Chapter 7

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TOWARDS AN EVOLUTIONARY EPISTEMOLOGY: REHABILITATING REASON, METHOD, CONTINUITY AND DEVELOPMENT IN SCIENTIFIC PROGRESS

7.1 The Infirmities in the Epistemological Traditions

In the present study, we were concerned with the fallacies that clouded and crowded the perspective of the discontinuist philosophers wedded to a revolutionary epistemology of scientific progress and their explorative directions. Among them, we found in Kuhn, a discontinuist revolutionary change built on the delicate mechanism of conversion experience that guided the passage of science across a revolutionary divide. His paradigms are insensitive to minor changes during normal science period, as it were. Neither was his scientific change amenable to any logic of discovery, nor was it historically explicable.

Popper's search, even within a revolutionary framework of progress, for a methodology of appraisal began with the realisation that since decision making is "an ubiquitous moment of research" there cannot be a methodology free research. The desire to make human endeavour in seeking the knowledge of the world through research an effective and efficient action as demanded by praxis, made the methodology free research unthinkable. In this context
he developed his methodology which rested on conjectures, criticism, variations, selective relations, falsifications and theory elimination, normally a pro forma of action characteristic and constitutive of, in an evolutionary enterprise. He preferred falsification to verification, as he sensed an epistemological asymmetry and distinction between them.

Though falsification has the consequence of catastrophe much more than verification implied, he felt that the first establishes the non-truth while the second fails to establish the truth, and that the first is definitive while the second is provisional. Further falsification has an edge over confirmation which is probabilistic in the sense that it is at least definitive in the establishment of non-truth. Falsification amounts to condemnation without appeal, while verification is at best a precarious acquittal. By the logic of falsification, one aims at a definitive epistemological judgement. By the logic of confirmation one tries to secure a process of progressive approximation to truth. This is the basis for Popper's consideration of epistemological superiority to falsification. For him verification is nothing but a series of 'aborted attempts at falsification'.

This is the key mechanism he used to create a revolutionary change between the old and the new. His failure lies in firstly depending on a naive streak of falsification that allowed no life to the refuted, secondly his failure to recognise the essentially evolutionary elements implied in the stages that led to theory elimination. A much chastened Popper, when he accepted and began expounding evolutionism in the programme of growth of knowledge, rested his evolutionism with his surmise that the aim of empirical method he implied in his falsificationist methodology of appraisal "is not to save the lives of untenable systems but, on the contrary to select the one which is by comparison, the fullest, by exposing them to the fiercest struggle for survival." 5 Thus he identified the basic requirement for change and growth in the process of struggle for existence and survival. 6 This identification equally applies to the development of knowledge, as is manifested in the struggle of theories for survival, for selection through competition, through their attempt to open themselves for refutation and falsification. Involved in this are conjectural hypothesis formulation, critical method, crystallization of their fertility, all of which attaining their stated purposes through phases, steps and events that can only be evolutionary.
Lakatos, in his methodology of scientific research programmes, gave more life to the refuted, but was stuck on with the idea of revolutionary change. Closely following Lakatos, but denying the need or viability of a methodology of appraisal or rules for demarcation of science, Feyerabend proposed a more radical, revolutionary change, partly borrowing from Kuhn the ideas of conversion experiences, fantasy etc. All these philosophers are guilty of directly or indirectly separating scientific progress and theory change as occurring through differentiated, though closely following contexts of discovery and justification. Kuhn is further guilty of "killing" innovation altogether during normal science, and for having separately earmarked a watertight, exclusive period of extraordinary science, in which, and in which alone, discoveries could occur.

Altogether these historiographer-philosophers have woven an epistemology of scientific progress bereft of reason, rationality and rational intelligibility apart from the concept of continuity of history and social human action. The knowledge, according to them would seem to be ungenerative, as they hold that the new theories always arise, not out of the old, but against, apart from the old, with nothing to take or give between them.
If this is a historical episteme, it is artificially constructed, ignoring the flow of time and knowledge through the developments in science.

Attempts to overcome the deficiencies created by adherence to a discontinuist revolutionary epistemology have gradually changed the orientation of the epistemology of scientific progress towards an evolutionary and genetic one. Among the contributions that came from history, psychology, philosophy, and biology towards an evolutionary epistemology, Campbell’s, Popper’s, Sonezi’s, Grmek’s, Gruber’s, Eccle’s, Lorenz’s, Simon’s etc. apart from contributions from psychologists like Newell, Piaget etc., are well known.

The word ‘revolution’ itself denotes different contextual and substantive conceptualisations. Even Mill’s use of the term ‘revolution’ is half hearted and hesitant. Fontenelle’s use of the term Revolution was only meant to characterise scientific progress and the impact of change, and, in fact, he used it only very sparingly in his work.7 Darwin also had interpreted his understanding of the growth of knowledge in terms of an evolutionary process8 which visualised evolution as occurring through a process of natural selection from minor, numerous chance variations of hereditary characters by those that gave the
best 'fit' to the environment and survival. He also visualised that the accumulation of these variations ultimately brought about significant qualitative changes in the organisms and caused speciation. His theory accorded the environment some selective power using which it selected species with new advantageous traits from among the diverse descendants while Samuel Butler (1870)\textsuperscript{9} accorded the organisms with the power to solve their own individual and species survival problems by bringing about heritable modifications on its own somatic structure or its behaviour. He vested in the organisms the power of problem solving. As in Darwin, here also it was the environment which created problems and demanded solutions through variations. Species just responded. The intent of the environment has been made very pronounced in both Darwin and Butler, unlike in the, say Mutation theory of De Vries, where mutation results from various types of changes in the genetic entity and here the changes occur as a result of internal and external environmental forces which have no more intent than has the species.

Butlerian metaphor also considered the fact that the subject of natural actions of problem solving is not single individual, but the whole evolving species to which the individual belonged. This concept was also extended to explain cultural progress as a natural extension of
the biological one, with the reservation that the mechanics of it is purely mental, and different from that of Darwin's evolution.

By granting support for an evolutionary epistemology and also to the internal history of growth, philosophers like Donald Campbell, Konrad Lorenz and even Karl Popper granted support to the concept of self-organising, problem-solving, and a self-creating role to the organisms at individual species and community levels. Of course, the drive for such activity comes from the need to find equilibrium and steady states at all stages and levels of living.

7.2 The Structural and Historiographical Significance of the Process and Context of Discovery

For a long time now, epistemologists have considered scientific theories to be parts or examples of a body of knowledge which is free of contradictions in its structure and is based on foundational propositions which cannot be reduced to others.\(^\text{10}\) A reciprocal and a more recent definition tends to hold it as an expanding body of knowledge which increases the domain of the known at the expense of the unknown. It considers scientific discovery as the instrument of growth of knowledge. In his book\(^\text{11}\), An Introduction to the Study of Experimental Medicine,
Claude Bernard viewed scientific discovery as a new fact whose newness and rational relation which it established between the phenomenon and the cause, make it a discovery.

Helmholtz considered discovery as a rational organic transcription in agreement with the empirical data. Thus the rational character of discovery, involving the elucidation of a new "property of nature" put in the form of a statement is implied in the act of discovery itself - that during discovery "the passage from perceiving to affirming is always fundamental to discovery." Such discoveries are statements of the facts, characterised by a novelty where novelty cannot be deduced but must be constructed within the sphere of logic or observed in the course of experimental science. This is sufficiently indicative of the fact that, during the construction of the statement, and prior to it, during the process of affirmation of the novelty and the process of discovery which cannot be separated from the context of justification, involves a rational, evolutionary process. This transformation of image of a phenomenon results from a rational discourse at every level conducted in order to demarcate it from non-science and finally some standards of theory appraisal and choice before affirmation/invalidation.

Knowing can be discovering if it is able to unfold itself and grow, and in growing, if it can renew its own
structure. With respect to new knowledge, old knowledge may be a cognitive or epistemological obstacle, if it hinders observation or construction of new concepts and structures, different from the old. Discovery is knowledge in growth, which thereby extends its domain or, attributes a different order to itself.

If science is expanding knowledge, renewing itself in the periphery as well as at the heart of its domain and, if innovation is identified with scientific discovery, then the history of discoveries will be the essential part of the historiography of science and their logical and ontological analysis will be the core of epistemology that seeks to answer as to how is our knowledge structured, on what axioms does it rest, what inference does it use, and how it develops and progresses. The epistemologists like Kuhn, Popper, Lakatos and Feyerabend refused to submit the process of discovery to logical analysis. Popperians analysed the progress and rationality of scientific thought and, face the problems of validations, steering clear of psychologism, induction and, holding that logic has nothing to do with history of rather, history has nothing to do with logic of growth of knowledge. Popper himself later emphasized an evolutionary epistemology and a relation between discovery and vocation which sets out to demonstrate the pragmatic value of analogic reasoning
though, in the attempt, saving induction. However, this submission to logical analysis of scientific progress was limited in its scope, as only the context of justifiability was considered here. In the attempt at historical reconstruction of scientific discovery, a process called 'crystallization', a process of "the mind which discovers fresh perfections ... at every twist of events" occurs, on the whole of the res gestae et scriptae of past scholars. According to Gmck, the dry branch of historical facts is, by 'a process of progressive theorization' enveloped little by little in a thick layer of seductive myths.

A careful study of the factors which intervene in the "crystallisation" process of scientific discovery will reveal the slow and gradual building up process, at the end of which, facts showing novelty will be unfolded. However, it is true that certain methodological presuppositions, which Gmck calls "methodological myths", rooted in history and fulfilling important psychological and social roles, will also become part of the process of discovery. They, in fact, exist as rationalised justifications of our desires and, these tenacious myths often govern the historical reconstruction of scientific discovery.
Many epistemologists, especially the neopositivists, ignore the study of the historical coming into place of each structural element of present knowledge and conjure away the problem of the actual genesis of the network of scientific propositions. Such attempts at best succeed in substituting history with a mere anatomy of knowledge, or the constituted science. It rarely is concerned or throws light on the morphogenesis of knowledge. In this context Grynkevich says that most historiographers commit the error of 'chronological inversion in the sequence of events or the concatenation of ideas, and 'the illusion of narrative's time-dimension'.

In the development of scientific thought and discoveries, the actual itinerary of ideas is conditioned by an internal dynamics. The structured aggregate of known facts and propositions are the products of an internal debate in the thinking mechanism and this debate is conditioned by the experiences of the historical time-space coordinates. A historiography which does not take into account the factors, both psychological and material, that intervene and facilitate the process of development of ideas which provide new meaning and new implications to the old theory or facts, at every one of its stages and levels of development, can only be incomplete. Unfortunately, psychologists dealing with the study of inventions arrive.
at a content-free picture of intellectual process, relying only on the processes and expunging meaning from materials, and often ignoring material that constitute knowledge itself. On the other hand, the structuralists, present an as-it-is anatomical and synchronic picture of knowledge, perhaps even meticulously showing the relationships between the constituents, but without enquiring into the process of development of the constituents and its relationship with each other in space and time.26

Discovery does not occur in one leap or lap, like 'Athena from the head of Zeus'.27 Successive approximations and objectivisation of facts into truer truths do not occur in a straight road, linearly. Says Grmek, "Kepler, Newton and Harvey did not make their discoveries in spite of their astrological, alchemical or Aristotelian prejudices, but through them and, in part, because of them.28 Only if we consider that the real epistemological and historiographical task has no onus to locate truth and brand errors, but only to understand the intellectual processes, then only we can subscribe to the linear-leap view mentioned above. Though the product, the scientific knowledge, and especially the new theory appears remarkably simple and appears in public as a miracle of simplicity, coherence and compression, the process by which this result is achieved is a complex, many-sided, sometimes even
incoherent and uneven one, and often greatly extended in time. 29

Neither are the discoveries made by following a single philosophical approach or methodology. For example, Harvey's discovery of the circulation of blood was not made possible simply because he followed rigorously the Baconian inductive method or the hypothetico-deductive method, but was equally influenced by the mystical symbolism of circles, gnostic philosophy and Peripatetic metaphysics. 30 Similarly, but in another context, Feyerabend 31 conceded that Newton's success cannot be attributed to his faithful observation of his axiomatic method, in fact, on the other hand, he never even applied his method in his Principia.

Sometimes, it is even difficult to decide who discovered what. For instance, for the discovery of spermatozoa to arrive, it had to await the theory of cells, chromosomes, and DNA. It is also difficult to study the discovery without bringing in the question of interpretation. 32 At best, all one can do is to specify who gave what interpretation to what phenomenon in a particular context and even there the legacy of the past cannot be ignored. This is more so because discovery is nothing but the statement of a new fact. The interpretation demands an understanding of practically the whole intellectual history/tradition and situation of an era, not only of
the same discipline, but also of related fields. Discovery cannot be separated from this general situation. Discovery also involves new language and terms, as terms record discoveries. Therefore it involves the refinement and restructuring of the terms and interpretations, which is gradual, compositional and therefore cumulative by qualitative effects. That is why despite his propensity towards a revolutionary view, Whewell says, 'The history of each science, which may ... appear like a succession of revolutions, is in reality, a series of developments', and 'the earlier truths are not expelled, but absorbed, not contradicted, but extended'.

The ideas of continuous and permanent revolutions are nothing but myths, even in the Popperian sense. Every sudden 'Eureka' is preceded by an incubation period, a slow, continuous, though uneven, process of intellectual ripening or maturation and restructuring. Even the so-called revolutionary reversals - historical falsifications or paradigmatic reversals - do not exclude the existence of a slow, not really discontinuous accumulation of scientific knowledge in the period separating two crises. Such accumulation help the preparation of the scientists' mind to visualise and accept the reverse view. The qualitative jumps are made possible by previous preparations.
intellectually. Thus there are no real revolutions, let alone the Popperian permanent ones. This view finds a strong elucidation in Whewell.36

The acquisition of knowledge bears the essential characteristics of biological growth in general — not mere progressive accumulation of elements, but a morphogenesis, that defines, in concrete, the structuration as it occurs through an alternation of cumulative transformations.37 These processes which occur are dynamic in the sense that the equilibrium is qualitatively different at different phases, and they are also steady state processes in the sense that equilibrium is constantly maintained. According to Piaget38, who developed his views on the basis of his study of the intellectual development of children, the morphogenesis of knowledge has close resemblance to embryogenesis. Lorenz has also demonstrated this in his studies.39

Illumination is only the sudden completion of a slow 'underground' maturation process marked by assimilation of new data and construction of explanatory patterns.40 Coming into being of a new pattern involves the generation of new structural elements (information) and their positioning at critical levels and stages, the assembly of which leads to the creation of the new pattern in place of the old, and a new meaning in place of the old.
Modern mathématisation based largely on the notion of function and on differential and integral calculus, favours an understanding of the continuous, evolutive aspect of each event. In spite of the Rene Thom's theory of catastrophe, we have still reason to conclude that the sudden reorganisation of states of equilibrium, is after all not that sudden or without structural lineage, but the culmination of a well structured orchestration, preparation and synchronisation of the substrate materials (hard facts), events and states. All scientific hypotheses are, in one way or another, induced or influenced by previous empirical knowledge.

In actual scientific research where we need facts to produce theories, and theories to observe facts, the dialectical interplay between theory and practice, between epistemic structure and empirical content are much advanced and show interdependence. The dialectical nature of the development of theories would preclude any revolutionary, discontinuous change in the body of growth of science. The interdependence will also make it imperative that theory development await generation of new facts or new interpretation of old facts, and the generation of facts and new meanings await the theory development. Therefore, evolutionary character of growth is unavoidable.
Only when the historiographer limits himself to a short period of history and a narrow canvas of knowledge realm, the progress appears revolutionary. On the other hand, a history encompassing the whole history of human knowledge can only affirm the evolutionary nature of change. It will not justify the supergreatness of any paradigms beyond holding them as mere qualitative quantum jumps.

Most historiographies consider that the contents and processes of thought, the diverse intellectual processes and even individual ideas can be studied and understood in isolation from each other, and therefore fail to construct an integrated image of the history of scientific progress. Such an approach to history has resulted in an unjustified backing to a discontinuous, revolutionary broken image view of the progress in science. Discovery results from a progressive and gradual piecing together of the mosaic of minor discoveries of tiny steps made by the forerunners, necessarily leading, by their added momentum, to the new pattern of knowledge. For any, even so-called revolutionary discovery such summation is an indispensable precondition.

The existence and proper working of normal science is a historical *sine qua non* precondition of extraordinary science. The alternation of a puzzle solving period and emergence of new scientific theories, if they can be
separated at all, seems to belong to the very nature of the process which produces the growth of our scientific knowledge. It is possible that there are qualitative jumps—changes which cannot be reduced to the accumulated mass of variations of secondary importance. And yet there cannot be permanent revolutions either which deny the role of slow transformations of scientific theories which come about by progressive adaptation, not by reversal of paradigms.

The two aspects are complementary. The gestalt switch characterised by Snap decisions depends certainly on the observer's mind. To him will be attributed the revolution in the interpretation of the whole, but it must not be forgotten that it will be impossible without the preceding stage, which gradually, by a cumulative effect, gives the drawing its ambiguity on the objective characteristic of the drawing, reinforcing the shape of the 'duck'. The gestalt model of scientific discovery can be made valid only by supposing that each of its points, the observer's state of mind and the drawing observed are in a condition of flux and that their link up works in both directions. Further it may appear to be a switch only to the perceiving scientist, who, with his view of a 'fly' in a 'fly bottle', fails to imagine the nebula of circuitry on which the switch is affected. To an outsider, the entire circuit
becomes important and, the transformation of the old facts into a new model of relationships and linkage, become clear.

7.3 Premises for an Evolutionary Epistemology

The acquisition of knowledge bears analogy to biological growth in general - not merely a progressive accumulation of elements, but the morphogenetic process, involving cumulative transformation with minor spells of imbalances with a continuous regulating mechanism and restructurizations including sudden breaks and new levels of equilibrium. Therefore a genetic epistemology is required to explain scientific progress. This view is in conformity with the contention of Piaget, that the fundamental transformation is slow, what is sudden is not the process of building up but the coming of awareness, the eventual comprehension at the moment of completion of the structuring of a stage. This coming of awareness has been misinterpreted as the conversion experience and gestalt switch. It is in this light that Newell insisted on the need for the development of more holistic methods of understanding scientific thought.

Evolutionary epistemology draws inspiration from studies of the individual's process of learning, invention and creativity as well as the collective processes of adaptation of species to an environment in a state of
change. Evolutionists recognised a telling identity between the process of biological growth and evolution and the intellectual growth of individuals and societies, as well as knowledge. In essence, the property of self organisation, problem solving and development was transferred to Popper's third world.47

Popper, despite his Platonic - Cartesian view of the interactions among the World I of nature, World II of individual consciousness and World III of language and culture, affirmed that 'novelty in evolution can be interpreted as being the result of a kind of invention by the organism of a new environment of a new ecological niche' and that 'new ideas have a striking similarity to genetic mutations'.48 A Darwinian type of selection among the possible ideas of World III can, through the action of inhibitory neurons, give rise to the formation of a new mental construction selectively. The sudden occurrence of new ideas like the creative illumination emerges as a result of resonances among patterns of neuron excitations and fluctuations of the cerebral electrical activity.49

The sudden change of an element is usually incompatible with survival, the new element (a 'thought' seen as a genetic mutation) survives only through slow readaptation or reorganisation50 of the whole structure of the organism. The Darwinian variations provide the substrate for selection,
and in the world of knowledge, novel facts or newly understood relationships provide the pattern for adoption and selection. In the 'incubation of new organisation of ideas as well as in its defacing, the same Darwinian character of change variation and selection is implied. Campbell has been able to establish the identity between the mechanism of natural evolution and that operating in the mind or brain of a creative man in the context of his attempt to trace the history of development of an evolulional epistemology.51

Campbell's contribution to the history of development of the concept of an evolutionary epistemology through his survey of the philosophical and scientific literature of the last two centuries, although it took no notice of Popper's attempt in this direction, stimulated Lorenz's interest in the concept.52

Popper considered that traditional philosophy can supply only the problems, and therefore advocated that a combined effort of natural and social scientists is needed to find solutions to these epistemological problems. Campbell recognised a qualitative distinction between the direct exploration of environment by animals through sense organs, and the exploration by a central nervous system's processing of information coming from sense organs using both external sources of stimuli like light, sound
and internal sources such as electrical, magnetic, electromagnetic fields, or even the blind motor explorations.\textsuperscript{53} Richard Gregory's work leading to an interpretation of the mechanism of sight as a mechanism for the formulation of a hypothesis about the external world pending a 'tactile verification' at least indirectly rented support to the concept of an evolutionary, biological epistemology.\textsuperscript{54} J.Z. Young\textsuperscript{55} also attempted to 'biologise' epistemology, in the same lines as Campbell's, by examining Kenneth Graik's pioneering work\textsuperscript{56} and recognised the need to relativize the world image constructed by our brain and expressed in our language along with the consequent search for general views unavailable or inaccessible to the senses.

Popper's schema presented in \textit{Logik der Forschung} (1935) had already stressed the Darwinian nature of the procedure of exposing scientific theories to the struggle for survival aimed at falsification of a greater part of them in their comparison with observational and experimental data.\textsuperscript{57} His conjectures and refutations can be likened to the trial and error of organic evolution to a large extent. He considered the growth of knowledge "as the most interesting result of the growth of common knowledge", sharing with the traditional gnosiology and epistemology from Descartes to Poincare, from Hume to
Russell - a faith in the possibility of applying their analysis, even if at first destructive, to the construction of methods which would augment the creativity of the scientist.\textsuperscript{58}

Thus, he writes that the method of learning by trial and error - of learning from our mistakes - seems to be fundamentally the same in all living organisms.\textsuperscript{59} In both cases it is "more of a case of directing rather than knowing, of proceeding with 'premature' forests founded on the prejudice of the regularity or lawfulness of the events under consideration".\textsuperscript{60}

Like the way feedback procedure (visual) help the survival of organisms, and natural selection leads to the loss of organs against the species themselves, human civilisations abandon the use or fabrication of certain redundant exosomatic instruments that have become unfit in the new environments built by the organisms. In human culture hypothesis are killed or abandoned. 'Our hypothesis die in our stead' as Popper says.\textsuperscript{61} Popper again saw in 'Of Clouds and Clocks' (1966)\textsuperscript{62} that the paradigm of natural selection as the universal non-teleological explanation of teleological phenomena, of processes, as in the case of formation of a crystal, or the generation of an order by a disorderly movement of molecules by
preference, or still the selection among nucleotides which
by chance approach the template RNA during DNA duplication
or even during protein synthesis. The same case of behaviour
occurs during cellular differentiation and organogenesis,
and in fact during all known morphogonetic biochemical,
physiological or anatomical processes.63

7.4 Biological Basis of Popperian
Schemata

Campbell64 abstracts the Darwinian model from widely
different physical and biological phenomena and processes,
and even extends the scheme of blind variation together
with processes of selection and of conservation or propa-
gation of selected variants to cases in which knowledge
seems to have been obtained in another way. The extension
is warranted in so far as such processes can succeed in
explaining also the distant chance origin of non-chance
procedures excogitated by scientists in order to short-cut
some non-compulsory stretches along their cognitive path.
It is to Popper's distinction that he could sense the
passivity of the animal or man's reception of information
from the environment without subjective participation,
implied in Lamarckism and Inductivism. As against this,
he proposed the activism of the explorations of this
environment by Darwinian chance variations of the genome
and by the blind trials of human brain. Like animal
knowledge: 'all human knowledge' is fallible and conjectural, and a product of the method of trial and error.65 Though Popper and Campbell shared Lorenz's idea of innate human tendency for exploration and imitation, Popper differed from Campbell in attributing to the scientist a preliminary human knowledge of the problem, also acquired through trial and error but 'nevertheless sufficient to render the search for a solution to this problem not entirely 'random' especially when many unsatisfactory solutions have been already tried or when new change is effected in the habitat which creates a wealth of tentative solution choices.'

Popper and Campbell differed also in the interpretation of Kantian a priori categories which are objectively valid for Popper, but are only mere preceding and necessary experience for Campbell. Based on these premises Campbell examined several examples of scientific creativity within the framework of the formation of new ideas by chance variation of preceding ones and the selection of their optimal combinations. It is in this context that we have to assess the epistemological description of the experience of sudden illumination of the new idea which, just emerging into the level of consciousness, appears capable of 'completing the mosaic of the previous knowledge with the missing 'tessera' which resolves the long studied problem.'
Mach speaks of the "result of a gradual selection" which 'appears as if it were the outcome of a deliberate act of creation'. Poincaré believes that the selective criterion of the mathematician is basically aesthetic in the sense that only 'harmonic' combinations of ideas have the possibility of proving under subsequent detailed analysis. Savon's appeals to statistics to immerse the few valid ideas in an enormous quantity of combinations without which the substrate and chance for selection remain limited, and therefore also the possibility of any valid idea lessing the filter of self criticism.

Paul Souriau also appealed to statistical consideration not only for the individual attempts to solve a problem but also in regard to all the attempts of the scientific community dealing with it. A reference to the procedure of artificial selection is made by him, but it has more of a Darwinian character than Lamarckian, as Campbell has remarked. William James attributes the selection of spontaneous variations to the excessive instability of human brain especially in regard to its functional activity which the external environment only confirms or refutes.

Aside from his reference to environmental selectors rather than to internal mental selectors of Mach,
Poincaré and Campbell, James too subscribed to the view of evolutionary epistemology which is interpretable today in the neurophysiological terms of task division or the differentiation of functions between the left and right cerebral hemisphere of man and anthropoid apes. If, the chimpanzees of Wolfgang Köhler and his followers also show a capacity for problem solving by mental insight instead of by trial and error of manual type this does not exclude the possibility that the process of a blind search for solutions takes place during the phase of 'meditation' or 'reorganisation of the perceptual field'. The neuro anatomical research evidence from the study of the behaviour of primates establishes the existence of cerebral lateralisation of linguistic areas in the dominant hemisphere, endowed with the ability to learn predesigned artificial languages and the capacity for holistic and immediate individuation of solutions to problems involving the deposition of objects and symbols. The motor organs commanded by the dominant hemisphere then will implement in time ordered steps these solutions. Evidences also point out the existence of transition from a silent information processing phase to a phase of logical and verbal processing, as explained in the description of 'personal experience' by Poincaré. The pattern recognition of an aesthetic type leading to the recognition of possible
harmonies in mathematical reasoning and the possibility of a parallel unconscious process with the artifice of time-sharing, of comparison of calculations made in different instants and explorative directions with the aim of choosing the most effective heuristics also lend credence to the view of an evolutionary structural process of problem-solving and even development of intelligence.

Something analogous to the model of incubation and illumination processes which Simon proposes as typical of scientific discovery seems to occur in the evolution of organisms when natural selection operates through 'neutral' and 'silent' mutations on the genotype or the hereditary programme, causing variations in its compositions. Darwinian evolution mainly referred to the phenotypic variations. Evolutionists faced with the facts of phylogenetic changes on the genus, family and order were often led to consider them as sudden macromutations or block mutations. In the Kuhnian terminology adopted by Simon, these macromutations would correspond to paradigm changes characteristic of scientific revolutions. And the origin of species of the Darwinian mould would constitute the first attempt to explain the biological revolutions not explained by Linnaeus' 'fixism' which confined itself to admitting intra-specific variations and, within the framework of this comparison, would have condemned nature to
doing routine scientific research work, continuing in the
direction of the principal taxonomic ramifications.63 The
mathematical theory of catastrophe would today be able to
explain, according to Rene Thom and his followers, the
diversification among orders, classes and types of organisms.

Unlike Campbell and contrary to the role he assigns
to blind trials in the evasion from the paradigms of a
crystallized science64, Simon reaffirms the continuity
of scientific progress as routine research's gradual
preparation for a change in paradigm.65 In Darwinian
evolutionism, intraspecific variations accumulate gradually
until they give rise to true speciation, and the same thing
happens for the variations within higher systematic
categories.66 That is, creative scientists cannot avoid
taking into consideration the previous results and,
according to Simon, his trials are also not so blind as
to make him again travel over the same paths tried by
others in vain, not even the path of proper formulation of
new questions which constitute, in the opinion of several
authors, the most important phase of a scientific revolution.

Simon dealt with the powerfully selective heuristics
employed by the great revolutionists although he did not
consider it necessary for them to employ radically different
procedures.67 His epistemological slant consequently does
not embrace the definition of 'artificial intelligence' which includes its use as a functional model of natural intelligence, as it is known to us, because, it refers and foresees the possibility of development of right programmes, structural elements and circuits that may permit electronic computers to acquire such natural intelligence and more by means of which they may be able to solve problems which human beings may not be able to.

According to this view greatest creativity is manifested during the first phase of acquisition of any language by the child through blind trials by examples of different animal species and rapidly imitated by other members of the collectivity to which these exemplars belong. This view is not far removed from Campbell's which does not find true creativity in choices oriented by the information the individual starts with, but here the 'operant conditioning interpretation of innovations' are cultural in an ethological sense. This view is reflected in Piaget also when he uses the Haeckelian principle that ontogeny recapitulates phylogeny, for a comparison between the development of the child's thought with regard to natural phenomena and the historical development of scientific thought.

This is further extended in Gruber who noted creativity in 'starting from the scratch' and exploring curiosity, both in the child and in the scientists, reaching the conclusion
that the full expression of creativity occurs, when adult
courage and tenacity is combined with the infantile factor,
of curiosity and exploratory sense as well as creativity
inherent in them. It is relevant to recall Lorentian
presupposition of a programming based on phylogenetically
acquired information or the innate, inborn hardwired
knowledge which the behaviourists dispute, as the creative
and evolutionary factor. Others like Kohler have elaborated
other mechanisms of brain activity such as diversion from
predominant concerns, interruption of nocturnal equilibrium
etc. which breaks the inhibition exercised by the dominant
hemisphere on the minor hemisphere, in repeated instances.

7.5 Dynamical Structure of Popperian
Evolutionary Epistemology

Popper proposed a rather evocative (than instructive)
evolutionary model which can initiate or stimulate instruc-
tion, although without implying induction which is the
characteristic of the Darwinian model. While Darwinian
shows that it is in principle possible to reduce teleology
(after having adapted it) to causation by explaining in
purely physical terms and the existence of design and
purpose in the world, Popperian scheme advocates that "only
an organism which exhibits in its behaviour a strong
tendency or disposition or propensity for survival will
in fact survive". His scheme visualised that during
evolution, such a disposition actually is simulated and becomes part of the 'genetic skill and aim structure' during mutational changes in the inherited 'central propensity structure'. This propensity will guide or direct itself in the behaviour and organisation of the evolving organisms in the context of problem-solving through trial and error method. As any mutational change can only be a potentially favourable and need not be so ipso favourable, this difference to become evident, the improvement will have to be implemented and such implementation often depends on a complementary accidental change in the central propensity structure.

Once a new aim or tendency or disposition or new skill has evolved in the central propensity structure, this fact will influence the effect of natural selection in the sense that what was previously only a potentially favourable change will become an actual favourable change if it supports the newly established tendency. Similarly, Popper finds that Lamarckian evolution by instruction may be simulated by Darwinian evolution through chance variations and natural selection. This view corresponds with those expressed by Erwin Schrödinger in his 'Mind and Matter' (1958) and J.M. Baldwin in his 'Development and Evolution' (1962) and Werner Heisenberg in his 'Tradition in Science' (1975) and elsewhere.
Popper drawing other examples from physics (see Objective Knowledge, p. 269) suggests that theories have built-in, hardwired survival elements even in their most primitive form and that can accommodate variations without forfeiting their ability to solve problems for survival. Thus he holds Lamarckism as a forerunner with such built-in elements to accommodate the novelties that are brought about as survival factors for the theory as held by Darwinism. Popper’s view in the present form amounts to a total acceptance of an evolutionary continuist growth of knowledge, the succession of theories result in further extended application and elaboration of the hidden survival elements of the old theories, as it were.

However, Popper’s theory falls short of correctly evaluating the depth of novelty as a contradistinction with the old theories. Therefore, while accepting the principle of evolutionism enunciated here, it may be noted that the changes are not merely the unfolding of the survival elements from the old theories and incorporation of them into the new bodies (of knowledge). This will amount to accepting that discoveries involve nothing but assigning new meanings to the old theory. It may also be noted that the newness need not and actually is not an extraction, or abstraction or even elaboration from the old, and the newness may have been generated dialectically
or imported from elsewhere or still, caused accidentally. In fact old theories do seldom and if at all only skeletally provide the basis or cause for the survival factors, in the new theory. Popperian explanation would amount to accepting that the only function of new theories and discoveries, as much as the variations themselves, is survival as the only business of their life. That would indeed make the engagement in discovering and the enquiry itself almost dull, curiosity-free, unadventuresome and unattractive. And it would make and restrict the scope of science itself as much as the scope of new predictions, which in such a case need not at all come if the function of research and discovery were to be limited to the question or acquisition of survivability of the theory alone.

Another basic implication of the growth of knowledge that should not be lost sight of, is the fact that, just as the intelligence structure if living organisms at every level is in pursuit of knowledge for problem-solving, and consequently for enabling them to adjust to the flux of changing needs and character of the environment and enabling their survival and in fact the survival of the species and life itself, the function of exosomatic search for knowledge is not merely an effort at problem-solving for the survival of the theories, but through the improved
theories (novelties) for the survival of life itself. In this sense the entire activity of knowledge search is just a part of the organisms' search for tools to enable them to solve their problems of survival encountered in their life. This then, because of the necessarily incessant interaction involved in their living and changing context between the problem situations and the problem-solving tool of innate knowledge-intelligence structure, is bound to be evolutionary in nature, as much as the growth of intelligence in a child, or even in an adult, growth of organs, organisms, species, communities among the milieu of life and growth of life itself. Popper's theory suffers from its neglect of this fact, despite its evolutionary posture. It needs to recognise emphatically that the knowing intelligence, the knower, the problems and environment are all relative and continuously in flux and therefore the results of reaction among them. That is, the knowledge cannot but be changing and changing harmoniously and gradually and therefore, evolutionary. The context of this change, surprisingly, occurs in a rule-governed manner and situation, and the rules are prescribed by the changes in other actor-components of the milieu.

7.6 Res gestae et Scriptae of a New Evolutionary Epistemology

Popper also attempted to reconcile the opposing
forces of goal-directedness of changes postulated in
Lamarckian model and the accidentality of mutations and
variations of the chance-like operant condition postulated
in the Darwinian model. Under such conditions of clash
between chance-like variations on the one hand and goal
directed development of organs, say, the human eye, on the
other hand, it is legitimate to doubt if such divergent
and opposing forces can permit a simulated and goal-directed
development of organs, organisms and species on the one
hand and on the other permit the elaboration of the inbuilt
survival elements to problem-solve their way through
evolution. In other words, can the process of evolution
reconcile the essential clash between the Lamarckian and
Darwinian behaviour of organisms?

Apart from Simpson, who considered evolution to be
not only a mixture of random and oriented changes but also
highly opportunistic in a purely impersonal sense, many
biologists, psychologists, and philosophers have attempted
to solve this problem. Many experimental results, including
that of the work of Kohler on chimpanzees, the work on
the growth of intelligence of children by Piaget, Cruber,
Simon, work on matter, mind, consciousness and creativity
by many psychologists, neurophysiologists, physicists, and
philosophers, and work on the Lorenzian studies on the
inherited behaviour and Baldwin's effect, apart from
several other problem-areas in this context. In brief, as admitted by Popper and Eccles\textsuperscript{101} (a formidable combination indeed) in their book, The Self and the Brain, probably a solution to this problem will be found around the ideas of Lorentzian\textsuperscript{102} and Baldwin hypotheses which together provide a framework within which these two opposing forces can be realistically made to coexist, that is, between and together the forces of Darwinian and Lamarckian behaviour. It must provide a compromise between the two theories by synthesizing a Darwinian development that simulates Lamarckian goal-directedness which accommodates both chance and teleology.

Apart from these compromises, support to such interpretations have also come from pure philosophy which postulates that a rejection of physical determinism as held by Heisenberg's indeterminacy theory\textsuperscript{103} or Compton's\textsuperscript{104} and Pierce's indeterminism does not amount to a surrender to sheer chance or leads to chaos or undermine rationality in behaviour and decision making. Statistical or chance-like behaviour at the level of neurons is not inconsistent with logical decision-making or thinking, although partially indeterministic decision-making need not guarantee rationality always. The fact that most decisions and behaviour of man are balanced and rational and not totally illogical shows that this stochastic process integrated into the
brain and overall cerebral processes goes on without any amplification of the wild excesses, snap decisions etc. arising from quantum jumps at molecular levels\textsuperscript{105} and synaptic decisions at neuron levels. In fact such a process is analogous and compatible with the general intricates homeostatic (cybernetic) control the body has over its parts.\textsuperscript{106} This situation is equally comparable to the integration and synthesis that occurs in evolution of life and species and organs, wherein, similar reconciliation of contrary forces of chance or orderliness competing and resisting each other occur through the synthesis of Darwinian development that simulates Lamarckian goal-directedness and rationality. In both cases of organic evolution and evolution of knowledge, as much as in intelligence and language, a remarkably silent integration, simulation, synthesis, and assimilation occurs to usher in perfect harmony during the evolutionary process, unlike in the social realm where it is noisy enough to deserve the revolutionary title. Further, Popper concaded that the advance towards theories of even greater or higher level of universality and from coherent homogeneity to coherent heterogeneity, the well recognized general direction of movement of science, and its evolution, occurs quasi-inductively, although it does not necessarily consist of a sequence of inductive inferences. He held that theories
of some level of universality are proposed and deductively tested and after that theories of higher level of universality are proposed and in turn tested with the help of those of the previous level of universality and so on. The method of testing is based on deductive inferences and therefore, this is a quasi-inductive solution. His model of quasi-inductive evolution of knowledge is a scheme in which ideas and hypothesis are like suspended particles in a fluid where the testable science is the precipitation of the particles at the bottom. They settle down in layers of universality, the thickness of the layer growing with time and the number of layers. Every new layer is corresponding to a theory more universal than those beneath it. As a result of this process, ideas previously floating in higher metaphysical regions, inaccessible to crucial tests may sometimes be reached by the growth of science, make contact with it and settle.

The question of determinism or chance is essentially related to this phenomenon of crystallization. Here, Popper held that something more than the 'indeterminism' is needed to explain the decision choices in man. This is because rational human behaviour cannot be explained on the basis of snap decisions triggered by quantum jumps and based on such models. Chance human behaviour is something intermediate in character between indeterminism
and perfect determinism or, in Popper's words, between 'perfect clouds and perfect clocks'. In this context, Popper brings the idea of the influence of such things as aim-structures, purposes, rules, agreements, volitions and a universe of abstract meanings and its influence on behaviour that control the body and mind. It is a subtle interplay between something almost random and something like selective control, probably achieved through some kind of 'operator' like masterswitches or control centres such as the pineal body as was suggested by Descartes. It may even be effected through the selective amplification of the quantum jumps by the nervous system which may then relay it to a cascade of relays that control the action points or implementation centres such as muscles.

However, Popper was not content with these major master switch model of decision making and he suggested that decisions which conform to all this (including indeterminacy, Compton's postulate of freedom and control, chance and perfection) are as a rule, reached almost imperceptibly through lengthy discussions/deliberations by the method of trial and error elimination in a maturing process.

Such a maturing process is involved in the phenomena of discovery, a series of which, with the help of its implied understandings and heuristics, enrich the body of knowledge and help it to grow. Involved in this
process is critical method through which rationality is decided. The argumentative use of language leads to the evolution of ideal standards of control or regulative ideas. The regulative idea of the descriptive use of language in truth and that of argumentative use is validity. These higher functions of language enables us to establish a plastic control over the lower functions of language, namely the signalling and expressive functions, that provoke reactions. These functions enable us to control the discussion on the basis of the regulative ideas of truth and validity. Thus critical arguments are a means of plastic controls for eliminating errors, a means of selection. We solve our problems by tentatively proposing various theories and hypotheses and by submitting them to critical discussions and empirical tests.

Thus evolution of higher functions of language may be characterised as the evolution of new means of problem-solving, by new kinds of trials, new methods of error elimination and control. Higher level language has evolved under pressure of a need for better control of our lower levels of language and our adaptation to the environment by the methods of growing new exosomatic tools, new theories and standards of selection. Popper, among others, considers that the same phenomena occurs in the selection, modification and growth of knowledge, as in the growth of organs, species
and life itself. This is so because 'even as adults, the forms of our thought are not static and, certainly historically, thought and knowledge, in their content, have undergone changes as a remarkable as that of the child to adult in intelligence and in the functions and evolution of language and the knowledge which it expresses, especially the scientific knowledge. 109

That there are similarities between the development of intelligence and knowledge in the individual and the development of knowledge itself and the idea that understanding the process by which the individual acquires knowledge can illuminate the more general epistemological process, is an important one. Further that the human intelligence and knowledge is a structure which is constructed step by step in the course of the epigenetic development through a process of assimilation and integration, has been clearly elaborated by Piaget in his studies. 110

The present formulation starts with the assumption that we start from practical problems or from a theory which has run into difficulties, then the growth of knowledge occurs when we proceed from old problems to new problems, the movement being effected by means of conjectures and refutations and critical arguments and
problem-solving. The inborn expectations and anticipations will, if disappointed, create our first problems and ensuing growth of knowledge may therefore be described as consisting throughout of corrections and modifications of our previous knowledge. The innate substantive experience and the universe of acquired knowledge in us, hardwired into our system itself, acts as the choice-maker and also sets the standards of choice relevant to its needs, pressures, opportunities and, as claimed by Popper, its aim-structures volitions, rules, agreements, universe of abstract meanings and the problems it is dealing with. This choice is also influenced by the opportunistic tendencies (Simpsonian) of matter and organisms and also their perception of opportunities. Apart from this, the curiosity, creative and adventurist elements of inborn experience may also play a role in the choice behaviour or organisms. In any case the governing standards of choice are the regulative ideas of truth, validity, utility, viability, harmony, economy and the problem-solving ability. Perhaps the Bayesian model of theory choice is applicable here.

The incremental elements that come with the choice of new-ness, and novelty of the theories and knowledge which was lacking in the previous knowledge structure and which now enables the organism to solve problems are then
incorporated, integrated and assimilated into the existing knowledge structure. This results in a continuous process of change and modification of human knowledge or knowledge itself. Accordingly the standards of choice set by the innate knowledge structure that chose the decision or the newness from the universe of alternatives becomes continuously modified, as much as the content of knowledge itself. This superstructure of innate knowledge which acts as the selector and the standard for selection, itself thus evolves through modification by assimilating the new knowledge and by reacting to feedbacks. It acts as the continually evolving regulative idea that restores wisdom of choice from anarchy, order from chaos and randomness and purpose from chance, thereby enabling itself to react and satisfy the necessities or avail the opportunities for survival and progress respectively.

Thus the ensuing knowledge may therefore be described as consisting throughout of corrections and modification of our previous knowledge.

7.7 Conclusions

Earlier, we have described a similar process that occur in the evolution of all life and life forms and functions, as also the evolution of intelligence in a child and adult. In both cases it is clear that such
growth or change or progress retains rationality, historicity, continuity, complementarity, commensurability and rational intelligibility, all essential for a rational process. In fact, we have seen that these processes, either the evolution of life or progress of knowledge and especially scientific knowledge, manifest more rationality and rational intelligibility than the many epistemologies that have sought to reconstruct the history of growth of knowledge and science. Perhaps it is redundant to mention that only an epistemology which can depict and translate the truly evolutionary nature of the growth of knowledge and scientific progress can adequately satisfy the demands and standards of philosophical rigour, validity, objectivity, rationality, truth, factuality, pragmatics, utility, secularity and correspondence.
Notes and References


2. This is the contention of Popper in his 'Conjectures and Refutations' (Routledge and Kegan Paul, London, 1963).


9. Butler, Samuel, Erewhon (Everyman's, London, 1872) not seen in original. Adapted from Popper's 'Objective Knowledge'.


14. This may in effect mean a 'consciousness gradually working by way of countless fumblings as held by Tielhard de Chardin. Cf. Chardin, Tielhard de, The Vision of the Past (Harper and Row, New York, 1966), p. 181, or an act of problem solving and decision making for survival in an atmosphere of uncertainties. It could be a growth through modification resulting in accumulation of truths even as such truths have only an ephemeral existence because of the possible criticisms and resulting invalidations in the light of 'ocean of anomalies' and recalcitrant evidences. This is especially so, as science is a critical enterprise, as held by Peggi Marchi, in specific for mathematics. See, Margarett Marchi, 'Mathematics as a critical enterprise', in R.S. Cohen et. al. (eds.), Essays in Memory of Imre Lakatos, 1976, pp. 379-93. The process of discovery itself is trial and error method, as Whewell describes it (see Cohen, I.B., William Whewell and the concept of Scientific Revolution, in R.S. Cohen et. al. (eds.), Essays in Memory of Imre Lakatos, 1976, pp. 55-63). The process itself begins as soon as a new theory is proposed and anomalies begin to surface, or, when it gives rise to practical problems, or when the theory has run into difficulties (see, K.R. Popper, Objective Knowledge, p. 258).


16. The reference here is to later Popper, as presented in Objective Knowledge. Also to Vincenzo Capelletti who in his essay on 'Discovery and Vocation' deals with the discovery from a pragmatic plane. Capelletti holds vocation for knowledge and rational construction: these make a discovery surpass the range of chance and transmute it into necessity, necessity of being so for a hypothetical world which could identity with the existing world.


19. Cf. Grmek, M.D., in M.D. Grmek et. al. (eds.), On Scientific Discovery, op. cit., pp. 9-39. The methodological myths he refers to are (1) the myth of epistemological adequacy of 'anatomising' acquired scientific knowledge and the patterns of its conquest. (2) the illusion concerning the adequacy of our present historical knowledge for reconstructing the process of scientific discovery or for validating hypothesis relating to this behaviour. (3) the myth of a perfect agreement between a rational reconstruction and the experience of discovery caused by deformation of reality in the researcher's report and by the historian or philosopher of science. (4) the myth of an impersonal historical development of scientific thought. (5) the myth of the unity of the discoverer, of the place and time of discovery. (6) the positivist myth of the straight road to truth. (7) the myth of revolutions. (8) the illusion resulting from the projection of initial circumstances in a developed sequence or events. (9) the myth of the clearcut alternation of the observation of facts and the invention of hypothesis. (10) the myth of Baconian induction. (11) the illusion of the fundamental epistemological role of verification. (12) illusion of a perfect symmetry between verification and falsification. (13) the illusion of a strictly logical nature of scientific reasoning. (14) the myth of strictly irrational nature of the origin of discoveries and (15) the myth of sociological explanation of scientific discoveries.

20. Grmek, M.D., ibid., p. 11.

21. The older positivists pin their faith to the method of induction and consider as scientific only those concepts or notions which were 'derived from experience, and those believed to be logically reducible to elements of sense experience or sense data, impressions, perceptions etc. The neo-positivists see more clearly that science is not a system of concepts but rather a system of statements and therefore admit as scientific only those statements of experience and judgements of perception or atomic propositions, protocol sentences etc. which smack of inductivist prejudices. For example Wittgenstein, for whom every meaningful proposition must be logically reducible to elementary atomic propositions. Positivists dislike the idea that there should be meaningful problems outside the field of positive empirical science, problems to be dealt with by a genuine philosophical theory. They also do not like a theory of knowledge, an epistemology of methodology and they see philosophical problems as pseudo problems.


31. Being sceptical about the eventual role which conceptions of reason play in establishing a form of life, Feyerabend criticises Newton who proposed an axiomatic, monistic methodology and yet violated every single rule that he proposed (claims Feyerabend), cited from John Krige, Science, Revolution and Discontinuity (The Harvester Press, Sussex, 1980), p. 137.


33. Whewell, William, History of Inductive Sciences: From the Earliest to the Present (John W. Parker, London and J.J. Delghton, Cambridge, 1837), vol. I, p. 11. Whewell in fact visualised in the growth of knowledge through discoveries a period of trial and error, though he called such a growth as revolutionary

34. Ibid., p. 10.


42. Rene Thom's catastrophe theory refers to sudden reorganisation of states of equilibrium, the development of new disciplines of discontinuous entities.


48. Ibid. World I as the physical world, world II as the world of experience and thought in the subjective sense and World III as the world of objective thought, especially the products of human mind. The Third World is the world of logical contents of books, libraries, computer memories and such like. It is an autonomous entity on which depends the world II, the world of our subjective conscious knowledge.


58. Popper, K.R., Objective Knowledge, op. cit., p. 266.

59. Ibid., p. 261. Popper writes, "the growth of our knowledge is the result of a process closely resembling what Darwin called 'natural selection' ... and 'From Amoeba to Einstein, the growth of knowledge is always the same: we try to solve our problems and to obtain by a process of elimination something approaching adequacy in our tentative solutions'.


63. An extensive elaboration of the morphogenetic processes in the anatomical differentiation of plants is described in S.K. Pillai and R. Divarakan, Plant Anatomy: An Introduction to the Dynamics of Development, in press. The dynamical structures presage an evolutionary developmental process.


66. Ibid., p. 245. He held that the method of trial and error elimination does not operate with completely chance like or random trials. Even though the trials may look like random, there must at least be an after effect. For the organism is constantly learning from its mistakes, that is, establishes controls which suppress or eliminate or let least reduce the frequency of certain possible trials. See also J. Mark Baldwin, Development and Evolution, 1902, pp. 174 and H.S. Jennings, The Behaviour of Lower Organism, 1906, p. 321. The difference here referred to is to the difference in the critical ability developed from experience and past trials.


63. Campbell, D.T., 'Evolutionary Epistemology', op. cit., p. 34.


67. Ibid.

68. Poincare, H., *Science and Method* (Science et Methodes) (Flammarion Press, Paris, 1908). He noted that the information processing phase is carried out by the synthetic and analytical right hemisphere and the logical and verbal processing is done by the analytical and numerical left hemisphere. He also implied that the pattern recognition of an aesthetic type brought about suddenly by the intuitive hemisphere would permit the recognition of possible harmonies in mathematical reasoning before this is translated into symbols and further specified by the critical activity directed by the discursive hemisphere.


81. The model of incubation and illumination processes which Simon proposes as typical of scientific discovery in terms of 'familiarisation', 'selective forgetting' and tree-blackboard schemata is suggestive of an imitation of the supposed human procedures by a programme for electronic computers. In a certain sense, the task of identifying the heuristically most suitable graph is removed from the analytic or serial procedure typical of the left brain and the digital computers and is transferred to the synthetic or parallel procedure typical of the right brain and electronic pattern recognition devices. Sommzi says that, the right hemisphere examines the form of physical and mental phenomenon and also the form of reasoning or the programme which the left hemisphere is made to execute.

82. Simon, Herbert A., 'Does scientific discovery have a logic?', Philosophy of Science, no. 3 (1973), pp. 471-80.

83. 'Fixism' of Linnaeus, refers to the belief in the original creation and fixity of species. It also refers to the stereotyped behavioural response shown by an animal regardless of whether it is accompanied by positive or negative reinforcement, and often shown in an insoluble problem situation.


91. Kohler, Wolfgang, Dynamics in Psychology (Dover, New York, 1940), pp. 24-25.


100. Baldwin effect means that if the trial and error method results in success, they increase the probability of survival of mutations which simulate the solutions so reached and then, tend to make the solution hereditary by incorporating it into the spatial structure of form of new organisms. See, J. Mark Baldwin, Development and Evolution, 1902, p. 177 and also C.G. Simpson, 'The Baldwin Effect', Evolution, 7 (1953), p. 110.

102. Lorenzian behaviour postulates that 'any modifiability which regularly presupposes a programming based on phylogenetically acquired information cannot be denied. To deny this necessitates the assumption of a pre-established/stabilised harmony between the organism and environment. See K. Lorenz, Evolution and Modification of Behaviour (Methuen, London, 1966), p. 12. Lorenz's innate psychology (inspired by Kant) held that the prior conditions are biological instincts and innate conceptual networks. For Lorenz these prior conditions produced, when allied to evolutionism, the notion that evolution is moving in the direction of closer and closer approximation to 'noumenon', the 'unknowable' thing in itself. For details, see James Russell, The Acquisition of Knowledge (Macmillan, London, 1978), pp. 1-3 and also pp. 229-32.


