

Chapter 12

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Evolving Scientific Inquiry

1. “For the mind of man is far from the nature of a clear and equal glass, wherein the beams of things should reflect according to their true incidence, nay, it is rather like an enchanted glass, full of superstition and imposture, if it be not delivered and reduced. For this purpose, let us consider the false appearances that are imposed upon us by the general nature of the mind.” —**Francis Bacon**, *Idol* [12.1a,b]

2. “It is the theory which decides what we can observe.” —**Albert Einstein**; quoted by **Werner Heisenberg** [12.1c].

3. “The basic trouble is that many quite different theories can go some way to explaining the facts. If elegance and simplicity are ... dangerous guides, what constraints can be used as a guide through the jungle of possible theories? ... The only useful constraints are contained in the experimental evidence. Even this information is not without its hazards, since experiment “facts” are often misleading or even plain wrong. It is thus not sufficient to have a rough acquaintance with the evidence, but rather a deep and critical knowledge of many different types, since one never knows what type of fact is likely to give the game away.” —Nobel laureate **Francis Crick** [12.1d]; this is also quoted by Nobel laureate **Philip Anderson** [1.14].

4. “How can we understand the world in which we find ourselves? How does the universe behave? What is the nature of reality? Where did all this come from? Did the universe need a creator? Most of us do not spend most of our time worrying about these questions, but almost all of us worry about them some of the time. Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge.” —**Steven Hawkins and Leonard Mlodinow** [12.1e].

5. “... Such crude anthropic explanations are not what we have hoped for in physics, but they may have to content us. Physical science has historically progressed not only by finding precise explanations of natural phenomena, but also by discovering what sorts of things can be precisely explained. These may be fewer than we had thought.” —**Steven Weinberg** [12.1j].

12.1 INTRODUCTION: WHY A CHAPTER ON METHODOLOGY OF THINKING IN A BASIC BOOK ON SCIENCE?

Discussing the issues related to the methodology of our scientific inquiry is an unusual chapter in a basic book on science. But the necessity of such a risky venture is justified by the cited quotations from thoughtful people who also have contributed substantially to advance human thinking and science. The collective sense of the quotations is that we have not yet successfully articulated a methodology of thinking that can keep us on the right path while we continue to seek out the ontological reality of nature.

Let us start with **Francis Bacon** (*see quotation #1*) [12.1a,b] who formalized the model of thinking behind the rapid evolution of Western Science through the structured approach of using *hypothesis–theory–observation*, which is continuing to yield great successes. Yet, right from the beginning, he alerted us that our minds cannot be reliable enough to seek out the ontological truths very easily. **Albert Einstein** (*see quotation #2*) alerts us that the theory determines what we consider measurable [12.1c]. Thus, Einstein urged us to maintain doubts in our mind whether a theory, validated by measurements, can be considered to have captured the final ontological map of the actual physical processes going on in nature. **Francis Crick** [12.1d] and **Philip Anderson** (*see quotation #3*) [1.14] underscore the same elusiveness in capturing ontological reality in spite of our great strides in unlocking the diverse codes behind biological life and the *emergence* of

superconductivity and other complex properties in nature. **Stephen Hawking** and **Leonard Mlodinow** (*see quotation #4*) [12.1e] are alerting modern scientists to become more self-aware of their methodology of thinking. Other critical writing on our current mode of thinking can be found in these references [12.1f,g,h,i]. **Steven Weinberg** is another major contributor to modern physics, in particle and cosmology, [12.1k]. His recent quote (*see quotation #5*), clearly underscores the frustrations

of many deep thinkers whether we really have to settle with anthropic explanations. The author believes that if we start framing our enquiring questions designed for the purpose of being evolution congruent; we will find ways for our sustainable evolution. In the process, the ontological realities will start emerging as natural answers to our enquiries.

Let us now engage our critically thinking readers of this book by raising the following set of questions.

(1) Why is our prevailing methodology of thinking making us ignore the natural phenomenon of Superposition Effect (SP) displayed by detectors and we insist on explaining everything in terms of mathematical Superposition Principle (SP) of amplitudes, which does not represent the energy exchange process between waves and detectors? Why are we ignoring the non-interaction (or non-interference) between wave energies while propagating as linear wave amplitudes as excitation of some wave-sustaining tension field? In the eleventh century, Alhazen (Ibn al-Haytham) carried out imaging experiment using a pin-hole camera and candles and concluded that light energy do not interact with each other (see Figure 2.1). The field of optics got re-developed over the next seven centuries and greatly advanced with modern experiments and mathematics, mostly in Europe, but nobody recognized Alhazen's work. Beginning late 1800 hundred through recent times, unusually rapid advancements has taken place in physics and optics supported by unusually precise experiments and new wave of theories. Many of these experiments and theories clearly indicate that light waves do not re-organize their energies in space or in time while crossing through each other, in the absence of any interacting medium; a brief list is given in Section 2.7. We have been consistently ignoring that mathematically correct Superposition Principle (SP) of summing amplitudes do not lead to re-organization of wave energies. As long as the parent tension field's linearity is not exceeded, all waves can cross-propagate or co-propagate as linear excitation of the same sustaining tension field in the absence of interacting medium.

(2) Have our attempts (Chapter 1 through Chapter 11) **to replace the prevailing mathematical Superposition Principle (SP) by the process-driven thinking of Superposition Effects (SE), as experienced by detectors, contribute anything of lasting value in optical physics, beyond just being interesting semantics?**

(3) Why, over the past couple of centuries, have we failed to recognize that the superposition effects always materialize only according to the interaction properties of detectors and not because of direct interaction between the waves, as implied by SP? We thus continue to ignore the generic NIW property (Chapters 1 and 2). These specific optics-related questions encourage us to raise further questions that are generic to physics.

(4) Why do we use the non-causal Fourier integral theorem to model causal natural phenomena, when the infinite integral implies existence of non-causal signal (Chapters 5–8), which violates conservation of energy? Would not a non-causal starting premise naturally generate non-causal answers, precisely because mathematical logics would always be self-congruent? Besides, the time-frequency Fourier theorem, by summing the EM field amplitudes, violates the observable NIW property (see Chapter 2). We also learn to model advanced and complex problems using Fourier's infinite integral theorem with conjugate variables belonging to *conjugate mathematical spaces*. Obviously, nature's interactions take place in the *real physical space*, guided by some natural force laws, operating between different interactants within their sphere of influence. There are well-demonstrated conveniences in analyzing natural phenomena utilizing such mathematically transformed conceptual spaces. If we use such pure mathematical spaces, then we should remain vigilant in transforming the states of the interactants along with the corresponding force laws into this new mathematical space to remain logically self-consistent. Then, we should remember to inverse-transform the entire analytical process back to the real space, before we assign physical meaning to our new mathematical results [1.18]. Successful mathematical tricks to eliminate divergences, or serendipitous match with measured data under conditions of measurements that happens to corroborate actual processes in nature do not remove the fundamental weakness behind using structurally noncausal mathematical theorems. (4) In modeling nature, why do we accept mathematical convenience and elegance over strictly causal framework? Dirac's delta function also belongs to this category, since we still do not know how to generate any real signal whose width is truly zero and the "area under the curve" is unity. *That mathematics is the best logical tool to explore logical operations behind natural phenomena, is beyond any doubt.*

(5) But, is the current system of mathematical logics the best humans can do? Now, let us consider the following two biological brains in actions (Figure 12.1).

(a) An archerfish [12.2] with only a limited number of neurons, is attempting to successfully shoot down a flying dragonfly hovering over the water surface. (b) An expert human basketball player with 100 billion neurons, while falling down under gravity's pull, is trying to successfully basket his ball [12.3]. Do both the above neural network systems keep on precisely computing all the time-varying initial conditions necessary for the launching velocity and the angle appropriate for the correct

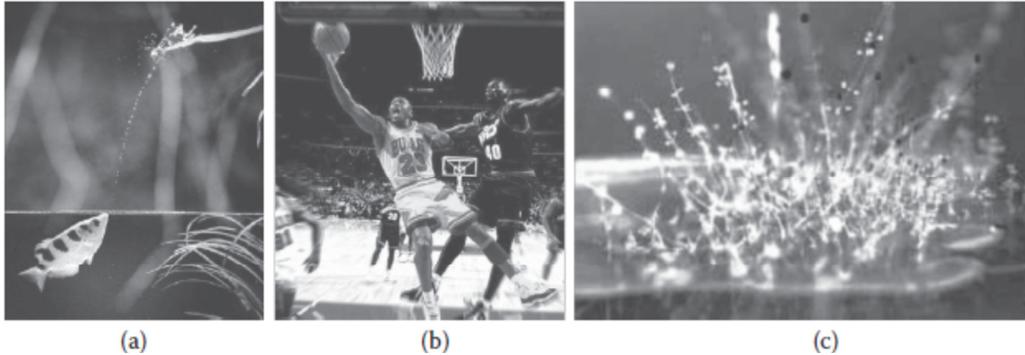


Figure 12.1 (a) [12.2] and (b) [12.3]: How do the neural networks of an archerfish with a tiny brain, and a human with a comparatively large brain, compute the initial conditions of angle and velocity of their “projectiles” before launching them, while their initial positions are quite dynamic? Derivation of the mathematical law of parabolic curve of a projectile is the output of Newton’s neural network! We can grasp Newton’s laws; but we cannot quite model direct biological action processes. How can we bridge the gap? (c) [12.4, 12.5]: Cooperative amoebas (slime mold) collectively launching some of their brave brethren to greener pastures (greener planets?) during a shortage of food. Does the biological intelligence, necessary for taking proactive actions, require a neural network (brain)? Amoebas have learned to come together and take collective decisions during periods of need and developed agricultural techniques besides system engineering technologies to promote a selected few of themselves.

Newtonian parabolic trajectory (spitting water or throwing the ball)? Most likely they are not. Yet, they are very precise to within the required accuracy for consistent successes. DNA’s intrinsic logics behind the *biological intelligence*, as emergent through living single cells, and through highly specialized organs of neural networks, have evolved differently than human-invented mathematical logics of very recent times. Strategies behind different emergent biological intelligence, transferable through progenies, have developed different strategy than solving differential equations, which they have been successfully honing through successive generations for several billion years.

Let us now consider Figure 12.1c. It is a snapshot of a slime mold [12.4, 12.5], organized collectively by single-celled amoebas during a period of food shortage. They are sacrificing themselves to promote a few selected brave ones for greener pastures (a greener planet?) to successfully carry on farming and agriculture. They have been doing this for at least a couple of billions of years. Humans learned to carry out well-organized agriculture probably about 10 thousand years ago [12.6], and we have started launching rockets to outer space only several decades ago! Obviously, proactive intelligent, imagination, and decisions taken by biological intelligence of single- or multicellular organisms do not require neural networks to think out of the box. The collective intelligence of DNA appears to be sufficient. Note that humans have about 23,000 DNAs compared to 15,000 for amoebas in each cell!

The key point is that human-invented mathematical logics, developed during the last several thousand years, do not represent the final, or the only, evolution-sanctioned logics to understand the physical processes that are constantly being executed by the physical systems in the biosphere and the cosmic sphere.

With the advent of the Knowledge Age, we can now safely claim that human evolution is now dominantly driven by our concepts (ideas); which are behind our overall socio-politico-economic culture, a product of our conscious thinking. Then it makes sense that we receive training from early childhood to be become self-aware of our diverse personal thinking processes and preferred thinking logics.

12.2 ACKNOWLEDGING THE OUTSTANDING ACHIEVEMENTS OF MODERN PHYSICS

The author certainly does not want to trivialize the staggering amount of progress brought about by modern science and technologies [12.7a,b]. On the grand scale, our concept for the universe has evolved from geocentric model to heliocentric model, and then to a center-less and limitless universe with billions of observed galaxies. On the micro scale, we have

learned to manipulate, create, and destroy micron-sized biological molecules to sub-nanometric atoms to femtometric nuclei to immeasurably small elementary particles. We have woven together a fairly logically self-consistent *story* of how the magnificently large and beautiful galaxies are built out of the elementary particles and how the different physical structures at all levels are evolving. We also have found the codes of conduct behind complex biological lives. Just four different molecules, woven inside a pair of helical chain of molecules, have been guiding the entire biological evolution and intelligence for almost four billion years on the Earth. However, is this the end of the knowledge-extracting capability of the human species? Experience tells us that emulating a success path helps us achieve many more successes, much more rapidly. But, continued emulation of the same success logic is equivalent to controlled locomotion through the same rut. Does not this imply that we are effectively training the inquiring minds of our successive generations not to evolve any further? We have created an environment to dissuade them from questioning the foundational hypotheses [12.1d,e,f,g,h,i,j,k, 1.15–1.18] that have been formulated by the great predecessor scientists and summarized recently by the author [12.1i].

12.3 TAKING GUIDANCE FROM NEWTON

Our view is that we should consistently remember the humility expressed by Sir Isaac Newton (1642–1727), the father of modern physics [12.8a]:

“I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.”

Newton also provided us with a profoundly important guiding tool [12.8b] to carry on the task of advancing science without feeling bewildered:

“If I have seen farther than other men, it is by standing on the shoulders of giants.”

Advancement in scientific thinking has been evolving through many iterative changes in our paradigms throughout the history. We have not yet established *the ultimate, or the final paradigm*, to perpetually lead our scientific inquiry. So we must continue our scientific journey by incorporating the idea of *perpetual iteration* in our paradigm. We should be mentally bold enough to climb on the collective shoulders of all the giant scientists of our past to continuously increase our logic horizon, rather than feeling overwhelmed by their accomplishments and bend down our head, which only reduces the range of our knowledge horizon. It was easy for the mathematically genius Newton, one of the inventors of differential calculus, to postulate the inverse square law for gravitational attraction and then derive the elliptical orbits for planets around the Sun. Empirically, the elliptical orbit, and two other planetary laws of motions, was already formulated by Newton’s predecessor, Kepler, based on lifelong observational data gathered and analyzed by him and by Tycho Brahe. Newton could not have succeeded in firmly establishing the inverse square law for gravity without the guidance of the established three laws of planetary motion by Kepler.

12.4 EVOLUTION OF OUR EXPLORING APPROACHES TO UNDERSTAND NATURE

It is clear from the examples of biological species in action in Figure 12.1 (humans, fish, and single-celled amoebas), that we are not yet in a position to define what is *total biological intelligence* in contrast to only cerebral intelligence and what are the precise physical processes behind the emergence of *biologically intelligent thinking* [12.9]. With the advent of the Knowledge Age, we can now safely claim that human evolution is now dominantly driven by our concepts (ideas); which are behind our overall socio-politico-economic culture, a product of our conscious thinking. Then it makes sense that we receive training from early childhood to be become self-aware of our personal thinking processes and preferred thinking logics. Given that we are under sustained pressure to persistently evolve, *we must try to think how we should organize and enhance our thinking* so that we will be able to keep on taking meaningful proactive actions, based upon the feedback obtained through the previous actions. We also know that making tools and technologies are behind sustainable better living. However, the functional processes behind the tools and technologies must conform to the rules allowed in nature. To rephrase, the capability to emulate diverse nature-allowed processes into necessary tools and technologies for better living is

the key to sustained evolution, whether the species has yet learned to articulate those rules of nature using mathematical logics or not. Then it is worth organizing the structure of our thinking that facilitates most efficiently the emulation of *physical interaction processes* allowed in nature. Such a thinking process can be characterized as Interaction Process Mapping Epistemology or IPM-E [Ch.6 in 1.6, 1.7, 1.8, 1.13]. The approach is down-to-earth utilitarian and our theorizing process remains anchored to ontological reality, even when we are consistently lagging behind articulating the final ontological laws behind the processes we are emulating. Let us recall the spore-disseminating capability of the amoebas (Figure 12.1c)! Sustainably evolving within the bounds of the laws of nature is being successfully practiced by all single and multicellular species, including humans. Unfortunately, based on the staggeringly rapid rate of successes we have achieved in modeling measurable data with the guidance of our current elegant mathematical logic system over the last several centuries, we have started to believe that seeking ontological reality may not be the right path to guide our sustained evolution.

Searching for ontological reality has become a secondary issue. We should raise concern for the need to understand the ontological reality to guide ourselves for our sustained evolution [12.10a,b]. Even now, since our current economic enterprise *manages the masses*, our educational system does not require us to become ontological thinkers. Most of us can survive within the current economic system as contextual and epistemic thinkers. We do not feel the pressure to hone our ontological thinking by standing outside our body and watching ourselves interact with the nature around us. We do not need to understand the objective reality of nature outside our biology-dictated interpretations. For example, our biological interpretation has evolved, for survival success, to interpret the presence of different combination of optical frequencies as different colors, even though *color* is not an objective (ontological) property of light. Photons are not painted with different colors! The frequency of oscillation of light is the objective property, which dictates light-matter interactions (dipole-like stimulations). Different frequency triggers different response in different frequency-selective retinal molecules, and the codes in our visual cortex creates the interpretation of a wide variety of magnificent *colors*, which are nothing but the figment of our biological imaginations (interpretations), now hardwired by our genome. Fortunately, our engineers have learned to differentiate between the objective reality of the frequency-sensitive retinal molecules and subjective propensity of our visual cortex. They have learned to engage us in *observing* movies on computer screens in *natural colors* using only three different frequencies (red, green, and blue) of appropriate intensities and using only a finite series of stationary snapshots, rather than really projecting continuous movements (that would be next to impossible for data limits). Similarly, molecules do not have either taste or smell as objective properties. Complementary physical structures in various large assemblies of molecules in our tongue and nose send distinctive signal to the brain, which are genetically programmed to send *recognition signals* for interpretation in the brain to interpret their acceptability for our nourishments.

Epistemic versus ontological realities in our cosmic system is still considered to be a philosophical debate rather than essential for our sustained evolution for billions of years into the future. We are required to really understand what space is made out of if we want to travel to habitable planets in distant stars of our galaxy or in other galaxies. The Earth will not remain habitable for humans beyond another billion years, even if we agree on how to invent and implement solutions in managing the current global warming, whether we take remedial actions, or geoengineering actions or a combination of both. We certainly cannot make our journey to such cosmic distances relying on our primitive rockets carrying enormous amount of chemical explosives. Hence, it is important for us to consciously differentiate between epistemic and ontologic thinking and consciously evolve toward the ontologic domain.

12.4.1 Prehistoric Thinking (to the Extent We Can Extrapolate)

We can try to extrapolate our analysis backward to prehistoric times as what possibly our forefather engineers were thinking and acting upon. If we think of several million years back, we know that they did not have advanced languages. Forget about books and mathematical theories. And, yet we must consciously feel very grateful to all those creative and brilliant forefather engineers for our happy existence today. It is because of their unusual capacity for critical thinking that they succeeded in consistently figuring out how to emulate various nature-allowed physical processes in many new ways and keep on inventing tools to ensure our dominance over other competing species. Our overall system engineering skills are far more advanced than those displayed by the slime molds of today. Even though our forefathers were not thinking in terms of theories and equations, as we do now, it was their modality of thinking, the persistent eustress they enforced upon their own thinking process to perceive the physical processes going on in nature, and to invent new technologies to overcome natural distresses. This is what triggered the rapid evolution of human brains. We are the first species to accelerate the rate of our evolution, better than the others, by being able to articulate and pass on to the following generations such understandings in various forms through story-telling, writings, and now through digital technologies. Human ambitions have now surpassed our survival needs. *We are now thriving to understand the possible meanings, purposes, and roles we can play in the vast cosmic system, beyond the earthly biosphere.* However, we must recognize that modern scientific enterprise and the necessary methodology of thinking behind them, are direct products of our evolutionary necessities. Biological evolution has given inquiring minds to all of us as a dedicated segment of our brain. In prehistoric times, we had not developed the mental skill to

observe ourselves interacting with nature and record all the outcomes for further analyses. Individual memory and interpersonal communications were the sole method of passing on successful outcomes. Thus, most of the survival skills, understanding logical patterns behind natural phenomena, and inventing tools had to be rediscovered and redeveloped many times, over and over. Of course, their focus was survival from year to year. Honing tools and skills for hunting, understanding natural cyclic rules for agriculture, taming animals for sustained food supply, controlling fire for food preparation and safety against large predator animals—these were the sought-after skills and knowledge obtained without books and documentation. That was a benefit in disguise, because nobody was blindly following any Newtons and Einsteins just because their proposed rules for certain natural phenomena appeared to be working. This assured the evolution of diversity of enquiring minds in all members of every tribe. We must pro-actively promote such diversity of thinking models, rather than forcing one “working” model to be followed by everybody. That is a recipe for ultimate slow de-evolution of our minds.

12.4.2 Emergence of Modern Philosophical Approach

Serious human inquiry about how the universe came about, as to what are the meanings and purposes behind the universe, and what could or should be the roles of humans in it, could not have begun much earlier than when humans learned to gather and store foods and gained excess time. This enabled pondering about the Earth and the limitless sky above, while accelerating the development of free will in our brain. *A component of our free will and concomitant power of imaginations allowed us to stand outside our own body and watch ourselves in relation to the rest of the world.* Recorded history shows that several thousand years back, Indian Vedic thinkers were literally posing such deep questions and tried to define the manifest universe as simply diverse undulations of some conscious energy field filling the universe, which they defined as Brahma [12.11]. Was that the best way to think? We cannot be certain. China, North African, and Middle Eastern countries were also developing serious philosophical traditions in their thinking, followed by Greeks, Romans, and eventually the rest of the Europe. While all this philosophical thinking was going through ups and downs over many centuries, Western scientific thinkers like Kepler, Galileo, Newton, and so forth, recognized the serious shortcomings of the pure, introspective philosophical approach in understanding and describing the evolving universe, which must be anchored by the reproducible measurement of well-chosen parameters. These thinkers formalized and ensured the historic rapid advancement in what we now call modern science and technology.

Pure philosophical thinking and proposing hypotheses to understand nature based on observations alone, but without good mathematical theories to guide experimental validations, can be characterized as a Direct Introspective Modeling Epistemology or DIM-E. DIM-E did not require equipment to generate quantitative, reproducible and verifiable data that could be carried out by anybody. One philosopher can develop his position using a logically self-consistent set of arguments to justify its explanation for a natural phenomenon. The position remains valid until another philosopher brings another set of logically self-consistent arguments to construct a newer position. And the process can continue for ages without any decisive solution. The professions of law and politics thrive on such logical skills. Many branches of social sciences depend on related modeling skills. Controlled experiments in these fields are too difficult to be carried out because of the enormously large number of involved variables, which are difficult to identify and quantify.

Modern scientific thinkers co-opted the power of DIM-E to develop first a refined set of hypotheses or postulates to bring some conceptual continuity [12.1a,b] to the set of interrelated observations. Then they thought through to bring some logical congruence among the diverse observations and hypotheses by connecting the measurable parameters with a set of mathematical logics (or a theory) to give birth to the concept of verifiability through reproducible and precision measurements by anybody, anywhere, and on any day. We may characterize this approach to understand nature as Measurable Data Modeling Epistemology, or MDM-E. Once hard sciences started systematically following the MDM-E approach, while restricting the mathematical theories to accommodate only a few variable parameters, their epistemology clearly helped moderate individual subjectivism from these fields and acquired a higher level of *scientific respect* compared to social sciences. However, influences of well-established philosophies into our cultures can never be completely eliminated from the most of the well-developed mathematical theories of physics, even after solidly validated by repeated experiments. This is simply because well-defined mathematical relations, validated by repeated experimental data, do not have an automatic *voice* to explain the *physical processes* behind the phenomenon under study. Human minds create the hypotheses and interpret the interrelations between the observable parameter and the theory. Human thinking is guided by our genome for evolutionary purpose and our prevailing culture to live in harmony within our respective societies. Thus, the state of perfect objectivity of scientists, who provide the interpretations behind physics theories, comes into question for further introspection. That such objectivity cannot be perfect is glaringly obvious from the decades-long debate between Bohr and Einstein regarding the completeness and reality [12.12] of quantum mechanics without coming to any serious agreement. Culture dominates our mode of thinking and how we frame questions to understand nature.

Eastern philosophers maintained a debate between duality versus non-duality while leaning more toward unity (or non-duality) [12.13]. But the West leaned toward duality and the concept crept into quantum physics, as wave–particle duality. This is most likely because 20th-century physics ignored the importance of searching for the *physical processes* behind emergence of measurable effects. Now, soft sciences are unabashedly picking up this concept of duality in explaining away ill-defined phenomenon like consciousness [12.14, 12.15] based on quantum mechanical (QM) duality. Fortunately, medical science is rapidly advancing diverse experiments to quantitatively connect human thinking processes with the signal producing neural network, including their specific geographic locations in the brain [12.16–12.18]. The author believes that the concept of duality arose due to our lack of understanding and detailed knowledge about the physical processes behind the phenomenon of superposition. We should not promulgate our *lack of knowledge* as *new knowledge* just because we have been failing to visualize the interaction processes behind the emergence of superposition effects. Otherwise, we indirectly suppress the enquiring minds of our follow-on generations and consequently slow down the evolution of their inquiring minds. It is worth noting that QM is fundamentally a statistical theory as far as validation of measurements with the theory is concerned [12.19]. Atoms have multiplicity of discrete allowed energy states. Molecules possess even more complex set of energy states. So the measurements in the QM world are dictated by multiplicity of transition propensities when molecules interact with each other in our instruments and produce one specific measurable transformation at a time. The statistical ensemble of this multiplicity of potential interaction processes should not be explained away by *duality* as if the excited atom or the molecule literally exists in a *superposition state* (simultaneously in all these states). We need to focus on visualizing the invisible interaction processes to allow the theories to keep on getting perfected along the right direction.

In the very beginning of this section, we have identified an ontological reality seeking thinking process as IPM-E (Interaction Process Mapping Epistemology). We have also characterized the prevailing scientific thinking process as MDM-E, which is clearly showing signs of its limitation to keep us anchored to a path on seeking out ontological reality in iterative steps. So, *our proposal is to strengthen and enhance MDM-E by making IPM-E as the initial guiding tool to develop foundational hypotheses and then keep on restructuring our working theories toward higher and higher-level theories that approach closer and closer to ontological reality*. Measurable data are physical transformations in nature, which generally corroborate energy conservation rule of nature. If we keep on framing our questions that lead to invent hypotheses as aid to construct theories that would only validate measurable data, we would correctly keep on finding that nature does conserve energy, and no more. But such hypotheses cannot guide us to explore the underlying physical processes, amplitude-amplitude stimulations preceding energy exchange and QM transition; which give rise to the measurable data. For that, we need to build theories whose foundational questions have been framed to explore the ontological physical processes going on in nature. Ontological realities would be accessible to our theories only if we frame them to ask such questions. We will justify our approach further through the rest of this chapter.

12.4.3 Physics up to 1850

Ptolemy's (100–170) Geocentric Model falls into the IPM-E (Interaction Process Mapping Epistemology) domain, even though he tried to place humans at the center of the universe! That is how *reality* appeared to him then, and it still does so to us even today until we are exposed to diverse observations whose logical congruency demands a heliocentric model for our planetary system. However, our religious culture has succeeded in instilling in us some epistemological human-centricity in general and a bias toward mathematical harmony and spherical symmetry. A “wobble” in the motion of the Mars, as observed from the Earth, was explained as secondary circular motion of Mars around an imagined center to match the observed “wobble” [12.20]. Thus, a modern theoretician would have needed only nine *free parameters* to explain most of the observable planetary motions. While *symmetry* and logical *harmony* has been justifiable through many successful theories, it is the *a-symmetry* and *an-harmony* perceived by particles and waves (through the four forces) that guide the interactions followed by physical transformations and hence the persistent evolution.

Copernicus (1473–1543) appreciated the complexity in the observational data for our planetary system and introduced a better model with better mathematics [12.21]. Guided by mathematics, IPME and MDM-E started becoming synergistic tools for doing science. Slowly, geocentricity began to be replaced by heliocentricity, but this change was far from being universally accepted! More precise data were gathered by Tycho Brahe (1546–1601), and still, the epistemology of *homo-centricity* prevailed! Kepler (1571–1630) formulated three empirical laws for planetary motion that were validated by meticulous observations, one of them being the elliptical orbits for the planets around the Sun. He thus ensured (1) the removal of humans from the center of the universe, and (2) the importance of continuously advancing data-gathering technologies. Kepler's meticulous work paved the way for Newton to demonstrate the power and elegance of mathematics by proposing the famous inverse-square law of gravitation! Differential calculus easily and elegantly validated Kepler's three laws of planetary motions. MDM-E started to take a dominant role in physics. However, Newton struggled to explain how the Sun keeps a hold on Earth at such an enormous distance. A concept about the vast cosmic space remained unsettled, as it is today, but the concept of ether as the space-filling *substance* started emerging.

12.4.4 Rapid Expansion of Modern Physics: 1850 and Forward

Let us fast-forward by another couple of centuries. Maxwell (1831–1879) showed in 1864 that all the separately experimentally developed laws of electrostatics, magnetostatics, electric currents, and associated magnetic fields can be merged and presented together as a coherent set of four differential equations. Then, with some simple but brilliant manipulation of the rules of calculus, he demonstrated that the electromagnetic wave is a result of a synthesis of electricity and magnetism. Light has to be a *propagating wave*. If it propagates through the vast cosmic space, then there must be some complex tension field (ether) to sustain the propagation of the waves! After all, the velocity of light is determined by two measured properties of free space, $c^2 = (\epsilon_0 \mu_0)^{-1}$, the dielectric constant and the magnetic permeability! MDM-E and IPM-E appeared to be inseparable thinking tools. Michelson (1852–1931) initiated the efforts to detect ether earnestly. But his efforts to prove the existence of ether through optical interferometry turned out to be a failure.

12.4.5 Early 1900

The last quarter of the 1800s and the first quarter of the 1900s saw a very rapid shift in our scientific thinking. Skillful mathematical theory development supported by MDM-E started effectively downgrading the synergistic need for IPM-E. Planck (1858–1947) in 1900 applied his mathematical skills to model meticulously measured data on blackbody radiation and found an elegant mathematical expression implying that EM radiations are definitely exchanged (emitted and absorbed) by the blackbody cavity as distinct energy packets. Planck held on to his model of light as waves, explaining that it is only atoms and molecules that exchange energies in discrete packets. This was most likely inspired by Rydberg’s empirical formula on atomic spectroscopic data that already implied some form of quantization or discreteness in the frequencies of light emitted by atoms. However, Einstein thought otherwise and presented in 1905 his theory of photo electricity by proposing that light always remains as discrete indivisible quantized packets, which were later named *photons*. The indivisible photon model still dominates our current epistemology even though it has been repeatedly shown that the semi-classical model (light as waves and detectors as quantized) explains all the observed experiments.

Relativity: As if the photoelectric theory was not enough, Einstein (1879–1955) presented Special Relativity (SR) in the same year of 1905 to resolve the absence of a detectable cosmic medium so his photons can travel at the highest speed as a particle without the need of a supporting medium. IPM-E was about to become irrelevant in scientific thinking within about a decade. Its last hurrah was in 1913 when Bohr (1885–1962) used IPM-E and gave us the “map” of electron orbits with quantized angular momentum around a proton to describe the hydrogen atom. Unfortunately, Bohr’s model could not advance since it could not be generalized for more complex atoms. In the meantime, SR had been drawing serious attentions from all physicists as its formulation continued to validate all measured data. SR has revolutionized the very foundation of physics thinking as our observed universe has become, as per SR, a space–time four-dimensional universe.

The concept of the 4D universe was further strengthened by Einstein with his General Relativity of 1916 where the gravitational force became a space–time mathematical curvature. Neither of these theories of relativity allows anyone to raise inquiring questions along the line of IPM-E. IPM-E requires that the key parameters of a successful theory must be directly measurable using some interaction processes in nature. Unfortunately, the running time t is not a physical parameter of anything that we can directly measure. What we measure is the frequency of some entity that executes harmonic oscillation. We invert the measured frequency ν and then define it as the period of the oscillation, $\delta t = 1/\nu$. Thus, we can only measure *time intervals* as inverse of a primary physical parameter, frequency, of some real physical entity. Of course, we can measure space also only in terms of *intervals* of some physical scale we choose. The significance of this point is obvious from the fact that we know how to physically alter both the physical length of a reference scale and a reference frequency of oscillation using appropriate laws of physics. But we do not know how to physically alter the running time. Should physical theories be considered final even when they are founded on parameters that are not directly measurable? Should we consider the concept of 4D space–time as the final reality of our cosmic system? The idea is not to discard theories of relativity, but to promote a logic-based debating platform that can keep us moving in the right direction regarding our map of the universe. Otherwise, we might get lost in epistemologically elegant theories without knowing how to get out into the ontological reality of the universe.

Limiting particle velocity: Consider the hypothesis of limiting velocity for light by Einstein. Based on our CTF proposal (see Chapter 11), it is obvious that the velocity of light cannot exceed $c^2 = (\epsilon_0 \mu_0)^{-1}$, because it is the tension-restoration force of a medium that determines the wave velocity in it. However, our IPM-E thinking and the existence of particles as local

resonances of CTF do not make it obvious that $v \leq c$ has to be the limiting velocity for particles. In SR it is derived from $m_v = m_0 [1 - v^2 / c^2]^{-1/2}$ which implies that m_v , will be infinity, hence limiting, when v approaches c . But, the physical process that imposes this limiting velocity remains obscured. According to Einstein's mass-energy equivalence, $m_0 = E_0 / c^2$, rest-“mass” is only a behavioral quality emergent out of its stable rest energy-packet E_0 ; which is related to the *inertia of motion* of particle, when a force field pushes or pulls it. In our CTF model (Chapter 11; 1.8), we have already posited that E_0 is the rest energy of a resonant particle oscillation. It can gather kinetic energy only when it is influenced by interaction between the mutual nonlinear potential curvatures surrounding each other; of course, the gradients have to be compatible to influence each other. SR does not help us discover the physical process behind the existence of limiting velocity of particles; which we observe in experiments. But the particles, as per our proposed model, are simply excited oscillatory states of the CTF (see Section 11.5.2). We can hypothesize that since particles are excited states of the CTF, like EM waves; albeit being more complex and localized, they cannot exceed the velocity of simpler excited states like EM waves; which is the velocity c .

12.4.6 1925 and Forward

Quantum mechanics: The formulation of quantum mechanics (QM) was presented in 1925 in two different forms by Heisenberg's (1901–1976) matrix mechanics and Schrödinger's (1887–1961) wave equation. Schrödinger's attempts to preserve mapping natural processes through representing particles as “waves” (a la de Broglie) got only lip service because his wave function was interpreted more as a mathematical probability amplitude, but not as something that can be directly measured [12.22]. Surprisingly, Bohr became the strongest proponent of *MDM-E*, and advised us that it is unnecessary to try to visualize the micro universe in every detail. Interpretation of QM, known as the Copenhagen Interpretation [12.22– 12.26], is basically Bohr's epistemology. Copenhagen Interpretation still prevails today because the original QM formulation provided us with enormous successes in predicting and experimentally validating the micro world of atoms and elementary particles. It has become fashionable to quote Feynman, another giant contributor to quantum physics, “*Nobody understands quantum mechanics!*” which glamorizes the sufficiency of *MDM-E*, ignoring *IPM-E*. We should *compute* and not waste our time visualizing and mapping the micro universe as we did in classical physics! Even in classical physics, detailed micro processes behind interactions are not visible.

We believe that if we insist on applying *IPM-E*, we should be able to find out the physical processes behind our working theories and at the same time understand their limitation better, which will then give us a better platform to iteratively improve/correct our existing theories. Or, we should find a logical platform on which to propose new fundamental hypothesis. After all, our evolutionary journey requires us to keep on refining the map of the universe continuously, so we do not get stuck in one blind alley.

From particle paradigm to field paradigm: We have mentioned earlier that almost every single major successful theory of physics indicates that cosmic space is not empty; it has rich properties. Surprisingly, most of our successful theories also are essentially field theories. Even QM and their extensions find *various concepts of fields* unavoidable. Even though Einstein's successful relation $m_0 = E_0 / c^2 = E_0 \epsilon_0 \mu_0$ implies that the origin of mass, or the inertial property of particles, lies with the electromagnetic properties of the space, and yet, we are still looking for a mass providing Higg's boson [12.27].

We can clearly appreciate the root of *particle paradigm*. The manifest material universe does appear to be built out of impenetrable localized particles and their assemblies of various sizes, from atoms to galaxies. But, why are we so reluctant to accept the guidance we are getting from our successful mathematical logics, invented by our own collective human logics, which are clearly capturing many of the operational cosmic logics? Do we think that successful theoretical *fields* are merely helping-tools and do not capture any physical realities of any physical interaction processes going on in the material universe? Are our theories meant only to model experimental data (*MDM-E*) but not the physical interaction processes that give rise to those data (*IPM-E*)? So, the author has made an attempt (see Chapter 11) in proposing a *field-based* universe, the CTF (Complex Tension Field) as the physical substrate of the universe. EM waves are propagating sinusoidal undulations of the CTF and the particles are 3D stable resonant self-looped harmonic undulations of the same CTF, triggered by some energetic nonlinear process. The origin of this energetic process is yet to be analyzed as to whether it could originate out of the CTF; or it is external to CTF. However, the various forces can be appreciated as secondary potential gradients imposed on the CTF around the particles by virtue of their undulations.

12.5 NEED FOR WELL-ARTICULATED EPISTEMOLOGY FOR STUDENTS

12.5.1 Ad Hoc Paradigms Have Been Enforcing Highly Structured Thinking for Generations

Historically, it is well demonstrated that successful scientific inquiry does require highly logical (structured) thinking. But it also requires enormous flexibility to change course because we are inquiring unknowns through observable effects only. We do not have direct access to the creator's mind, or the entire set of cosmic logics in operation. Thus, we have become adept in following and then shifting from one revolutionary scientific paradigm to another one provided to us by great thinkers through the last several millennia as underscored by Kuhn [12.28]. These paradigm shifts have been quite disruptive in human efforts and historical durations. We have not yet succeeded in developing a methodology of thinking that allows us to evolve continuously without serious loss in our efforts. Disruptive technology implies definite progress. But a series of disruptive shifts in scientific paradigms imply that we have been forced to make repeated and fundamental changes in the directions of our scientific path of inquiry because the earlier paradigms were no longer considered congruent with our search for natural phenomena. *How can we derive the assurance that the latest shift in our scientific paradigm is the final and the correct one?* We cannot. We need to develop a different strategy. We must explicitly set our focus on exploring the ultimate ontological reality, not just easily measurable data, which is only an intermediate step.

During the modern history of humans, we have experienced many scientific revolutions, of which the real big ones are: (1) the Copernican revolution (geocentric to heliocentric), (2) relativity revolution of the classical 3D- to 4D-universe, and (3) quantum mechanical revolution of grudging acceptance of wave-particle duality and limited causality in nature's behavior as our new knowledge.

The conflict between the geocentric versus the heliocentric paradigms was resolved before the end of 17th century through the lifelong experimental and theoretical work of Brahe (1546–1601), Kepler (1561–1630), and Isaac Newton (1642–1727). From the standpoint of the theoretical model, the hypothesis of epicycle [12.20] was logically self-consistent in explaining the heliocentric model. However, Newton's hypothesis of universal inverse-square gravitational law won over because there was no comparably strong universal causal hypothesis to support the epicycle model. Still, the so-called revolutions of relativity and quantum mechanics (QM) to replace classical physics have not been resolved and cannot be resolved a la heliocentric versus geocentric. This is because classical physics was not outright wrong. Its foundation till the end of the 19th century was based on (1) the ether as a space-filling novel substance, and (2) the continuous energy exchange in all interactions. These were not wrong, but they were insufficient to explain many newly observed phenomena of energy exchange in well-defined discrete amounts by atoms and molecules. Relativity and QM simply filled the vacuum with mathematically self-consistent MDM-E formalism along with a set of new hypotheses for each of the two new theories. While these two theories are consistently validating most measurable data, their mathematical formalisms do not lend themselves to facilitate the visualization of the invisible interaction processes for deeper understanding of the operational (ontological) logics of nature. These theories were not formulated for that purpose. This desire of classical physics to persistently map the physical processes behind all interactions has been abandoned by these two new theories. Instead of leveraging these limitations as reasons for developing better theories, the interpreters of relativity and QM have convinced the current culture to demand less out of our theories henceforth, as if, MDM-E is sufficient for all future purposes. This is not a forward-moving revolution. The imposed paradigm shifts, 3D to 4D and wave particle duality, have forced generations of enquiring minds to become doubtful whether it is fruitful to ponder over the ontological reality of this universe beyond what current mathematical logics (theories) can extract.

Without built-in interactive process-mapping epistemology, we cannot be efficient in understanding and emulating nature-allowed physical processes to invent new working tools and technologies. Without the power to keep on inventing necessary next-generation technologies, we cannot ensure our sustained evolution under very difficult cosmological pressures.

Surprisingly, the root cause behind disruptive scientific revolutions is due to our human tendency of reserving our sustained faith and belief for our great messiahs even in the domain of science. The persistence of this tendency is surprising, considering the fact that Newton was humble enough to acknowledge that he was leveraging observations made by his predecessors. The clear implication is that we should persistently promote the growth of our inquiring minds by respectfully climbing on the collective shoulders of our scientific leaders to see farther and deeper, rather than bowing down at their feet, while reducing our vision of the scientific horizon. The key lesson from all the major and minor scientific revolutions is obvious: All successful theories designed to carry out social engineering or nature engineering, are necessarily incomplete as they are always constructed based on our incomplete knowledge of the interconnected whole cosmic system.

Unfortunately, that is not how we teach in our classes, nor does the hierarchy of our scientific culture explicitly promote such a view. Current scientific culture persistently promotes the view that the foundational hypotheses behind these working theories of relativity and quantum mechanics are fundamentally correct and must not be challenged. In fact, some books claim that the final foundations of the edifice of physics have been laid. The implication is that for all future young scientists, the contributions they can think of making in physics are to add only new bricks or stones, which can be accommodated by

the current edifice of physics. In other words, they are forced to think only how to extend the existing theories but not to inquire about the validity of the original foundational hypotheses behind the theories in light of broader knowledge available today.

12.5.2 MDM -E Alone Is Insufficient to Provide Us with Continuously Evolving Guidance

On the basis of measurable data, Newton’s inverse square law for gravitation has been working quite well until we discovered the anomalous precession of the perihelion of Mercury, which was explained by Einstein’s general relativity. Let us consider another more modern case example. Modern precision measurements on the velocity distribution of stars in the outer periphery of galaxies are not matching up with any of our existing gravitational theories [12.29]. The power of mathematics still prevails today, even though its elegance and symmetry are getting repeatedly called into question in many branches of physics as our measurements become more precise with our rapid technological advances! Astrophysicists are proposing many different solutions, including the existence of conformal gravity [12.30], dark matter [12.31], and dark energy [12.32]. Figure 12.2 for the galaxy NGC3893 has been copied from Reference 12.30. This reference has developed a remarkably excellent solution to this problem using conformal gravity for more than 100 galaxies. The need for the hypothesis of dark matter appears to be slim. Our proposal of CTF [1.8] holding all the energy of the cosmic system clearly eliminates the need for a separate hypothesis of dark energy.

This above example underscores that a working theory, validated by many observations, does not necessarily mean that the theory has captured the ultimate cosmic logics. Suppose we give a very smart 5-year-old child a jigsaw puzzle of the global map to solve, with the conditions that all the pieces must remain upside-down without showing the printed map segments to aid in matching the pieces. Nonetheless, the child will very quickly solve separate segments of the world map, most likely, those of Australia, Madagascar, southern segments of India and Africa, and so forth. His progress after this will slow down severely. If we now invert his solutions to see the printed map side, most likely we will find that many pieces of the map are mixed up among different countries, even though they are fitting perfectly. This is because puzzle pieces consist of only a very small set of identifiably different shapes, except for the edges of the different countries. The uniqueness of the edge-pieces guide a child to quickly solve some segments of the

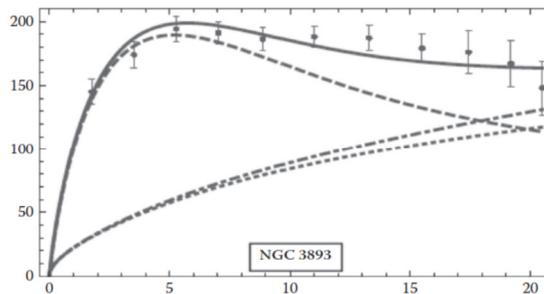


Figure 12.2 Measured and expected rotational velocity distribution of stars in the galaxy NGC 3893, from its center to the outer edge. The dashed curves represent different theories. The solid curve corresponds to the conformal gravity theory as proposed in [12.30], which does not require the hypothesis of dark matter. The solid circles represent measured data.

world map correctly, but the pieces that go inside countries can be easily switched because some of them have identical physical shapes! When a very large and very complex system is built out of only a small set of basic rules completely unknown to us and we have access to solve only a few small segments of the vast cosmic system, we may succeed in solving these small segments by inventing a set of rules none of which may exactly coincide with the actual rules behind rules behind the entire system. We have already learned this from modern complexity theory [12.1g, 12.33–12.35]! To our current state of knowledge, the magnificently large and enormously complex universe is running under the guidance of only four forces. We have been solving small separate segments of this observable universe using human-invented mathematical logics, which have not been designed to explore ontological reality. So we need to be cautious before declaring that all of our working theories have correctly captured the final cosmic logics (rules) exactly.

12.5.3 Broader Recognition that Progress in Physics has Slowed Down

A good number of books have been written by several major leaders of the knowledge gatekeepers, and a few outsiders, on the subject that it is time for us to revisit the very foundation of physics by questioning the

foundational hypotheses [1.14–1.18, 11.17, 12.1d–k]. We are also fortunate for another deeper reason. Biological evolution has given inquiring minds to all of us, shown as a dedicated segment of our brain. While our sociopolitical cultures over many millennia have been consistently training us to conform to the social rules and cultures [1.13,12.36–12.39] set by the various tribal leaders of human societies, time and again, through the ages, we have experienced that human social cultures and pressures cannot completely brainwash all the people, all the time, all over the world. We all just need to consciously bootstrap this biological endowment, the inquiring brain, to frame questions to find solutions when we face problems. We also know that *framing the question determines the answer we can extract out of nature*. In fact, this approach is the key tool in the arsenal of reporters who interview political leaders. When they fail to get the answer to a specific query, they rephrase the question, depending on the sociopolitical context, whereas scientists tend to hold on to their initially framed question about a particular problem of nature they have identified to explore. While this tenacious faculty has historically been found to be beneficial behind many successes, limitations are in general not underscored in our history books. So, scientists are generally not trained to be conscious about the root of their faculty of framing questions; neither do they try to reframe their questions like the political reporters do.

12.5.4 Framing the Question Determines the Answer, and the Answer Is Never Final

Our brilliant social engineers understood very well how to guide inquiring minds. Comfortingly, they advise us to keep on asking and we will receive. In the world of introspection, framing the question determines the answer we receive. When we try to understand the world through its working processes, we become adept in inventing tools and technologies. When we try to understand the world based on empathy for people, we develop ethics and religion as the best tools for living in harmony. When we try to understand the world through detached logics, we develop philosophy. When we try to understand the world through both logics and validated measurements, we develop scientific theories. There is something, which is working and defensible, for every thinking mind in our complex universe.

Today, in the world of scientific theories, we are both fortunate and confused. We are fortunate because our current guiding giants have been divided among themselves as there is some recognition that the advancement in our fundamental knowledge of nature has become stagnant [1.15-1.18] while our technology is advancing quite rapidly, albeit, leveraging only the existing fundamental knowledge. However, our knowledge gatekeepers are consistent about promoting and holding on to the current consensus epistemology. This, of course, maximizes the economic benefits for the consensus-followers enforced on the society by the hierarchy of our modern scientific enterprise; an enterprise that is obligated to conform to the socio-politico-economic reality. Thus, any concept that challenges Descartes-Einstein-Heisenberg foundation will not pass through the gates held by the gatekeepers. The assumption is that the final foundation of our scientific edifice has been laid. We are now allowed to find only those *stones and bricks* that can fit on to the existing edifice. We train our graduate students to publish in conformity with the current *foundation* of physics or perish. We are consistent in our training tools to ignore their deeply inquiring questions. Culturally imposed systematic self-suppression of inquiring minds slowly and undetectably becomes a functional tool for the slow de-evolution of our creative minds. On the other hand, in the process of collectively conforming to the socio-economic reality, we have become overconfident about the finality of our mathematical tools invented from centuries past until the middle of the 1900s. We are now telling nature how she ought to function and behave, instead of humbly keeping on trying to discover the actual logics behind all the ongoing cosmic evolutionary processes, whether animate or inanimate.

Let us make our point using a historical example. Like a true scientist, never surrendering his inquiring mind, Einstein has been known to question all his life everything, including his own theories. During the last decades of his life, he kept on working to formulate a unified field theory for the universe with which he would be more comfortable than his earlier theories, as well as quantum mechanics (QM). He kept on diligently raising questions regarding the very foundational hypotheses behind the QM [12.40]. He kept on asking question about the nature of light, “*What are light quanta?*” for almost 50 years, even though his hypothesis of *indivisible photon* has been universally accepted. Unfortunately, Einstein kept on asking the same question with his favorite built-in answer (“*quanta*”) rather than reframing his question as an open-ended one. This is why we have initiated our conference series with the open-ended question, “*What are photons?*” [1.32]. Einstein, of course, defied Planck, who originally discovered the *quantumness* in the nature of emission and absorption of EM waves through his law of black body radiation. However, Planck firmly believed that photons, after the release of a quantum of energy, evolve and propagate diffractively (Huygens–Fresnel principle) as a classical wave packet. Semi-classical models for photoelectric effects modeled as light-dipole amplitude-amplitude stimulation do not require *indivisible quanta* [1.43–1.45]. Yet, we are so conditioned over a century of Einstein’s *indivisible quanta* that we are extremely reluctant to entertain any other alternate concepts, even though Einstein himself was expressing serious doubt about his original hypothesis.

Preceding his 1905 paper on photoelectricity, as Einstein was pondering how to frame a theory, he brilliantly recognized the *quantumness* in the experimental data on photoelectric current. Had Einstein followed Planck's view of photons, and tried to model the *physical process* behind electron emission, he would have assigned the quantumness in photoelectric data on the binding energies of electrons and the optical frequency as the required resonant frequency for *stimulating the bound electrons before they were released*. Then, he would have formulated a QM with a very different mathematical approach than what we have now. This was about 8 years before Bohr's heuristic quantum theory and 20 years before the formal QM. Had Einstein reframed his question from *light quanta* to *electron quanta* (and its quantized binding energy), quantum philosophy would have been dramatically different! Thus, framing and reframing questions regarding the same problem at hand should be a critically important part of our scientific epistemology. Could there be some logical framework that can be used to iterate and reframe our questions in a logical, efficient, and productive way? We believe that our proposal of iteratively applying IPM-E would be such a referent platform for persistent feedback and reframing the inquiring questions.

12.5.5 Culture: Its Implied Purpose and Limit, Dictating How We Frame Questions

Culture drives our thinking. The evolution of human minds is now dominantly dictated by various cultures, which probably started some 100 thousand years ago. Human culture is designed for collective social well-being, not for becoming objective scientists [12.36–12.37]. Unfortunately, the prevailing human culture and education train us to overlook and/or ignore the fact that even the best working theory, whether modeling issues pertaining to social-engineering or nature-engineering, because we never know everything there is to know about any relevant problem. The reason is that, since ancient times, for the necessity of successful evolution of each tribe, the tribal family had to invent and facilitate the development of a social culture that systematically transformed our thinking to conform to the ruling family's viewpoint as long as it *works*, meaning, as long the culture allows the members to survive. Slowly, the unchallengeable god-culture evolved as a key tool to manage the large membership of the tribe. Perhaps, through millennia, we are thus genetically trained to accept the *messiah complex* and accept the concepts handed down by our hierarchy as the ultimate truth, especially if it *works*. So, as we find the concepts of many Newtons and Einsteins are working brilliantly, our *messiah complex* accepts them as the unchallengeable final truths. We become reluctant to allow further freedom to our nature-endowed inquiring and questioning minds on which we were thriving in our childhood

12.6 SEAMLESSLY CONNECTING IPM-E WITH MDM-E BY DISSECTING THE MEASUREMENT AND THEORIZING PROCESSES

12.6.1 Dissecting the Measurement Process

Founders of QM appreciated the deeply embedded and intricate "Measurement Problem," which is behind the interpretation of QM. Accepted solutions turned out to be various elegant mathematical theorems [12.41, 12.42a,b], perhaps, because the founders were essentially mathematicians. Let us try to dissect and understand the measurement problem from the stand point of process visualization. How do we succeed in registering data in any experiment? Let us try to articulate the steps based upon our current experiences [Chapter 6 in 1.6, 1.7, 1.13].

1. **Measurables Are Physical Transformations:** We can measure only physical transformations that take place in our instruments. The velocity recession of the most distant galaxy is calculated by using Hubble's hypothesis using the measured red shift of the characteristic atomic spectral lines that appear as detector currents in a spectrometer attached to a telescope focused on the galaxy of interest. But, in this model, the measured red shift is hypothesized as Doppler shift. (See Chapter 11 for alternate explanation.)

2. **Proceeded by Energy Exchange:** There are no transformations without energy exchange. (Energy from the light collected from the galaxy and dispersed by the spectrometer is absorbed by photo detector array, which produces the signal as photocurrent.)

3. **Guided by Forces of Interaction:** Energy exchange, and consequent transformations, must be guided by an allowed force of interaction. (Light beam induces dipolar undulation on the quantum mechanically bound discrete photoelectrons via electromagnetic force. So the discreteness in the emergence of photoelectrons does not validate that photons are indivisible particles.)

4. **Must Experience Physical Superposition:** Interactants must be within each other's sphere of influence to be able to interact under the guidance of an allowed force to exchange energy and undergo transformations. Thus, *all interactions* producing transformations *must be local* in the sense that the interactants must be within each other's sphere of influence.

(Only during the moment of direct physical illumination by a light beam, or a pulse, can one observe the emission of a photoelectron. Superposition effects cannot be nonlocal.)

5. *Through Some Physical Stimulation Process:* Although invisible, all transformations are preceded by some real physical stimulation process before the interaction can be consumed through energy exchange. Our conscious and systematic attempts to understand and visualize these invisible stimulation processes provide us with a logical tool that can directly connect us with the ontological reality, albeit through many iterative steps. We have been significantly underutilizing this IPM-E tool. For photo detection, it is the dipolar stimulation, induced in the photo detector by the oscillating E-vectors of the incident light, which corresponds to a peak at the ontological reality.

6. *Always Requires a Finite Duration:* Transformations in the interactants from one specific state into another specific state requires “quantum compatibility sensing dancing period” between interactants before they can acknowledge the force of interaction as a legitimate stimulation and then exchange energy and then undergo the measurable transformation (transition). (Photoelectron release requires stimulation for at least one cycle to establish the resonance between dipolar undulation frequency of the bound electron and the stimulating frequency of the incident light beam.)

7. *Impossibility of Interaction-Free Transformation:* The above set of self-consistent logical arguments clearly implies that we cannot observe any measurable transformation unless the entities under study interact with each other under the guidance of some allowed force operating between them. (The detecting dipoles cannot release photoelectrons unless the incident light directly impinges on the detector.)

8. *Perpetual Information Retrieval Problem:* Our theory-constructing enterprise suffers from perpetual information retrieval problem for the following reasons: First, we have not succeeded in constructing any instrument that has 100% fidelity in transferring all the quantitative data (information) it generates as secondary transformations induced by the primary transformations experienced by our chosen interactants. For example, the high-frequency information regarding a photocurrent gets cut off by the slow time constant of the associated LCR circuit. Second, we have never succeeded in setting up an experiment where the interactants can experience all the allowed forces that could introduce various measurable transformations in the same experiment helping us to construct a unified theory with all the forces in nature. So, we are unable to gather all the four force-related properties of any entity in any single experiment.

9. *Information out of Transformations:* Useful information is always limited by our subjective human interpretation of some observable transformation. The interpretation may be reproducible, but it does not exist independent of a physical transformation triggered in an experiment. In other words, information is what we make out of our observations, and hence, it is very subjective as it depends on who interprets it. The objective part lies with the interaction process that exist hidden within the interactants and is determined by the allowed force of interaction between them.

Thus, the root behind our Measurement Problem is the loss of some real information and some information that could never be directly extracted out of the entities we study through any experiment. This *lost* and *unknown* information cannot be recovered *unequivocally* by some elegant mathematical theorems! Only our creative imaginations can fill this information gap, which, then, has to be refined through repeated iterative reconstruction of the *working theories* by gathering feedback through process-visualization approach (IPM-E) and thereby inch forward closer and closer to the ontological reality. *Evidence-based knowledge* is definitely the best knowledge, however, by itself, it is insufficient for us to extract the complete story out of nature.

12.6.2 Dissecting the Theorizing Process

Now that we realize the fundamental limit in our capability to gather complete information about anything through any set of experiment, we need to figure out how to improve on our currently successful theorizing method by dissecting the thinking process, as per *reductionism and emergentism* [12.1f,g, 12.35a,b] so we can critically analyze each step separately to enhance our *IPM-E guided iterative progress*. The issue is how to ensure that we do not get stuck in a dead-end street. Our measured data represent a set of precise logical numbers. Our hypotheses that guide us in the construction of a theory are based on finding logical patterns among diverse observations. Our successful theories are all based on pure mathematical logics. Such a logical approach has been consistently yielding better and deeper understanding of natural phenomena. Accordingly, it is safe to assume that our cosmic universe is evolving under the guidance of a set of cosmic rules or laws, which themselves are interconnected by a set of cosmic logics. Hence, we are dividing our theory construction process into three steps for the convenience of analyzing them separately, as well as collectively. This is important because we have already accepted that all theories will always be incomplete and must be iteratively improved upon. The question is how we define our logical reference platform that can keep on providing us with necessary feedbacks for continuous and iterative advancements.

1. *Introspective logics or hypotheses logics:* A pioneering scientist groups a set of observations that appears to be interrelated, but all the necessary information is still not available to us through diverse measurements. The pioneer, then, refines his mental logics by searching for conceptual continuity among the diverse observations by imposing some *logical*

congruence upon them. Then the knowledge gap is breached by imposing some new behavioral characteristics on nature. For example, Einstein conjectured that the velocity of light should be constant in all frames of reference to eliminate the need for unobservable ether, and it appears to be *working*. Unfortunately, he has not given us any explanation that is based on the visualizable physical process. In absence of a stronger and better theory, we keep following Special Relativity. The reader may note that a pioneer's construction of an inquiring question and solution will always be deeply influenced by the prevailing scientific and sociocultural paradigms. This is the step where we need a fundamental shift in framing our question before *hypotheses logics*: What are the ontological physical processes, albeit invisible, that are giving rise to the observable data?

2. *Mathematical logics*: On the basis of the data and hypotheses, the pioneer scientist constructs a mathematical relationship that gives a comprehensive structure to the refined set of hypothesis. The resulting theory equates the hypothesized *cause* (or behavior) of nature with the observed *effects*. The algebraic symbols usually refer to the various intrinsic behavioral *parameters* of nature and those of interactants used in a measuring instrument. The mathematical operators, used in the equation to represent interrelationships between the physical parameters, are supposed to represent nature-allowed *operations* (nature's force-guided interactions) between the parameters of the interactants. Thus, the symbols and the operators in a theoretical equation are supposed to directly capture the interaction processes in nature that give rise to measurable data. In QM, Schrödinger's ψ -function is a non-real complex function and supposed to be an abstract mathematical probability only, without directly representing any physical parameter of the object under study. But $\psi^* \psi$ consistently yields correct *measurable real numbers*. We find this methodology of thinking to be incongruent with the desired primary starting assumption that nature is real. On the basis of its pervasive successes, we believe that QM has more realities built into it than the Copenhagen Interpretation has allowed us to extract from it (see Chapters 3, 10, and 11). The structure of QM theory and its built-in confusing interpretations have evolved under the dominant scientific paradigm of MDM-E, which guided us to accept our incomplete knowledge of wave-particle duality as the final reality of nature. Mathematical theories, by definition, are constructed based on rigidly closed set of mathematical logics. One cannot find its logical flaws by arguing from within the same set of self-congruent logical system. Ad hoc insertion of *hidden variables* [12.40b] within the logically closed QM formalism cannot succeed in extracting ontological reality out of the theory that has not been designed for that purpose. It will naturally show logical self-consistency. Broader debates to extract ontological reality out of the QM will remain unresolved. Nature can be modeled as non-dual only if our starting logical platform is non-dual, both in hypotheses and in mathematical structure. In other words, *formulating the foundational hypotheses to explicitly seek out ontological realities, using IPM-E, or a better epistemology when available, must be the starting platform*.

3. *Cosmic logics (accessed through understanding interaction processes)*: Because of our approach to understand the observable cosmic system has been consistently successful by applying the above-mentioned logical approaches, we should rationally accept that rules of operation in the cosmic system follow well-defined set of logics. Let us name them as *cosmic logics*. However, we should restrain ourselves from assigning these rules discovered by our current theories (*work in progress*) as the final cosmic logics, or the final *cosmic laws* governing the universe. Let us recall that none of our measurements and interpretations, singly or collectively, could guarantee retrieval of 100% relevant information about any phenomenon we study. At a deeper level, none of the relevant interaction processes are directly observable to us, whether classical or quantum mechanical (nature does not classify them as such). We suffer from an information retrieval problem, which we supplement by using our neural network dominantly structured to interpret limited sensorial inputs (including instruments) dictated by our evolving cultures of epistemic thinking. This is why we need to explicitly start to incorporate IPM-E to complement the prevailing MDM-E so we can avoid getting stuck in a logically self-consistent path that is not leading us toward the ontological reality of our cosmic system. We should recognize our working theories as “working rules”; without calling them “Laws of Nature”!

12.7 HIGHLIGHTS OF THE BOOK AND ITS ACCOMPLISHMENTS

We are seeking to understand, visualize, and appreciate the ontological reality of nature. Let us very briefly review the contents of the book in light of the methodology of thinking just presented. The core content of the book derives from the application of the process-driven concept of SE (Superposition Effect), which replaces the mathematical Superposition Principle (SP) in view of the NIW property, albeit neglected for centuries. We believe NIW is closer to ontological reality, than MIW (Mutual Interaction between Waves). However, it is not yet widely accepted that propagating waves in the linear domain *do not interact (or interfere) with each other*; even though it is built into our key wave equations, which accepts linear combination of multiple sinusoids as sustainable (allowed linear) waves. Physics has yet to formalize the existence of

any force of interaction between cross propagating or co-propagating waves in the linear domain. So, the NIW property and its consequences should have been explicitly recognized for at least about 200 years, dating from the time Fresnel formulated the *Huygens principle* (1678) as a mathematical theory (1816) using his *interference principle*, which is now the backbone of physical optics. To appreciate our modest attempt to promote the necessity of being aware of one's methodology of scientific inquiry, let us briefly recapitulate observations made in the previous chapters.

12.7.1 Highlights of the Book

Chapter 1. We have identified a series of contradictions that are now being used to explain various optical phenomena. These are results of not accepting the NIW property explicitly.

Chapter 2. Here we present logical arguments and a series of experiments to demonstrate that well-defined wave groups can cross-propagate or co-propagate through each other and then reemerge unperturbed without interacting (interfering) with each other as long as the medium is non-interacting and linear in response to all the waves.

Chapter 3—Superposition Basic: Mathematically, we just need to replace the traditional “summing of wave amplitudes” by “summing of conjoint amplitude stimulations carried out by the detecting dipoles.” Replace SP (mathematical superposition principle) by SE (superposition effects as experienced by detectors), because SP promotes the misconception, MIW (Mutual Interaction between Waves), rather than accepting the reality of NIW property (Non-Interaction of Waves).

Chapter 4—Diffraction: Here we discuss that Huygens–Fresnel diffraction integral, representing summation of secondary sinusoids (wavelets), obeys the NIW property; so does Maxwell's wave equation. SP works only through the process described by the acronym SE. A detector array placed at any forward plane will display the recorded intensity as the square modulus of the HF integral because the detector carries out this physical quadratic algorithm to absorb energy from the composite field. The HF amplitude integral continues to represent the unperturbed spatial expansion of all the secondary wavelets, as if they are not experiencing each other's presence while evolving.

Chapter 5—Spectrometry: Traditional spectrometers (gratings and Fabry-Perot's) are linear amplitude replicators of the incident beam into a train of periodically delayed set of new beams. Our approach recognizes spectrometers' characteristic time constants and their temporal evolutionary behavior by propagating carrier frequency of time finite pulses, instead of propagating non-causal Fourier monochromatic modes. Resolving power is never limited by the Fourier bandwidth product; there is no time-frequency uncertainty limit in nature, $\delta\nu\delta t \geq 1$. Limits of human-invented theories and experimental devices should not be assigned as principles of nature.

Chapter 6—Coherence: We replace the prevailing “coherence property of waves” by measurement-driven property, “correlation property of detectors,” and recognize their (1) intrinsic quantum mechanical “time averaging” property and their (2) system-driven “time integration” property. A wave packet is always a “coherent collective bundle” in nature. It is never incoherent.

Chapter 7—Laser Mode Lock: We replace the prevailing “mode lock” concept (modes sum to create energy pulses), by the “synchronous time gating” behavior of intracavity phase-locking devices, which allows the emergence of energy pulses out of the cavity.

Chapter 8—Dispersion: We drop the concept and the theory of “group velocity.” It is based on the non-causal SP as it accepts MIW (mutual interaction of waves) as assumed reality, while ignoring the factual reality, the NIW property. We should always propagate the source-generated carrier frequency contained in a pulse.

Chapter 9—Polarization: We drop the concept of elliptical polarization.

E-vectors do not sum to spin helically. Wave interactions with the boundary molecules and/or bulk materials of optical components that modify the propagations of all the E_x 's and E_y 's, are correctly modeled by the Jones' matrix method. This method, just like the HF integral, has the NIW property built into it. We should always propagate the source-generated carrier frequency contained in a pulse.

Chapter 10—Photons: Photons are non-interacting and diffractively expanding classical wave packets conforming to QM frequency and energy requirements. They are not indivisible quanta. We should not assign the QM properties of photoelectrons to photon wave packets. Properly polarized light beams and the stimulations induced by the orthogonal E- and B-vectors can be modeled as angular momentum of material particles. However, we should not assign these characteristic responses of particles as those of the waves.

Chapter 11—Optics, Relativity, and Space: We replace “space as a vacuum” by space as a Complex Tension Field (CTF). We reinstate the old concept of “ether” by the enhanced postulate of “CTF.” EM waves crossing the entire universe with a steady and very high velocity, $c^2 = (\epsilon_0\mu_0)^{-1}$, without further support from the emitters, while also crossing through each other without interacting, requires them to be *linear undulations of a physical tension field*. *The NIW property requires CTF*. Existence of a stationary CTF demands revitalizing physics through iterative reevaluation of all fundamental postulates behind all major “working” theories.

Chapter 12—Evolving Scientific Enquiry: This is the ongoing current chapter that summarizes the evolution of past thinking in modeling nature and how we should keep on modifying our thinking to assure that we can keep on seeking ontological realities of nature without stagnation.

12.7.2 Apply Occam's Razor to Reduce the Number of Hypotheses

The concepts developed in this book may appear to be proposing unusually bold postulates and hypotheses, but they are based on established principles of causality and commonsense physics, which also encourages us to make the following suggestions to bring back causality in all branches of physics.

- 1. Replace Einstein's "indivisible quanta"** by Planck's divisible classical wave packet, while accepting the reality that binding energies of all photoelectrons are quantized in all materials: Our instruments can register only "clicks" because released photo electrons are discrete.
- 2. Replace Dirac's statement "A photon interferes only with itself"** by "A detector's simultaneous stimulations due to multiple excitations engender superposition effect." Frequency resonant detectors are at the root of engendering superposition effects, whether classical or quantum.
- 3. Replace Dirac's photon as an "infinite Fourier mode of the vacuum"** by "classical time-finite wave-packet mode of the vacuum" enforced on the CTF, excited by electrical dipoles like radio antenna, atoms, and molecules.
- 4. Replace Born's interpretation of ψ as an abstract "mathematical probability amplitude"** by "real physical undulatory stimulation of internal structure of particles." This also eliminates the need for de Broglie's "pilot waves." The square modulus of the complex Psi-function models the brief time averaging process when the resonance is identified before energy exchange through quantum transition.
- 5. Replace de Broglie's "pilot wave"** by "harmonic frequency proportional to its kinetic energy." A principle of nature should not diverge under realistic conditions. De Broglie relation diverges as the speed of a particle tends to zero: $\lambda = h/p \rightarrow \infty$ as $v \rightarrow 0$.
- 6. Drop Bell's "inequality theorem" as the guide to accept completeness of QM formalism.** It does not mathematically model the physical process of SE in interferometry, and hence, it promotes the acceptance of a non-causal concept of non-locality in superposition effects without having any foundation in modeling nature.
- 7. Replace Heisenberg's "uncertainty principle"** with "information retrieval problem." It is not a principle of nature. It is the human limitation of extracting all possible information about any natural entity we try to study.
- 8. Replace Einstein's "relativistic Doppler effect"** by "classical Doppler effect." Doppler shift suffered by a wave packet as it emerges out of a moving source is real, and persists as it propagates through CTF. Different moving sensors will perceive this same wave packet as having different carrier frequencies. Consistent success of the QM rules behind spontaneous and stimulated emissions require this proposed modification.
- 9. Replace Hubble's cosmological red shift as due to "relativistic Doppler shift"** by a better physical phenomenon to be refined to accommodate the measured distance dependent cosmological red shift. It could be that the CTF is mildly dissipative. The postulate "Expanding Universe" may have to be revised.
- 10. Replace "wave-particle duality"** by separate physical realities for waves and for particles. We should not convert our lack of knowledge, clearly implied by the word *duality*, into a definitive new knowledge as if that is the rule of nature.
- 11. Replace "4-D space"** by "3-D space." We have not yet found any physical entity that has continuously running time as one of its measurable physical parameters and influences the temporal evolution of everything else. Primary parameters of a theory should be directly measurable physical parameter of some physical entity. We always measure frequency of some physical object and invert it to obtain a reference *time-interval*. Such frequencies are physically alterable, but not the running time.
- 12. Accept "Entanglement" only conditionally:** All physical interactions are local in the sense that the intractants must be within each other's physical sphere of force field. Particles cannot remain entangled beyond the range of the QM allowed force of interaction.

12.8 CONGRUENCY BETWEEN SEEKING "ONTOLOGICAL REALITY" AND "SUSTAIONED EVOLUTION"

The quotations presented at the very beginning of this chapter clearly imply that *evidence-based knowledge* is definitely the best knowledge we have so far. Yet, by itself, it is insufficient to guarantee that we are definitely along the right path for our continued enquiry into ontological truth, or the real physical processes that are driving the cosmic evolution. It is clear that

mathematics is the best tool we have invented so far to advance analytical and quantitative science. However, from the diverse biological intelligences presented in Figure 12.1, it is also evident that the current human mathematical tools alone are not the exclusive guide to assure us that we will not be diverging away from the correct path for our continued exploration of the ontological realities. We have yet to discover the final methodology of thinking that can assure us that our inquiry of nature is moving along the right path based only on *evidence-based knowledge* (reproducible measurable data or MDM-E). The success of MDM-E has been facilitated by the subtly embedded epistemology of reductionism [12.43] and energy conservation (emergence of measurable data through exchange of energy). It is natural for any species to *bite out* only a very small segment out of the vast unknowable food-providing system (the biosphere), which is manageable for understanding. Humans have been refining this approach as reductionism through the invention and persistent development of our mainstream mathematics over several millennia. However, the limits of reductionism have now been well recognized [12.1g,f, 1.15, 12.34], and we are now using a two-pronged approach by combining reductionism and emergentism as a grand synthesis of consilient epistemology [Chapter 6 of 1.6, 1.13, 12.38], which can be holistically stated as being *evolution congruent*. Emergence of staggeringly advanced innovative intelligence, displayed by amoebas by joining their collective hands in response to food shortages to promote life elsewhere for a few of their brethren did not require the evolution of a specialized organ like that of human brains consisting of 100 billion specialized neural cells [12.44]. Our pride as the most advanced biological species should not detract us from recognizing that quite sophisticated and advanced biological intelligence can emerge out of the DNA of a *single cell*, including the appreciation that collectively they can achieve much higher level of desired innovative tasks that are impossible to carry out individually. Intrinsic biological characteristics like the *desire* to live better, the *belief* in carrying out higher levels of functional capability, maintaining the persistent *faith* in this capability of executing newer and newer difficult tasks, the *hope* to overcome survival threats with collective endeavors, and the *imagination* to construct desired new tools, or processes or technologies—all these characteristics together can be defined as the *love* to fully enjoy life forever. These qualities (capabilities) are not the exclusive domain of advanced species like the human mind alone. Let us recognize that these complex and/or sophisticated behaviors always appear to be emergent out of complex structures. However, these structures are rule-abiding constructs out of elementary undulations of the cosmic vacuum. Our “conscious” brain function emerges out of the interactions between diverse neuron-cells; cells are built out of molecules; which are built out of atoms; which are built out of protons, neutrons and electrons; and these particles are resonant localized undulation of CTF (the cosmic vacuum). Hence, the cosmic vacuum must possess the potentiality of all the complex qualities that emerge out of macro bodies, whether galaxies or biological entities with self-awareness or consciousness [12.45, 12.46].

Let us then recognize that there is no force stronger than evolution. The state of our knowledge about the universe has not yet reached the stage that we can conquer nature or the cosmo-sphere! We, and the vast living biosphere together, represent a minuscule spec in the grand design of the evolving cosmo-sphere.

The best choice or, effectively, the only choice, for us is to proactively and consciously become evolution congruent in all of our human enterprises, social engineering, and nature engineering. We must also explicitly recognize that the biospheric evolution is inseparably collective. Our body, constituting 10 trillion human cells, is still being nurtured by another micro-biome of 100 trillion symbiotic bacteria of wide varieties [12.47].

Defiance against evolution in favor of ancient *working social engineering theories*, defiance against the responsibility to choose activities congruent with the collective well-being (individual happiness), in favor of priority for abstract individual freedom, will eventually push us to become Knowledge Age Neanderthals.

The physical processes behind natural evolution do not appear to have a single predetermined outcome either, whether biological or cosmological. Causal but multiple statistical outcomes are at the root of diversity in the universe, whether triggered by classical or quantum interactions. This statistical propensity of nature should not be artificially divided as totally separate phenomena. Innumerable biological functions, going on in any macro (classical) human body at any moment, are essentially driven by quantum mechanical interactions between diverse molecules. And diversity is also at the root behind our creative universe, while engendering the profoundly important platform for sustained evolution. Different propensities for different outcomes in any allowed interaction may appear to be somewhat elusive to our limited understanding, but that does not make the universe either non-causal or an illusion like a holographically reconstructed image [12.48]. It is the symmetry in the elementary oscillations (particles and waves) that provides them with the necessary stability. But their *stable oscillations* create *potential gradients* around themselves (Chapter 11), and hence the propensity for forces of interaction or asymmetry around themselves. This is the origin of the intrinsic *dialectical behavior* we observe in the cosmic system. Consequent interactions drive physical transformations. The resultant products are pushed to collectively achieve the minimum possible energy states for newer stability. However, the bigger assembly creates newer emergent potential gradients for newer interactions and the cycle goes on, both in the inanimate galactic and in the animate biological world. On

the grand scale, as if the space, as a living complex tension field, or as a sea of quivering quarks, is entertaining its own body by nurturing rule-abiding perpetual dances of creation and destruction [12.45, 12.46].

Our far-sighted choices, made while zigzagging our way through attempts to enhance our knowledge-gathering methodology, will determine our future along one of the many possible congruent paths. *Humans do not have a predetermined single destiny.* Our sustained evolution will split into many successful paths provided they all are definitely congruent with the overall set of operational cosmic logics. We do not yet know enough to declare nature to be non-causal while at the same time structuring all of our fundamental working theories that equate hypothesized *causes* (forces) to the observed *effects*, using quite rigid mathematical logics. We do not yet know enough to declare that the ontological reality is inaccessible to our creative imaginations. In other words, we should keep on insisting on *visualizing the invisible interaction processes* going on in nature that give rise to the measurable data; even though the Copenhagen School advises us otherwise [12.22–12.26]. *If we keep on asking to understand the ontological reality, and the meaning and purpose of this creation and our role in it, we will eventually discover it.*

Our scientific inquiry and the concomitant methodology of thinking must be guided by a rigorous and reproducible process that is continuous and retraceable as we continue to evolve without going through revolutionary disruptions in our epistemology, which has been the history of physics during the last few millennia [12.28]. How can we derive the assurance that the proposed IPM-E will always keep us in step with our desire to be dynamic and yet evolution congruent? Further, our knowledge of the universe is still quite limited. So, it would be impossible to claim any ultimate assurance that IPM-E is the final epistemology. However, IPM-E, or the interaction process mapping epistemology, itself has been defined to be a changing system of thinking to remain evolution congruent, not as another paradigm with its built-in *final structure*. This evolution congruency is further underscored with the choice of the word “map” in IPM-E. Since we cannot take pictures of the invisible interaction processes at the deepest levels, we have to *imagine the maps* of the processes and patiently, through generations, keep on iterating them towards perfection. *A map is not the real terrain*; but it can be refined iteratively and indefinitely to get closer and closer to real terrain with an accuracy approaching high-resolution photographs. It is the faculty of human imagination that allows us to step outside our body, study everything around us, and relate to it. But we must remain vigilant that we do not accept “seeing is believing.” Colors are evolution-dictated biological interpretation; they are not objective properties of light; the frequencies are. Trying to be evolution congruent is a *double-edged sword*! We must take advice from Francis Bacon [12.1a].

Thus, the purpose and the path for scientific inquiry need to be clearly articulated.

The purpose needs to be explicitly defined as seeking ontological realities behind natural evolution and the path should be the visualization of the invisible interaction processes that are creating all the diverse evolutionary transformations.

This is congruent with our desire for perpetual evolution through our progenies as a species. If we do not explicitly seek out ontological realities, we will not find them. Tools and technologies ensure our biological evolution, and emulation of nature-allowed processes facilitates the continued inventions of necessary diverse technologies. The persistent acts of process visualization, our DNA-provided emergent faculty of imagination (liberation), must be prudently utilized to override the embedded interpretations (like color) in our neural network by the same DNA for our successful evolution. Thus, IPM-E is a better thinking tool. It accepts the key strengths of the prevailing MDM-E, which is gathering of evidence-based knowledge through systematically reproducible experiments. But IPM-E will guide us away from getting dangerously wedded with evidence-only-based theories that may be incongruent with our sustainable evolution. We are proposing that the primary purpose of structuring the foundational hypotheses behind the construction of any theory should be to *facilitate the visualization* of the invisible interaction processes that generate the measurable data for validation of the theory. We also suggest that the foundational hypotheses behind the prevailing working theories should also be reconstituted. Einstein’s hypotheses of indivisible quanta, and his photoelectric equation for energy exchange, were framed to model the existing observable data. If Einstein’s primary attention was to visualize the *physical processes* executed by the bound electrons, *amplitude–amplitude stimulation*, before electrons get released, he would have discovered quantum mechanics. The concept of dipolar undulations by bound charges were already there. The inherent concept behind IPM-E is very ancient, as we have mentioned earlier. Without articulating so, our forefather engineers used this epistemology, and kept on inventing newer technologies. And the history continues even today. We are in the Knowledge Age due to engineering feats accomplished by our communication engineers in inventing techniques and technologies to generate, manipulate/modulate, propagate, and detect electrons and EM waves. Yet, none of us still know the precise structure of either electrons or photons. When we learn to visualize the very processes that create electrons and photons, our technologies will become far more advanced than we can imagine now.

However, IPM-E cannot take hold in our scientific endeavor unless the human societies, or their *representative cultures*, accept the concept of becoming evolution congruent. We have underscored earlier that framing the question determines the answer we can get when we try to postulate foundational hypotheses for a potential theory. The culture and its embedded human purpose dictate how we frame our questions. The desire to continue to live forever through our progenies should be leveraged to consciously reorient all of our cultures to become congruent with nature’s evolutionary vector, while

maintaining separate cultural diversities to remain in tune with the generic principle of diversity; no individual philosophy, or no specific culture, has yet reached the maturity to become the sole guide.

We must also structure our enquiring theories such that they provide us with mechanisms for very *frequent feedback* from nature. This would allow persistent incremental improvements in our hypotheses and theories, instead of waiting for some major disruptive revolution after a big mistake. All biological species have adopted this strategy since the beginning of evolution. Sustained enhancement in biological intelligence has been happening through frequent proactive and purposeful actions, which trigger and generate useful feedbacks for continuous learning. Constructing purposeful actions require well-defined purposeful vision behind our inquiry, which should be endless such that our motivation behind the technological and scientific inquiry becomes more and more energized as we keep on advancing in our purpose. Again, this *indomitable purpose* is our innate desire for sustained evolution, beyond global warming [12.49] and beyond solar warming [12.50]! What technologies do we need to invent to manage global warming? What scientific advancements we must achieve to ensure the inventions of the necessary technologies? Have we ever carried out any really successful geoengineering technology [12.51] on a planetary scale? We cannot venture to move to another planet without having demonstrated such technologies repeatedly and successfully. Do we have any rocket technology worthy of inter-star or inter-galaxy travel [12.52]? Do we not need to settle the question whether space is really a vacuum or a complex tension field [12.53]? If it is a tension field, can we figure out how to utilize its dormant tension energy, which is available at every point and everywhere around us and in space [11.15,12.54]?

Centuries of history tells us that the sustained desires of individual scientists to unravel the mysteries of the universe cannot be realized within a single lifetime. So we do not have any choice but to revitalize our attention to proactively *nurture the inquiring minds of our children* so they can appreciate the significance of seeking out ontological realities for the sake of our sustained evolution. Genetically, the children are endowed with insatiable inquiring minds and unbounded capacity of imaginations. Anybody, who has raised or is raising two-year-olds, is aware of these evolutionary gifts in every child. Ancient tribal cultures have evolved to ensure the survival of the entire tribe against all the ancient existing threats to the tribe by “properly” training and controlling their children toward adulthood. Many of this cultural training is still embedded in modern cultures so deeply that by the time modern children come out of their schools and colleges, most of them lose their bubbling inquiring minds, and simply conform to what they have already been taught as the final knowledge. We claim to be a very advanced species, yet we do not nurture our children to become seekers of ontological reality. It gets worse: modern physics actually inculcates the belief that ontological reality cannot be accessed by our theories. This last part is correct—if we design our theories to model only measurable data; then that theory cannot naturally lead to ontological reality, except by accident.

The human paradigm of the ownership of private property, and the concomitant responsibility to maintain and nurture the property, must now be extended to nurture our bigger home, the spec of blue biosphere floating in infinite space. Our scientific knowledge, gathered up to now, tells us that we cannot thrive without maintaining the sustainability of the biosphere, which functionally implies that we must proactively learn to promote the collective well-being of all the species.

Diversity is at the root of the success behind the magnificent biospheric evolution, of which we are a small part.

“Diversity” is not just a politically expedient word. We must consciously co-opt this successful natural rule of biodiversity in the domain of human culture as *concept diversity*, leading to culture diversity. We must proactively nurture all those diverse concepts that promote varieties of cultures that conform to and enrich our grand vision of sustained and purposeful evolution [12.55]. It is time for us to graduate out of the prevailing tradition of accepting the rule of one major revolutionary paradigm after another, as in the past. We are a gift of the biological evolution process, and so is our mind—and so should be our cultures [12.56]. We now need to shift from ad hoc and haphazard development of our cultures to *consciously constructing diversity of purposeful cultures* that are congruent with the principles behind continuous and steady biological evolution. Our enlightened cultures, in the domains of both social engineering and nature engineering, must welcome conceptual diversity. Inquiring minds of children should be encouraged to imagine and develop diversity of concepts that conform to their sustainable evolution. Without critical oversight facilitated by a diversity of concepts, we may stick to a set of *working theories* that may lead us into a path of unsustainable evolution and away from the path to the ontological reality.

Let us again underscore the need to inculcate the necessity of being aware of logics and methodologies of our thinking from early childhood. Children need to learn to be aware that our knowledge about everything is limited and we successfully live with *subjective realities*, in contrast to what are ontological realities. This point can be illustrated using a trivially obvious set of observable phenomena like speeches, music, storms, and cyclones. These are now all highly advanced and complex fields of science and technologies and are still evolving. But they are just diverse emergent properties of a common source of energy, the pressure-tension field held by the air, which is a thin layer of atmosphere around our spherical globe. The origin of the tension energy is due to the gravitational attraction of Earth on each and every air molecule, which generates a compressive stress in the bulk air, resulting in the emergence of pressure tension. Winds and storms are all due to

pressure variations, orderly or disorderly. The substrate that manifests the pressure tension is the air under the compressive stress, imposed by the gravitational force. Macroscopically speaking, this is the ontological reality behind the propagation of our speeches, music, storms, and cyclones from one place to another. Of course, orderly speeches and music, a linear response to perturbations of the pressure tension field, will be highly distorted in nonlinear cyclonic environment.

Now, what about exploring the deeper ontological reality behind the elementary particles at the bottom that create the atoms, which create the molecules of air and also all the biological molecules and DNAs, and then the emergence of humans with emergent capabilities to read and write? We are very far from developing the ultimate methodology of thinking that will guide us to visualize the microscopic universe such that it seamlessly allows us to visualize the emergence of all the observable macroscopic complexities out of the cosmic substrate.

There is no vision for us that has higher pragmatic value than seeking sustained evolution by conforming to the rules of evolution and hence persistently seeking the ontological realities of nature. Our current state of knowledge about the cosmic evolution is so meager that it is futile for us to declare any theory as the final one, or declare war against evolution. Let the inquiring minds of all future generations keep on developing technologies to explore the vast cosmic system while intellectually evolving to figure out the meaning and purpose of the universe and our possible proactive roles in it. We need to recognize that the global Internet system has brought the potential reality of the dreams of many past and present thinkers to promote Self Actualization For Everybody (SAFE) around the globe. Our Children just need to repeatedly hear and read that we do not have any *final theory* for any field of human endeavor, whether it is for social engineering or for nature engineering. Their mind will be simultaneously challenged and energized by recognizing that the vast universe lies before them for limitless and perpetual explorations! Our desired very long lasting evolutionary SAFE-ty will be assured only when our future generations become evolution congruent space travelers and cosmic thinkers while evolving out of the rut of anthropic thinking only.

12.9. SUMMARY AND COMCLUSIONS

Through Chapter 1 to 9, we have demonstrated that several major optical phenomena are better expressed in terms of Superposition Effect (SE) mediated by material dipoles. SE is a natural physical phenomenon displayed by detectors while they absorb energy through a quadratic *interaction process* from all the simultaneously stimulating EM waves. The mathematical Superposition Principle (SP) is a correct initial step; but it is devoid of any *interaction process* as it does not contain material dipolar properties; and hence we have used the expression, Non-Interaction of Waves (or the NIW-property) of wave amplitudes. *We assume that this cumbersome expression should eventually be dropped from physics literature; since it is superfluous to underscore a non-existing phenomenon in nature!* In Chapter 10 we have used the broad background of Chapter 1-9 to propose a classical- and quantum-physics-congruent model for photon as a semi-exponential wave packet that evolves out of the quantum of energy released by atoms and molecules. Logical self-consistency for the existence of the NIW-property requires the existence of a Complex Tension Field (CTF); which perpetually propels the linear excited states as waves. So, Chapter 11 shows how the existence of physical CTF can play a serious alternate role in developing a unified field theory, the dream of Einstein.

This last chapter has developed the viewpoint that we need to adopt and adapt a pre-historic methodology of thinking, Interaction Process Mapping Epistemology (IPM-E). IPM-E should be applied over and above our prevailing successful methodology of thinking, Measurable Data Modeling Epistemology (MDM-E). This need should be obvious from the realization that the interaction process free mathematically correct approaches like SP must be anchored to reality of natural interaction processes; even though these microscopic processes are invisible. But we can visualize them by iteratively applying IPM-E, while using our highly developed evolution endowed capacity of imagination. Our fore father engineers of million years back used to use this intuitive imagination to emulate nature allowed *processes* while making tools and technologies to assure our successful evolution to current existence. Today, just like our fore fathers, we can take great pride that we have ushered in the Knowledge Age with technologies that manipulates electrons and photons; yet none of us can describe the exact nature of electrons and photons.

Thus, IPM-E paves the way for us to consciously become evolution congruent; and as a logical consequence, the purpose of physics can be directed back again to seek the ontological reality of nature. Evolution congruent thinking will naturally lead to the emergence of steady consilience [12.38, 1.13] among all the diverse knowledge generating endeavors. We will find that the diversity of thinking logics among the theories of social engineering and nature engineering can actually help us agree on necessary actions for today; while staying prepared to take corrective and better actions for tomorrow. Physics cannot become directly relevant, productive and useful by following a paradigm that is not directly connected towards our collective desire of achieving sustainable biospheric evolution.

Being human, it is quite obvious that all human constructed theories, whether designed for social engineering or nature engineering, will naturally be based upon anthropic logics. Unfortunately, over the last several thousand years, we have steadily veered towards becoming anthropocentric instead of remaining evolution centric; like all other specie naturally are. This has limited the evolution of our thinking and our actions from remaining evolution congruent; and we have become *conqueror of nature*. This process started several thousand years ago when we started imagining that we have been created in the image of the creator of the magnificent star-studded geo-centric system; and, the animal and the plant kingdom are provided by the creator for our food and pleasure only. But, our scientific knowledge has advanced far enough to re-connect ourselves with our biological origin and our inseparable dependency with the rest of the biosphere. The hard truth is that we now need to learn and appreciate that our body-defense, digestive system, and even our state of mind, that arise out of our human-biome of 10 trillion human cells, are pro-actively nurtured and influenced by 100 trillion micro-biome of thousands of different species. Hence, we must learn how to proactively nurture this micro-biome for our own wellbeing. We cannot keep on evolving very long without assuring the sustainability of the biosphere consisting of all the diversity of species.

It is high time for us to consciously re-construct a purposeful and consilient methodology of thinking to keep on discovering the processes behind our inter-dependent natural evolution. The physical or ontological reality, of nature cannot be understood unless we start framing our enquiring questions that are firmly grounded through the over-riding purpose and needs for our collective evolution driven by logics behind physical reality.

REFERENCES

- [12.1a] F. Bacon, *Idol*. See also: <http://plato.stanford.edu/archives/win2012/entries/francis-bacon/>
- [12.1b] L. J. Snyder, *The Philosophical Breakfast Club: Four Remarkable Friends Who Transformed Science and Changed the World*; Random House, 2011. See also: http://www.ted.com/talks/laura_snyder_the_philosophical_breakfast_club.html?utm_source=newsletter_weekly_2013-04-13&utm_campaign=newsletter_weekly&utm_medium=email&utm_content=bottom_right_button
- [12.1c] W. Heisenberg and A. J. Pomerans, *Physics and Beyond: Encounters and Conversations*, World Perspectives Series, Vol. 42, 1972.
- [12.1d] F. Crick, p.141 in *What Mad Pursuit: A Personal View of Scientific Discovery*, Basic Books, 1990.
- [12.1e] S. Hawking and L. Mlodinow, *The Grand Design*, Bantam Books, 2010.
- [12.1f] A. J. Leggett, *The Problems of Physics*, Oxford University Press, 1987.
- [12.1g] S. A. Kaufman, *Reinventing the Sacred*, Basic Books, 2008.
- [12.1h] F. J. Dyson, *Disturbing the Universe*, Sloan Foundation Science Series, 1981.
- [12.1i] C. Roychoudhuri, "Appreciation of the nature of light demands enhancement over the prevailing scientific epistemology," *Proc. SPIE*, Vol. 8121–58, 2011.
- [12.1j] S. Weinberg, "Physics: What we do and don't know", *The New York Review of Books*, Vol. LX, No.17, p.84 (Nov.7, 2013).
- [12.1k] S. Weinberg, *Dreams of a Final Theory: The Scientist's Search for the Ultimate Laws of Nature*; Vintage Books (Aug 31, 2010).
- [12.2] Go to website at <http://inspirationalknowledge.blogspot.com/2012/06/which-fishspits-at-insects.html>
- [12.3] Go to the website: http://www.google.com/imgres?hl=en&authuser=0&biw=1241&bih=536&tbm=isch&tbnid=bpN66634rEgUyM:&imgrefurl=http://www.dailyherald.com/article/20130217/sports/702179819/photos/AR/&docid=9HtT4SiCDR6DBM&imgurl=http://www.dailyherald.com/apps/pbcsi.dll/bilde%253FSite%253DDA%2526Date%253D20130217%2526Category%253DSPORTS%2526ArtNo%253D702179819%2526Ref%253DAR%2526maxw%253D234%2526maxh%253D370%2526Q%253D70%2526%2526updated%253D&w=234&h=369&ei=bnuYUfGXF_i84A0ngIGIAQ&zoom=1&ved=1t:3588,r:76,s:0,i:321&iact=rc&dur=1411&page=6&tbnh=197&tbnw=120&start=71&ndsp=16&tx=54&ty=91
- [12.4] Launching Spores. Cornell Plant Pathology Lab: <http://www.youtube.com/watch?v=DCyrmrx4EoI>
- [12.5] D. A. Brock et al., "Primitive agriculture in a social amoeba," *Nature*, Vol. 469, No. 7330, 2011.
- [12.6] M. B. Tauger, *Agriculture in World History (Themes in World History)*, Routledge, 2011.
- [12.7a] C. A. Pickover, *The Physics Book: From the Big Bang to Quantum Resurrection, 250 Milestones in the History of Physics*, Sterling Milestones, 2011.
- [12.7b] T. Taylor, *The Artificial Ape: How Technology Changed the Course of Human Evolution*, Palgrave Macmillan, 2010.

- [12.8a] R. Porter and M. Ogilvie; editors, “The Hutchinson Dictionary of Scientific Biography”, Vol.2, p.719; 3rd Ed. Helicon Publishing Ltd. (2000).
- [12.8b] C. Roychoudhuri, “Shall we climb on the shoulders of the giants to extend the reality horizon of physics?,” Conf. on Quantum Theory: Reconstruction of Foundations—4, Invited paper; *AIP Conf. Proc.*, Vol. 962, 2007.
- [12.9] W. A. Dembski and J. Wells, *The Design of Life: Discovering Signs of Intelligence in Biological Systems*, ISI Books, 2008.
- [12.10a] D. W. Sherburne, *A Key to Whitehead’s Process and Reality*, Macmillan Publishing, 1966.
- [12.10b] J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing among Five Approaches*, SAGE Publications, 2013.
- [12.11] S. Knapp, *Proof of Vedic Culture’s Global Existence*, The World Relief Network, 2009.
- [12.12] D. Home and A. Whitaker, *Einstein’s Struggle with Quantum Theory*, Springer, 2007.
- [12.13] N. C. Panda, *Maya in Physics*, Motilal Banarasidass Publishers (Reprint 1999).
- [12.14] D. Chopra, R. Penrose, H. Kragh, and M. Kafatos, *Cosmology of Consciousness: Quantum Physics and Neuroscience of Mind*, 2011.
- [12.15] E. H. Walker, *The Physics of Consciousness: The Quantum Mind and the Meaning Of Life*, Perseus Book Group, 2000.
- [12.16] P. L. Nunez, *Brain, Mind, and the Structure of Reality*, Oxford University Press, 2010.
- [12.17] S. Pinker, *How the Mind Works*, W. W. Norton & Co., 2009.
- [12.18] D. Bor, *The Ravenous Brain: How the New Science of Consciousness Explains Our Insatiable Search for Meaning*, Basic Books, 2012.
- [12.19] G. Greenstein and A. G. Zajonc, *The Quantum Challenge—Modern Research on the Foundations of Quantum Mechanics*, 2nd ed., Jones and Bartlett, 2006.
- [12.20] N. S. Hetherington, *Planetary Motions: A Historical Perspective*, Greenwood Publisher, 2006.
- [12.21] M. J. Crowe, *Theories of the World from Antiquity to the Copernican Revolution*, Dover Publications, 1990.
- [12.22] M. Jammer, *The Philosophy of Quantum Mechanics*, John Wiley & Sons, 1974.
- [12.23] American Institute of Physics web, “The Triumph of the Copenhagen Interpretation,” <http://www.aip.org/history/heisenberg/p09.htm>.
- [12.24] R. I. G. Hughes, *The Structure and Interpretation of Quantum Mechanics*, Harvard University Press, 1992.
- [12.25] H. P. Stapp, “Quantum theory and the role of mind in nature,” *Found. Phys.*, Vol. 31, No. 10, pp. 1465–1499, 2001.
- [12.26] M. Kumar, *Quantum: Einstein, Bohr, and the Great Debate about the Nature of Reality*, Norton Paperbacks, 2011.
- [12.27] C. Rangacharyulu, “Higgs boson: God particle or divine comedy?” *SPIE Proc.*, Vol. 8832–47, 2013.
- [12.28] T. Kuhn and I. Hacking, *The Structure of Scientific Revolutions*, 50th Anniversary Ed., University of Chicago Press, 2012.
- [12.29] V. Rubin, N. Thonnard, and W. K. Ford, Jr., (1980). “Rotational properties of 21 Sc galaxies with a large range of luminosities and radii from NGC 4605 (R = 4kpc) to UGC 2885 (R = 122kpc),” *Astrophys. J.*, Vol. 238, p. 471, 1980. doi:10.1086/158003.
- [12.30] P. D Mannheim and J. G. O’Brien, “Galactic rotation curves in conformal gravity,” <http://arxiv.org/abs/1211.0188v1>, 2012.
- [12.31] S. A. Dallal and W. J. Azzam, “On supersymmetry and the origin of dark matter,” *J. Mod. Phys.*, Vol. 3, No. 9A, pp. 1131–1141, 2012. doi:10.4236/jmp.2012.329148.
- [12.32] F. M. Lev, “Do we need dark energy to explain the cosmological acceleration?,” *J. Mod. Phys.*, Vol. 3, No. 9A, pp. 1185–1189, 2012.
- [12.33] M. Mitchell, *Complexity: A Guided Tour*, Oxford University Press, 2011.
- [12.34] E. J. Chaisson, *Cosmic Evolution: The Rise of Complexity in Nature*, Harvard University Press, 2001.
- [12.35a] H. Herrmann, *From Biology to Sociopolitics: Conceptual Continuity in Complex Systems Book—Conceptual Continuity*, Yale University Press, 1998.
- [12.35b] P. W. Anderson, “Physics: The opening to complexity,” *Proc. Natl. Acad. Sci. USA*, Vol. 92, No. 15, pp. 6653–6654, 1995:
- [12.35c] S. Vitali, J. B. Glattfelder, and S. Battiston, “The Network of Global Corporate Control,” *PLoS ONE* | October 1, 2011 | Volume 6 | Issue 10 | Open access from: www.plosone.org; See also the “TED-Talk” at: http://www.ted.com/playlists/126/the_big_picture.html
- [12.35d] K. Christensen and N. R. Moloney, *Complexity and Criticality*, Imperial College Press, 2005.
- [12.35e] H. J. Jensen, *Self-Organized Criticality: Emergent Complex Behavior in Physical and Biological Systems*, Cambridge University Press, 1998.
- [12.35f] J. Gribbin, *Deep Simplicity: Bringing Order to Chaos and Complexity*, Random House, 2005.

- [12.36] J. Henrich, S. J. Heine, and A. Norenzayan, “The weirdest people in the world?,” *Behav. Brain Sci.*, Vol. 33, No. 61, pp. 1–75, 2010. doi:10.1017/S0140525X0999152X.
- [12.37] P. Mavrodiev, C. J. Tessone, and F. Schweitzer, “Quantifying the effects of social influence,” arXiv:1302.2472v1 [physics.soc-ph], February 11, 2013.
- [12.38a] E. O. Wilson, *Consilience: The Unity of Knowledge*, Alfred A. Knopf, 1998. See also: “The Riddle of the Human Species,” *New York Times*, February 24, 2013; http://opinionator.blogs.nytimes.com/2013/02/24/the-riddle-of-the-humanspecies/?nl=opinion&emc=edit_ty_20130225.
- [12.38b] E. O. Wilson, *The Social Conquest of Earth*; W. W. Norton & Company Ltd. (2012).
- [12.39] J. Brockman, Editor, *This Will Make You Smarter: 150 New Scientific Concepts to Improve Your Thinking*, Harper Perennial, 2012.
- [12.40a] A. Einstein, B. Podolsky, and N. Rosen, “Can quantum mechanical description of physical reality be considered complete?,” *Phys. Rev.*, Vol. 47, pp. 777–780, 1935.
- [12.40b] D. Bohm, *Wholeness and the Implicate Order*, Rutledge Classics, 2002.
- [12.41] J. A. Wheeler and W. H. Zurek, *Quantum Theory and Measurement*, Princeton Series in Physics, 1983.
- [12.42a] C. Roychoudhuri, Measurement epistemology and time-frequency conjugate spaces, doi:<http://dx.doi.org/10.1063/1.3431483>; *AIP Conf. Proc.* 1232, pp. 143–152, 2010.
- [12.42b] A. Hodges, “Novel math to model ‘reality,’” *Nat. Phys.*, Vol. 9, pp. 205–206, April 2, 2013.
- [12.43] S. S. Rothman, *Lessons from the Living Cell: The Limits of Reductionism*, McGraw-Hill, 2002.
- [12.44] See the articles in the special issue: E. Pastrana, Editorial, “Focus on mapping the brain,” *Nat. Methods*, Vol. 10, No. 6, 2013.
- [12.45] G. Zukav, *Dancing Wu Li Masters*, HarperCollins, 2009.
- [12.46] N. C. Panda, *Maya in Physics*, Motilal Banarasiidass Publishers (Reprint 1999).
- [12.47] D. N. Fredricks, *The Human Microbiota: How Microbial Communities Affect Health and Disease*, Wiley Blackwell, 2013.
- [12.48] M. Talbot, *The Holographic Universe: The Revolutionary Theory of Reality*, Harper Collins Publishers, 2011.
- [12.49] G. D. Robinson, *Global Warming: Alarmists, Skeptics and Deniers; A Geoscientist looks at the Science of Climate Change*, Moonshine Cove Publishing, 2013.
- [12.50] K.-P. Schröder and R. C. Smith, “Distant future of the Sun and Earth revisited,” *Monthly Notices of the Royal Astronomical Society*, Vol. 386, Issue 1, pp.155–163, 2008.
- [12.51] M. A. Brown and B. K. Sovacool, *Climate Change and Global Energy Security: Technology and Policy Options*, MIT, 2011.
- [12.52a] P. Kirsch, *This Way to the Stars: How Quantum Physics Changes Current Space Propulsion Paradigms, Making Inter-galactic Travel A Possibility*, Timeless Voyager Press, 2008.
- [12.52b] C. Kitchin, *Exoplanets: Finding, Exploring, and Understanding Alien Worlds*, Springer, 2011.
- [12.53] M. Jammer, “Concepts of space,” *The History of Theories of Space in Physics*, 3rd ed., Dover Science, 1993.
- [12.54] V. Konushko, “Stability of atoms, causality in elementary processes and the mystery of interference and hydroscope,” *J. Mod. Phys.*, Vol. 3, pp. 224–232, 2012.
- [12.55] W. T. Anderson, *The Next Enlightenment: Integrating East and West in a New Vision of Human Evolution*, St. Martin’s Press, 2003.
- [12.56] M. Pagel, *Wired for Culture: Origins of the Human Social Mind*, W. W. Norton & Co., 2012. See also: http://www.ted.com/talks/mark_pagel_how_language_transformed_humanity.html.