Science and Technology

"From Making Artifacts, To Understanding What They Are, To Intelligent Design"

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We homo-sapiens began our journey on this planet rather recently, only some 150,000 years ago in Africa, evolving from our hominid ancestors, who as a result of an earlier climate change gradually had to descend from the trees and try to survive on the grasslands. There, apparently further tested through the crucible of the Toba catastrophe, a small band of our ancestors with larger brain, standing upright with hands equipped with thumbs opposing the fingers (needed for tree climbing) and with 3D vision, began making artifacts in form of crude tools, which not only helped them survive against great odds, but enabled them to multiply and flourish. This is where technology started.

Technology is best defined as "our accumulated knowledge to make all we know how to make". It is the "domain of man-made", claim Bugliarello and Doner, because "where there is man there is technology – and direct line links the first chip made in the first hand worked stone to the development and use of the computer chip" (1). Indeed, technology flows relentlessly from Stone Age hand tools to jet planes; from making fire to French cooking; from pyramids to nuclear bombs; from wooden wheels to plastic composites and artificial hearts; from domesticating animals and discovering agriculture in the Neolithic times, to unraveling the human genome and other specifies, enabling us to modify species and plants and developing personalized medicine; from fermenting beer to making modern drugs.

So technology is part and parcel of human beings since the beginning of time – our time. Thus, there is nothing more 'human' or characteristic to human beings than technology. It was technology that enabled us – human beings unlike any other species – to carve our own special evolutionary niche (and in the process, to also adapt to an increasingly technological environment); to produce abundance, to create art and music and great literally works, as well as tools of war and destruction and to bring us, these very days, to the verge of a global catastrophe, either by nuclear war or by man-made climate change.

Indeed, it was technology that enabled us to rule and inhabit this planet to the brim. If plague is defined as the uncontrolled growth of a species than on this planet certainly we are the plague. Just consider the growth of world population. There is a natural desire of any species

to reproduce, but what limits this desire is the supporting capability of the environment and the ability to take care of the offspring. However, technology, freed the human race, time and again, from these limitations. If the human population is plotted on a logarithmic scale for the past 50,000 years, we clearly see 3 major jumps in human population all due to technological breakthroughs: first as a result of tool making, second as a result of the agriculture, and the third as a result of industrialization. Thus the small human population say 50,000-75,000 years ago grew as a result of tool making, to an estimated 5M at the beginning of the Neolithic era 5,000 years ago; then there is a huge jump with the beginning of agriculture and the domestication of animals – thus, at year 1, the population is estimated to have grown to 250M and by the beginning of industrialization in 16^{th}-18^{th} centuries human population grew already to 600M, then as a result of modern industrialization it grew to 6.5B in 500 years and in 100 more years, by 2100, the estimate is 12B.

Surely, it is not technology that caused this explosive expansion, but technology is what enabled it. So above anything else technology is what defines the human condition. On the human population graph, famines plagues, and wars do not even show up as tiny blips.

Now from a philosophical point of view there were those who argued that technology is 'good' and there are others who argue that technology is 'bad', and yet others that it is 'neutral'. Among the former, as pointed out by Leo Marx (2), are the founding fathers of the United States: Thomas Jefferson, Robert Paine, Benjamin Franklin among others, who believed, as Marx pointed out, that technology "reflects the idea of modernity, founded by Francis Bacon and René Descartes and the18th century enlightenment, claiming that history is a records of humanity's growing knowledge and power. That the progress of humanity is driven by continuous, steady, cumulative, predestined or somehow inevitable expansion of knowledge and consequent power over nature". Thus, technology is a "liberating force and a central tool for a more just and less hierarchical society, at peace with itself and others, in which the people are governed by consent and not by coercion". So technology was also conceived as an important element in building a democracy. No wonder that the US with such philosophy and enormous wealth and a free economy became the most powerful nation on earth.

However, it was Melvyn Kranzberg (3), who said that technology is not good, neither it is bad, but nor is it neutral, because it interacts with society in unexpected non-linear way, not necessarily inherent in the technology.

Indeed, David Landes (4) in his book "The Wealth and Poverty of Nations" outlines the dominant role of technology in shaping our world. He takes up and answers such key questions as: How did rich countries get rich? Why are poor countries so poor? Why did Europe ("the West") take the lead in the changing world ?". The answer is complex, but it can be summarized in a nutshell by stating that all these are determined by the way that technology interacts with society, or in other words the ability of a particular society – dependent on the nature of its culture – to use technology for economic and social progress.

Thus it was Europe, where a hectic technological progress began back in the middle ages, which then led to the modern technological industrial revolution, which is characterized by (4):

- First the substitution of inanimate for animate source of power: primarily the Steam Engine;
- Second the substitution of machines for human skills: in other words the invention of the factory, and
- Third the substitution of abundant minerals and artificial materials for vegetable and animal substances

The consequences of this revolution were vast says Landes. It brought about a rapid self-sustaining rise in productivity; an economy which grew faster than population; and not less importantly the transformation of the balance of political power within nations, between nations and between civilizations.

So the industrial revolution also revolutionized the social order and changed the way of thinking and doing.

The industrial-technological revolution and the invention of the steam engine by James Watt (or really James Watt radical improvement of the Newcomen steam engine) , was followed by a long list of the great inventors from Watts himself to Eli Whitney; Samuel Morse; Alexander Graham Bell; William Henry Perkins; Thomas Hancock; Guglielmo Marchese Marconi; Thomas Alva Edison; George Eastman; Leo Bakeland; Charles Goodyear; John Wesley Hyatt; the Wright brothers; Nicola Tesla and many others.

What is interesting is that none of them were scientists! They were entrepreneurs who wanted to get rich – much like the high-tech entrepreneurs of today – yet they also felt that they are

doing important work by ushering in a new era, even a new social order – again much like the current high-tech entrepreneurs.

But, the fact that they weren't scientists and the fact that science had little if anything to do with their invention has a more profound significance: namely, that technology, from the very beginning of time, could be practiced by trail-and-error without the need to understand its very nature. The ancient pyramids and in the middle ages the magnificent churches and mosques were built without computerized stress analysis, the Damascus sword was developed without any understand what iron or steel are, and Watt invented the steam engine without any theoretical knowledge on phase transition of water, a subject matter that, by the way, happened to be investigated at the very university – The University of Glasgow – where he was instrument technician, by no other than his friend Professor Black. But, theory and practice were completely disconnected.

Though the scientific revolution – that complex set of changes that the Western world began to undergo during 16th and 17th centuries preceded by some two centuries the industrial-technological revolution. The two revolutions moved on two separate tracks which, with some exceptions, didn't meet until the beginning of the 20th century.

In this context we must remember that *science* and *technology* were practiced by very different classes of people. Science says Jacob Bronowsky (5) in his famous MIT lectures "stems from philosophical theological and speculative contemplations and inquires about nature". The study of nature in the middle ages was regarded as adjunct to understanding God. Science was a branch of theology, which was the Queen of Sciences (recall that the early universities focused on teaching law, theology and medicine). Science was practiced by upper-class people and scientists were considered intellectually & morally superior.

Technology, on the other hand, was practice by ordinary lower-class people, artisans, adventurers, people of the professions, who practiced it in order to make a living and to strike riches. These two classes of people hardly met each other.

Yet the scientific revolution brought about a "phase" transition in human evolution. By inventing science and the scientific method, mankind invented a method of thinking that for the first time in history could give real answers to ancient questions about nature, life and man himself - as well as about the artifacts he makes. Answers were no more rooted in legends

and stories supplied by religions all over, formal and not, rooted in superstitions or dogmas, but rooted in facts and truth.

However, science is not only a means to explain nature, but" it is a world-view based on the notion that we can plan by understanding", says Bronowsky. Not by faith, dogma or by magic! There is only one truth in it. Independent as to who said it but dependant only on proof. [Just consider the wonderful example how the Linus Pauling, the world renowned, scientist's, DNA model was immediately rejected when Watson and Crick published the correct model and how Pauling himself.

In science, Bronowsky adds, there is no distinction between man & nature as in religious dogmas. That is why the synthesis of urea a 'natural material' by Wöhler, raised such havoc at the time, and that is why Darwin's evolution is still rejected by so many until this very day.

The US Academy of sciences, by-the-way in the wake of the very powerful Creationist movement or Intelligent design movement in the USA, released in 2007 a report entitled "Science, Evolution and Creationism" written by eminent scientists, who correctly explain what science is, why evolution is science and why creationism or intelligent design is not, and therefore it should be not taught in schools, as such. But then they add in a somewhat conciliatory way that "Science and Religion Offer Different Ways of Understanding the World". They say that many scientists have written eloquently about how their scientific studies of biological evolution have enhanced rather than lessened their religious faith. And that many religious people and denominations accept the scientific evidence for evolution.

This may, of course be true, but it seems that it only proves that people can compartmentalize their beliefs. As the famous essayist Ehad Haam (**Asher Zvi Hirsch Ginsberg** 1856 – 1927) – who was among the first to write and publish essays in the newly revived Hebrew language - so eloquently said in his essay "Two Authorities", which deal with science and religion. In this easy he takes about a rabbi who was also an astronomer, and when was asked how can he be the two at the same time, he answered : its is very simple, when I do astronomy I forget my rabbinical vocation and when I do rabbinical duties I forget my astronomy.

But something began to happen at the course of the 19th Century, slowly and gradually the science revolution and the technological revolution – which have been progressing in separate tracks – began to approach each other, and to feed upon each other. Sparks were flying from the one to the other, accelerating both. Historians of technology consider the first preconceived formal contact to start in 1900 at the General Electric research laboratory in

Schenectady USA, were scientists were brought in to study and promote technology, though the German chemical industry, employing chemical sciences, preceded this.

From this point on, throughout the 20th century science was systematically applied to technology to understand its nature, to understand <u>what exactly the artifacts that we create really are</u>. To understand what the Damascus sword is made off, the grain structure of the steel, and why the alternating soft and hard layers improve its performance. To make a stress analysis of the pyramids, churches, mosques bridges, and understand everything we make or practice.

Throughout the 20th century the professoriate of all engineering schools, which evolved from the first civil engineering school in France the École Nationale des Ponts et Chaussées in 1716, focused their research on analyzing the technologies with scientific tools and creating the 'engineering sciences, which are the core of all engineering programs to the present day.

Indeed, Karl Taylor Compton President of MIT, made this the theme of his inaugural address in 1930:

"I hope" he said *"that increasing attention in the Institute may be given to the fundamental sciences; that all courses of instruction may be examined carefully to see where training in details has been unduly emphasized at the expense of the more powerful training in all-embracing fundamental principles.* ", which of course are based in the sciences.

Interestingly I was surprised to find in the first Technion – Israel Institute of Technology, catalogue in 1925 the same notion of emphasizing science and the fundamentals, and in fact it is stated in the brochure that a good education in fundamentals is prerequisite for further education abroad.

However, the major strides for the fusion of science with technology occurred in the course of WWII, when science was systematically applied on a large scale to the war effort, and in fact secured the victory of the allied forces. Outstanding among the achievements were the development of artificial rubber – the styrene butadiene rubber (GRS), the development of the radar and development of the atomic bomb in record time within the framework of the largest scientific and technological effort of all times – the Manhattan project.

It was the enormous usefulness of science in the war effort that convinced the decision makers in the USA and elsewhere that science is power and that investment in science can be enormously useful. That is why Vannevar Bush's strategic plan entitled "Science the Endless Frontier" (6), was adopted by the US Government and led to the establishment of the NSF and to the massive investments into science bringing into being the *Golden Age of the American Research Universities* (7). Yet we must remember that the driving force for the huge investments in science world-wide was defense driven to assume military superiority. Only now, at the dawn of the 21st century, investments into science are driven by economical ambitions.

The consequences of the convergence of science and technology is that during the 2nd half of the 20th century they fused into an indistinguishable entity and **ignited a new revolution – bigger that the scientific revolution and the industrial revolution combined and this is the new scientific-technological revolution that we have just begun**. It is this scientific technological revolution that is the alma-mater of all the high-technology, be it electron or gene based, and which makes globalization possible and probably inevitable.

Indeed in many fields one cannot say anymore where science ends and where technology begins. In science we still ask the question "why" and in technology "how", but in the advanced research laboratories, we do the same thing. Characteristic to this new era, among many others, is that the research universities are becoming the fountainhead of economic progress; that the time from invention to application shrinks to sometimes nil; and that it brings entrepreneurship to the heart of the research university. But, above all the main characteristic of this new age is that sci-tech tools enable us to go down into the micro, nano and sub nano scale and rather that analyzing systems, material and living things, we can create now new materials atom-by-atom, systems and processes from the bottom up; And, as the late Professor Ephraim Katzir, professor of biophysics at the Weizmann Institute and former President of the State of Israel, in a lecture at the Technion years ago, succinctly defined our era: "we now entered the kitchen of the Almighty" because we can now modify living things to be passed on to the offsprings and maybe create new forms of life.

So gradually, in response to human needs driven by scientific curiosity, we are reaching the stage of intelligent design – the intelligent creation and design of materials, of processes, of drugs, of human artifacts, and of living things with inheritable characteristic.

This new sci-tech revolution holds enormous promise and immense dangers. Which one will prevail, depends on the manner in which this exploding knowledge interacts with society, cultures and civilizations. It is not all good neither all bad, but to reiterate Kranzberg, nor is it neutral.

So for 50,000 years and more, man through ingenuity and experience made artifacts , did technology, without understanding their exact nature; since the invention of science 400 years ago, it took only a single century of applying science to technology to elucidate the exact nature of artifacts and the processes. And, in the last quarter of century, since science and technology fused into a non-distinguishable entity, we entered into a new yet unexplored world of man-made intelligent design full of promise, hope and dangers.

Were I sagacious like Echad Haam was, I should perhaps conclude by saying that only God knows where all this will lead us…. and perhaps not even she…

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