

Science for Sustainable Societies

Rajendra K. Bera

# The Evolution of Knowledge

Scientific Theories for a Sustainable  
Society

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*Integrated Research System for Sustainability Science*



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# Science for Sustainable Societies

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*“To Mansi Balsari, a brave teenager facing a  
brave new world with dignity and poise.”*

# Preface

What is it about their research that people like Galileo Galilei, Isaac Newton, Albert Einstein, James Maxwell, Max Planck, and hundreds of others seek, not wealth but fame, by discovering some nugget of fundamental knowledge about the Mother Nature? I believe it is sheer curiosity. Their discoveries have changed the face of human civilization through development of new technologies. But there was a time not so long ago when even scientists thought their quest for scientific knowledge was about to end, and scientists would have to move on to other things in life.

In 1894, the American physicist Albert Michelson said, “The more important fundamental laws and facts of physical science have all been discovered, and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote... Our future discoveries must be looked for in the sixth place of decimals.”

In 1895, Lord Kelvin (William Thomson, 1824–1907) had confidently said, “Heavier-than-air flying machines are impossible” (He had perhaps never seen a flying bird or a bat!). I was studying to be an aeronautical engineer and was obviously appalled when I first heard of it as a student and was trying to understand Kelvin’s theorems in fluid dynamics. Such is life! Fortunately for me, in 1903, the Wright brothers (mere bicycle mechanics, but highly gifted with imagination) flew a heavier-than-air powered aircraft they had designed and built. They aptly called it the “flyer”. The rest, as they say, is history, and I fulfilled my dream of becoming an aeronautical engineer and a pilot.

In 1905, Albert Einstein showed that space and time are interlinked, and the theory of relativity was born, and an equivalence between mass and energy was shown. The detonation of the first atom bomb (16 July 1945) amply verified that. In 1916, he showed that the presence of matter warps space and time. Physicist John Wheeler pithily remarked, “Matter tells space how to curve, and space tells matter how to move.” Our notions of space-time till then were shattered.

The world’s first, general-purpose digital computer called Electronic Numerical Integrator and Computer (ENIAC) was introduced on 15 February 1946, under a contract for the U.S. Army and built by John Mauchly and J. Presper Eckert. It occupied about 1800 square feet, used about 18,000 vacuum tubes, and weighed almost

50 tons. It calculated about a thousand times faster than a human. In comparison, seven decades later, the smartphone that sits in our pocket is a piece of science fiction come true.

In 1956, John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon proposed the Dartmouth Summer Research Project on Artificial Intelligence and thus was born artificial intelligence (AI). Through several ups and downs and sarcastic barbs since, AI now holds centerstage. The future of human civilization now depends on it, and so does the livelihood of the undereducated. Makes you wonder, what is your worth in the job market if your competitor turns out to be an AI-embedded cognitive robot.

From hunter gatherer to farmer to scientific researcher, to modern-day inventor, humans have bounded from one breathtaking milestone to another. Its success and extent are such that we began using natural resources faster than nature could recycle and replenish. We also started educating people on an increasingly larger scale in science, technology, engineering, and mathematics (STEM) to keep pace with the expanding potential of industrialization, first locally then globally.

Industrialization created so much wealth that the world was suddenly urbanizing at an unimagined scale. Towns and cities were being populated by enthusiastic, rote educated young people who began to form a rapidly expanding middle class. Even more interestingly, the hitherto inherited rich were being brusquely pushed aside by the nouveau riche whose wealth was sourced on their education and their productive efforts in wealth creation. The brainiest among them eventually began to dream of AI. Their creations first excelled in arithmetic and now they endeavor to compete against university educated scientists, engineers, doctors, lawyers, etc. This is turning out to be a grand example of a self-referential system where humans by using their natural intelligence create machines with superhuman intelligence and the intelligent machines through a feedback loop enhance the natural intelligence of humans and so on. Eventually a stage may come, where we preempt natural evolution and self-evolve ourselves into a super species. The present human mind boggles.

Inter alia, the average *Homo sapiens* of today is gripped with fear of its inability to compete against AI machines which can handily uproot them from their present livelihood and make them destitute. Additionally, gifted inventors too can be turned useless once AI machines begin to prolifically invent and discover patentable artifacts and thereby demolish the present patent system. This book ponders over such issues to understand the scale of the problem the *Homo sapiens* face and what they may do to survive. Briefly, the book covers the following topics:

- (1) It discusses the uncanny similarity between evolutionary biology and evolutionary knowledge. Darwin's theory of evolution teaches us about adaptation for survival (goal-directed) and about establishing a relationship relative to some feature of environmental order (relational quality). The evolutionary aspect of knowledge is about learning to survive with a better understanding of nature by using intelligence and rational arguments to enable us to anticipate the future and adapt accordingly. In this regard, we depend on a tenuous link between instinct and intelligence. Instinct appears to serve as an invisible hand of nature that



nudges us toward what we must know but what we know is what nature permits. When we observe the world inquisitively, instinct provides subtle cues for further exploration. Intelligence embellishes those cues with one or more plausible conjectures and sifts them through a rigorous fitness trial on available observations by making strenuous refutations to find flaws in every selected conjecture. Surviving conjectures are then used to make predictions of unseen but in principle experimentally observable phenomena that may exist. Conjectures that excel in predictions gain currency and are lauded.

- (2) Scientific theories are essentially intellectual constructs. They have advanced at an exponential rate since the industrial revolution (1760–1840). *Homo sapiens* are now experiencing the birth pangs of a new era that encompasses AI, robotics, and automation. They are changing industry dynamics, socio-economic fundamentals, and what it means to compete. The central lesson we learn is that a rapid rate of progress or too much connectivity comes at a price one may not always want to pay or even know how to manage.
- (3) Our future employability and survivability will depend on our ability to competitively coexist with AI-embedded machines in the job market. We have to be smarter than AI machines. The alternative is working in the gig economy or finding a rare benevolent benefactor. Darwin's theory of evolution says that our existence depends on how nature selectively weeds out the unfit in a given environment. Progressively, we have thus arrived at a stage where survival dominantly favors those with superior intelligence and the ability to create new knowledge. At every stage of human evolution—hunter-gatherer, agriculturist, industrialist—survival demands progressively greater intellectual contributions and competitively productive skills from individuals for success and a dignified place in society. The time has now come when survival will demand even greater intellectual contributions from individuals which rote education cannot provide, because it is mechanizable in terms of AI. Our future adversaries in the job market will be intelligent machines, other egotistical intelligent *Homo sapiens*, and combinations of them. The heart of AI is algorithmic computation. Computation is all about addition, subtraction, multiplication, division, and comparison of numbers, and problem-solving is all about attaching meaning to numbers. When it comes to knowledge and employability, rote education is now irrelevant.
- (4) The exponential rise of science, technology, engineering, and mathematics (STEM), since the 1900s, has completely changed the socio-economic context in which the Patent Act of 1790 and its successive amended versions were enacted. Since then, a person of ordinary skill in the arts (PHOSITA) and in relation to this hypothetical person, the meaning of utility, novelty, non-obviousness, of an invention requiring human ingenuity and the manner in which the invention is to be disclosed to the public in exchange for a limited period monopoly over the invention by the inventor has undergone a sea change. In the last few decades, the world has seen a dramatic change in socio-economic-political structures, remarkable advances in STEM, for example, in information and computing technologies, quantum computing, genetic engineering and synthetic biology,

AI, etc. These have had an enormous impact on the environment in which the *Homo sapiens* find themselves in. Such drastic changes are harbingers of natural speciation, an event that may not be too far off with unknown consequences. The species that succeed the *Homo sapiens* will likely be so far superior in intellect, intuition, and serendipity as to drive the *Homo sapiens* to extinction. This book assumes such an unfolding scenario and, therefore, suggests interim changes to the patent system so that the present debilitating stresses it faces, especially in the form of litigation, are substantially reduced. Our successor species will then perhaps remember us based not solely on our fossil record but also on our ability to anticipate the future and prepare for it intelligently.

- (5) This brings us to the vulnerabilities of the present patent systems around the world, in particular, inventions related to advances in quantum computing, synthetic biology, and AI. They have begun to raise serious concerns. Advances in AI are particularly problematic because their influence will be felt on all hitherto patent eligible inventions. Because AI machines have the potential to prolifically invent patentable technology, it will undoubtedly shake the very foundation on which the patent system rests. It will require us to redefine what we mean by novelty, non-obviousness, and written description of the invention (e.g., shouldn't a binary string suffice as written description because it is the lingua franca of computers).

This book in a way chronicles my journey in search of knowledge from a middle-class birth to the fringes of the rich class, initially propelled by rote education but eventually as a researcher and an inventor, and in a modest way as a contributor to AI. The impulse to write this book arose when COVID-19 suddenly burst on the scene and catalyzed an upheaval where rote education must increasingly surrender to AI and humans must reorganize their lives to survive in a world where vast numbers from the middle class must henceforth become gig workers and lose their secure livelihoods to intelligent machines even as they fight against COVID-19 for their lives and livelihoods. We live in dangerous times but also in extraordinary times of human intellectual achievements. I wonder if Charles Dickens would view our predicament as he did of the time, he described in his famous novel *A Tale of Two Cities*:

It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to the Heaven, we were all going direct the other way ...

Bengaluru, India

Rajendra K. Bera

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# A Note for the Readers

This book is the result of a study I have been pursuing since the past several years about intelligence and whether it can be mechanized. It has resulted in a series of documents. A selection from those were placed in the public domain and are listed below. The material included in this book is mostly derived from those documents.

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