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Sustainable Resource Development

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Preface

This volume is organized into a chapter-length introduction, six chapters of detailed content, some concluding remarks and an Appendix. The central issues of sustainability are rendered from an engineering point of view. They are fleshed out with rich and detailed examples of technologies that both fulfill the requirements of true sustainability and are infinitely extensible. The Appendix discusses a very different approach to sustainability, exemplified by the 2001 Nobel Economics Prize lecture in which Professor Joseph P Stiglitz elaborates the significance of the economics of information for stabilizing market structures. The aim of including it in this book is to show how a number of key premises from Prof. Stiglitz' award-winning work would in fact render sustainable engineering solutions impossible.

An introductory chapter discusses the central preoccupation of this book, viz., the renovation of engineering practice towards true sustainability across the board. Material is grouped under under two broad rubrics: a) how engineering practices themselves are transformed in the field of resource development; and b) the relationship of such renovation of practice to the renovation of economic theory so as to favor truly sustainable solutions.1

1 All kinds of theories may come out of practice. As a "first approximation," it seems reasonable to expect — indeed: almost trivially obvious — that the theory (or theories) that come out of sustainable practices will be the soundest. However, this still leaves open a crucial question, viz., on what criteria should we rely to illuminate the true sustainability of any practice(s) in particular? The answer(s) to this particular question, on the other hand, turn out to be highly fraught. For most of the Industrial Revolution of the last 250-plus years, the key criterion for sustainable development of a given resource was assumed to the sheer quantity, scale or geographic extent of the resource. (It was further assumed within this that the raw material would be subjected mainly, or at most, to some kind of usually mechanical primary process — digging, extraction, etc.) When it comes to discussing the Canadian tar sands, for example, this remains the key notion associated with the tar sands' supposed
The concluding portion of the introductory chapter includes capsules that preview the main preoccupations and contents of the remaining chapters and appendix of the volume. Supplementary material is embodied in the footnotes of each of the chapters. These run in sequence, restarting from “1” at the beginning of each chapter. Some chapters are further supplemented with Documents — materials from government agencies, the court system, corporate reports and scholarly literature that further illuminate various issues raised in the chapter and the responses of various social elements to those issues.

Sustainability. Over the last decade, the tar sands have been predicted theoretically to last anywhere between another six decades to another two centuries — always at “present” rates of exploitation. However, matters have changed dramatically since 2010 — as public criticism and demonstrations mounted in Canada and the United States. These protests have carved out stances of opposition in at least three directions: a) opposition to further development of the tar sands in the present mode of technologies being applied; b) opposition to government regulatory authority being bent or neglected; and c) opposition to the capture of value being limited almost entirely to export of the raw material. This last indignity is being inflicted by means of entities not owned or regulated in Canada, the host country. That is something that ensures further value-adding activities will not take place in Canada. Similarly, although no one in the last couple of years (when the dominance of the Potash Corporation of Saskatchewan appeared headed for takeover by BHP Billiton) has ventured such predictions, the useful lifetime of the potash deposits in the southern one-third of the territory of that Canadian province were similarly being reckoned back in the 1980s to last another three centuries. The pattern seems to be as follows: first declare the arrival of El Dorado; then, the moment some of the less pleasant facts surface — such as the potential scale of the waste that would be created by applying current technologies to the extraction of these materials in their raw state — any further talk of the seemingly infinite character of the bounty (at least compared to anyone’s lifetime) suddenly and inexplicably ceases... This pattern suggests that the hosannas originally sung to the sheer scale of the raw material, although heralded as assurances of the sustainability of the particular resource to be developed, signal exactly the opposite. The volume of these hosannas is intended precisely to drown out, or intimidate into silence, any Cassandras pointing out the unsustainability of such development, or talking about how existing technologies might need re-examination and re-design first. It may be concluded from the above, then, that the sheer quantity of a raw resource and its scale ensure availability and some indication of the range of further possibilities of that quantity. However, quantity and its availability as things-in-themselves ensures nothing about sustainability. True sustainability is first and foremost a function of whether the process or technological means applied to the raw material violates the surrounding environmental norms attending the presence of that raw material within the natural order, or harmonizes these norms.
Introduction

1 Initial Remarks

Within the real-life subject-matter of this book and its companion volume, *Sustainable Energy Pricing*, a serious if largely silent struggle carries on beneath the surface of the exploration and production, in their original state, of both fossil fuels and "alternative" energy sources. As was pointed out in the introduction to that volume, it is a war that is under way on the one hand between the real value of these energy sources as "gifts of nature", and the nominal value they acquire in the form of a market price on the other. What was not mentioned there but which must be mentioned here — although it would seem to go without saying — is that sustainable development of natural resources in general is actually premised on the sustainable engineering of energy resource development in particular.

Many features of this struggle lie as hidden from view (or otherwise just beyond our full understanding) as the earth's reservoirs of oil and gas themselves, as the atmospherics driving the world's wind farms, or as the solar fluxes reaching our planet. The veil concealing some of the relevant processes of research and engineering applications is being gradually lifted. That is the mission, for example, of the work to simulate exploration and production prospects as a "virtual reservoir" (Islam *et al.*, 2006). This line of investigation has also provided a starting-point from which to re-examine many aspects of energy pricing that have long been taken for granted.

As also discussed and illuminated in *Sustainable Energy Pricing*, an entire "futuristic" energy-pricing model is implicit in the "virtual reservoir" concept. Equally implicit are technologies incorporating a high sustainability quotient. Some of these technologies, and the
unifying principle of true sustainability underpinning them, form this book's central preoccupations.

True sustainability entails that development of energy resources of all kinds, beyond fossil fuels or the conversion of thermal energy into electricity in various forms, be sustainable. As argued consistently throughout the previous volume, if the technology does not make use of what is available in the natural environment first and foremost, it will be anti-nature and inevitably unsustainable. When it comes to energy, however, probably the single greatest challenge arises from the general tendency to invest in those technologies whose source or output is electric power, delivered over "The Grid," i.e., the existing system of electrical services. Although matter in all its forms possesses its electrical character, the technologies talked about here make little or no use of this naturally-based electrical potential. In general, it must be admitted that at present, of all the known energy-delivering technologies, "The Grid" represents probably the single greatest anti-Nature challenge.¹

There is no immediate solution at hand or even visible on the horizon regarding this anti-Nature aspect of The Grid. What was pointed out in the Introduction to the previous volume on Sustainable Energy Pricing regarding problems with energy sufficiency, however, once again applies. There is a class of solutions that depends in the first place on a deliberate decision to render, as consciously as possible, all the knowledge gathered about available energy resources. This human factor, or what might be better described as "understanding based on acts of finding out," is decisive.² Repeatedly, society emerges from a stage of seeming beset by various problems to a stage of accomplishing solutions. Subsequent developments disclose how partial and incomplete previous solutions were. This movement itself becomes fundamental to how human beings socialize their relations in the realm of material production. One can imagine what life was like before The Grid about as clearly as one might imagine their life was like before they could read. At the level of theory and its cognition, this fundamental movement expresses itself as a

¹The sustainable technologies examined in this book skirt this problem in various ways; they do not, however, tackle it directly. Perhaps another generation will take up how ultimately to convert all surplus electrical output into combinations of hydrogen and oxygen, i.e., water, that can be returned to the natural environment without harmful impacts.

²This living involvement of the investigator is what invests knowledge and its gathering with actual purpose, with a direction or "intention" in the sense of the Arabic word "niyah" (نتيجة).
process, or processes, of becoming conscious. Although the dawn of awareness is conventionally represented as a light bulb going on above the head, the movement being spoken of here expresses itself as a struggle waged to establish actual knowledge of a way forward to solutions. This process emerges as a two-phase movement. It has its “theory” phase and its “practice” phase. The work of Theory elaborates the essential principles of a solution. At the same time, Practice develops as the realm in which humans individually and in society sort out precisely how principles elaborated at the level of theory are to be applied in particular cases.

For engineers, theory comes out of practice and, in turn, serves practice. What is often overlooked, however, is that practice gropes in the dark without theory. There are theoretical assumptions embedded even in the questions formulated as a sequence for any step-by-step procedure. All that can be said for absolute certain, at the outset of any problem-solving process, is that

a. component theory-practice phase-pairs of the process are not necessarily comprised of equal amounts of theory and practice; and
b. the length of time each phase consumes is not predictable in advance.

One specific class of solutions that envisions harmonizing human social demands on the energy front with what nature can usefully provide if a consciously worked-out program is followed are those that produce “zero net waste.”

As pointed out in Sustainable Energy Pricing, one of the most demonized modes of energy production in the world today is the extraction of crude oil from underground and-or undersea reservoirs. Ironically, however, the potential developed in that field to shift from demand-based to supply-based modeling is bound to increase the potential in the hands of those forces involved most directly in primary energy production.

2 Sustainability Criteria and Economic Theory

Is sustainability possible without inducing scarcity, deliberately or otherwise, somewhere within an economic process?

This question is crucial. Economics as a science is broadly associated with notions of producing, distributing or managing finite
INTRODUCTION

quantities of inputs and outputs, and often this finitude is interpreted as a relative scarcity. That can be misleading, however, and even highly so. What really counts is whether a process is sustainable. Sustainability is to be measured by more than mere availability or unavailability of some supply of raw material.

The primary criterion of sustainability is whether a given process, and all the other processes to which it connects, are “natural” – in the sense of characteristic – within whatever context the process normally unfolds. A secondary, derivative criterion is whether a process is truly “time-tested”, i.e., capable of persisting indefinitely (assuming no other elements on which it depends are removed from the environment). The extent to which the second criterion is fulfilled defines relative sustainability. The first criterion, which constitutes a definition of inherent sustainability, defines sustainable in an absolute sense. If the primary criterion is not met, no other criteria matter.

The question of sustainability addresses the matter of the pathway of a process. In our own day, this has emerged as the arena in which the supply-demand models of conventional economics fail most spectacularly. Under modern conditions, there are countless pathways by which potentially to finance, staff and operate the production of almost any given commodity for any market. It is even entirely possible that all of them are unsustainable. Nuclear energy production, for example, currently falls in that category and it appears — from the evidence discussed in Chapter 2 infra — almost certain to remain in that category for some time to come. Back in the 18th and 19th centuries, when the foundations of scarcity-based economics were laid, economic space was far more open. Markets, far from being saturated, were frequently and chronically undersupplied at various times of the year. Competition, while fierce in markets between purveyors of the same goods or services, was almost non-existent between technologies, i.e., between pathways.

This matter of pathway is an especially rich vein. In practical terms, as discussed in depth at Chapter 4 infra, it can provide the entry-point for introducing innovations in managerial and other practices as well as policies that impinge on sustainability, including many under-appreciated arrangements, such as green supply chains.3

3 Advanced work around all these aspects of sustainability can be found in (Khan, 2006), (Khan & Islam, 2004), (Khan & Islam, 2005a), (Khan & Islam, 2005b), (Khan & Islam, 2005c), (Khan & Islam, 2006), (Khan & Islam, 2007a), (Khan & Islam, 2007b), (Khan et al., 2005d), (Khan et al., 2006) and (Khan et al., 2008).
The first level of observation & reflection employed by practitioners of what we have been calling the “nature-science” approach is something else that we call “root-pathway analysis.”

Root-pathway analysis falls within a class of what may be deemed “organic” — as opposed to, or distinguishable from, “mechanical” — analytical methods. Its greatest “weakness” would appear to be the lack of any elaboration of any pre-existing scientific laws or principles to account for phenomena observed in any portion of the time continuum proceeding from the root down to the present day. In fact, however, this is its greatest strength. Thus, phenomenon B may be observed following phenomenon A without assuming any inherent connection — be it a priori assumptions about the existence of either phenomenon, or assumptions about causation or even correlation between the phenomena.

Could awareness of the principles of sustainable engineering be far older than generally assumed? The author decided to test this idea by applying root-pathway analysis to an utterly familiar and almost three-millennia-old myth surrounding the “labors of Hercules” — the so-called Fifth Labor (to clean the Augean stables).

First, however, why bother?

Objectively considered, much of what is known within Anglo-American scholarship (and more generally throughout Eurocentric scholarship) as ‘myth’ actually comprises the recording and transmission for the present and future generations of important social or societal knowledge under conditions of general illiteracy and non-publication of research findings. This reality has become obscured by a focus on particular elements from the narrative of the myths themselves that seem physically impossible, standing in absolute contradiction to everything known or predicted by modern science. There is undeniably a widespread ready acceptance of such a dismissive characterization of the content of the ancient Greek myths today. Among most practicing scientists and engineers and other educated people, few see anything in these myths but charming fairy tales suitable for children. The author has noticed how such a dismissal fits into a larger overpowering sense of Anglo-American and Eurocentric cultural hubris — the same hubris identified in the Greek myths themselves as the most fatal of sins among their gods. 4

4 Colleagues have asked if this is not qualitatively the same hubris on display in all its ugliness following the destruction of the Twin Towers in New York City on 11 September 2001. Blaming this destruction of a 31-year old pair of skyscrapers on an allegedly Islamic
Deconstruction of the historical circumstances of British academia between the 1860s and the First World War provides much to corroborate this hypothesis.

Charles Darwin provided and published extremely disturbing proofs that the norm throughout nature was neither stasis nor gradual evolution, but transformative change by leaps. During the last third of the 19th century, the impacts of this insight began to roil all areas of scholarly investigation, in the social and natural sciences.

This was especially the case in Great Britain, the global imperial superpower of its day. In a conscious effort at least to blunt if not entirely extinguish these impacts, British imperial scholarship invented the entirely new field of anthropology, including social anthropology.

The study of ancient mythology was promptly transformed into a branch of the new "science." In the works of Edward Burnett Tylor at Oxford and more popular accounts such as James Frazier's *Golden Bough*, far from being recognized as resistance by the subject population in defence of their own thought-material, "differences" between the British rulers and their subjects were ascribed to differences on the evolutionary scale in the development of tribal societies towards a reconciliation with or acceptance of modernity.

This notion of peaceful evolution towards modernity for less-civilized peoples provided a cosmetic screen serving to conceal a reality far less benign. On the North American continent in the 17th and 18th centuries, throughout the Asian subcontinent from the 17th to the 20th century and on the African continent since the 19th century, the reality of British policy was always and everywhere the genocidal extermination of indigenous peoples and tribes as first principle. This was also the case even when or where the British were compelled by circumstances to rule, as in India, through elite members from either these indigenous groups, or, as in Canada, from among the colonial settler population living otherwise more or less peacefully alongside local indigenous peoples.

The British ruling classes' acceptance of a pseudo-Darwinian model of "civilization" as yet another organic evolutionary process...
from lower to higher stages was grounded in a crucial unstated assumption, viz., that civilization originated with the Greeks, sometime in the second or first millennia BCE.

The two-fold truth, meanwhile, was that:

a. neither Greece nor any other European part of the Eurasian land mass could provide the starting-point or epicentre from which human social, economic and political organization within Europe, beyond that of the cave, tribe, village, river-shore or lakefront, developed; and

b. the “Greek” foundations of European civilization were infused from the outset, from at least the midpoint of the 2nd millennia BCE, with the accomplishments and even mythological structures and thought-material of much older social formations in the Fertile Crescent and the Indus Valley going back into the 3rd and 4th millennia BCE, as well as those of peoples along the southern littoral of the Mediterranean.

It was therefore no accident that the structures and narratives of the Greek myths shared so many points in common with the mythologies of these other social formations. Indeed, Greek myth could be seen to embody the unity of human thought material across regions of the Eurasian continent lying to the west of China, including — most critically for the British ruling classes in general and the Raj in particular — the thought material of many peoples from northern parts of the Indian subcontinent.

It was this very unity, however — something which would place their Indian subjects on an equal footing — that the British could never accept. As the imperial poet Rudyard Kipling would popularize: “East is East and West is West and never the ’twain shall meet.”

By the end of the 19th century, within British scholarly discourse, two crucial foundational principles of human civilization-in-general would emerge:

a. that smashing this Eurasian-wide link by repeatedly asserting its nonexistence became the watchword and focus of everything British scholarship had to say concerning the Greek paternity of European culture; and

b. that human knowledge itself, as an overwhelmingly European cultural achievement, possessed an inherently hierarchical structure, comprising modern science,
followed by revealed religion (headed by Christian religious forms), followed by mythic and-or literary traditions, followed by folklore, followed by animist belief.

According to the unstated principles of such a rigid hierarchy, the ancient Greek myths had a value already assigned by their place within this hierarchy. The important implication of such a position is that the Greek myths were trivial in themselves, and thus could never be usefully mined for insights into such recondite matters as the engineering practices of ancient Eastern civilizations.

Nevertheless, looking out upon the world beyond the Anglosphere without any Eurocentric blinders, and applying the key understanding of the role of myth — garnered from root-pathway analysis above as a record and transmittal of engineering ideas and thinking in the ancient world — a careful re-examination of the actual content of the story of Hercules' Fifth Labor turns out to be most illuminating and instructive on this very point, and especially its connection to notions of true sustainability:

For the fifth labor, Eurystheus ordered Hercules to clean up King Augeas' stables. Hercules knew this job would mean getting dirty and smelly, but sometimes even a hero has to do these things. Then Eurystheus made Hercules' task even harder: he had to clean up after the cattle of Augeas in a single day.

Now King Augeas owned more cattle than anyone in Greece. Some say that he was a son of one of the great gods, and others that he was a son of a mortal; whosever son he was, Augeas was very rich, and he had many herds of cows, bulls, goats, sheep and horses.

Every night the cowherds, goatherds and shepherds drove the thousands of animals to the stables.

Hercules went to King Augeas, and without telling anything about Eurystheus, said that he would clean out the stables in one day, if Augeas would give him a tenth of his fine cattle.

Augeas couldn't believe his ears, but promised. Hercules brought Augeas's son along to watch.

- First the hero tore a big opening in the wall of the cattle-yard where the stables were. Then he made another opening in the wall on the opposite side of the yard.
- Next, he dug wide trenches to two rivers which flowed nearby. He turned the course of the rivers into the yard. The rivers rushed through the stables, flushing them out, and all the mess flowed out the hole in the wall on other side of the yard.
When Augeas learned that Eurystheus was behind all this, he would not pay Hercules his reward. Not only that, he denied that he had even promised to pay a reward. Augeas said that if Hercules didn’t like it, he could take the matter to a judge to decide.

The judge took his seat. Hercules called the son of Augeas to testify. The boy swore that his father had agreed to give Hercules a reward. The judge ruled that Hercules would have to be paid. In a rage, Augeas ordered both his own son and Hercules to leave his kingdom at once. So the boy went to the north country to live with his aunts, and Hercules headed back to Mycenae. But Eurystheus said that this labour didn’t count, because Hercules was paid for having done the work.

The Greek myths have been deeply and extensively analyzed for centuries — almost invariably from the standpoint of mentioning or commenting on the moral lesson(s) which these stories have indeed been framed to extract and impress on the listener/reader. However, from a nature-science standpoint — meaning in this particular context, comprising both the overwhelming presence of living human labor power unassisted by the dead labor of machinery and the singular absence of “hi-tech” — the objective content of engineering interest here comes in the following five sentences:

“First the hero tore a big opening in the wall of the cattle-yard where the stables were. Then he made another opening in the wall on the opposite side of the yard. Next, he dug wide trenches to two rivers which flowed nearby. He turned the course of the rivers into the yard. The rivers rushed through the stables, flushing them out, and all the mess flowed out the hole in the wall on other side of the yard.”

The importance of this technical detail cannot be overstated: only as the byproduct of “something else” are the stables being cleaned, i.e., the obligatory task set by Eurystheus (in the name of the other gods) is accomplished. What Hercules’ labor has also accomplished, however, — indeed, it is actually the central accomplishment — has been to render Augeas’ entire livestock-raising operation truly sustainable for some lengthy period extending indefinitely into the future.
All versions of the story make it more than clear that King Augeas was dealing with Hercules in bad faith. The King assumed from the outset that the stable-cleaning task could not possibly be accomplished in the assigned time period of one day, and therefore he would never have to worry about rendering Hercules any payment whatsoever, much less a one-tenth ownership share of his herd. Then, after the task was accomplished, King Augeas acted like the thief who yells ‘Stop, thief!’ Claiming he had dealt with Hercules without knowing that Hercules was in fact under orders from Eurystheus, he sought to wriggle out of his obligation.

Eurystheus saddles Hercules with the final indignity of refusing to “count” the accomplishment as one of the twelve labors because an independent arbitration process by a judge has ordered King Augeus to pay Hercules. This order appears to settle a conflict of opposing human-social interests ... but only at the cost of transforming the character of this particular labor of Hercules from that of an obligation discharged at the behest of the gods into mere labor.

From the vantage point of our particular interest in this story, the inner meaning may be summarized thus: a major feat of sustainable engineering is reported faithfully and stands on its own merit. However, recognition of the significance of Hercules’ using the opportunity presented by the immediate demand for stable cleaning to solve the far more significant problem of sustainable livestock raising is hindered and obscured by the hopeless tangle of human-social relations attending the working-out of conflicting lines of self-interest.

Reconsidered thus, the issue of “scarcity” raised at the opening of this section is in fact irrelevant. From a nature-science standpoint, at the dawn of the 21st century (as compared to the time of Hercules and King Augeus several millennia ago), unless there is a broad social movement and-or intellectual consensus standing behind them and occupying the space for change opened up by such accomplishments, how differently should present-day authorities be expected to respond to successful sustainable engineering solutions that appear as “one-offs”?

2.1 Sustainability for Whom?

For a new economic model, and a new energy-pricing model and other models within its paradigm, the question of “sustainability for whom?” is posed and answered as follows: any development that
degrades or limits a society's ability to reduce, reuse and-or recycle waste or excess products cannot be considered truly sustainable. Here a serious gap emerges, however, between the notion of sustainability developed for the new theory on the one hand, and the conventional view of sustainability on the other. The conventional neo-Malthusian view long assumed that sustainability only arises as an issue in the first place either because resources are finite or because resources are maldistributed.\(^5\)

The general method of the conventional approach consists of absolutising a single factor, then extrapolating its downward spiral to negative infinity. For example, much of the discussion of "global warming", which entails an almost morbid preoccupation with carbon and CO\(_2\), assumes "climate is destiny" as it goes on to extrapolate Humanity's doom. All choices among alternative courses are thus always rendered as Hobson's Choices among equally unpalatable options. These analyses frequently come up badly short in the predictions department. However, they never fail to marginalise any role or relevance for human intentions and interventions. Sometimes it becomes necessary to stand up and call a spade a shovel: it is difficult if not impossible to see how any discussion of "sustainability" proceeding from premises of this kind can be helpful.\(^6\)

It does not take long to discover that, for all their gloom about Humanity's future prospects, proponents of this conventional view seem generally rather satisfied with the status quo. Although the ongoing need for science or research is not explicitly denied, the possibility of harmonising human strivings and Nature's possibilities is ignored and largely dismissed.

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\(^5\)This view is named for the English preacher Rev. Thomas Malthus. He argued in his *Essay on Population* (1798) that human population must always tend to grow in geometric progression so as to outstrip food supplies, which can only increase in arithmetic progression. The category of what are called neo-Malthusian arguments includes later writers who were compelled to acknowledge that Malthus was wrong, and incapable of taking into account already known facts that refuted his claim, not to mention extremely reactionary as well. Today's neo-Malthusians have gone on to factor in food shortages and other catastrophic events in order to argue that the imbalance is the general problem, be it the "gap between the North and the South" (WCED, 1987), or a "technology gap", or "global warming". Malthus himself has modern-day emulators in Dr Paul Ehrlich and his book *The Population Bomb* (1968), as well as the work of Garrett Hardin on "the tragedy of the commons" (Hardin, 1968).

\(^6\)The science of these scenarios — as distinct from their melodrama — remains ever thin on the ground. That has proven no impediment to their often being often put forward as the "left"-liberal version of, or response to, the Armageddon and "End of Days" scenarios popularised by various U.S. religious broadcasters (Website 3).
3 The Basis of Change and the Conditions of Change

The basis of all real change is internal, whereas the conditions of change are external: this distinction is particularly important when it comes to accounting for the co-presence of tangible alongside intangible elements in any phenomenon — including technologies that are promoted less for their immediate than for their longer-term benefits. Assigning a proper place to what has been elaborated elsewhere as "the tangible-intangible nexus"7 is a key task of the program proposed here for renewing approaches taken to the fostering of technological alternatives whose greatest value may not be particularly dramatic immediately or in the short term. Here it specifically has two immediate implications:

a. external conditions cannot provide the basis of change, hence, e.g., the underpinnings of Newton’s First Law and all theories of ‘Prime Mover’ go out the window; and

b. existence of an internal basis for change cannot in itself guarantee an unfolding or expression of change in the absence of suitable external conditions, hence, e.g., apparently spontaneous (and otherwise externally unprovoked) miscarriages or stillbirths

The implications of the first point are profound.

As an enterprise entailing apprehension and comprehension of the material world existing external to consciousness, “science” — meaning: the scientific approach to investigating phenomena — requires examining both things-in-themselves and things in their relations to other things.

One of the fundamental issues of this exercise involves mastering and understanding “laws of motion,” so to speak, as they apply to the matter under investigation. The importance is simply that motion is the mode of existence of all matter. Whether it is energy, or matter that has become transformed into energy, or energy that became transformed into matter, there is no form of material existence that is not in motion.