Visuals and Visualizability as Scientific Themata

THE THEMA OF CHANGE

The ancients started it all. "What is the reason for change?" The early thinkers were perplexed with environmental change. They were ecologists mystified by a philosophical problem. With more *thinking* than *doing*, the 'guesses' appeared highly provocative and today, we realize, prognostically prophetic.

Let us reminisce over the scenario very briefly.

Thales thought that the *reason* for change was water; Anaximenes chose air and Heraclitus chose fire.[1] As the source of all reality, the materials variedly were adaptive and reversible according to the now greek classic, the *cyclic* motion. Diffusibility and omnipresence facilitated the cycle. Anaximander was more abstract with his "indeterminate" (*apeiron*) and Anaxagoras foreshadowed the Philosopher with his "simple substances" (*homeomerai*).

Illustratively, the four elements compounded by Empedocles appear very prophetic into what moderns now accept as the four

[1] John McDermott (ed), *A Cultural Introduction to Philosophy* (New York: Alfred Knopf, Inc., 1985) pp. 51-67.

states of matter, i.e., solid (earth), liquid (water), gas (air), and plasma (fire).

Plato geometrizes by representing fire as a tetrahedron, air as octahedron, water as icosahedron, as multiples of an isosceles triangle. This was the basis of the elemental cyclic interchangeability. Earth being a cube and a multiple of an equilateral triangle is scattered all throughout the other elements. Plato was convinced that mathematics constituted all physical phenomena as structure and key. It is of no small wonder therefore that many a commentator record that the sign "Let no one ignorant of geometry enter my door" was inscribed at the entrance of his school.

The model introduced by Anaxagoras was recognized by Aristotle's salute with the encomium "the most sane" (*velut sobrius*) of them all.

The standard commentary which classifies the majority of the thinkers mentioned above as sensualists or naturalists does not seem to require any apology. They initiated the ground breaking for what we now appreciate as models and paradigms aside from having ignited the seminals in the developmental historicity of scientific themata. The physical models were nonetheless prophetic of a Plato, a Newton, or an Einstein. Ranging from mechanistic to mathematicals, to dyads or triads, the stage was set. The scenario and the performers would continue to change.

The *visuals* were installed. What was needed was *visualizability*.

The Aristotelian Initiation

By and large, reference is made to the kind of induction which was formulated by Aristotle in his monumental opus, *Posterior Analytics*.

Induction and deduction are complementary. Induction is considered as the *starting point* and a prerequisite of deduction which is considered as *the* syllogism by the Philosopher.[2]

[2] *Ethics*, VI, 1139b.25. "Now induction is the starting point which Knowledge even of the universal presupposes, while syllogism proceeds from universals. There are therefore starting-points from which syllogism proceeds, which are not reached by syllogism; it is therefore by induction that they are acquired."

Thomas Aquinas views the instrumentality of induction as a necessity in order to arrive at *some* universal.[3] From this point on, *the* syllogism begins to function. We now oscillate between the necessary and the necessity.

The Philosopher mentions *memory experience* whereby an integration of a series of the same species of individuals produces a *single* experience.[4] Experience is analogized (*seems pretty much like*) with *science* and *art through* which experience thrives on as a channel.[5] Experience thus made *art,* or experience made *science,* is the "mystical" gulf which when fathomed, becomes the consummation of the *art* or *science* of inductive thinking in the Aristotlelian initiation.

Thomas Aquinas distinguishes experience as dealing with singulars, and art as comprehending universals.[6]

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[3] In *Ethicam Aristotelis* VI, 1.3, no. 1148. "There is a twofold teaching from things known: one, indeed, through induction the other through syllogism (deduction). Now induction is introduced in order to know some principle and some universal at which we arrive through experience of singulars, and is stated in *Metaphysics 1.* But from the universal principles known previously in the aforesaid manner proceeds the syllogism. Thus, therefore, it is evident that there are certain principles from which the syllogism proceeds, which are not certified by syllogism — otherwise one would proved to infinity in the principles of syllogism, which is impossible, as is proved in *Posterior Analytics I.* What remains, then, is that the principle of the syllogism is induction. But not any syllogism is teachable, i.e., causative of scientific knowledge, but solely the demonstrative syllogism, which concludes necessary things from necessary.

[4] *Metaphysics 1,* 980b 25. The animals other than man live by appearances and memories, and have but little of connected experience; but the human race lives also by art and reasonings. Now from memory experience is produced in men; for the several memories of the same thing produce finally the capacity of a single experience. And experience seems pretty much like science and art, but really science and art come to men through experience; for 'experience made art,' as Polus says, 'but inexperience lack.' Now art arises when from many notions gained by experience one universal judgement about a class of objects is produced. For to have a *judgement* that when Callias was ill of this disease, this did him good, and similarly in the case of Socrates and in many individual cases, is a matter of experience; but to judge that it has done good to all persons of a certain constitution, marked off in one class, when they were ill of this disease, e.g., to phlegmatic or bilious people when burning with fever — this is a matter of art.

[5] *Ibid.*

[6] In *Metaphysicam Aristotelis, I.* 1.1, no. 18-19. "Now the way in which art is produced from experience is the same as the aforesaid way, in which experience is produced from memory. For just as from many rememberings there is produced a single experiential science, so from many experiences there is produced the universal grasps of all similar cases. Whence art has this over and above experience: namely, that experience is concerned solely with singulars, while art is concerned with universals. Sub-

A *complete* enumeration of singulars is ruled out, for obvious reasons. This is attained on the basis of species . Thomas Aquinas in fact employs this restriction and viability of induction in his opus, *Exposition of the Posterior Analytics II*, to propositions regarding *some certain* herbs as a common medicine for *certain* skin diseases.[7] *Specificity* is the name.

While science pertains to the necessary, e.g., numbers or figures; art, in the restricted sense, deal with the *makeable*, and in the broad sense, as compounding with science regarding the necessary, e.g., *those things which are always in the same way.*[8]

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sequently he (Aristotle) expounds this with an example, saying, "For to have a judgement that when Callias was ill...," for when a man has received into his knowledge that this medicine has benefited Socrates, and Plato suffering from some certain sickness, and many other singulars — no matter what the thing is — this pertains to experience. But when someone receives into his knowledge that this benefits all in some determined kind of sickness, and according to some certain complexion — as that it has benefited those with fever, both the phlegmatic and the bilious — this already belongs to art."

[7] Exposition of the *Posterior Analytics, II*, 1.20, no. II. nevertheless in different singulars, experience is seen to be nothing other than to receive something from many things retained in the memory. But nevertheless experience requires some ratiocination about particulars, through which one is related to each other, which is proper to reason. For example, when someone remembers that a certain herb has many times saved many from fever, this is said to be experience that such a herb is curative of fever. But reason does not come to rest in the experience of particulars, but from particulars of which one has had experience, it grasps one common thing, which is confirmed in the soul, and considers it without any consideration of any of the singulars: and this common thing it takes for the principle of art and science.

For example, as long as the doctor considered that this herb cured Socrates when in a fever, and Plato, and many other singular men, it is experience; but when his consideration rose to hold that this species of herb cured a feverish man absolutely, this is taken as a certain rule of art of medicine. This, therefore, is what he (Aristotle) says, namely, that just as from memory experience comes about, or even further, from the universal coming to rest in the soul ("i.e., from the universal now stabilized in its entirety within the soul"), which, namely, is taken as being thus in all, as experience gives it to be in certain ones... from this experience, therefore, and from such a universal arrived at through experience, there is in the soul that which is the principle of art and science.

[8] *Ibid*... He (Aristotle) distinguishes between art and science, as also in *Ethics VI*, where it is stated that art is the right reason of making things. And therefore here he says that if from experience there is arrived at something universal concerning generation, i.e., concerning any makeable things whatsoever, e.g., concerning curing or agriculture, this pertains to art. But science, as he there says, is concerning necessary things. And therefore if the universal is considered concerning those things which are always in the same way, it pertains to science, e.g., concerning numbers or figures. And this mode which has been stated applies to the principles of all the sciences and arts.

But how does a sample of singulars precisely evolve into an intelligible universal?

The words used by Aristotle are *congregate, immovable* — until the principle of art and science is attained. While singulars can be added without resulting in a universal, the emergence of the universal from a gathered sample of singulars requires the facility of some kind of an *intellectual vision,* the resultant of which is no mere numerical sum but a *unified* whole, the identity of which is entirely distinct from mere addition of perceived commonalities or an aggregation. Thomas Aquinas quotes the emphasis which Aristotle places on what is ultimately the principle of *'natura non frustrat'*, i.e., the intellect possesses the faculty of being susceptible of universal knowledge —possible intellect; and the faculty to realize such potency — active intellect, which makes things intelligible in act through abstraction.[9]

The qualities which are 'universalized' need not pertain to the essence. They may pertain to the samples in an *accidental* mode such as lustrous, powdery, melts at such temperature, etc. In the opus, *Physics,* Aristotle asserts that the intellect perceives in *one* sample, though vaguely, the initiation into the *earliest* universal.[10]

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[9] *Ibid.* Someone might believe that sense alone or the memory of singulars might suffice to cause the intelligible Knowledge of principles, as certain of the ancients laid down, not discerning between sense and intellect. And therefore, to exclude this, the Philosoher adds that along with sense it is necessary to presuppose a soul of a nature such that it is able to undergo this, i.e., which is susceptible of universal knowledge, which comes about through the possible intellect, and again which is able to do this, according to the active intellect, which makes things intelligible in act through abstraction of the universals from singulars.

[10] *Ibid,* no. 14. How this one thing can be arrived at he manifests subsequently. For it is plain that the singular is sensed *properly* and *per se;* but nevertheless sense is, in a certain way, of the universal. For it know Callias not only as he is Callias, but also as he is 'this man', and likewise Socrates as he is 'this man.' And thence it is that when such a grasp of the sense pre-exists, the intellective soul can consider 'man' in both.

But if it were such that the sense apprehended only that which was of a particular nature, and in no way apprehended with this the universal nature in the particular, it would not be possible that from the apprehension of sense there should be caused in us the knowledge of the universal.

And he manifests this same thing subsequently in the process which is from species to genus. Whence he adds that again in those things, namely, in man and horse, the soul persists in its consideration until it arrives at something indivisible in them, which is the universal. For example, we consider this animal and that, e.g., man and horse, until we arrive at some common animal which is the genus, and in this we do the same until we arrive at some superior genus (i.e., ultimately the category of substance).

Thomas Aquinas shifts from the word immovable in a *congregated* set of singulars of Aristotle to his own *indivisible,* which he asserts as *the* universal in the same commentary on the Philosoher's *Posterior Analytics.*[11] In this way, induction arrives at the *immediate* propositions by proving that the major term belongs to the third term by means of the middle term; whereas the syllogism proves the major term to belong to the middle by means of the third.

Since inductive product statements are not arrived at by numerical counting, the issue on the validity of the statements does not address itself to 'complete' or 'incomplete' enumeration, if we may reiterate the point. A physical law or a judgement on "the best remedy for a certain kind of skin disease" will not emanate from the arithmetical process of addition.

This 'universal' however, could either be *necessary* or *probable.* The concept of probability equates with the issue on constructs, conditionals, hypotheticals, etc. The probable lends its force on the samples *at hand.* This means that what has been demonstrated has not yet graduated into being the solution, absolute and exclusive. This trial and error method Aquinas terms as the discovery method (*via inventionis*) as a prelude to the judgement stage (*via resolutionis or via judicii*).[12]

Since therefore we attain the knowledge of universals from the singulars he concludes that it is necessary for the first universal principle to be known through induction. For thus, namely, by the way of induction, sense brings about the universal within the soul, inasmuch as all the singulars are considered.

Exposition of the *Posterior Analysis,* II, 1.20. no. II. The soul is so constituted as to be capable of this process (whereby the universal becomes 'estabilized in its entirety within the soul.'). Particulars has made a stand, the earliest universal is present in the soul: for through the act of sense-perception is of the particular, its content is universal — is *man,* for example, not the man *Callias.*

[11] *Ibid.,* no. 14

[12] St. Thomas not only mentions the system contrived by Eudoxus at the behest of Plato, but also the subsequent system involving excentrics and epicycles, evolved by Hipparchus and Ptolemy, and gives this also as a system which, while saving the appearances, and thus having probability, does not attain to an exclusive necessity: "... In astronomy there is posited the explanation of excentries and epicycles on the basis that, this supposition having been made, the sensible appearances with regard to the heavenly bodies may be saved. Nevertheless this explanation is not sufficiently probative, since possibly they might also be saved on the basis of some other supposition." *Summa Theol. I, q. 32, a. I, ad 2.* ...Hipparchus and Ptolemy contrived *adinvenerunt* the movements of excentries and epicycles, in order to save those things which appear to the senses in the heavenly bodies. Whence this is not a demonstration, but a certain supposition." *In De Caelo, I, 1.3, no. 28.* Also see *In De Trin., 1.2.q.2,a.1,c.*

The tentative firms up into definitiveness. Thus Aristotle promotes an attribute which is found in every instance of the subject to an *essential* attribute. Given a difference in the magnitude of 'sampling' and in the usage of more sophisticated instrumentation, today's approach in the study does not bear an essential difference.

The intermediate premisses are a product of the same process which leads to the dialectical premisses, which premisses lead to the scientific stage. Again, this is essentially similar to the proof by elimination utilized by modern science today.

Hence, induction involves both the rigors of *systematic* syllogism and the ultimate *'intuition'* of the universal.

The various stages which the intellect undergoes are not *per se* disparate and independent of each other but one essentially involved process differing in levels and in intensities. Consequently, the end-product of either a necessary or a probable, Aquinas considers as something not proved, but something that is *seen*, "coming to rest in the soul".[13]

THE SCIENTIFIC METHOD

Generically, the underlying problem is twofold: 1) the epistemology of the *content* which deals with the theory of Knowledge of *how* the content of the object under study works in its environment, and 2) its embedded ontology, e.g., *what* is the basic structure of the same material object.[14]

The pendular swing of the cognitive historicity has been no less colorful.

There were the sensualists or observationalists to use a current terminology. The atomism championed by Democritus is characterized by both epistemological and metaphysical intents.

[13] *Op. cit.* 1, 20, no. II.

[14] Werner Heisenberg, *Physics and Philosophy*. New York: Harper & Row, 1962, p. 4. See also J.O. Wisdom, *Changeability in Modern Science*. England: Tower Publishing Co., Ltd., 1987. p. 5. The atomism conceived by Democritus also gave ambivalent implications, e.g. metaphysical and epistemological.

Plato and Aristotle were incorrigible essentialists, the impact of which experienced hot or cold in the context of later alchemy and theological disputes.

The Renaissance saw the adrenalins boil for the art and a reaction *against* the suffocating hylemorphic duo.

The anti-essentialistic wave was brewing and was set to stratify. In this frame of mind was modern science born. The leitmotif included observationalism trumpeted by the *Novum Organum* of Bacon. The list of personalities includes Berkeley, Hume, Russell, etc., giving rise, among others, to such ferments as logical analysis, logical positivism, linguistic analysis, etc.

While the past was considered mythical and superstitious, and therefore, to be rejected, the logic of induction in whatever form they have applied it to use, was generally accepted.[15]

Wittingly or unwittingly, the inductive inference which transforms a set of particulars to a universal was being revived again. But whether the inductive skeletons were being drawn from the closet of its traditional formula is the more interesting episode.

If such issue were then highly debatable as they were made to appear, it was not farfetched to imply that the extended flow from the generalization level to constructs, would suffer the same epistemological quicksand.

Furthermore, would this mean that scientific research and discovery, and technology as the concrete evidence, would in reality, be a simple case of *reductio ad absurdum?*

There is no argument against (technological) success (*contra factum, nullum argumentum*). More than caution, the terms such as constructs, approximates, conditionals, hypotheticals, and the like, appear to be more than just and realistic. The possibilistic or probablistic stance of such concepts are determined to the extent that an additional confirmatory evidence comes to the fore. This is further evidenced by the emergence of the other schools of thought which bore one unifying fabric — they were fundamentally anti-essentialistic.

[15] J.O. Wisdom. *op. cit.* pp. 36-39. See also Imre Lakatos, *Mathematics, Science* and *Epistemology*. London: Cambridge University Press, 1978. pp. 128-160.

Instrumentalism points to theories as predictive tools. Influenced by logical positivism, this school appears to be a clone of the infamous Galilean controversy.

Bridgeman takes up operationalism.[16] True to form, the concept in meaningless until one is able to make it *function* and *operate*. Concerned with meaning and reality, *doing* is capsulated in an operational definition.

Conventionalism stresses on theories. Definition of terms is motivated by the prospect of the terms integrating into the structure of the theory and play the role of either verification or falsification.

Experimentalism is an incorrigible conviction that all science is about and within experiments. No experiment, no science, and the only *true* science is the *doing* science.

While the contemporary currents of philosophy of science harbor a mirage of what would seem ultimately as skepticism in sheep's clothing, the sixteenth and seventeenth century science exuded an air of confidence and certitude. The pillars of the succeeding periods such as the likes of a Kepler or a Newton assumed a stance of *fallibility*.

Regardless of wineskins, the same pendular swings remind us of the old favorites and familiar tunes in terms of nominalism, conceptualism and realism of the medieval times.

Friedrich Dessauer outlines the so-called hypothetico-deductive or inductive method of science.[17] He mentions five steps:

> (1) Tentatively, propose as a hypothesis a provisional statement obtained by induction from experience and previously established knowledge of the field. An example, drawn from experimental work in physics, might be this: the observed large loss of sound energy when ultrasonic waves pass through a liquid such as water is possibly due to a structural rearrangement of the molecules as the sound wave passes by

[16] R. Harre, *The Philosophies of Science, An Introductory Survey*. Oxford: Oxford University Press, 1985. pp. 76-87, 162-167.

[17] Friedrich Dessauer as quoted by G. Holton, *Thematic Origins of Scientific Thought*. Massachusetts: Harvard University Press, 1973. pp. 47-48.

them. (2) Now, refine and structure the hypothesis — for example, by making a mathematical or physical analogon showing the way sound energy may be absorbed by clumps of molecules. (3) Next, draw logical conclusions or predictions from the structured hypothesis which have promised experimental check — for example, if more and more pressure is applied to the sample of water, it should be more and more difficult for the associated molecular groups to absorb sound so striking. (4) Then check the predicted consequences (deduced from the analogon) against experience, by free observation or experimental arrangement. (5) If the deduced consequences are found to correspond to the "observed facts" within expected limits — and not only these consequences, but all different ones that can be drawn (behavior at constant pressure but changing temperature, or similar effects in other liquids) — then a warrant is available for the decision that "the result obtained is postulated as universally valid". Thus the hypothesis, or initial statement, is found to be scientifically "established".

Given the pathways above, the modern scientist is to assume the widest realm of objectivity, intellectual integrity, error-consciousness and nature-centeredness as the inviolable reference point. The latter criterion for example, makes the stand that the repeatability of experiments carried out under precisely the same results, hence, the underlying transcendental cause — effect structure. This works on the important assumption that we are intently trying to dissect nature as it really is and we do not really produce a new phenomenon other than what nature does not originally possess. What we have precipitated is a set of the regular patterns which occurs in nature through the instrumentality of artificial sophistication. Galileo's defense of Copernicus was reinforced by the use of a newly invented instrument, the telescope, demonstrating that science and instrumentation are bonded by a mutuality of 'destiny'. Hence, their studies on the suction pump, mechanical clock, optical instruments, etc. Of Copernicus, Galileo, and their successors in the 16th and 17th centuries, we follow the same essential method today. Galileo's theory of nature was based on *Posterior Analytics*.

When Aristotle stated that light bodies fall at less momentum than heavy bodies, Galileo amended that all bodies fall with the same speed in an experiment of an empty space.

The dividing line in the inductive inference therefore lies between what Aristotle confirms in *Posterior Analytics* as the knowledge of the fact (observation, recording, analysis, classification of these facts) and the knowledge of the reasoned fact (inductive derivation of generalization, modeling, prediction and retrodiction).

VISUALIZABILITY

Visual thinking is a way of thinking which is viewed as non-algorithmic and almost non-analytic. Visual images "float" in the mind and this could be sketched on paper. The *Gestalt* overview of visualization transcends the part-by-part or step-by-step approach which we are more familiar with. As elementary intuitions, they are pictures or imitations of reality midway between object-experience and mental construct. In the articulated level, the intuition attains an 'equilibrium' which is both stable and mobile. Gestalt psychologists consider perpetual frameworks and constructs as a product occasioned by psychological changes occuring in the nervous system of the individual as a reaction to the stimuli ignited by physical objects. The sensorimotors account for a large degree of the outcome of the "look of things." Jean Piaget affirms that ". . . . we can get to know objects only by *acting* on them and by *producing* some transformation in them."[18] The stimuli referred to involve a totality, a *"togetherness of a series."* Hence, descriptions such as "roughness" or "volatility" are not considered merely as local impressions. They are translocal and field attributes. The Ehrefels' qualities such as "simple, complex, harmonious, regular", and the like, are predicated to a totality, or to an organization, so to say. If the attributes possess translocal characteristics, the process involved in transcribing them must possess the same intensity. They involve extended events which distribute and regulate themselves as functional wholes.[19] The

[18] Jean Piaget, *Six Psychological Studies*. New York: Vintage Books, 1968. p. 128.

[19] Wolfgang Kohler, *Gestalt Psychology*, New York: Mentor Books, The New American Library, 1947. p. 105.

term comprehends attempts, learning, acting, visuals and visualizability.

Retinal stimulation is connected to the formation of visual images. The visuals of the present exclude the past though the current image maybe an integrated form of past attempts to visualize. Relations of a given pattern are very crucial. After the *experienced* form reaches its "dead" interval or "empty time" slot, it is absorbed into the wholes or subswholes. It has been proven though that past experience does not necessarily impose an automatic effect on subsequent patterns. In all these, shapes and visuals are always correlated. Relations of the stimuli determine the shape though a pre-judgement of which relation is more important than the other, is an open game.

Gestalt psychologists in their intent to formulate laws of "how things appears", i.e., how parts combine into wholes include factors among others such as proximity, similarity, direction, uniform destiny, etc. The endpoint takes on the pattern which is of the greatest simplicity and clarity (simplicity of uniformity or a simplicity of articulation), and of figures which are of maximum symmetry and regularity. This is based on the fundamental premise that percepts tend toward "as good a figure." This, in effect is the law of *pragnanz.*

Equilibrium is a factor which means the balancing of all forces involved in the construct, both intrinsic and extrinsic, in the attainment of maximum continuity, regularity and symmetry. Thus frameworks, contours and boundaries are all assumed into the equilibrating process. *Meaning* is distilled in terms of configurational dynamics which is a property of an equilibrium — a whole which has attained organization, articulation, and goodness of figure.

This involves a three-pronged approach of cognition: "seeing", imagining and designing.

Seeing deals with a visual perception of the object which is then "paired" with past experiences. The gift of 'seeing' is the storehouse of the *level* or *quality* of visual images that is transported. A complex design for example can relate a multifarious

number of relationships depending on the depth and breadth of the thinker.

Imagining means creativity in perceptions, insights and options. It is the ability to conjure and compose mental images which goes beyond the here and now and stretch the sketch into its myriad of possibilities and probabilities.

Designing relates to the *expression* and the explicitation of the mental vision into an objective form.

These three general steps are one and integrated. They do not necessarily work according to a strict sequence but rather delve on a unique combination and chamistry of all these activities.

A typical illustration would run this way using the following simple problem.

> Imagine a jar with a lid that is 6 cm. across. The jar is 8 cm. high. At the bottom of the jar, there is a caterpillar. Each day the caterpillar crawls up 4 cm. Each night he falls down 2 cm. How long will it take him to touch the lid of the jar?

Algorithmic solution

Since the caterpillar climbs up 4 cm. each day and falls back 2 cm. each night, he will climb a total of 2 cm. after each full day. Since the jar is 8 cm. high, it will take him 4 days to reach the lid.

$4 - 2 = 2$	1st day
$+ 2 = 4$	2nd day
$+ 2 = 6$	3rd day
$+ 2 = 8$	4th day

Non-Algorithmic Solution

Close your eyes and "look and see" at the mental image of the problem at hand. Avoid the numerical data. Can you "see" the caterpillar inside the jar? Is it a glass jar? How

does a caterpillar look like? Draw an image of the jar and the caterpillar. Include the numerical information. The drawing properly labelled should evoke the correct answer.

There are approximately two phases which are attendant to a scientific discovery in general. The *private* and the *public*. The personal and the institutional. The human and the codified or canonical. Given the public, institutional and codified forms of, for example, a benzene ring, a helical DNA, an Einsteinian relativity or a Keplerian universe; what is the private, the personal and the human phase? How does the ordinary, apparently mechanistic process of data gathering analysis metamorphose to a model of a theory?

The situation is complex, not to mention exciting and mystifying. It consists of a web of factors which are psychological, sociogenetic, epistemological and a host of other components which defy the rigor of a step-by-step and linear process which many of us, on account of our familiarity with the codified form of science, are inclined to assume. The one-sided presentation of the codified form of science has robbed science education of the *essence* of the scientific enterprise, nay, it has deprived the learner of the "agony and ecstasy", where lies learning *per se*. Gunther Stent writes that the domain of the sciences "is the outer objective world of physical phenomena. Scientific statements therefore pertain mainly to relations between public events," and the rest pertain to art and the affective. This "agony and ecstasy" refers to the *art* and the affective aspects of science. To Max Born, there are no signposts, it is a jungle, in fact. Roads are built behind us and we agonize through trial and error, to construct the continuation of the road which lies ahead of us until we attain the ecstatic "high" of the *eureka* of the construct. This 'prescientific' stage or transition is immersed in its own motivations, temperaments, and intuitive leaps. The personal struggle experienced by the scientist is usually termed *intuition*, *invention* or *"happy guesses"*, etc., terms which do not bring us any further, if we are to insist on the structural over creative cognition. It requires a radical shift to explore the world beyond and beneath the phenomenic dimension of the empirical fact, a world where the signposts of an established logical calculus will have to be fathomed and distilled. In this sense lies the interminability of science, understood not to be

primarily made up of a body or a collection of traditions and protocol sentences but rather pictured as a 'Heisenbergic' cloud of potentialities and approximations.

Given thus, the *real* science lies in the *before* and *after* of the codified protocol statements. The *pursuit* of science, is *the* science. Historians of science in fact advance their observations that the trail can be besieged with the most outrageous incongruities and some of the most important contributions have mushroomed from wrong premises, erroneous hypotheses, faulty experiments and chance situations. It is not farfetched that trivial conclusions are drawn from significant findings and correlations are derived from apparently questionable facts. The atomic theory of John Dalton in 1800 is a classic case.[20] Yet, we are grateful to this man for concepts of the chemical atom, atomic weight and the Law of Multiple Proportions, despite the logical inconsistency and the inadequacy of his postulates. H.D. Smyth writes, "We have a paradox in the method of science. The research man may often think and work like an *artist*, but he has to talk like a bookkeeper, in terms of facts, figures, and logical sequence of thought."[21]

Kekule was dozing in front of a fireplace when he imagined he was "witnessing" the sight of dancing atoms moving in a snake-like motion. The snake grabs its tail and whirls in front of Kekule.[22]

The rest of the night became historic. Kekule 'forced' the daylight, testing the implications and the consequences of the hexagonal ring construct. The verdict: satisfactory. The cons-

[20] The Atomic Theory of John Dalton is dated at 1800. As a budding scientist, Dalton was engrossed in the study of meteors and specific gravities of gases. In his perusal of Newton's *Principia*, he admitted that if the gas particles repel each other with a force proportional to their distances, then so will their pressure and volume relationships. Dalton grabbed this relationship as a proof that real gases therefore *must* be made up of forces and particles. This gas particle is surrounded by a caloric fluid which is endowed with self-repulsion. Given different types of gases, then we have different sizes of the gas particles. With all these data, we have an explanation for the absence of equilibrium in the atmosphere. Despite the series of "discrete" statements, Dalton formulated several concepts on the chemical atom, atomic weight, the law of Multiple Proportion, etc. Here we have a concrete example of a set of discoveries without a proportionate "cause".

[21] As quoted by G. Holton, *op. cit.*, p. 387.

[22] Carl Hempel, *Philosophy of Natural Science*. New Jersey: Prentice Hall, 1966. p. 15.

truct is codified until such time when a better Kekule emerges and stands up.

Watson's helical DNA was prefaced by his long periods of hands-on tinkering and manipulating molecular models illustrating his mental gymnastics. The hands-on situation catalyzed Watson's mind into what is now universally accepted as the accepted structure further blessed with a Nobel prize.

Kepler is a concrete example of the multivalent influences of his age, quite different from that of the overly specialized contemporary scientist. In Kepler, we are deluged by the odd combinations of physics and metaphysics, astronomy and astrology, geometry and theology. This is quite understandable if we consider Kepler's times as steeped in animism, alchemy, astrology, witchcraft, etc., as the ideological metamorphosis was undergoing the birth pangs which always accompany the transitional pains from doubt to certainty and vice versa. The *"sacred ecstasy"* which Kepler would indulge in, reflected the theological strains of his thematic proposition.

In the ambivalence of Kepler's situation, Kepler's genius controlled the gears by shifting from physics to metaphysics, from a mechanical model to a mathematical representation. He was preoccupied with a *central, unifying image* and *principles* on the basis of a thema of a dynamic and mathematical harmony. Pythagorean by avocation, Kepler in his "feeling" for nature merited for him the earliest *'premonition'* and *'intuition* for the existence of a universal gravitation. His "personal struggle" is mentioned in his writings and like a true intellectual, he would not hesitate to admit an obvious error after a very lenghty scribbling. By his own admission, Kepler was set to come up with a philosophy on the physics of the universe to replace the theological or philosophical interpretation current during his times, vis-a-vis, Aristotle. Yet, it is worthy to note that Kepler was convinced that the *harmony* he was trying to establish, must be congruent with the data of experience. Evidently however, he possessed a bias for platonic archetypes, making the Trinity as an analogon to his heliocentric planetary system. While his readings of the Greeks inclined him to the circular motion and rational numbers as the reasons for harmony, Kepler cast his lot in the elliptical motion

and exponential proportions. The *aesthetic* reign of mathematical laws in cosmic proportion is reaffirmed. Through this kind of connaturality does the mind of man commune with the Ultimate. Following Plato, the deity geometrizes. He is the root of *pure harmony*. The reluctant scientist who was originally a philosophy and theology student for a career in the ministry, he repositioned his gears by combining science with his previous backgrounds. Gifted with an intense *vision* and *insight*, he witnessed the universe become a trinity — a physical machine, a mathemtical harmony and a theological order.

Einstein is a figure inseparably cut with the theory of relativity which was described as a principle, a procedure, and an explanation. No better set of encomiums could be attributed to an intellectual treasure which had withstood the test of time. It was the solution for his audience who witnessed its development. Abstruse was the complaint by some who failed to vibrate with the theory.

Einstein often insisted that constructs, if they were worth their salt should be very general in kind and few in number if possible. This assertion sounds very much like Aristotle when the Philosopher was discussing the wise man and wisdom. They should assume a worldview which ultimately explicitates the metaphysical genes of the human mind towards symmetry and simplicity, in the concrete, a return to the *classical purity* set forth by the ancients. As Newton did, the old mechanistic models had to be reexamined or be dispensed with, agonizingly though within the context of a philosophical ecclectism which he was familiar with, outstanding of whom, was Kant. And Newton's God suffered the same fate upon Einstein's adoption of the abstract *GedanKen experimenter*[23] which secularized the total immensity.

To state that Einstein was a precocious genius is an understatement. Even as a young student, he was considered by his

[23] Given source S of a light wave at rest in ether. A point on the light wave moves with a velocity c relative to S. The laboratory moves with the velocity v relative to the ether. Hence where c is the velocity of light relative to the GedanKen experimeter, $v = c$ so that $c = 0$:

$$\overset{r}{}$$

a) $c = c - v$ (contemporary science)

$$\overset{r}{}$$

b) $c = c$ (always, according to Einstein's intuitions)

$$\overset{r}{}$$

mentors as one whom they could not teach anything more. Aside from being independent in his thinking, he was however perceived as a slow learner specially in verbal and language skills. Indeed Einstein considered his mentor's lectures as self-explanatory. If at all, Einstein respected some of his mentors for their mathematical ability, but their knowledge in physics was another story.

Fopple was one mentor who impressed the mind of the young Einstein rather immensely. Here was the man who baptized the budding genius into the epistemological aspects of physics. Like the ideal mentor, Fopple was known to reduce the complex to the simple and ignite the learner to conduct his *own* work. From him, Einstein imbibed the genes which nourished his fanaticism for the epistemological.

And from Mach, despite the avowed anti-metahpysical motivation, Einstein learned to accomplish more and more accomodation of thoughts to one another in the formulation of his now famous "principle of the economy of thought". Hence, the motions of ether, matter and electricity are integrated by means of mechanistic pictures and hypotheses. Perusing Mach's Science of Mechanics, Einstein imbibed a physical orientation towards a restructuralized *fundamental* concepts and laws. Einstein was profoundly changed. Two evident strains become very apparent in the developing Einstein: 1) fundamental problems in physics were analyzed epistemologically as an essential step, and 2) identification of reality with sensation.

The philosophical pilgrimage embarked on a positivistic spirit of *intuitive unity*. Experience did not consist of the atomary and the discrete but it was the totality of experience which was *creatively* harmonized and *freely* conceptualized. Like his predecessors, nature for him was the externalization of the *simplest* mathematical constructs. The platonic mirage was emerging.

Reason, grasping the eternity of the objective world, was for him, a process which was nothing short of a *miracle*. This description might seem very strange for one who is a physicist but this precisely depicted the internal agony of a committed scientist who saw the problem as transcendentally epistemological. With this conviction, his loyalty for Mach as a respected peer remained

unflinching despite its wavering allegiance to the positive physics of his idol. The logically simple was not necessarily a physical truth, but the physical was necessarily logically simple. Underneath his scientific convictions was his religious belief in God as the Promethean basis. The quest for the theoretical construct was over and above the knowledge of what and how nature is. It is by and large, the knowledge of why nature is not otherwise. The path is excruciating as there is *no* logic involved. *Intuition* formulates its own houserules. Akin to Planck's tenor, there seems to be an *irrational* and *mystical* element which is best experienced rather than written about and which is best felt than verbalized. In this element lies the eternity of science. Facts do not equate the hypothetico-deductive theory. They are meant to create the scenario so that a general principle is intuited and therefrom, deduction will operate. The totality of the facts require an 'intuitive leap' transformation. Here lies Aristotle resurrected in Einstein. And moreover, here goes Einstein transforming Plato. An aesthetic-mathematical construct contrives the internal harmony which orchestrates the philosophical and the empirical.

Dirac singles out the blending of beauty and symmetry in equations. An "ugly" construct is false. This was precisely how the quantum mechanics was discovered. The *artist* in the scientist is one aspect which does not deserve the underplay it is getting. The philosophico-scientific thinker is actually an aesthetico-scientific discoverer. Einstein was said to have emphasized how devious a route our minds snake through a problem. The final construct which is published and made public hardly manifests any trace of the 'wounds', the 'injuries' and the humiliating or humbling experience undergone. The *indirectness* can never be perceived through ordinary means. And when Einstein says that there is no way from experience to the setting up of a theory, we understand that the *no way* means never the usual way. Words or language do not seem to play any crucial role. If at all, they come as wrapping and ribbons for the gift of the contemplation. The psychical entities as components serve as signboards and as props for the mind. Even Aristotle's initiation of the mind to the 'earliest universal' with the first sample finds equation with Einstein's 'from the very beginning it appeared to me intuitively clear

that...' The *germ* of a paradox occasions the *leap*. Revolution, and not evolution is the case in point.

When he cites external confirmation as a criterion for a sound theory, he did not at all mean that experiments both visible and empirical, were the *only* straw to build upon, nor even that the theory will have to be verified by *decisive* experimentation. It simply meant that there should be no contradiction between theory and facts and any attempt to adapt facts and theory would complicate or even falsify the incommensurable quantities involved.

Copernicus mentions a cryptic criterion for rejecting a hypothesis as being 'not sufficiently pleasing for the mind', referring to some kind of 'scientific taste buds.' This separates the budding scientific methodologist from the blooming theorist. The theorist has reached the aesthetic stage and would adopt or reject a hypothesis for its *psychological acceptability* regardless of its logical status so called. Hence, it is not surprising that we find in scientific literature such words as *appealing, elegant, likely,* to signify acceptance of a hypothesis; and words such as *bothersome, unlikely, ugly, etc.,* to signify rejection. It was Newton who insisted that nature is pleased with *simplicity.* This is what Einstein was referring to when he referred to inner *perfections.* And the road to this kind of simplicity is everything else but simple and is not feasibly reducible to empirical terms or to the criteria set for public and institutional science.[24] We have with us the groping

[24] The quest for Scientific Knowledge is therefore regulated by certain standards or criteria which may best be formulated in the form of ideas to be approximated, but perhaps never fully attained. The most important of these regulative ideals are:

1. Intersubjective Testability — This refers to the *objectivity* of science. It means freedom from personal on cultural bias, from partiality. The finding is subjected to peer confirmation or otherwise.

2. Reliability of a Sufficient Degree of Confirmation — This refers to a distinction between a fact and an opinion, from a finding which is well substantiated and well tested from one which is not.

3. Definitiveness and Precision — This standard of scientific method requires that concepts used to be delimited to reduce vagueness to the barest minimum be this be qualitative or quantitative. Mensuration facilitates this goal of objectivity so that interpretations do not result as simple impressions.

4. Coherence or Systematic Structure — When scientists claim that everything is imaginable in science so long as no contradiction exists, they are referring to an exciting system of definitions, divisions, classifications, projections, extrapolations, inferences, etc.

constructive attempts to wrestle with. In this context, the word *feeling* indicates the difficulty of pinpointing the exact locus, whether cognitive or affective, when the theory is "made".

Michelson's impact on Einstein dwelt particularly on artistic sense, symmetry and form despite the fact that Michelson's ether was grounded by Einstein's relativity. Yet, the conscious-subconcious cycle remains untouchable, implicit and for the conceptual frames of an empiricist, unconventional and unframable. Developmental psychologists of learning among which Piaget stands out, suggest a wider circle made up of logico-mathematics, physics-chemistry, biology, psychosociology, and reverse to the logic-mathematical. In a more traditional set-up of the scientific method, the *adhoc* hypothesis is presented in the form of a symbolic model and undergoes a reconstruction, after passing through the various levels, into a transformed consequent hypothesis. Einstein later summarizes the connection of reciprocity between epistemology and science. Epistemology without science is ethereal and science without epistemology is barren and primitive.

The Einstein ecclecticism evokes a degree of *realism* insofar as the world is perceived as objectively existing outside of and independent of the mind; an *idealism* insofar as theories and hypotheses are uniquely and freely conjured, a *positivism* insofar as these concepts are data-based as the logical representations of predictive or retrodictive tools; a *pythagoreanism* insofar as mathematics looms as effective epistemological and abstractive tool to factual analysis.

Poincare, one of Einstein's major influences, was said to be at his peak at the age of 51. To his mind, any attempt to make science 'appear' as containing nature is like making the part greater than the whole. With his genius, one can hardly expect a man to be caught in a dilemma as elementary as one which involved the first principles. Like Einstein's complaints,[25] he accepts the

5. Comprehensiveness or Scope of Knowledge — With the advent of very sophisticated equipment in scientific experimentation, the senses avail of an information which hitherto would have been unexplored and left unknown.

[25] Albert Einstein, *The World as I See It.* New Jersey: Citadel Press. 1979. p. 5. He says, "Academic chairs are many, but wise and noble teachers are few; lecture-rooms are numerous and large, but the number of young people who genuinely thirst after truth and justice is small." Henri Poin-

fact that the majority of men do not like thinking. Yet intelligence *must* guide instinct. With a very Aristotelian flavor, he concedes that the more general a law, the greater is its value.[26] Change can mingle but it cannot unmingle.[27] The scientist, the real one that is, studies nature for reasons which are more than utilitarian. Rather, he finds *pleasure* in such a study because nature is *beautiful.* Otherwise, nature would not be worth knowing and Life would not be worth living. Pure intelligence extracts, so to say, this intimate and special beauty, a task so common among *artists.* It is on account of this same beauty that scientists aim, instinctively as it were, to an economy of thought.[28] This concordance and connaturality between nature and intelligence becomes the eternal bond which a true scientist establishes for himself and pursues like an avowed commitment. Phenomenic events level off to a progressive series of 'construction'. As the subject graduatedly penetrates the object, the subject rethinks and restructures. Logico-mathematics is a product of the psychology of the mind and this psychological activity can in turn be modeled by logico-mathematicals.

Poincare was a true blooded mathematician. Recalling the initial simple problem we have illustrated, Poincare makes a more pointed *analogy* between the algorithmic and non-algorithmic approaches in solving a problem. In his book, *Science and Method,* he uses the word *savage* for the former. The education of children should put emphasis on those aspects which *order* the confusion and the 'mysterious', accessible. Order however does not pertain only to the 'traditional' type but more specially so, the *unexpected order* for the *soul* of the fact will never be spoken about by an equipment. Hence the justification of *models,* whether they be physical, sentential or better, mathematical.

Discovery may be considered as the process of ordering of facts and results. We recall the admonition however that we do not feel any guilt for any logical error we may commit. But being an efficient organizer or a precocious calculator is only half the

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care, *Science and Method,* trans. by Francis Maitland. Massachusetts: Dover Publications. 1965. p. 17. "It is necessary, therefore, to think for those who do not like thinking, and as they are many, each one of our thoughts must be useful in as many circumstances as possible.

[26] Henri Poincare, *Ibid.* p. 17.

[27] *Ibid.* pp. 18, 65-77.

[28] *Ibid.* p. 28.

task as Aristotle himself may have warned us about. Selection is too primitive if we may say so. *Discernment* is altogether another thing.

Poincare recounts his schedule of daily mental exercise trying to come up with various combinations. In vain was the daily effort. One evening, he took black coffee which he usually avoided and his normal cycle was disturbed. The mind of Poincare started to function and continued to operate the whole night. As he was tossing the sleepless night, he "saw" two combinations coalesce forming a stable form. The morning after was not just another one. It was *the* morning of his life. It was a veritable *lux et lumen* for the Theta-Fuchsian function and later verification came as natural as the morning.

Scientists and mathematicians are indeed a rare breed. They are 'eternally' *obsessed* with their 'trade'. Poincare was no exception and his scribblings made during his trips are preserved even to this day.

During another quaint occasion, he was walking along a cliff beside the sea. Like a flash, accompanied by a strange certainty and conciseness, it occured to him that arithmetical transformations of indefinite ternary quadratic form are identical with those of non-Euclidian geometry. The subconscious-conscious-subconcious cycle was clearly evident. Poincare describes this as the appearance of a "sudden illumination, obvious indications of a long course of previous unconscious work."[29] He outlines this phenomena more in detail thus,

[29] *Ibid.* pp. 55-58. et ff. These sudden inspirations are never produced (and this is sufficiently proved already by the examples I have quoted) except after some days of voluntary efforts which appeared absolutely fruitless... These efforts, however, were not as barren as one thought: they set the unconscious machine in motion, and without them it would not have worked at all, and would not have produced anything... It is necessary to work out results of the inspiration, to deduce the immediate consequences and put them in order and to set out demonstrations; ...I have spoken of the feeling of absolute certainty which accompanies inspiration... This feeling was not deceptive... I have observed this fact most notably with regard to ideas that have come to me in the morning or at night when I have been in bed in a semi-somnolent condition... That the unconcious ego, or, as it is called, the subliminal ego, plays a most important part... The rules which must guide this choice are extremely subtle and delicate, and it is practically impossible to state them in precise language; they must be feet rather than formulated... The subliminal ego... has tact and lightness of touch; it can select, and it can divine. More than that, it can divine better than the conscious ego...

> Often when a man is working at a difficult question, he accomplishes nothing the first time he sets to work. Then more or less of a rest, and sits down again at table. During the first half-hour he still finds nothing, and then all at once the decisive idea presents itself to his mind. We might say that the conscious work proved more fruitful because it was interrupted and the rest restored force and freshness to the wind. But it is more probable that the rest was occupied with unconscious work and that the result of this work was afterwards revealed to the geometrician exactly as in the cases I have quoted, except that the revelation, instead of coming to light during a walk or a journey, came during a period of conscious work, but independently of that work, which at most only performs the unlocking process, as if it were the spur that excited into conscious form the results already acquired during the rest, which till then remained unconscious.[30]

The subliminal and the subconscious, the rest and intermission, which the thinker undertakes, provide the precise threshold where the final blueprint is formulated and the negatives are hung to dry. Tact is important for the 'touch' to unearth the 'subtle' and the 'delicate'. The intensity which the excitement is held on and captured practically distills the sensitivo-intellective faculties of its "genes" for beauty, harmony, form and elegance. The faculties play the role of a "selection committee" for the agreeable. Like the *hooked* atoms of the ancient, the *right* combination is not assembled, so to say. It is *born*. It buds forth. Calculations, verifications, etc., are all *posterior* processes. They only follow the inspiration or the illumination previously sealed and marked open. Neo-Kantian innatism is construed by Poincare when he refers to two synthetic priori intuitions that act to organize perceptions into knowledge namely, the principle of mathematical induction which is inaccessible to analytical proof and to experiment and the intuition of continuous groups which exists in our mind prior to all experience.[31] Thus the principle of induction does not obtain in experimentation, since it would mean the transit from the finite to the infinite. Mathematical reasoning performs this operation. Experience *guides*, it does not *impose*. As in a race,

[30] *Ibid.*

[31] Arthur Miller, *Imagery in Scientific Thought*, Boston: MIT Press, 1986. pp. 16-27.

experience triggers the start and mathematical construction forges ahead. In the Piagetian analysis, the process bears a deductive fecundity which does not need the sanction of reality for the construct born. What emerges here is some kind of a subject-object preestablished harmony, be they causal or implicative. To ignite, to signal and to catalyze seem to be the role experience that is meant to play. The choice of the construct is not because one is more true than the other but because it is more *convenient* to us. The ingredients of spontaneity, aesthetics, instinct, intuition and the like are omnipresent in Poincare's thoughts. Perhaps there would be no better encomium than Einstein's *"sub specie aeterni,* Poincare in my opinion is right."[32]

Werner Heisenberg invented the quantum mechanics, the new atomic theory in 1926. The new theory set the foundations for molecular physics, quantum theory of magnetism, nuclear physics and the elementary particle theory. In the same year Pauli deduced the Balmer formula from Heisenberg's theory. Schrodinger however was not inclined to Heisenberg's theory due to the difficulty it occasioned on account of the lack of visualizability. The alleged discontinuum theory raised by Heisenberg was in contraposition to the continuum theory of Schrodinger's wave mechanics which offered visual representations of the atomic phenomena. The issue, it seemed, was an either — or — situation: visualizability versus unvisualizability.

But Heisenberg insists.[33] Blame it on the Cartesian partition. In effect, the affirmation states that the experimental data of physics do not imply its theoretical concepts. The object of science *per se* is never known directly by observation or experimentation but through speculation, the theoretic construction or axiomatic postulation is proposed and tested. Heisenberg continues thus:

> In theoretical physics we try to understand groups of phenomena by introducing mathematical symbols that can be correlated with facts, namely, with the results of measurement.[34]

[32] As quoted by Arthur Miller, *Ibid.* p. 41.

[33] Werner Heisenberg, *Physics and Philosophy*, F. Northrop, introd; New York: Harper and Row, 1962. pp. 81 et ff. "This partition has penetrated deeply into the human mind during the three centuries following Descartes and it will take a long time for it to be replaced by a really different attitude toward the problem of reality.

[34] *Ibid.* p. 172.

The statistical and probabilistic perspective of the quantum theory is analogical to the *potentia* of Aristotle. Electronic orbits are an example of his case. But the language produces *pictures* which are directive or indicative of reality. But how is the theoretic construct formed in the first place? Heisenbery recalls:

> ... we must first arrange our sense impressions by an *unconscious* process that helps to transform them into a coherent, 'meaningful' picture. Only through this transformation, only through this fitting together of individual impression into a 'comprehensible' whole, can we claim to have perceived anything.[35]

Therefore, 'authoritative' statements can be made regarding the interpretation of experience. It is a search for order, the *central* order, and order in diversity is like a musical arrangement. And when scientists talk about atoms, they are referring to *form* in the broad sense akin to what Kobler refers to as a "special constraining arrangement".

Heisenberg's intimate familiarity with the ancients and the great minds of his youth such as Weyl, Sommerfeld, Bohr, including his own father who was a philologist at the University of Munich, created no small impression on the budding scientist.

Understanding nature means the explicitation of the *connections* which reflected the intrinsic operation of nature which is thus reducible to a common principle. Poincare termed this, *relations*. Prediction is a consequent process emanating from this understanding.

The scientist works like an *artist*. This aesthetics, he describes thus,

> "Bohr uses classical mechanics or quantum theory just as a painter uses his brushes and colors. Brushes do not determine the picture, and color is never the full reality; but if he keeps the picture before his mind's eye, the artist can use his brush to convey, however inadequately, his own *mental picture* to others."[36]

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[35] Werner Heisenberg, *Physics and Beyond*. Encounters and Conversations. New York: Harper and Row, 1972. p. 4. (underscoring mine)
[36] *Ibid.* p. 37.

Bohr appealed to the philologist's son on account of his "carefully formulated sentences (which) revealed a long chain of underlying thoughts, of philosophical reflections..." Analogical thinking in science is to explain a new phenomenon by contextualizing it within a known phenomenon or law. When it comes to the atomic model for example, the language of the scientist is no different from *poetry*. Both would, at best, create images and forge mental connections. Pauli, who at one time attended the same school with Heisenberg, coins the term *symmetry reduction*. The spectrum of elementary particles for example convey a kind of universal symmetry. Symmetry is a more congenial "germ" than the Democritean 'particle'. Even *accidents* must 'fall' and fit neatly into the developmental process.

Hence the Platonic graduation of the theoretical construct. The elementary particles are similar to the regular bodies imagined by Plato's archetypes. They perform very crucial teleological roles. They are orginial models and serve as the vortex of the central order. Accidents are centrifugal and centripetal of this order.

Aristotelian induction and Platonic forms complement the empirical scientist. It has now become quite obvious that behind the scientific themata lies a very dense picture of these minds working out of the ordinary, nay, in a very extraordinary manner. Lesser mortals finds the analysis of such minds awesome and forbidding. These minds were gifted with an unusual and special perception which could only be understood, if ever, in dosages and by fragmentary stages. They appear to possess a kind of *tactile vibrations* with nature in a manner as if the objective light of nature and the perceptual penetration of the mind were speaking the same language, and the seeming operation of nature becomes their very lifestyle! In the Aristotelian analogy of proportion with Piagetian ontology, the mental structures assimilate reality as the constructs visualize the physical sciences. The Socratic-Platonic mirroring assists the scientist in the sense that he can know himself only by mastering the external world and vice versa. The object of the study leads to and capitulates in the study of the subject. Yet, what might appear to be an ordinary question to many of us, assumes a penetrating ray into the heart of the matter for these personalities and the complex becomes, to their "eyes"

simple and beautiful. With an intensity and scope which surpass the normal threshold, their minds 'sense' the inconspicuous and 'reads' what is hardly spelled out.

These men are uncircumscribable. Who can decipher a sustained concentration on a *single basic* problem in physics for a whole life time and pursue to deathbed regardless of confluence and counter-influence? Behold their colossal obstinacy made supple by their tender readiness to discuss with their peers! Behold their ambivalence between their solitude of contemplation and the publicity of a celebrity as unique types of personages who waged their struggle for justice and freedom on one hand and insist on what an academe should be on the other. Only men whose science have replaced the ego and the self of their pedestal could combine the seemingly conflicting and contrary. But deep down in them was a lifestyle which was starkly simple and could put a monk ill at ease and the Author of nature rejoice. And the triangle is set for the genius: mind, lifestyle and the laws of nature. And to think that these men did not strike their mentors with few exceptions, for anything more than their tales of woes!

The collective interaction of a community of scholars becomes evidently a very important factor which leads and propels the individual thinker to blooming and fruition. Intellectual maturity ripens when the future genius outlives the Parmenidean stubborness, or the Heraclitean fickleness, or the Sophistic aggrandizement. Certainly the mentor-learner relationship within such community of scholars has produced an eternally fruitful symbiosis to the point that the learner ultimately became greater and more famous than the mentor! This happens when the teaching-learning bond becomes a learning process altogether. Such communion, we witness in Albert the Great-Thomas Aquinas, Socrates-Plato, Plato-Aristotle, Fopple-Einstein, etc. Einstein was well acquainted with Planck; he discussed with Heisenberg on observables in a theory; he corresponded with Sommerfeld about relativity and quantum theory; he was a close friend of Bohr although he disagreed with him on the statistical interpretation of the quantum theory, he discussed with Bohr on the philosophical implication of uncertainty. Bohr saw the real difficulties created by the wave mechanics and he discussed the matter with Schrodinger.

After some weeks of discussion, the quantum theory, the concept of complementarity and the uncertainty relations were never the same again. This is live genetic epistemology which in the broad sense captures the artistry of the mosaic of truth-growth and truth-claims. It considers all the factors perceived to have contributed, directly or indirectly, to the inception, and conception of truth, the passage from states of lesser knowledge to more advanced state is traced and tracked. Hence the inclusion of neural events and sociological aspects by the more intense psychologists of learning. The interpersonal exchange, the common issues or themata, nay, even the "scientific" rumors, are analyzed and coordinated. Piaget explicitates this matter further thus,

> For example, what one person does is completed by another (addition) or corresponds with what is being done by others (multiplicative correspondence). Similarly, what one person does may differ from what is being done by others, but their different points of view can be interrelated (reciprocity), etc.[37]

It is clear that the Platonists and every theoretician who was consciously or unconciously inspired by its hierarchical superstructure considered mathematics as the form *antecedent* to the phenomenic and purely deductive from virtuals. Recollection and reminiscence of the Platonic scientific method meant the actualization of what was *virtually* encased and innate. Truth possessed in a previous existence is revived after going through a liberating process of which matter plays but a supporting role, to say the most.

Aristotelianism considers the mathematical structure as a mental abstraction formulated by leaving out the trapping of matter, motion and time. It is a consequence of any physicality or corporeity. They connote quantitative dimension representative of a type. *This* or *that* dimension becomes the original source of what will be idealized and reduced into its parsimonic elementary representation. In so doing, the mathematician not only regularizes what is irregular but more so, eliminates the very nature begetting corporeity from consideration. As a consequence too, the problems of mechanism of change, temporality, natural agency

[37] *Op. cit.* p. 129.

and the like, are transcended. The mathematical representation of nature becomes suitable description of the phenomenic events and which way lead to a scientific explanation. Contrary to what the Platonic material shadow meant, the Aristotelian mathematical abstraction now is a shadow reflective of the formal cause. This shadow is a construct in terms of geometrical figures and in the proportionate shapes. Ptolemy's excentrics and epicycles, devices to fit the observed facts, are considered a paradigm of this school of thought. Such model however bears suppositional impact only.

While a Platonist would consider a mathematical construct as an emergence from virtual existence, e.g., *universale ante rem*, an Aristotelian would view the mathematicals as an *"universale post rem"*, to put a contrast.

St. Thomas commenting on the Philosopher's assertions considers mathematicals as a *remote cause*.[38] Abstracting from the real and the concrete, it is a formalized copy of the event.

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[38] In *I post. Anal.*, lect. 25, n. 6.