reference to them when he reaches the stage of the theoretics. He must do this, as Hanson insists; and the fact that he is capable of reaching and scaling such flights without experiencing a fatal vertigo, means, I reckon, an essential role of his being truly a discoverer. This talent is of course not found in mere laboratory technicians, and much less, in those who are suffering from anti-social lunacies. In addition, he is constrained to avail of other instrumentations, the *'poeticon'* for example, which is inherent in him as member of the human species, and intricately used by him as an outstanding member of his species. This is not entirely alien to his profession, that is, if his profession is meant truly, for man, nature, and ultimately, for himself. This element is his contact point with the philosopher, the artist and the poet, what Einstein referred to in the Temple. In this universe, the scientist interfaces, abducts, and conjures

the Temple for all. He does not cease being a scientist; indeed, he does not have to. That he is able to scale such privileged heights is precisely because of his having been true to his scientific commitments which he had lived so devotedly.

Yukawa' observes that scientists can be sorely bedeviled too, by an outlook that swings between the unbelief of anything that is not verified, and the outlook that will discount nothing that was not verified not to exist or not to have happened. Herein lies the genius of the 'via media' realism of Yukawa' and Einstein. The laddenness of facts with truth and logic will have to be interpreted and hermeneuticized. This means that the scientist will have to be 'more' of a scientist when he leaves his *in vitro* encapsulations and live *in vivo* for others.

4. We have seen that a tool which remedies the chasm is by 'changing' the situation, so to say. It ought to be an epistemic instrument which is capable of putting the situation under charge and control by 'substituting,' extrapolating, or enlarging the scope of the confines of the concrete. The usual univocal sense ceases to function at this point. This is what Yukawa' did in our discussion in the Analogous Referent, for example.

The process of analogy creates a metaphor, or an ornament (kosmos). It is a very curious matter that the Greek equivalent is prodigious about the formation of some kind of a worldview. The metaphor or ornament then, performs the function of a representational task by the principle of substitution.

Obviously, the job description for the task to be accomplished warrants an extraordinary kind of a taskmaster. This is necessary for a unique set of circumstances which transcend the material frontiers of the 'normal' and the pedestrian.

In the Aristotelian thought tradition, metaphors are of highest regard. Metaphors are considered the "best and the most popular."[65] This observation may seem to lead to two points at least. Metaphors are the best ways of expressing, given the situation needs; and it is the best way because it is able to accomplish the job description of being understood and being intelligible even in its inexhausitible intimations.

5. As a product of analogical thinking process, similarities are sustained in a determinate context, and dissimilarites are occasioned by a system of 'forgetting' or suppressing a sector of the meaning. Within this interplay is the substitution that is processed which is understood and recognized by the mutualities of cross-referencing. It is here too that imagination plays its unique role of futurology in metaphor building and

[65]Gruber, Op., cit.

usage. It is at this point that imagination plays its own nature and goes native, e.g., it insinuates, it intimates, it suggests, the image or metaphor in the absence of the object. How this is expressed in language forms is of course another issue. We have seen samples of these forms in some first person quotations above.

6. Identification of subject and object does not in any way forestall objectivity in scientific activity. Objectivity does not require and demand the loss of identity of the subject in its union with the object. It is an objectivity which recognizes and accepts the emergence of the object within the framework of a social dimension wherein the theoretic is submitted to intersubjective assessments. Objectivity is not simply a matter of having the true or correct assertion statements. It is required that a grasp of the reasons for such convictions is necessary for which reason probably why it appears tenable that justification and discovery are not clearly demarcated. They can not be sharply demarcated for the obvious reason that the 'probings' will always seek for the proofs. As was mentioned earlier, it is a kind of personalism that is submitted to universal criteria, so that, what disappears or diminished is the kind of 'individualism' that has no locus in such an undertaking endowed with a public trust. There could be not better manifestation of a more graphic scientific attitude than that of one's self-critical and reflexive use of referents, and the facile admission of one's fallibility. It was within this same set of parameters that this study of *ante hoc* personal convictions of some discoverers was attempted. Hereon, the terminal points are established, i.e., between the subjective and the objective, between the intuitive and the discursive, between experience and the theory.

This reminds me of a very striking statement which Hanson made regarding the nature of scientific discovery debate. He writes, ". . . The exclusive and exhaustive dichotomy `Psychology or Logic," may win debates occasionally, but it cannot win the guerdon of truth. . ."[66]

Hanson's wisdom saves him from viewing the issue of discovery in a simplistic manner. Rather, it is everything but that.

Psychology? Or Logic?

7. It is inevitable that a frame of the idea of scientific progress be conceived in terms of epistemic ruptures of conceptual constructions, destructions and deconstructions, both in terms of increasingly more intense features of scientific approximabilities and continuabilities. This is possible in a context of a reflexively, critically conscious rational being. Such features obtain from at least two flanks, the empirical and the theoretical. The increasing sophistication of the treatment of the empiric materials occasion greater accuracy and mastery, and the heightened

[66]Thomas Nickles, Op., cit., p. 25.

mathematicization of the dialectical generalization leads to a more abstract theoretic. It is implicit here that Yukawa's 'when' point of convergence, compared to the 'how' process, is more crucial in discovery as it is more difficult to determine. The 'unique' factor, that of the knowing subject and the character of his thought processes taken as historically developmental, is more profoundly positioned in a reflexive and reflective 'turn' of the discovering.

8. It is inevitable too, that the nature of the dynamics of conceptual change is spread out within a matrix of interconceptual relational issues, since an 'atomary' type of change of a concept is difficult to conjure, as it is unrealistic to conceive an object independent of the world of which it is more realistically a part. Within an analogous view, the 'success-referent' theory so called, finds application here wherein the historical emergence of a solution takes place within a specific and determinate epistemological field, which parameters, the problematics was fertilized and conceived. The epistemology of science does not only demand a historical component. It is in itself, historical by nature.

9. From the foregoing, the observation that a tractatus on the role of intuitions and imaginations in scientific discoveries as 'bogus and non-science,' akin to what we have seen on several occasions earlier, can now be better handled. Aside from the fact that such 'amorphous' phenomena are humanly inevitable, it is deemed that it is during these 'amorphous' situations that the 'dynamic' principles of a unique kind are made operative in the broad context of a seeming absence of coherence and convergence, the very goal toward which the intuition – imagination tandem are working. It must be admitted though that while intuitions must change, and indeed quite so often in the most drastic and radical fashion; but like the 'metaphysics' so called of nature, change and transform they must as made manifest by scientific progress that visibly takes place.

10. Complete adaequation between rational representation and the represented domains of experience is at once an idealism that is unimaginable in science, from both sides. This is short of saying that the modifier as completed does not belong to the vocabulary of nature, nor, to the capacities of a scientist. Thus, a continuing cyclic development which leads the virtuals to the 'virtuous' existent is properly, and as a matter of fact, the only countables as scientific knowledge. The only 'permanent' feature of science is change, and when it ceases to do so, it ceases to be one. This revision involves the diverse spectra of the theoretics, rational structures, conceptions of rationality, causal explanations, etc. ❑

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