IV-35 Mathematics Tracks Reality

Virtue of logical proof is not that it compels belief but that it suggests doubts.

- Nietzsche

Probability is nothing more than a measure of our ignorance. Our feeble intellects are unable to perceive all the influences operating in a particular situation, and therefore we declare the outcome to be unknown, or that one outcome is no more improbable than another. This is illusory.

- Laplace

Every equation cuts the number of readers in half.

- Wisdom from quantitative sciences

Reality shapes the reason as well as the quality and quantity of information. In some cases it is possible to identify the invariance of inference with facts of reality, as in inference of fires from the smoke. Facts of reality also adhere mathematical constructs, as in the spiral pattern of nautilus shell and the spiral patterns of florets in sunflower correspond to Fibonacci sequence. Mathematical descriptions of physical worlds have provided great insights into the common motifs of the universe. The wisdom is *Thoughts must also compute for their completeness to assure their validity and ensure that love will stay true.*

Reality based descriptions permit processing of evidence in terms of tangible connections to the facts as we know. As commonly used the word "know" has flexibility built into it. For example, beliefs ranging from *I know I am going to win a lottery* to *I know my youngest son's name is…* have degrees of doubt built in the assertions. Approaches that increase the reliability of what we know and how we know follow acceptable procedures that identify and address particular concerns. Incremental validation of the knowledge relies on justification of existing beliefs - not only by new inputs of facts but also by critical examination of the implications. Ultimately all this has to compute to come together.

Reality and mathematics share consistency. Methods of logic and mathematics keep reasoning grounded in reality. Its power and beauty appears unreasonable to some. It may not be intuitive to many but mathematics starts with the simplest relationships based on numbers, operators, and assertions that follow from the discreteness of entities and events. Mathematics is effective in describing real world behaviors because such manipulations of discrete parts have correspondence to reality. Such methods of reasoning and interpretation with parts are inevitable for natural science as well as any other reasoning that aspires to be consistent and free of contradictions.

Ability to deal with symbols of language and numbers is probably hard-wired in human brain. Very early we also learn syntax ability that facilitates cognition though the symbols of language. Manipulation with numbers, ratios and fractions, is also to be learnt early. There is compelling evidence that both ability to recognize syntax and do ratios and fractions can not be easily learnt after the age of 11 to 13. Such abilities to manipulate parts systematically is paramount in the use of motifs of language as well as in natural sciences where we deal with reality-based relations and functions between multiple variables.

Instances of mathematics-based beliefs. Mathematics is more amenable to transformation of quantities without concerns for the quality. Plato regarded numbers as the closest thing to reality, and the forms and geometry as the knowledge of eternally existent. Pythagoreans clearly saw, if not heard, the *music of the spheres* in the regular movements of the heavenly bodies. Towards the end of nineteenth century Henri Poincare suggested that geometry is invention of human mind, if not mere convention. When Einstein used non-Euclidean Geometry, God the mathematician was also relegated to the pantheon of the lesser gods realized by humans with a few assumptions and transformations.

The question of existence and nature, epistemology and ontology, of mathematical truths has been debated. Pascal, Descartes and Kant support an intuitive character. Others in the footsteps of Plato's forms suggest that mathematical structures exist in their own right waiting to be discovered. Godel resonated the conundrum with: *It seems to me that the assumption of such objects (sets) is quite as legitimate as the assumption of physical objects and there is quite as much reason to believe in their existence.* However, he warned that all such constructs are necessarily *incomplete,* i.e. from such sets one cannot infer about the worlds that are not included in the construct. It shows futility of attempts to reduce all mathematics, and therefore pure thought, to a purely formal structure based on a finite number of axioms.

Mathematics has been unreasonably successful. This provocation is attributed to Eugene Wigner. Mathematics is useful in natural sciences to consolidate ideas to generate new physical insights. Mathematical descriptions are almost always approximations when applied to physical systems. Several physical phenomena and models may have similar mathematical form. There are many mathematical concepts for which there are no known physical counterparts. Also there are many physical concepts for which there are no known mathematical forms. Is it just a question of improper fit? Or the garb of mathematics is not fashioned for the complexity of the physical world. Does that means that bulk of the real world will remain untouched by mathematical abstractions?

The foundation of mathematics is rooted in physical reality, and therefore all real world behaviors have to conform to mathematical constructs. An not the other way. Success of experimental sciences, physics to biology, is impressive, especially in terms of the technological outcomes in manipulating materials and organisms. It is all the more impressive because the tinkering is based on the choice of simple problems and approximate descriptions. Not that what has been accomplished will be inconsistent with what lies ahead, but that often mathematical abstraction is not useful for thinking about laws and forms of the more complex real world situations.

Molecular biosciences have definitely placed mathematics to a subordinate role - although simulations and modeling with mathematical tools continue to be helpful every step of the way. The nonlinear and chaotic constructs of complexity, as well as empirical models and simulations, offer promising insights into the rules for the higher level and multivariable interactions for emergent patterns of group behavior. The predictive power of such mathematical tools is not significant, which does not mean that these systems do not obey physical laws of reality.

Is there structure to complexity? Representation of the chaos of the real world may also be an apt metaphor for the thought processes. Think of the patterns intrinsic in a tree, cauliflower, lightening, or coastlines. On a more abstract level, the chaotic behavior of storm, tornadoes, earthquakes, and social upheavals, distribution of personal income and other aspects of group behavior have similar fractal forms. Such forms begin with a simple trunk, from which appear in succession branches, twigs, leaves and finally the visible fibers from the stem of each leaf. The blood circulatory system, as well as the lung and brain tissues, also has basically similar form. These structures arise from arrangements of bundles of molecules each produced from genetic blue print where subtleties are managed with microscopic changes.

In the evolution of hierarchy the meaning of the relationships and values of the variables remain in the range of plausibility. In such situations apparently minor features offer marked advantages over a time period. It is not the kind of evidence on the basis of which one can convict somebody. In the same vein, the appeal to quantify forms of evidence, practice and management does not call for substitution of sensible course of action. The stock markets may also have similar behaviors, where the risk takers rely on the fluctuations in the branches that sway with winds of uncertainty, whereas the long terms investors rely on the organic growth of the trunk.

Analogously thought processes can also be viewed as branches and trunk, where the trunk remains unperturbed by new information. Yet the branches of knowledge extend wherever there is light and space. The main property of the fractal and chaotic forms is to repeat itself at smaller and smaller scales - not just a variation on a theme but built in instability and local fluctuation lead to a somewhat erratic translation in different dimensions in order to absorb the perturbations. Clearly, in order to go beyond superficiality such a description has to be applied with sense and care. Here forms may resemble but not necessarily correspond to function. For each system the underlying drive and detailed dynamics at the microscopic level have unique characteristics. That is what makes cauliflower different from brain.

Room for Doubt