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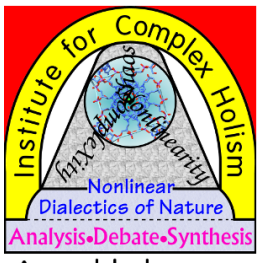
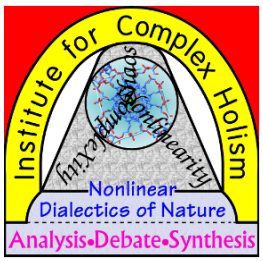


INSTITUTE FOR COMPLEX HOLISM, Kolkata

A world-class non-degree-granting residential research centre mandated to critical inquiry in the foundations of Chaos-Nonlinearity-compleXity and Holism in Nature

"The research that has the most profound impact on knowledge and understanding, and so often that which ultimately has the most profound impact on everyday life, is that driven by curiosity rather than immediate application. In a world where funding bodies tend to support research that is programmatic and promises predetermined deliverables, the freedom provided by the Institute to its Faculty and Members is increasingly rare. The Institute exists to encourage and support fundamental scholarship --- the original, often speculative, thinking that produces advances in knowledge --- (it) is dedicated to the disinterested pursuit of knowledge." http://www.ias.edu/about

ICH WILL ENCOURAGE AND SUPPORT "FUNDAMENTAL SCHOLARSHIP DEDICATED TO THE DISINTERESTED PURSUIT OF KNOWLEDGE" IN PHYSICS (FOCUS: QUANTUM AND GRAVITATION), MATHEMATICS (FOCUS: NONLINEAR SCIENCE), BIOLOGICAL SCIENCE, AND SOCIAL, ECONOMIC & MANAGEMENT SCIENCES AS AN INTEGRATED, CROSS-FERTILIZED DISCIPLINE. THE INSTITUTE IS MORE THAN A CENTRE FOR COMPLEXITY RESEARCH: IT IS DESIGNED TO BE AN INTERNATIONAL HUB FOR THE GENERIC PATRONAGE AND NURTURE OF CHAOS-NONLINEARITY-COMPLEXITY AS THE NEW SCIENCE OF COLLECTIVE HOLISM.



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What ICH? – Why?

• *I think that the next century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together, and what happens under extreme conditions. But I expect we will find a complete unified theory sometime this century. There is no limit to the complexity that we can build using those basic laws.* **Stephen Hawking (2000).**

• *We don't know what we are talking about. Many of us believed that string theory was a very dramatic break with our previous notions of quantum theory. But now we learn that string theory, well, is not that much of a break. The state of physics today is like it was when we were mystified by radioactivity. They were missing something absolutely fundamental. We are missing perhaps something as profound as they were back then.* **Nobel Laureate David Gross (2005).**

• *If string theory turns out to be right, string theorists will turn out to be the greatest heroes of science. . . . If string theorists are wrong, they can't just be a little wrong; then we will count string theorists among science's greatest failures. Theirs will be a cautionary tale of how not to do science, how not to let theoretical conjecture get so far beyond the limits of what can rationally be argued that one starts engaging in fantasy.* **Lee Smolin, "The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next" (2006).**

• *The beauty and elegance of superstring theory lies in the hopes and dreams of its practioners, hopes and dreams that are vanishing as every year it becomes more and more unlikely that they are ever to be realized. Superstring theorists would like to believe that someday a simple equation, beautiful physical idea, or fundamental principle will be found that will explain the intricate structure they have been studying. The present situation of the field is that no such thing is actually in sight despite more than twenty years of effort looking for it.*
The failure of the superstring theory program must be recognized and lessons learned from this failure before there can be much hope of moving forward. As long as the leadership of the particle physics community refuses to face up to what has happened and continues to train young theorists to work on a failed project, there is little likelihood of new ideas finding fertile ground in which to grow. Without a dramatic change in the way theorists choose what topics to address, they will continue to be as unproductive as they have been for two decades. **Peter Woit, "Not Even Wrong: The Failure of String Theory and the Search for Unity in Physicsl Laws" (2006).**

Science of the last 400 years has essentially evolved by the reductionist tools of linear mathematics in which a composite whole is regarded as the sum of its component parts. Increasingly, however, a realization has grown that most of the important manifestations of nature in such diverse fields as ecology, biology, social, economic and the management sciences, beside physics and cosmology, display holistic behaviour which simply put, is the philosophy that parts of any whole cannot exist and be understood except in their relation to the whole: the system as a whole determines in an important way how the parts behave. These complex self-organizing systems evolve on emergent feedback mechanisms and processes that "interact with themselves and produce themselves from themselves": they are "more than the sum of their parts". Thus society is more than a collection of individuals, life is more than a mere conglomeration of organs as much as human interactions are rarely dispassionate.

The Institute for Complex Holism (ICH) has been conceived as an autonomous centre for basic and supporting applied research in the dynamics of open systems that interact with their environment in attaining a state of homeostatic equilibrium. ICH is conceptually distinct, being conceived after the Perimeter Institute for Theoretical Physics at Waterloo (http://www. perimeterinstitute.ca/en/) established by the founder of Research In Motion with a grant of 100 million dollars, and the Institute of Advanced Studies, Princeton (http://www.ias.edu/ about/). It is important for such an institution to be academically and financially independent, with full operational autonomy.

The linear reductionist framework of present mainstream science raises many deep-rooted and fundamental questions that defy logical interpretation within its own framework; as do questions involving socio-economic, collective (as opposed to individualistic), and biological relations. The issues raised by this dichotomy have been well known and appreciated for long leading often to bitter and acrimonious debate between protagonists of the reductionist and holistic camps; linear systems cannot be chaotic however, thus complex, and hence holistic. The guiding motto of ICH is a complete and full understanding of the "why-what-how" of the interactive and interdependent nonlinear dialectics of holism and collectiveness. This is expected to lead to a more complete conceptualization and appreciation of the physical, social, and moral issues in which we are necessarily embedded.

The fundamental mandate of ICH is the furtherance of the scientific unraveling of this tension between individualism and collectivism — between dispersion and concentration — in the spirit of open foundational inquiry. This the Institute proposes to achieve by encouraging a synergistic atmosphere of interactive collaboration where resident and visiting academics from across the world can focus on multi- and intra-disciplinary fundamental research in all aspects of chaos-nonlinearity-complexity. Developing a tradition of cross-fertilization that encourages and motivates both orthodox and speculative approaches, ICH will aim to constructively interact with surrounding academia through seminars, workshops, schools and conferences, and appointments in the adjunct and visitor categories. The Institute will encourage and support "fundamental scholarship dedicated to the disinterested pursuit of knowledge" in Physics (focus: quantum and gravity), Mathematics (focus: nonlinear sciences), Biological science, and Social, Economic & Management sciences as an integrated, cross-fertilized, discipline. ICH is more than a centre for complexity research (http://www. santafe.edu/): it is designed to be an international hub for the generic patronage and nurture of chaos-nonlinearity-complexity as the new science of collectivism.

ChaNoXity — the new integrated discipline of Chaos-Nonlinearity-compleXity — is possibly the first rigorous scientific, self-contained, and unified formulation of complex holism. We are now beginning to understand how these composites work — why and how "life" sustains itself — in terms of a new (nonlinear) mathematics with its attendant new physics and new interpretational philosophy and a "metaphor" of reality. ICH aspires to provide a world-class institutional forum for the development and fertilization of this foundation as a hard rigorous science of holism, complementing mainstream reductionism — linear science has after all stood the test of the last 400 years as quantum mechanics is acknowledgedly one of the most successful yet possibly among the most mysterious of scientific theories. Its success lies in the capacity to classify and predict the physical world — the mystery in what this physical world must be like to be as it is supposed to — in order to provide a global dialectic of the dynamics of Nature. The foundations of this new science constitutes the basis of activity at ICH.

We solicit participation and sponsorship from individuals and organizations to transform the ICH dream into reality, adequate to generate the necessary foundation for the Institute to function efficiently and independently. Complex holism — the self-organizing, emergent manifestation of intense nonlinear interactions of a system with its environment -– cannot arise linearly and be described by traditional reductionist approaches; the distinctive philosophy structured around the distinctive mathematics of ChaNoXity justifies and obligates an institution exclusively dedicated to the cultivation and promotion of this New Science. The large number of teaching and research organizations in and around Kolkata, coupled with its continued interest in the sciences, makes this an ideal location for ICH.

The Preamble

A. Why Chanoxity?

In the analysis of nearly all natural phenomena one is confronted with systems that do not obey the simple laws of linearity. The mathematics of linear objects is particularly nice and elegant which can be sometimes misleading, enjoying as it does, an identical and simple geometry. The simplicity of this geometry allows a relatively easy mental image to capture the essence of the problem, with the technicality growing with the number of parts being essentially a material of detail. This has led to a historical prejudice against real world problems that do not necessarily enjoy such simple or universal geometry. Linear physics and mathematics circumvent real life by reducing it to linear approximations that are often unsatisfactory; hence the need to study nonlinear systems.

One of the most striking aspects of physics is the simplicity of its laws, and everything appears simple and neat except of course the actual world, outside the classroom, where one encounters a world of amazing *complexity*. A living organism is complicated because it has many different working parts, each formed by variations in the working out of the same genetic coding, interacting with each other in a hierarchically stratified manner. *Chaos* is also found very frequently; in a chaotic world it is hard to predict which variation will arise in a given place and time. A complex world is interesting because it is highly structured. A chaotic world is interesting because it is unpredictable. Our world is chaotic, nonlinear and complex: it is a *chanox* world. Nature can produce complex structures even in simple situations and obey simple laws even in complex situations.

Since the beginning of his scientific inquiry, man has suffered a special ignorance of disorder in the atmosphere, in the turbulent sea, in the fluctuations of wildlife populations, in the oscillations of the heart and the brain. But in the 1970s some mathematicians, physicists, biologists, and chemists started finding a way through the apparent disorder, and the insights that emerged led directly into the natural world: the shapes of clouds, the paths of lightning, the microscopic intertwining of blood vessels, the galactic clustering of stars. The impact of this emerging science of chanoxity on various disciplines and the broader implications for science and society can be gauged from its universality and ubiquity, and over the last 30 years or so it is possible to find scholars representing an incredibly vast and divergent range of distinct fields discuss and deliberate topics in their respective fields from the comprehensive viewpoint of chaos, nonlinearity and complexity. In fact it might well be justified to expect the present century to belong to the macroscopic world of chanoxities governed by intra- and multi-disciplinary (rather that inter-disciplinary) approaches, just as the previous was of the microscopic, raising "new hopes, new styles, and most important, a new way of seeing things".

The relative unfamiliarity of nonlinearity can be primarily attributed to the all-embracing character of twentieth-century calculus and its immediate consequence, analysis. Analysis, with its eminently successful tools of differential equations, integration, and series expansions finds successful application in almost all branches of modern science and technology. The unbroken success of calculus and analysis is responsible for the belief that "analysis was the way of the world, that all problems would eventually yield to it given enough effort and enough computing power", leading to the notion that "everything can be reduced to little pieces $\cdots$ (and) can be known and understood if we analyze it on a fine enough scale". This success of calculus is in large part responsible for the decidedly reductionist attitude of most of twentieth century science of breaking down natural systems to its constituent units whose properties combine in a relatively simple manner to yield the complex structure of the whole. The belief in absolute power arising from detailed segmented knowledge has dominated the natural sciences over the last century and with good reason: it has served to explain some of the most fascinating intellectual challenges of mankind. But shortfalls in reductionism have become increasingly apparent, and chanoxity the science of "synthetic cohabitation of the opposites"[1], not based upon calculus as its founding pillars "destroys our reductionist dream, the dream that we have absolute power if we only know enough of the details". The importance of non-reductionist nonlinearity in general, and chaos and complexity in particular, stems

[1] A. SENGUPTA, Chaos, Nonlinearity, Complexity: A Unified Perspective. In A. Sengupta (Ed.), *Chaos, Nonlinearity, and Complexity: The Dynamical Paradigm of Nature,* StudFuzz, **206,** 270–352, Springer-Verlag, Berlin, (2006).

from this entirely new — though complementary — view of nature and the dynamics of its evolution. As examples of complex systems mention can be made of governments, families, the human body, an individual from the psychosocial perspective, the brain, a corporation, the weather, and the world ecosystem. Coping with chanoxity will generally involve a process of re-education and reorientation to supplement the fundamentally reductionist attitude of modern science.

The goal of the proposed Institute for Complex Holism, devoted to research and study of chanoxity, is to foster and encourage excellence in the study of the physical and mathematical aspects of the world we live in. Its aim is to highlight the intra- and multi- disciplinary character of the natural and applied sciences, and to encourage and stimulate interaction among the different disciplines that contribute to this field. The basic objective of the centre will be to "develop the capacity to respond to our changing science and to new ideas about the nature of the world as they relate to reality", providing a common platform from which scientists with diverse backgrounds can interact intelligently in promoting, through a common language, the growth and development of this evolving science of the twenty-first century. It is believed that from such interaction is likely to emerge "the kind of representation of the world that no one individually possess or could possess." If the job of the sciences is to discover and explain the laws of nature then we must be prepared to accept nonlinearities as a fact of life and try to understand and interpret it.

B. Nature is Complex

Complexity is the science of the *synthetic cohabitation of opposites,* of interactive, hierarchical, and self organizing evolving systems that are distinguished by being more than the sum of their constituent parts. Broadly speaking, a complex system is an assembly of many interdependent parts that interact with each other through competitive nonlinear collaboration leading to a self-organized and emergent structure. While these characteristic features of emerging, dissipative systems have long been recognized it is only now that its significance in explaining the laws of Nature is being fully appreciated. This discrete, difference equation based approach avoids the continuity and smoothness of differential equations[2] and is distinguished by the occurrence of unexpected surprise implicit in difference equations — and unavailable in differential equations — leading to a new perspective founded on multifunctions and non-injective ill-posedness. This has been found to be ideally suited for the propagation of structures and patterns due to uneven amplification of initial perturbations.

While the basic and possibly the most significant example of a complex system is intelligent life in general, and the human brain in particular, complexity has applications among others, to

Example 1 A feedback mechanism is called *positive* if the resulting reaction acts in the same direction as the triggering action reinforcing the change or trend, *negative* if they oppose each other. Thus the concentrating pump of the direct iterates of the logistic map is the positive feedback promoting emergence and changes in the system, the dispersive engine of the inverse iterates of negative feedback organizes this emergence into a homeostatic whole; if negative feedback loops hold a system stable, then positive loops allow systems to explore their environment and follow new development paths. Feedback is the basis of exploration in cybernetic systems: it denotes the information that the system uses to adjust its behaviour to achieve a desired goal; it is the "study of systems and processes that interact with themselves and produce themselves from themselves".

(a) *Ecology.* In the logistic map $n_{t+1} = \lambda n_t(1 - n_t)$ describing the dynamics of non-overlapping generations of population with λ the reproductive rate of the average number of offsprings surviving to adulthood, absence the negative feedback $(1 - n_t)$ results in a linear growth of the population by the factor of $\lambda \in (0, 4)$ in every successive generation. With the feedback present, however, the resultant nonlinearity regulates the size of a population according to the standard "complicated" prescriptions of the logistic equation for $\lambda \in [3, \lambda_*)$ when the population size progressively oscillates between these increasing number of stable values, extinction for $\lambda \in (0, 1)$, a unique constant size when $\lambda \in [1, 3)$, and an erratic behaviour marked by the absence of any regular pattern for $\lambda \geq \lambda_*$

[2] C. S. BERTUGLIA AND F. VAIO, *Nonlinearity, Chaos and Complexity. The Dynamics of Natural and Social Systems,* Oxford University Press Inc., New York, (2005)

when the system not only fails to reach a stable limit but also does not frequent any set of stable fixed points.

(b) *Biology.* Blood sugar levels in biological systems are regulated by a negative feedback by release of insulin upon increase of its level due to intake of food, converting thereby the glucose to glycogen and fat. Malfunction of the pancreas results in the dangerous and fatal consequences of diabetes. Satiation of hunger and thirst also represents positive-negative feedback loops that maintains optimum levels of life supporting constituents in living systems.

As another example of the deadly consequence of the failure of biological homeostasy in living systems, mention must be made of the dysfunctional cell bifurcation system leading to uncontrolled positive feedback, growth, and cancer: abnormal growth of cells occur because of malfunctioning of the mechanism that controls cell growth and differentiation, and the level of cellular differentiation is sometimes used as a measure of cancer progression. A cell is constantly faced with problems of proliferation, differentiation, and death. The bidirectional control mechanism responsible for this decision is a stasis between cell regeneration and growth on the one hand and restraining inhibition on the other. Under healthy and normal conditions, cells grow and divide to form new cells only when the body needs them; in its normal functional form, Nature chooses the bifurcation-differentiation route to express itself as multicellular complex systems rather than nonadaptive unicellular monoliths. Mutations can sometimes disrupt this orderly process, however. New cells form when the body does not need them, and old cells do not die when they should. This cancerous bifurcation, which is ultimately a disease of genes, is represented by the chaotic region $\lambda \geq \lambda_*$ where no stabilizing effects exist. Typically, a series of several mutations are required in a process involving both oncogenes that promote cancer when "switched on" by a mutation, and tumor suppressor genes that prevent cancer unless "switched off" by a mutation.

Camazine *et.al.*[3] give the following definitions in the context of pattern-formation in biological systems

• *Self-organization* is a process in which pattern at the global level of a system emerges solely from numerous nonlinear interactions among lower-level components of a system. The rules specifying interactions among the system's components are executed using only local information, without reference to the global pattern

• *Emergence* is a process by which a system of nonlinearly interacting subunits acquires qualitatively new properties that cannot be understood as the simple addition of their individual contributions.

(c) *Social and Economic.* Bionomics is a theory that studies economics using the principles of biology as a self-organizing ecosystem. Economics, that "branch of social science that deals with the production distribution and consumption of goods and services and their management", is after all the brainchild of human society invented for interaction and communication with each other; outside of its societal institutions, monetary capital loses all its commanding power, privileges and dispensation. "Where mainstream economics is based on concepts borrowed from classical Newtonian physics, bionomics is derived from the teachings of modern evolutionary biology. Where orthodox thinking describes the economy as a static, predictable engine, bionomics sees the economy as a self-organizing information ecosystem. Where the traditional view sees organizations as production machines, bionomics sees organizations as intelligent social organisms. Where conventional business strategy focuses on physical capital, bionomics holds that organizational learning is the ultimate source of all profit and growth".[4] Mainstream neoclassical economics operating on the guiding principles that (a) people have rational preferences among outcomes, (b) individuals maximize utility and firms maximize profits, (c) people act independently on the basis of full and relevant information, attempts to "present economics as a science. As a result the field of economics has become substantially detached from real-world behaviour and has tended toward a closed theoretical discipline disconnected from the world it tries to explain. Instead of being a science, I suggest that economics should become a systems profession".

[3] S. CAMAZINE, J-L. DENEUBOURG, N. R. FRANKS, J. SNEYD, G. THERAULAZ AND E. BONABEAU, *Self-Organization in Biological Systems*, Princeton University Press, Princeton (2001)

[4] MICHAEL L. ROTHSCHILD, *Bionomics: Economy as Ecosystem*, Henry Holt and Company, New York (1995).

Economics as "a science which studies human behavior as a relationship between ends and scarce means which have alternative uses"[5] should properly be considered to be integrated with human society with the individual consumer and the collective firm serving not merely to maximize utility and profits respectively, but co-existing as a dynamical, interdependent and interacting, holistic order. The systems approach exemplified by the top-down engine, bottom-up pump paradigm suggests that a planned-and-controlled firm-pump actively monitored and tuned, collaborating with the consumer-engine, generates the best synthesis of the opposites of individualism and collectivism in society. Emergence and adaption, and not the "stable clockwork mechanism of the heavens described by Newton" of neoclassical vintage, is implied just as efficiency in a world of limited resources demands differentiation, diversity, individuality and decentralization. Adam Smith, widely regarded as the father of modern economic culture, claimed that selfish behaviour of individuals is "somehow transmuted by capitalist social relations into public benefaction"[6]. However, "since workers and capitalists meet as antagonists in the market, there is no reason for capitalists to share the increases in labour productivity with workers as high wages. The selfish persuit of gain by capitalists may create the *potential* for broad social benefits through the accumulation of capital and the widening division of labour [pump: bullish, concentrative]. But society as a whole can only achieve these potential gains by going beyond capital accumulation to *distribute* the resulting wealth" [engine: bearish, dispersive]. [7]

In the social, economic and management sciences, the holistic attitude maintains that the "law-like statements" that formal mainstream analysis generate often do not adequately explain "the nature of social reality". For example, whereas classical growth theory talks about the effect on output of changes in rates of saving, holists analyze the causes behind mobilization of resources in its social, political, cultural, beside economic, manifestations: holists, acknowledging the organic unity of human system, study the whole rather than a part taken out of context. The context of a particular event is important "because the character of any given part is largely conditioned by the whole to which it belongs and by its particular function and location in the larger system. *Thus, reality for holists is viewed as a process of evolutionary change driven by the dynamic interaction between the parts and the whole*".

Whereas it had been widely believed that economic reality could be reasonably described by sets of pairs of linear supply and demand curves intersecting in single equilibrium points to which markets easily and automatically moved, now it is understood that many markets and situations do not behave so well. Economic reality is rife with nonlinearity, discontinuity, and a variety of phenomena that are not so easily predicted or understood. At the same time the broad coherence of economic systems is more impressive than ever in the face of such phenomena. The order of the economy appears to emerge from the complex interactions that constitute the evolutionary process of the economy. These phenomena have come to be labeled as *complexity in economics*. Even what seems simple in economics generally arises from behavior not reflecting rational expectations: what

[5] LIONEL ROBBINS, *An Essay on the Nature and Significance of Economic Science*, 2nd. Edition, MacMillan and Co., Ltd., London (1945)

[6] Smith's *Invisible Hand*: The theoretical foundation on which economics is based asserts "the apparently self-contradictory notion that capitalism transforms selfishness into its opposite: regard and service for others. Thus by being selfish within the rules of capitalist property relations, Smith promises, we are actually being good to our fellow human beings. The logical fallacy (of this 'amazing argument') is that neither Smith nor any of his successors has been able to demonstrate rigorously and robustly how private selfishness turns into public altruism."

"If [the unit as the prime mover of the social world] is a collective of individuals, could its behaviour be deduced from the sum? Or could its behaviour be governed by other things than the sum of its components? $\cdots$ Modern economics is fundamentally an individualistic theory. It is a theory based almost entirely on the analysis of the behaviour of a single individual and his interaction with others. Any group analysis is viewed as a consequence of individuals' interactions. The group as such has no significance.

"The crux of the debate was the famous dilemma about the consistency of thermodynamics with Newtonian classical mechanics. In mechanics all actions are reversible; in thermodynamics the direction of time is unique. How can atoms which are subject to the Newtonian principle of reversibility constitute the foundation of matter which is subject to the laws of thermodynamics? $\cdots$ Thus it is quite conceivable that the atoms of a gas will act according to Newtonian mechanics but the *statistical* behaviour will be subject to the laws of thermodynamics. $\cdots$ In society the collective may be working according to rules different from those controlling its individual components."

[7] DUNCAN K. FOLEY, Adam's Falacy: *A Guide to Economic Theology*, Harvard University Press (2006).

emerges in the aggregate may have little to do with what happens at the individual level. But this aggregate cannot be simply described by some set of aggregate equations. It emerges out of the soup of the individual and particular with all its multiform interactions and peculiarities.

This change of perspective has brought forth a variety of new approaches to analysis. Previously a premium was placed on deductive formal proofs of theorems that sought to derive general solutions broadly applicable. Now we see a greater emphasis on computer simulations and experimental methods to inductively determine possible outcomes and ranges of solutions. Emergent phenomena from complex systems are not usually discovered by theorems but more frequently by the use of increasingly powerful computers to explore the limits and possibilities that can arise. The new awareness of the ubiquity of complexity is transforming the way that we think about economics.

"The implications of the application of complexity theory to organizational sciences are significant, so much so that they signal a paradigm shift in the way we understand organization and leadership. Complexity theory alters core perceptions about the logic of organizational behavior and, consequently, "discovers" the significant importance of firms' informal social dynamics; informal behaviors have long been treated as something that should be suppressed or channeled. This altered perspective has implications for how we coordinate, motivate, and lead in firms. A complexity view of organizations is particularly useful and germane in light of recent movements among industrialized nations toward knowledge-based, rather than production-based, economies.

"Complexity would seem to pose an alternative to formal structured organization. Indeed it is tempting to conceptualize elements of social dynamics as top-down versus bottom-up opposites — formal structure versus informal complexity in organizations, Western authority structures versus Eastern Taoism, MS Window's closed structure versus Linux's open structure, standing armies versus guerrilla warfare. But such dichotomies over-simplify reality. Both dynamics — top-down and bottom-up — coexist because both are necessities. They are interdependent, often embedded within one another (executive groups are simultaneously authority-oriented and interactive), and inter-supportive (e.g., top-down structures in organizations support complexity by managing routine tasks and organizing spaces and work processes to enable interactive dynamics).

"The relative dominance of top-down and bottom-up dynamics in organizations is dependent on technological and managerial forces. Managerial forces include personal preferences of authorities (managers who are driven to be in control will tend toward top-down). Technological forces are related to what needs to be accomplished. Generally, knowledge oriented processes demand a more bottom-up structure while commodity-based processes require a more top-down structure.

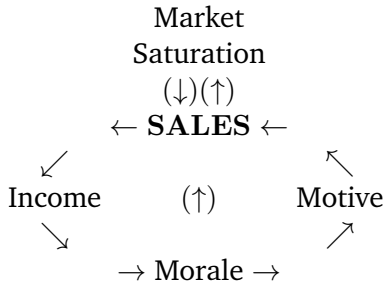
"More general questions of social complexity are evaluated in a similar manner. The nature of a given phenomenon is heavily dependent on contextual conditions — the beliefs and dispositions of the people involved, the available resources, and the nature of tasks to be performed. The strongest strategy is a context-appropriate mix of complexity and top-down coordination. Based on this, we can tentatively address "versus" questions. Will democracy be able to defeat terrorism? The answer will depend on which side is the more robust (adaptive, complex) and has the top-down capacity to enable and support that robust dynamic. Will Windows or Linux dominate the future of computing, or will democracy defeat totalitarianism? Again the same answer applies.

"Complexity helps explain the processes by which a system optimizes its strategic fitness, but the very nature of dynamic systems precludes predictions about its future. One can say, however, that the more robust a system (characterized by both complexity and top-down coordination), the more likely it will succeed. As Ross Ashby put it in the late 1950s. it takes variety to defeat variety.[8]

(d) *Management.* The traditional view to management is through a linear cause-effect relationship; thus poor sales in a business might be attributed simply to inadequacy of resources and/or incompetence of the workforce. While this approach is probably adequate for simple "linear" problems, it is unlikely to be so in the complex real-life situations where a "system behaviour" would be more appropriate. This requires that "we move away from looking at isolated events and their causes, and start to look at the organization as a system made up of an interdependent group of in-

[8] RUSS MARION, Complexity in Organization: A Paradigm Shift, In A. Sengupta (Ed.), *Chaos, Nonlinearity, and Complexity: The Dynamical Paradigm of Nature,* StudFuzz, **206,** 270–352, Springer-Verlag, Berlin, (2006).

teracting parts forming a unified pattern. When we face a management problem we tend to assume that some external event caused it. With a systems approach, we take an alternative viewpoint — namely that the internal structure of the system is often more important than external events in generating the problem" [9]. Kirkwood gives the following self-explanatory example of collaboration of positive and negative loops in stabilizing the sales growth of a new product.



The concentrating "Sales → Income → Morale → Motive → Sales" loop is $(\uparrow)$, while the dispersive loop "Sales → Market Saturation → Sales" is $(\downarrow)$. The positive loop leads to an early exponential growth, but after a delay the negative loop dominates the behaviour of the system leading to an overall S-shaped pattern of the eventual "goal seeking behaviour" for sales of the new product. "Most growth processes have limits on their growth. At some point, some resource limit will stop the growth. As the above display illustrates growth of sales for a new product will ultimately be slowed by $\cdots$ the lack of additional customers who could use the product", sums up the interplay of the opposites in maintaining a balance of growth and decay leading to homeostasy.[10]

At one end of the spectrum, there is the dominant voice in organization and management theory, which speaks in the language of intention, regularity and control. In this language, managers stand outside the organizational system, which is thought of as an objective, pre-given reality that can be modeled and designed, and they control it. Managers here are concerned with the functional aspects of a system as they search for causal links that promise sophisticated tools for predicting its behaviour. The dominant voice talks about the individual as autonomous, self contained, masterful and at the centre of an organization.

At the other end of the spectrum there are voices from the fringes of organizational theory, complexity sciences, psychology and sociology who are defining a participative perspective. They argue that humans are themselves members of the complex networks that they form and are drawing attention to the impossibility of standing outside of them in order to objectify and model them. With this inter-subjective voice people speak as subjects interacting with others in the co-evolution of a jointly constructed reality. These voices emphasize the radically unpredictable aspects of self-organizing processes and their creative potential. These are the voices of decanted agency, which talk about agents and the social world in which they live as mutually created and sustained. This way of thinking weaves together relationship psychologies and the work of complexity theorists who focus on the emergent and radically unpredictable aspects of complex systems. The result is a participative approach to understanding the complexities of organizational life. This series is intended to give expression to the second of these voices defining a participative perspective.

(e) *Nuclear Reactor Control.* A fission nuclear reactor which generates energy by repeated fission (bifurcation) of a heavy nucleus is controllable due to the presence of a small fraction of delayed

[9] CRAIG W. KIRKWOOD, System Dynamics Methods: A Quick Introduction, http://www.public.asu.edu/$\scriptstyle\sim$kirkwood/sy (1998).

[10] "In terms of organizations interacting with their environments, traditional mechanistic organization and management theory views a firm moving through its business environment as a separate, fixed and rigid machine that scans its environment, calculates its options, and plans its responses. It relies on information feedback, forecasting and prediction, calculations, contingency planning and rationality. This artificial separation of an organization from its environment and greater society within which it is embedded and dependent, is quite dysfunctional. A more holistic view sees a successful firm as an integrated, flexible, adaptive organism, as a self-restructuring system, capable of self-reshaping and adapting to a variety of environmental variations and needs. These organizations are expected to rely more on flexible response patterns, distributed sensing and scanning, and a continuous process of integrating with its surroundings. Such an organization is viewed as an integral part of its environment, simultaneously creating it and being created by it, taking from it and giving back to it".

neutrons β. If all neutrons produced in fission were to be born prompt ("instantaneously"), it would be impossible to control the reactor due to the large response times that would be needed to keep pace with the very rapid generation of neutrons. For large reactivities ρ, neglect of all delayed neutron concentrations leads to the exponentially growing neutron density $n(t) = n_0 e^{(\rho-\beta)t/\ell}$. A self-induced feedback $\rho_f(\theta) = \alpha\theta$, where α is a temperature coefficient of reactivity and θ the reactor temperature, in $\rho = \rho_0 - \rho_f$ results in the altogether different behaviour $n(\rho) \propto (\rho_0 - \beta)^2 + (\rho - \beta)^2$, typically logistic-like comprising rising and falling branches with the generated feedback actually halting the growth of $n(\rho)$ and forcing it to decrease and eventually vanish at $\rho = \rho_o$ and at $2\beta - \rho_0$. The resulting variation of the neutron density $n(t) = n_0 \text{sech}^2(\omega t)/2$ with characteristic rising and falling components bears no resemblance to the no-feedback exponential $e^{(\rho-\beta)t/\ell}$.

Understanding, explaining, and formulating the laws that govern the steady states of open, out of equilibrium systems in Nature — despite the ubiquity of the Second Law of Thermodynamics — in all their rich manifestations ranging from human relations to gravitationally induced black holes[11] comprises the manifesto of ICH.

[11] J. D. BEKENSTEIN, Information in the Holographic Universe, *Scientific American*, **289**, 58–65, (2003); JOCHEN FROMM, On Engineering and Emergence, *arXiv: nlin.*AO/**0601002,** 1–11, (2006); G. 'T HOOFT, Quantum Gravity as a Dissipative Deterministic System, *Class. Quantum Grav.*, **19**, 3263–3279, (1999); J. MALDACENA, The Illusions of Gravity, *Scientific American*, **293**, pp. 56–63, (2005); C. TSALLIS, Thermostatistically Approaching Living Systems: Boltzmann Gibbs or Nonextensive Statistical Mechanics?, *Phys. Life Revs.*, **3,** 1–22, (2006); R. M. WALD, Gravitation, Thermodynamics, and Quantum Theory, *arXiv: gr-qc/***9901033,** 1–24, (1999), The Thermodynamics of Black Holes, *arXiv: gr-qc/***9912119**, (2000).

The Institute

This is a proposal for the establishment of a fully autonomous *Institute for Complex Holism* (ICH) promoted by ICCR Trust ("Committed to Chaos-Nonlinearity-compleXity"), for the institution, advancement, and furtherance of a culture and tradition of multidisciplinary collaborative research among the diverse disciplines where nonlinear methods and tools are assuming increasing importance in understanding of the common themes that arise in Nature. It is the opinion of many that while the last century threw up the three most significant intellectually challenging concepts of relativity, quantum physics and chaos, it is only the third that relates to the macroscopic world we live in and is therefore relevant to our existence and evolution. Chaos and complexity are believed to be manifestations of strong nonlinearity that are reshaping our view and understanding of nature and the universe. While the past century can be considered to have been intellectually dominated by the first two, it is expected that chaos, nonlinearity and complexity will play a similar role in the present. The principal mandate of ICH is to contribute to the foundation and growth of chanoxity.

The Institute is being advanced for the promotion and encouragement of study and research in the fundamental and applied aspects of nonlinear sciences through the establishment of a centre of Complex Holism of international standards. The goal of ICH will be to foster and encourage excellence in the study of the physical and mathematical aspects of the world we live in. Its aim is to highlight the intra- and multi- disciplinary character of chanoxity studies in the natural and applied sciences, and to encourage and stimulate interaction among the different disciplines that contribute to this field. Although the Institute is not designed to be specifically a domain of mathematicians, by its very nature mathematics must form a vital and sustaining core of its pursuits. ICH wishes to provide a common platform from which experts in mathematics, physics, biology, economics, management sciences can communicate intelligently with each other in promoting and contributing to the growth and development of this new evolving science of the twenty-first century. ICH aims to offer all who work here the freedom to undertake research that will make significant contributions to knowledge in nonlinear sciences.

Beside a small core body of resident faculty, the academic personnel of ICH will be broadly structured as follows.

► Post doctoral fellows (for one to two years), and research scholars will pursue research and post-graduate studies leading to a Ph.D. degree of an University/Institute with special relevance nonlinearity.

► Short term visitors for duration of two weeks to a year supported (partially) by the Institute.

► Efforts will be made to attract leading Indian scientists working abroad to spend (part of their) sabbatical at the Institute who would thus be primarily funded by their home institutions.

► Adjunct Faculty based at leading national and international research centres and universities.

1. Aims and Objectives of ICH

The *Institute for Complex Holism* is to primarily function as a focal meeting ground of chanoxity scientists worldwide, necessitating the establishment and availability of adequate working and living facilities for hosting conferences, seminars, workshops and schools in the related areas, that is expected to be the basic and major activity of the Institute. Of course, in order to sustain this ambitious level of international interaction, it is essential for ICH to be able to develop the capability to attract and retain a distinguished and dynamic body of resident faculty and research scholars as well as visitors from across the globe. The goals of the Institute will be to promote the acquisition of critical thinking and of new problem solving skills through

1. Organizing *Special Year(s)* in the theoretical and applicational foundations of the various disciplines represented by chanoxity and related (including linear) sciences. Thus we may have Special Years in

► Nonlinear Dynamics

► Nonlinear Inverse and Ill-Posed Problems

► Set-Valued Analysis and Nonlinear Optimization
► Biological Sciences
► Bioinformatics and Nanotechnology
► Thermodynamics and Statistical Mechanics
► Gravity, Cosmology, and Relativity including holism, nonlocality, and interpretations of Quantum Mechanics.
► Chaos and Complexity.

2. Holding tutorial and research workshops of one to two weeks duration on each of the above identified topics.

3. Having regular bi-weekly colloquium and seminar on various aspects of chanoxity studies.

4. Bringing out publications based on the above activities.

The administrative structure of the Institute will be as follows:

A1. The **Director,** an eminent scientist in any field of relevance to ICH, will provide academic leadership, guidance and vision to the Institute. He will be responsible, in association with the Programme Coordinator, to define the present and future goals of the Institute and will have the overall responsibility for planning and execution of the scientific reach of the Institute. The Director will set the standards in fostering and cultivating the competitive standards of excellence and creativity that ICH hopes to attain.

A2. The **Programme-Coordinator (P-C)** an important functionary in the rank of Deputy Director, is entrusted in collaboration with the Director with the implementation of the academic mandate of the Institute. He/She need not necessarily be a Resident Faculty of ICH, but will generally be a Visiting Scientist in a specified field of study invited to the Institute for mutually agreeable duration(s). The Coordinator, in association with the Director, will plan and execute his activities at ICH that will include (i) inviting other scientists worldwide to the Institute for definite periods of time, (ii) planning and conducting lectures, seminars, workshops and scholarly discourses that may be necessary in promoting, sustaining and cultivating the activities of his discipline, (iii) generally act as the liaison between ICH and the international academic community to articulate the stated aims and objectives of the Institute.

A3. The **Joint Director-Administration (JD-Admin)** is the administrative officer of ICH who will assist the Director with functioning of the Institute. The JD-Admin should generally be a Resident Faculty of the Institute.

In order to successfully implement, nurture and foster the above goals and aspirations, ICH will have its own Rules and Statutes operable through the

Advisory Boards

1. Academic Advisory Board. This Board, chaired by the Director of ICH, will advise the Institute on academic and scientific matters and assist in generating funds for operation of the Institute. The composition of this Board of 8 to 10 Members will be as follows.

► 4 to 5 scientists of Indian origin.
► 4 to 5 International scientists.

2. Administrative Advisory Board. This Board with the Director of ICH as a Member, will be composed of one representative each of ICCR Trust, the principal public and private funding agencies and the Government of West Bengal. It will advise the Institute, within the framework of the Rules and Statutes, on national and international administrative matters of relevance to the promotion of its academic goals and objectives.

2. Plan of Activity

ICH will concentrate and develop infrastructural support in the following areas of study and research of relevance to chaos, nonlinearity and complexity.

► Mathematical Sciences.

- ► Physical Sciences.
- ► Biological Sciences.
- ► Social, Economic & Management Sciences.

3. Infrastructure Required

In order to establish an Institute of the highest international standing, ICH will be designed with functionality and aesthetics in mind. The relatively small modular components with their layout as shown in Figure 1 of the Appendix, have been structured keeping these twin objectives in view: The Academic Complex will promote a warm and sociable atmosphere, be aesthetically pleasing with a balance of private and public spaces for formal and informal discussion integrated with areas for quiet reflection, solitude, and rationalization. Thus the following infrastructure must be available at the Institute in order that ICH attract and retain researchers of the highest international standing.

► A sophisticated international communication facility, as also a seminar and conference complex that should be self-sufficient for the projected national and international events. The Seminar Complex of 1×250, 1×150, 4×60 rooms, and the Auditorium with a capacity of 400, are to be adequately computer-internet connected and furnished with modern amenities like multimedia projectors. This complex is expected not only to serve our own needs but also that of sister educational and research institutions.

► A modern computer and internet centre beside being the focus for chanoxity studies shall also serve to spread the message of relevance and importance of chanoxity among high school and university students through occasional display of graphical and other applications which are available in the market.

► An Amenities Center at the rear end of the Main Building that is to serve also as a structural support for the First Floor of the building. The Center is to be a paid outlet for facilities such as xerox, telephone including STD/ISD, e-mail, photocopy, a book store, and a coffee kiosk.

The first floor of the Main Block will provide space for the following. Offices for Faculty and Visitors, 2 spacious halls for Doctoral (common office space) and Post-Doctoral researchers, the Computer Institute with terminal facility, 1 Seminar Room of capacity 50, and spacious lounges $\mathbb{L}$ at the two sides, see. The Guest House (Figure 2) is for both the Visitors and Doctoral and Post-Doctoral scholars of the Institute.

From the point of view of aesthetics, the Institute will have murals depicting some of the world's greatest legends in the arts and sciences — typically persons of the stature of Mozart, Gauss, Einstein and Rabindranath — which can motivate and encapsulate the ambitions and ideals of ICH. The layout and design of the campus as shown in the Appendix provides a relaxed working and living atmosphere with the lounges and open sitting spaces in the Main Block, Library and Seminar Complex being a reflection of this objective. The Main Block, the Library-Seminar Complex and the Auditorium as an integrated unit, is to be centrally air-conditioned. ICH is to be fully residential.

(A) Land

Fifteen acres of land for the campus is envisaged for the fully residential, integrated campus of the Institute.

(B) Main Building

I. Ground Floor, Carpet area

1. Directorate	100 sqm
2. Programme Coordinator	$25 \times 2 = 50$ sqm
3. Administration	100 sqm
4. Meeting Room	$45 \times 2 = 90$ sqm
5. Class/Seminar Room	$40 + 50 + 60 = 150$ sqm
6. Amenities Institute	45 sqm
7. Reception, Lobby and Lounge	450 sqm
8. Toilet	$20 \times 2 = 40$ sqm
	Total: 1025 sqm

II. First Floor, Carpet area

1. Resident Faculty (20)	$20 \times 20 = 400$ sqm
2. Visitors and Adjunct (20)	$20 \times 20 = 400$ sqm
3. Post-Doctoral Fellows (10)	100 sqm
4. Doctoral Scholars (40)	400 sqm
5. Server Room	50 sqm
6. Toilet	50 sqm
7. Lounge	$75 \times 2 = 150$ sqm
	Total: 1550 sqm

(C) Computing Systems

I. Internet and Local Area Network

A three-tier network architecture is proposed. The Backbone Switch is a Layer 3 managed switch with Fiber and UTP ports. The Backbone switch connects to Layer 2 Distribution Switches located in various departments/buildings over Fiber Optic links. The end nodes will get connectivity from the Layer 2 Access Switches. Buildings where the node requirement is very less, the end connectivity can be given from the Distribution Switch also.

Wireless LAN access is also to be provided.

Multimode (62.5/125 1300 nm) Fiber Backbone cabling and structured UTP CAT 6 access cabling can be used. An adequate high-speed leased line for Internet connectivity.

EPABX (200 lines).

II. Other facilities

1. Multimedia Projectors for every Seminar Room.
2. Video conferencing.
3. Photocopying machine.
4. Fax machine.
5. UPS and Generators.
6. Fire Alarms.

III. Software

Matlab, Mathematica, Maple and non-linear specific software.

(D) Library and Seminar Complex

I. Seminar Complex

This constitutes the ground floor of the Library and Seminar Complex, and is to comprise a total of six seminar halls as shown in Figure 1. The Complex is to be self-contained with reception area, lounge and PC room, as also a coffee and snacks outlet. The Complex will have to be fitted with modern audio and video facilities for not only the seminars and conferences that are expected to

be a regular feature of ICH, but would also be required for graphical display and demonstration of non-linear specific software modules to senior school and college-university students. The PCs are for the participants at the seminars and conferences as also for the students and teachers at the software demonstration sessions.

II. Library

The Library of ICH is to be a repository of information and knowledge on chanoxity in general and the fields of relevance to ICH in particular. In keeping with the general philosophy of ICH, the 2-storied Library building is to be designed with both functionality and aesthetics in view for a user strength of 100-120 readers, with all standard services, and a stock of approximately 1,50,000 volumes. The ground floor will have offices for the Librarian and other staff, conference and meeting rooms, the circulation counter, stack halls and reading rooms for books, the acquisition and technical processing unit, a new-arrival lounge with generous sofa facility where users can relax to discuss and communicate with each other, user terminals, a photocopying unit and a visitor lounge. The first floor, mainly for journals and periodicals, will also provide for user terminals and a new arrival display lounge.

The Library is also to function, in association with the Seminar Complex, in arranging book display and exhibitions during Conferences and Symposia to be held at the Institute. The basic role of the Library should be to function as a dynamic information centre providing access to current information on specialized fields — and not just as a lending and reading centre — a goal that can be achieved only with a dedicated and competent staff that can provide the required leadership and vitality to this educational enterprise. This will require the services of 1 Librarian, 3 Senior Professional Assistants, 2 Library Assistants, beside 2 or 3 helping staff. Ideally, the library should function round the clock on all days of the week and provide both Current Awareness Service and Selective Dissemination of Information to its users.

The impact of computer-based information technology has been momentous on the functioning and growth of libraries in the world today. Automation has brought major improvements in the access to information sources through a phenomenal growth of machine-readable database and online systems that make them available. As future developments in accessibility and availability of information resources in electronic form is expected to far outstrip comparable advances in the print media, it is imperative that provisions be incorporated in the planning of the library so that it may mature to a model of a digital library; adequate provisions for the construction and sustenance of a state-of-the-art digital library at ICH will be needed.

(E) Residential

I. Guest House

The three-storied Guest House will accommodate Visitors, Post-Doctoral Fellows, and Doctoral students of the Institute, and have adequate common recreational facilities for all the residents.

East Block: Residences for the Manager and other essential staff. Student Rooms (30) of area 12 sqm each.

North Block: Kitchen, Dining Room and Lounge. Guest Rooms, Double (10) of area 41 sqm each.

West Block: Recreational facility comprising Reading Room, Indoor Games etc. Guest Rooms, Single (15) of area 28 sqm each.

The North and West Blocks are to be air-conditioned.

II. Residences

Residential accommodation for all will be provided in multistoried blocks, except for those of the Director, and two Programme Coordinator who will have single houses according to GOI norms. The apartments for Faculty, Joint Director Administration and other Officials will be of two types A and B of floor areas 125-150 sqm (I phase: 20, II phase: 10) and 100−125 sqm, (I phase: 6, II phase: 4) respectively.

4. Funds Required

An estimate of the construction and associated cost for the campus is shown in the tables below. An enhancement factor of 1.4 is assumed for conversion from carpet to plinth area.

(A) Establishment

Catagory	Head	Cost INR
Academic Complex	Main Building: 4200 sqm Library: 4200 sqm for a volume strength 150,000 Seminar Complex: 960 sqm Auditorium: 450 sqm, floor area ~ 1.5 sqm per seat Total Area: 9810 sqm	20 cr
Residential Complex	Director, Programme Coordinator: 0.5 cr Faculty, Officials: Type A: 2.5 cr, Type B: 0.75 cr Guest House: 1.5 cr	10 cr
Internet and Computing	Includes Fibre Optic cabling, 25 Mbps leased line	4 cr
Library	Furnishing etc	2.00 cr
	Grand Total	36 crore

Crore $= 10^7$, Lakh $= 10^5$, 1 USD $\simeq 45$ INR (Indian Rupees)

(B) Recurring

Catagory		Number	Avg. Monthly	Ann. Total
Academic Salary	Director	1	Rs. 80,000	Rs. 9.6 lakhs
	Distng. Research Professor	N	80,000	$9.6N$ lakhs
	Professor Associate Professor Assistant Professor	25[1]	65,000 55,000 45,000	180 lakhs
	Adjunct Faculty	10	55,000	66 lakhs
	Visiting Faculty	10	55,000	66 lakhs
	Post Doctoral Fellow	10	30,000	36 lakhs
	Doctoral Scholar	40	20,000	96 lakhs
Admin Salary	Joint Director-Admin	1	65,000	7.8 lakhs
	Finance Officer	1	55,000	6.6 lakhs
	Audit Officer	1	55,000	6.6 lakhs
	Librarian	1	65,000	7.8 lakhs
	Staff (PA: 1, OA: 4+4+2)	11	25,000	3.3 lakhs
Total		$111+N$	43.75 lakhs	5.25 crore
Conference, Symposia, School, Workshop, Travel[2]				100 lakhs
Library Current and Back Volumes			Books	100 lakhs
			Journals	300 lakhs
Security, Medical Insurance, Provident Fund				75 lakhs
Electricity, Telephone				10 lakhs
Contingency				20 lakhs
Total Annual Budget at Saturation				Rs 11.5 crore

[1]The relative strengths will remain open, governed by the availability of candidates

[2]These events occurring throughout the year in a foundational, semi-directed "open-source", tutorial-review format, is to encourage "fundamental scholarship" that stimulates "original, often speculative, thinking that produces advances in knowledge". Through these largely unstructured open-ended discourses welcoming diversity of approaches in both theoretical and applicable aspects of holistic collectivity, ICH hopes to foster a culture of innovative excellence in "both orthodox and more speculative approaches" in a spirit of "*chitto jetha bhoi-shunno, uchho jetha shir*".

5. Closure

An international research centre of the type envisioned here engaged in frontal theoretical research that many feel capable of ushering in a new technical revolution of the 21^{st} century "eventually dwarf(ing) the industrial revolution of the 18th and 19th centuries having already produced drastic changes in the rules of economics" cannot function and sustain itself without active institutional encouragement, promotion, and support by national and international agencies and government. It is necessary therefore to raise a corpus fund from

► Industrial houses in India.

► Prominent Indian business fraternity abroad.

► International funding and sponsoring organizations; this is absolutely essential for the success of an Institute such as this. Possible sources that come to mind are UNESCO and ICTP Trieste.

ICH should ideally have a major single funding source. In this desirable ideal scenario, the Institute will be free to channel its research and creative efforts to chaos, nonlinearity and complexity. In case, however, such funding is not forthcoming we need to explore every other possibility for raising money under the general categories listed above, and might like to consider having, for a reasonable yearly fee, Institutional and Corporate Members as supporters/sustainers of ICH. In this case, the Institute could organize *consulting clinics* on modeling and nonlinear analysis for the solution of specific problems of its Corporate Members, for which a fee will be payable to the Institute. Such Corporate Members would be entitled to participate in the academic activities of ICH like the conferences, workshops and symposia that are to be an integral part of the Institute.

APPENDIX

A. Guidelines for Statutes

The research that has the most profound impact on knowledge and understanding, and so often that which ultimately has the most profound impact on everyday life, is that driven by curiosity rather than immediate application. In a world in which funding bodies tend to support research that is programmatic and promises predetermined deliverables, the freedom provided by the Institute (for Advanced Studies, Princeton) to its Faculty and Members is increasingly rare. The Institute exists to encourage and support fundamental scholarship — the original, often speculative, thinking that produces advances in knowledge — (it) is dedicated to the disinterested pursuit of knowledge. `http://www.ias.edu/about/`

The *Institute for Complex Holism* (ICH), a fully autonomous, residential, non degree granting advanced research centre aiming to provide an "open-source repository" in Chaos-Nonlinearity-compleXity and Holism in Nature, is mandated to create a lively and dynamic atmosphere at the highest levels of international excellence for the formulation, promotion, and growth of conceptual foundations in theory and applications arising from an unified perspective of chaos, nonlinearity, and complexity as the emerging dynamical paradigm of Nature. ICH will focus on nonlinearity manifest in the holistic characterization of Nature encompassing the global perspective of a "participatory universe" of linear reductionist superpositions and nonlocality, and the issues associated with diverse interpretations of quantum mechanics. The Institute hopes to meaningfully contribute to an understanding and resolution of the growing sentiments ranging from *Could Quantum Mechanics be an Approximation to Another Theory?*[12] to being an effective linear representation of the nonlinearly induced multifunctional holism of maximal illposedness[13], and expects to provide the impetus and leadership necessary for a reorientation and reeducation from local atomistic reductionism of current mainstream science to the global holistic signature of complex nonlinear systems that is increasingly being brought into relevance in recent times.

The Institute, dedicated towards providing a dynamic atmosphere of intense "open-source" critical intellectual inquiry though a public-private synthesis in support and funding is to be governed by a *Board of Governors* of 12 to 15 Members comprising the following Advisory Boards.

1. **Academic Advisory Board.** This Board, chaired by the Director of ICH, will advise the Institute on academic and scientific matters and assist in generating funds for operation of the Institute. The composition of the Board of 8 to 10 Members will be as follows: (a) 4 to 5 Indian Scientists, (b) 4 to 5 International Scientists,
2. **Administrative Advisory Board.** This Board with the Director of ICH as a Member, will be composed of one representative each of ICCR Trust, the principal public and private funding agencies and the Government of West Bengal. It will advise the Institute, within the framework of the Rules and Statutes, on national and international administrative matters of relevance to the promotion of its academic goals and objectives.

The salary and other benefits admissible to the staff of the Institute as defined below will be structured on the lines of the Indian Institutes of Technology, Indian Institute of Science and leading research organizations of the country.

► **Academic Staff** of 15-20 Regular Faculty and Guest Faculty of approximately 40 per year in the Mathematical, Physical, Biological, and Social, Economic & Management Sciences and allied disciplines. The aim will be to synchronize the stability of experience with the persistence of youth in sustaining a core body of faculty capable of translating the vision of ICH of a world-class research centre mandated to a spirit of critical inquiry into the pragmatically profound and conceptual foundations of the overlapping sub-disciplines of Chaos, Nonlinearity and compleXity into reality. The

[12] L. SMOLIN, Could Quantum Mechanics be an Approximation to Another Theory? *arXiv: quant-ph /***0609109**, 1–10, (2006).

[13] A. SENGUPTA, Is Nature Quantum Non-Local, Complex Holistic, or What? I—Theory & Analysis, doi: 10.1016/j.nonrwa.2008.09.001, II—Applications, *Nonlinear Analysis: RWA* doi: 10.1016/j.nonrwa.2008.09.002, Toward a Theory of Chaos, *Inter. Jour. Bifur. Chaos,* **13,** 3147-3233(2003).

Academic Staff is encouraged to foster introspection with foundational thinkers of different orientations and specializations in sub-disciplines related to ChaNoXity and holism in order to imbibe a culture of plurality where orthodox and conceptually adventurous approaches can coexist simultaneously.

All Regular Faculty must have earned a Doctorate degree from a respectable institution in India or abroad.

Regular Faculty

★ **Director.** Contractual appointment for a period of 5 years; an eminent researcher who can translate the ethos of ICH into reality. In addition to the basic facilities admissible to the Regular Faculty, the Director will be entitled to free furnished on-campus housing and official conveyance.

★ **Distinguished Research Professor.** Individuals who have made *significant original contributions* to the understanding and development of knowledge in any of the disciplines relevant to the Institute will be eligible for consideration in this category, within the rank of Professor, as an acknowledgement of their scholarly distinction throughout the world as leaders in their fields. They will qualify for support beyond their regular period of service through a Distinguished Research Professorship for a further period of 5 years, with full housing and office facilities and such other benefits as may be applicable to them from time to time.

★ **Professor.** At least ten years of research or research-and-teaching experience following the qualifying degree.

★ **Associate Professor.** At least eight years of research or research-and-teaching experience following the qualifying degree.

★ **Assistant Professor.** At least three years of research or research-and-teaching experience following the qualifying degree.

The requirements are relaxable in case of outstanding candidates.

Guest Faculty

★ **Adjunct Faculty** based at other teaching and research institutes, and in relevant industry of repute will complement the in-house Regular Faculty of the Institute, with the same duties and obligations, and will be extended all usual research and living facilities when on campus. The adjunct faculty may not receive a regular salary but will draw an appropriate honorarium.

★ **Visiting Scientist** at an appropriate level will be on a contractual appointment for a period ranging between one to five years on regular salary.

Research Scholars and Fellows

of a projected strength of approximately 3-4 per Regular Faculty, divided between the two categories below.

★ ***Doctoral Scholars and Fellows*** will be expected to assist the faculty in implementing and achieving the objectives of the Institute. **Post Doctoral Fellows** will contribute to ongoing research activities of the Institute that might be assigned to them.

The Institute will have four **Academic Groups** of roughly 6 Regular Faculty in each of the four disciplines of Mathematics, Physics, Biological Sciences, and Social, Economic & Management Sciences under the stewardship of the respective **Group Heads** (to be appointed by the Director for a term of three years) who will be responsible for providing leadership to his Group and cultivating and nurturing contacts with national and international academia. The Groups will be organized and integrated into the overall structure and perspective of the Institute of highlighting the intra- and multi- disciplinary nature of chanoxity, and encouraging and stimulating inter-group interaction by a **Programme-Coordinator (P-C)** who will be appointed by the Director for a five year period.

► **Facilities for Faculty:**

★ An yearly book grant, to be enhanced for the first three years to fresh incumbents at Assistant Professor level. Full Membership Fees for one International Society and two National Societies.

★ Telephone, including STD and ISD, subject to a maximum as may be in force from time to time.
★ Full funding for one international and two national conferences per year. Faculty members will in addition be eligible to participate in international/national Conferences on self-generated resources.
★ Any other benefits as may be decided by the Board of Governors from time to time.

► An adequate body of **Administrative Staff** serving the academic, residential, and infrastructural requirements of the Institute based on the

★ **Joint Director-Administration** (JD-Admin) reporting to the Director, is the chief functionary entrusted with translating the governing statutory provisions of the Institute. In this he will be assisted by the **Finance Officer** and **Audit Officer.** The JD-Admin, with an adequate body of supporting staff, will be committed to the ideals and aspirations of the Institute, and will interface with government, industry, and academia in the discharge of his duties. He will be supported by a **Supervisor** as a Personal Assistant, and two **Office Secretaries** who will also be responsible in providing all necessary administrative assistance to the academic body of the Institute. The Joint Director-Administration should preferably be a Regular Faculty of ICH.
★ **Librarian** should have the depth and breadth of vision and commitment required to build, in association with the academic faculty, a referral repository base of both electronic and conventional knowledge in the fields of relevance to the Institute. The Librarian will also be in charge, through appropriate support staff, of the Seminar Complex and will be responsible for its successful operation.
★ One **Personal Assistant** attached to the Director and the Programme-Coordinator.

All personnel of the Institute will be entitled to standard medical facilities under insurance cover. The Institute being fully residential, all staff is expected to live on-campus at the housing they are entitled to.

► **Retirement benefits.** Regular Academic Personnel will be on service till attainment of the age of 70 years; individuals can opt for voluntary retirement at the age of 68 years. Those inducted to the Institute after retirement from elsewhere as Regular Faculty will receive full salary but will not be entitled to any retirement benefits from the Institute.

B. Some Quotes

Linear approximations become increasingly unacceptable the further away we get from a condition of stable equilibrium. The world of classical science has shown a great deal of interest in linear differential equations for a very simple reason: apart from some exceptions, these are the only equations of an order above the first that can be solved analytically. The simplicity of linearization and the success that it has at times enjoyed have imposed the perspective from which scientists observed reality, encouraging scientific investigation to concentrate on linearity in its description of dynamic processes. On one hand this led to the idea that the elements that can be treated with techniques of linear mathematics prevail over nonlinear ones, and on the other hand it ended up giving rise to the idea that linearity is intrinsically "elegant" because it is expressed in simple, concise formulae, and that a linear model is aesthetically more "attractive" than a nonlinear one. The practice of considering linearity as elegant encouraged a sort of self-promotion and gave rise to a real scientific prejudice: mainly linear aspects were studied. The success that was at times undeniably achieved in this ambit increasingly convinced scholars that linearization was the right way forward for other phenomena that adapted badly to linearization. However, an arbitrary forced aesthetic sense led them to think (and at times still leads us to think) that finding an equation acknowledged as elegant was, in a certain sense, a guarantee that nature itself behaved in a way that adapted well to an abstract vision of such mathematics.

At the moment there is no formalization of complexity that enables it to overcome its current rather confused state and to achieve the objective of first becoming a method and then a bonafide scientific theory. The complexity approach that has recently appeared in modern scientific circles is generally still limited to an empirical phase in which the concepts are not abundantly clear and the methods and techniques are noticeable lacking. This can lead to the abuse of the term "complexity" which is sometimes used in various contexts, in senses that are very different from one another, to describe situations in which the system does not even display complex characteristics.

Formalizing complexity would enable a set of empirical observations, which is what complexity is now, to be transformed into a real hypothetical-deductive theory or into an empirical science. Therefore, at least for the moment, there is no unified theory of complexity able to express the structures and the processes that are common to the different phenomena that can be grouped under the general heading of complexity. There are several evident shortcomings in modern mathematics which make the application of a complexity theory of little effect. Basically this can be put down to the fact that mathematics is generally linear. We are now faced with the following problem. We are not able to describe chaotic phenomenology or even that type of organized chaos that is complexity by means of adequate general laws; consequently we are not able to formulate effective long-term predictions on the evolution of complex systems. The mathematics that is available to us does not enable us to do this in an adequate manner, as the techniques of such mathematics were essentially developed to describe linear phenomena in which there are no mechanisms that unevenly amplify any initial uncertainty or perturbation. Bertuglia and Vaio, Footnote 2

Equipped with an optimal site, we then set out to create an appropriately spectacular facility that could fully capitalize on the magnificent setting. Our inquiries led (the) architects to design the building based on the following principles:

1. The building must present a warm and convivial atmosphere, be aesthetically pleasing, and contain an abundance of natural light.

2. There must be a harmonious balance between private and public space throughout — a productive mixture of formal and informal discussion space combined with areas for quiet reflection and calculation.

3. The facility should be capable of running scientific conferences and occasional public events without unduly impinging on the resident research activities.

4. The Institute should be a landmark building for the entire community — to showcase a top quality, international research centre made possible by the vision and the success of a local company and its founder.

The building has uniquely inviting atmosphere throughout with its lounges, informal meeting areas and numerous espresso machines. A reflecting pool abuts the north side of the building offering an added perspective of reflection and tranquility. The building is open on the western side to diminish shadows and to allow for the maximum passage of light in the afternoon. Three bridges span the exterior garden connecting the building on the third and fourth levels, with each bridge culminating in an informal meeting area allowing an easy continuance of scientific discussion for researchers returning from a seminar or a meal.

The building has four levels and is approximately 65,000 square feet. There are 44 scientific offices on the north side. These, together with larger offices on the south side, give the Institute a steady-state capacity of some 80 researchers in the building at any given time, in addition to some administrative staff and an additional 20-30 graduate students. The facility also contains the bi-level Library, two seminar rooms (each with a capacity of 50-60 people), the 205 seat Mike Lazaridis Theatre of Ideas and the naturally attractive Black Hole Bistro, complete with a rooftop deck. `http://www.perimeterinstitute.ca/en/`

(It was) recognized that there are tendencies toward stability and tendencies toward variance. Our assumption about the value of stability may lead us to to the assumption of the value of permanence. There is evidence that the value of permanence may be a socially constructed Western trap that is not shared by Eastern philosophies. Complexity science leads us to understand that the degree of variability in the distribution of fluctuations in system dynamics is more important than any average quantity, which is counter to the traditional paradigms of medicine, management, and scientific research. We used to believe that equilibrium was the optimal for systems. Complexity science leads us to believe that stability is death and survivality is in variability. The tension between stability and variability is similar to the tension in the social sciences between exploitation and exploration. We often think of exploitation as a strategy for maintaining stability and exploration as a strategy for exploiting variability. We may need a balance between exploration and exploitation, stability and variability, convergence and divergence within a state.

An issue that resurfaced several times throughout the conference was the relationship between individual elements and collective elements. Traditionally Western thought has tended toward the individual over the collective; the opposite view is often taken by Eastern thought. It is not a question of either the individual or the collective, but the interaction of the two that is needed; · · · the individual and the group are the singular and plural of the same process. In order to honor the tension between the individual and the collective, a good model might be "If you win I win; if I lose, you lose". One of our best levers for facing uncertainty and surprise might be to encourage quasi autonomy (individual-

ity) but at the same time willingness to cooperate across disciplines because this kind of collaboration gives us more capabilities and skills. Jordan[14]

Perhaps there is something wrong with the way we are going about trying to make a revolution in physics. It goes without saying that people who are good at asking genuinely novel but relevant questions are rare, and the ability to look at the state of a technical field and see a hidden assumption or a new avenue of research is a skill quite distinct from the workaday skills that are a prerequisite for joining the physics community. It is one thing to be a craftsperson, highly skilled in the practice of one's craft. It is quite another to be a seer.

The seer need not be the most technically proficient. History demonstrates that the kind of person who becomes a seer is sometimes mediocre when compared with the mathematically clever scientist who excel at problem solving. The prime example is Einstein, · · · Niels Bohr was an even more extreme case. There is only one person who was both a visionary and the best mathematician of his day: Issac Newton; indeed almost everything about Newton is singular and inexplicable.

Normal science is based on a paradigm, which is a well-defined practice with a fixed theory and a fixed body of questions, experimental methods, and calculational techniques. A scientific revolution happens when the paradigm breaks down. I don't think that science always works this way, but there are certainly normal and revolutionary periods, and science is done differently during them. In normal periods you need only people who, regardless of their imagination (which may well be very high), are really good at working with the technical tools — let us call them master craftspeople. During revolutionary periods you need seers, who can peer ahead into the darkness. Master craftspeople go into science because they have discovered in school that they are good at it: they are usually the best students. Seers are very different. They are dreamers. They go into science because they have questions about the nature of existence that their schoolbooks don't answer. We are indeed in a revolutionary period, but we are using the inadequate tools and organization of normal science. · · · We are horribly stuck, and we need real seers, and badly.

I have nothing against people who practice science as craft, whose work is based on the masterly of technique. This is what makes normal science so powerful. But it is a fantasy to imagine that foundational problems can be solved by technical problem solving within existing theories. It would be nice if this were the case — certainly we would have to think less, and thinking is really hard. But deep persistent problems can never be solved by accident; they are solved only by people who are obsessed with them. These are the seers and this is why it is so crucial that academic science invite them in rather than exclude them.

Indeed the transition from dominance by Europeans to dominance by Americans, which took place in the 1940's, was very much the triumph of master craftspeople over seers. It brought about a reversal in the style from the reflective mode of Einstein and his peers to the pragmatic, aggressive mode that gave us the standard model. Between the early twentieth century and the last quarter century, science has become much more organized and professionalized. This means that the practice of normal science has been enshrined as the single model of good science. Even if everyone can see that a revolution is necessary, the most powerful parts of our community have forgotten how to make one. We have been trying to do with structures and styles best suited for normal science. The paradoxical situation of string theory — so much promise, so little fulfillment — is exactly what you get when a lot of highly trained master craftspeople try to do the work of seers.

Do you want a revolution in science? Do what businesspeople do when they want a technological revolution: Just change the rules a bit. Let in a few revolutionaries. Make the hierarchy a bit flatter. Create some opportunities for high-risk/high-payoff people, so as to balance the huge investment you made in low-risk, incremental science. The technology companies use this strategy. Why not use it in academia? The payoff could be discovering how the universe works. Smolin[15]

[14] M. E. JORDAN, Uncertainty and Surprise: Ideas from the Open Discussion. In R. R. MacDaniel and D. J. Driebe (Eds.), *Uncertainty and Surprise in Complex Systems,* Springer-Verlag, Berlin, (2005).

[15] LEE SMOLIN, *The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next*, Houghton Mifflin Company, New York (2006).

C. Layout Plan Of *Institute for Complex Holism*

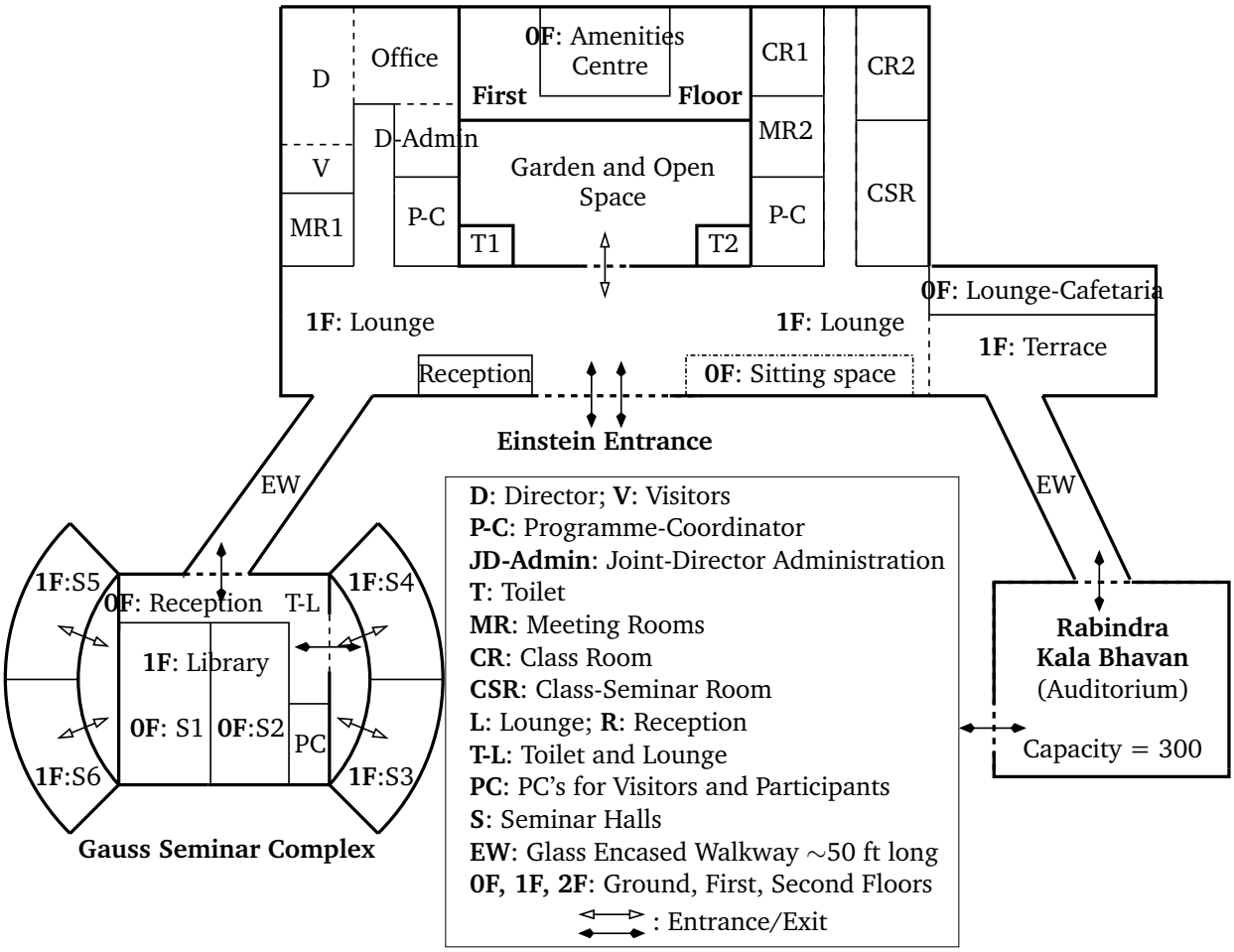


Figure 1. Einstein Academic Complex

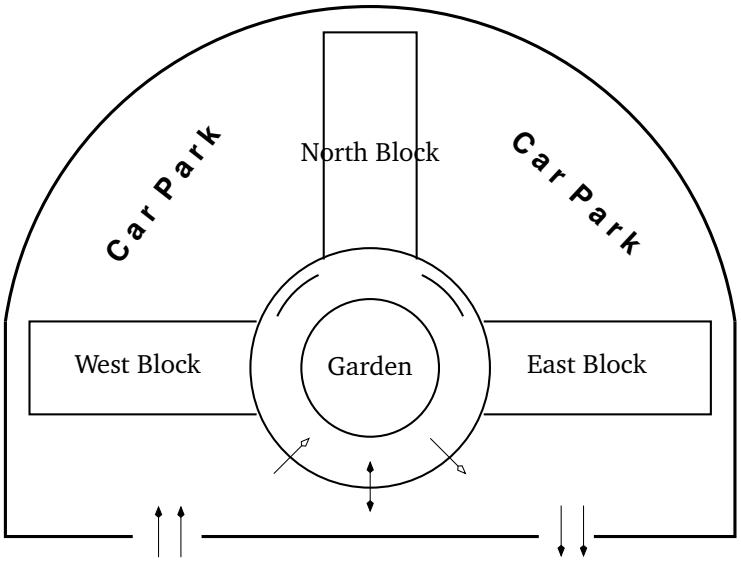
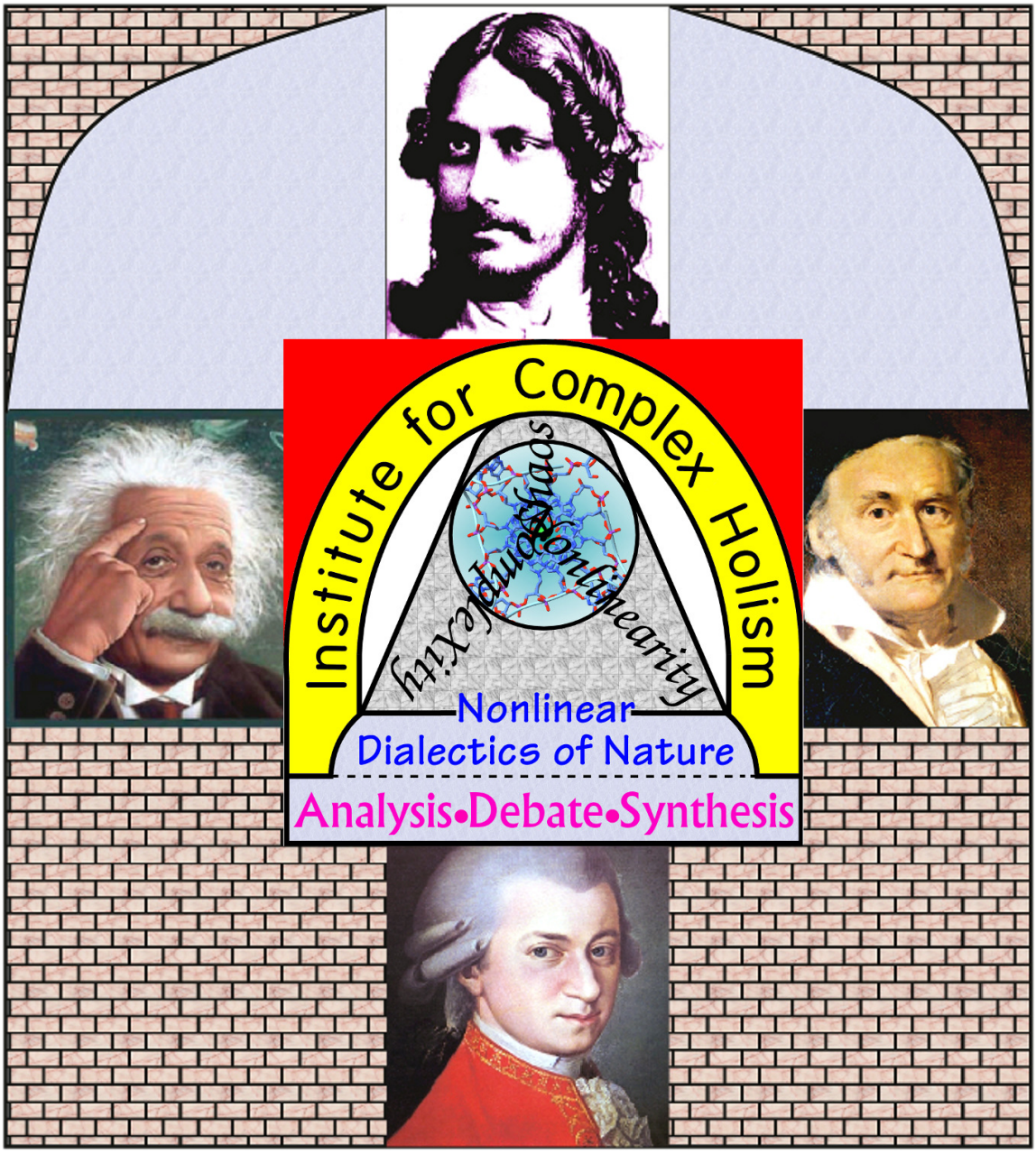


Figure 2. Mozart Guest House

D. The ICH Aspiration



Where the mind is without fear and the head is held high;
Where knowledge is free;
Where the world has not been broken up into fragments by narrow domestic walls;
Where words come out from the depth of truth;
Where tireless striving stretches its arms towards perfection;
Where the clear stream of reason has not lost its way into the dreary desert sand of dead habit;
Into that heaven of freedom · · ·

· · · let ICH guide, steer, promote propagate and advance, the New Science of Complex Holism.