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The Synergy in Science and Technology: An Investigation into the History of the Philosophy of Science

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ABSTRACT

What this paper sets out to investigate is the nature of the relationship between science and technology today. The relationship between science and technology is akin to the contentious relationship between knowledge and production, theory and praxis, or idea and progress. The history of the philosophy of science records two models of this relationship: the "liberal" and the "materialist" models. The liberal model holds that idea leads the way; that idea comes first and then it is put into practice. The materialist model, deriving from Marxism, holds that in their relationship, practice leads the way and idea follows (Gibbaons, 99). This paper considers these two models out-moded and proposes the synergistic model. The synergistic model, a *via media* between the liberal and the materialist models, holds that science and technology today are symbiotic and mutually re-enforcing. It holds that science and technology are interacting more closely, exchanging relevant information, insights, and theories. It holds that science and technology are mutually illuminating, stimulating and bolstering up each other.

INTRODUCTION

The objective of this paper is to advance and clarify a new insight into the relationship, the synergy (mutual re-enforcement and cross-fertilization) existing between science and technology today. In doing this, we hope to radically re-orient the attitude towards the relationship between science and technology. We also hope that when this new attitude is achieved, public policy on science and technology would, on balance, become more adequate.

Clarification of Key Concepts

Science: The various definitions of science so far given can be grouped into two: the extended and the strict. From the time he appeared on earth, man faced the threat posed by his environment and the challenge to survive. He had the curiosity and the need to account for his origin, his place in nature, and the purpose of life. Consequent upon these, he has always gathered reliable knowledge about nature. Knowledge geared towards understanding, explaining, predicting, and controlling nature. *Knowledge* in this extended sense is co-terminious with *science* from the Latin *scientia* meaning *knowledge.* In this vein, science is generally defined as "the systematic attempt to understand and interpret the world" (Encyclopedia Britannic 2005 Delux Edition). That is, science is the age old endeavour of man to make nature intelligible. In this extended sense, all academic disciplines, physics, chemistry, biology as well as theology, metaphysics, history and sociology, qualify as science. It is also worthy of note that science in this sense has ontological or a-historical origin. This means that science taken in this extended sense could not be said to have originated in a particular place and time. Its origin is co-existent with man.

The other sense of science is the strict sense. Following this sense, Nagel understands science as an "institutionalized" (VIII) meaning (scientifically methodic) system of inquiry into "the perceptible phenomena of the world" (Einstein, 28). It is defined as the discovery of explanations built into the logical structure of nature (Weinberg, 258); for instance, modern atomic theory, quantum theory, relativity theory, molecular biology (genetics), and the chemistry of hydrogen. In this sense, the empirical or experimental natural sciences, physics, chemistry, biology become the models of science (Fuller,8). Understood in this strict sense, science has temporal or historical origin. Its origin is the 17^{th} century scientific revolution and its *locus* is Europe. This is the sense of science associated with the scientific societies, academies and communities. It is the science associated with such notable scientists as Galilei Galileo, Isaac Newton, Robert Boyle, and Albert Einstein.

Science in this sense has the following features which differentiate it from other forms. It is experimental. Experiment is the designed or contrived interference in the course of nature to test a hypothesis. It is testing nature to see how it responds. Experiment is carried out to demonstrate a theory and repeated to confirm it or not. Experiment is key in defining science but it is not definitive of science. There are some sciences like pure mathematics, astronomy and evolution which are not experimental yet they are true sciences. Some sciences are more descriptive and theoretical (explanatory) than experimental (Herrick, 42f).

Another significant feature of this sense of science is that it takes place within a scientific community. This implicates scientific objectivity. Scientific objectivity, according to karl Popper, means that scientific knowledge should be able to be justified independent of scientists' caprice (44). There are two components of the scientific objectivity: inter-subjectivity and epistemic reliability. Inter-subjectivity means that scientists are capable of achieving consensus about scientific knowledge. Inter-subjectivity implies that scientific knowledge is "public knowledge", meaning that scientific knowledge "is a consensus of rational opinion over the widest possible field" (Ziman,11). Epistemic reliability means that scientific method gets it right about the world or observables.

Another feature of science is that its statements ought to be capable of being couched in mathematical language. This is a way of underscoring that scientific statements and explanations should be precise and exact. This implicates the kind of questions asked by science. To make its questions precise so as to elicit precise answers, science asks the "how" or proximate questions, not the "why" or ultimate questions. "Why" questions are susceptible to vague answers.

Corollary, science is also predictive. This means that theories of science should be able to predict those facts that it explains and possibly new facts. On the basis of the foregoing, we can in the strict sense define science as the exact, precise, objective and predictive knowledge of nature. In this strict sense, so many areas of study called science in the extended sense would not qualify to be called science.

Technology: The coinage *technology* first appeared in English literature in the 17th century in the context of the discourse on applied arts (Encyclopedia Britannica, 2005 Delux Edition). It however came into wide use in the 19th century as a designation for industrial and technical processes, tools and ideas in the production of material goods. Etymologically, the word technology is a combination of two Greek root words: *techne* and *logos. Techne* means *art, skill*, or *craft.* It shares the same stem with the Greek word that means *artificial* (Ekweke,256). *Art* is a transliteration of the Latin *arts* and it means *skill* or *way* or *method.* The English dictionary defines art variously as "the employment of means to accomplish some end: opposed to nature", or "a system of rules to facilitate the performance of certain actions," or "the skill in the application of a system of rules, as opposed to science". The other root of *technology* is *logos,* which means *word, study, knowledge,* or *science.* Etymologically, therefore, technology means the study , science or knowledge of art, skill or craft; the skill involved in the fabrication or making of a thing. Technology is also occasionally used synonymously with the French derivative *technique* (technics) to mean the science or study of arts especially as applied to industrial skills or the application of this science or arts. Based on its etymology, various definitions of technology have been given; some of these are presented directly.

- "The word technology refers to the tools, knowledge, and inventions that help people satisfy their needs and improve their way of life" (World Book Encyclopedia, CI-CZ Vol.4).
- "Technology is defined as the application of science and scientific methods to harness the forces and resources of nature in order to improve the quality of life of mankind" (Bassi, 65).
- Technology according to galbraith is "the systematic application of scientific or other organized knowledge to practical tasks" (97).

- Technology is "the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment" (Encyclopedia Britannica 2005 Delux Edition).
- "Technology is the systematic study of techniques for making and doing things" (Encyclopedia Britannica, 2005 Delux Edition).

There are some discernable orientations in the definitions, these needs to be explained in order to achieve comprehensive understanding of technology. Some definitions, the first for instance, designate technology as hardware; some designate technology as simply the application of scientific knowledge.

Technology is much more than hardware. There are two inclusive components of technology: the hardware and software. The hardware component comprises artifacts, tools, implements, gadgets, machines, and equipment. The software component comprises all those special kinds of precise knowledge, which spring from practical human need; or those special kinds of knowledge applied while solving practical problems, of designing for instance; or the precise knowledge of how to do things; commonly referred to as know-how. This includes skills, production methods or methodologies, organizational patterns, manuals, procedures, processes, rules of achieving practical end-states in the first component of technology. A definition of technology lacking any of these two components or leaning on only one of them is severely narrow and as such a side-view of technology.

In the same light, technology is much more than the application of scientific knowledge *simpliciter.* Science has two aspects: pure science and applied science (also vulgarly, as we shall see, called technology). Pure science is concerned with the systematic development of scientific knowledge, ideas concepts, theories, and models. It increases the knowledge of the natural world. Pure science is knowledge for the sake of knowledge. It is geared towards the understanding and explanation of the processes, mechanisms, and relations of the natural world. The motive for pure science is the desire to know. Pure science results from the will to make intelligible. It has no application in view. Applied science, on the other hand, is basically scientific knowledge geared to control and manipulate reality for the achievement of practical human goals. Applied science (technology) results from the will-to-do. That is, applied science results from man's will to control nature. Hence productivity, instrumentality, experimentality, and utility are the basic driving motives for applied science.

Today, the attempt to draw a line of demarcation between pure and applied sciences is becoming increasingly tenuous. If the line of demarcation is drawn based upon application and non-application than it is not clear for every knowledge is ultimately applicable. The knowledge that is neither applicable or intend for application today might become so tomorrow. Thus the attempt to distinguish scientific research into pure and applied, curiosity-oriented and mission-oriented is increasingly becoming futile. Thus technology cannot without qualification be defined as applied science.

Science-Technology Relationships:

One of the insights that arise from the conceptual clarification above is the nature of the relationship between science and technology. Three of such relationships are discernable in the history of their relationship. There was the kind of relationship that existed in the ancient world. Then science and technology maintained separate or parallel developments. There was the kind of relationship that existed during the modern period. Then science and technology started making contact.

In the Ancient World: In a sense it is said that science and technology have ontological or a-historical origin. This means that science and technology are as old as man. Stone Age (Paleolithic, Mesolithic, Neolithic) and Bronze Age are ancient civilization epochs divided according to tool-making materials. The Old Stone Age, also commonly called the Paleolithic Age covers the whole of Prehistory up to 3000 B.C. when it was succeeded by the Bronze Age. Paleolithic people were hunters and gatherers using sticks and stones fashioned into tools.

With the emergence of Bronze Age, that is, with the invention of metal tools, which were hard and more durable, hunting and gathering became more specialized and farming improved immensely. These resulted into settlements and villages and cities, the first centers of civilization. The improvement of farming also resulted in abundant food supply. Abundant food supply in turn freed people from too much engagement in manual labour and food production. Some of these freed people switched to other trades or skills. This is the root of the craft tradition. Some of the leisured people formed the aristocratic and priesthood institutions. This leisured class developed comparatively more sophisticated skills of literacy and numeracy – this became the scribes, the scholars, the aristocratic class, the root of the development science.

A striking phenomenon of the ancient world was that the scholarly class showed absolute contempt for manual labour and craft. The leisured or scholarly class engaged exclusively in science (mathematics, astronomy, philosophy). They disdained the works of craftsmen. A father's advice to his son contained in an Egyptian Papyrus of about 1100 B.C. expresses the general scorn for craftsmanship:

Put writing in your heart that you may protect yourself from hard labour of any kind, and be a magistrate of high repute. The scribe is released from all manual tasks; it is he who commands. I have seen the metal worker at his task at the mouth of the furnace, with fingers like a crocodile. He stank worse than fish-spawn. I have not seen a Blacksmith on a commission, a founder who goes on an embassy (Mason, 25).

Perhaps, the most outstanding contribution of the ancient Greeks to the development of science, a contribution still treasured till today, is deliberate abstraction or theorizing. This is the practice of rational and disinterested explanation of the abstract principles of a thing. Contemplation. Speculation.

The objective is to operate in the realm of the more stable world of essences and ideas in order to transcend the grubby and unstable world of matter. A typical example of this practice is Plato's theory of ideas. The scholarly class made abstraction their business and elevated it into an art.

The ancient Greeks were also as good as the Egyptians and the Babylonians in technology. In Greek society, as in other ancient societies, there was *theoria-techne* division. The ancient Greeks could not understand how theory could aid the development of craft or craft add to the development of theory. Theory was the business of the scholars and the cultivated mind while *techne* was the concern of craftsmen or the uncultivated mind. *Techne* was passed on from craftsman to apprentice. In ancient Greece, therefore, science and technology developed separately. There was no *theoria -techne* contact.

The reason science and technology maintained parallel courses derived from the social structure of ancient Greek society. Ancient Greek society was compartmentalized into classes, which were largely exclusive. According to Plato, "…there are three distinct classes, any meddling of one with another, or the change of one into another, is the greatest harm to the state, and may be most justly termed evil-doing?" (434). This, however, should not be construed to mean that there was not any instance of *theoria-technie* contact in ancient Greece. In Aristotle, we notice a meeting of theory and practice. He was said to have practically studied over 500 different species of animals, about 120 kinds of fish and 60 kinds of insects. This involved dissection and observation and reports from experts (Lloyd, 116). Archimedes and his patron, king Hero, both of Alexandria, combined engineering and science and made useful practical inventions. Archimedes invented water screw with which water was raised from a source of quite some depth. He also invented a catapult that could haul heavy stones. With this, his city Syracuse was defended for three years against the invading Romans. When he was, however, invited to write a handbook on engineering, he turned it down because he regarded engineering work as vulgar; he rather wrote his physical Treatise, a work on statistics (Nwalozie et al 323f). Hence, there were isolated instances of *theoria-techne* contact but in the main, ancient Greek scientists and craftsmen did not see the need for contact between science and technology.

The Medieval and the Modern Periods: The outstanding picture of the relationship as already hinted, shows science and technology gradually coming together for the first time with science illuminating, stimulating and engendering technology, which is perceived as a corollary. That is, science is seen as breeding technology.

The Middle Ages was the long period from the 5^{th} to the 15^{th} century A.D. It is usually divided into the High Middle Ages (Dark Ages) and the Late Middle Ages (9^{th} -15^{th} A.D.). The Dark Ages was naively taken to be barren with regard to intellectual activities in science and philosophy. There appeared, however, at that time, fundamental technical innovations: New plough, water-wheel, stern-post rudder, spinning wheel, gun powder and firearms, paper-making, printing, and mechanical clocks. These made the way of life of the medieval man materially superior to that of the ancient man. The benefits of the crafts were becoming obvious and they were attracting the attention of the scholars. The possibility that theory and practice would meet was becoming real. Hence theory and techne were for the first time coming together. But there was not yet theoria-techne interpenetration. The reason being that direct appeal to observation, though not completely absent, was over-shadowed by the bookish nature of learning (citing of authorities) during the High Middle Ages (Mclean, 77f).

Science-technology contact experienced a further boost during the 13th century, the renaissance of natural science. An indication of this was the appearance of ‘Utopia literature’, a new kind of literature expressing felicitous fantacies expected from future mechanical devices. Roger Bacon, for instance, fantasized about a flying machine (aeroplane). He believed that if people could build the right kind of machine, the air would support it, as water supports a ship” (World Book Encyclopedia, **A** Vol.1). Later, Leonardo da Vinci sketched a design of a flying machine. Robert Grosseteste and Roger Bacon were among the early advocates that with effective methods of observation and experiments, science would engender the technology that would actualize these fantasies. Bacon urged that the true scholar ought to know “natural science by experiments, and medicaments, and alchemy and all things in the heavens or beneath them, and he would be ashamed if any layman, or old woman, or rustic, or soldier, should know anything about the soil he was ignorant of” (Mason, 114). In this way, Roger Bacon advocated a unity of theory and *techne.* He did experiments himself in the area of optics and was called the founder of experimental science (Courtenay, 18f).

Perhaps the loudest and most advertent initial effort to merge science and technology was made during the Age of Reason, a period of great excitement in intellectual activity starting from the late 1600’s to late 1700’s. During this period, scientists began to believe that through reasoning and experimentation, the laws by which nature operates could be discovered and that this would bring about improved material condition of man. Francis Bacon (1561-1626) is arguably the most vociferous proponent of this novel idea. He criticized the bookish nature of traditional learning and its motive of contemplation. For him, “experiment was the only true necessary ingredient of scientific endeavour” (Boas, 252), and “the benefit and use of men” (Bacon, 240), was the motive. By “the benefit and use of men” Bacon had a lot of things in mind: power, truth, control of nature, “relief of man’s estate”, that is, that the application of science to the useful arts would improve the material wellbeing of mankind. Thus Bacon proposed “a true and lawful marriage of the empirical and rational faculties, the unkind and ill-starred separation of which has thrown into confusion all the affairs of the human family” (Boas, 242). Bacon’s proposal that science should provide material wellbeing just as the crafts were already doing was as radically novel as the other proposals that science should apply experience and experience should learn to read and write.

Rene Descartes (1596-1650) also criticized the bookish nature of scholasticism. So he "commanded men to shake off the yoke of authority, recognize none save that which was avowed by reason" (Condorcet, 9). He believed that certain and indubitable knowledge was possible but could only be achieved by "the light of nature", reason. Descartes shares the Baconian conception for he writes in the *Discourse on Method* that the science he was envisioning was:

"practical philosophy by which, understanding the forces andaction of fire, water, air, the stars and heaven and all other bodies that surround us, as distinctly as we understand the mechanical arts of our craftsmen, we can use these forces in the same way for all purposes for which they are appropriate, and so make ourselves the masters and possessors of nature. And this is desirable not only for the invention of innumerable devices by which we may enjoy without trouble the fruit of the earth and the conveniences it affords, but mainly also for the preservation of health, which is undoubtedly the principal good and foundation of all other good things in this life" (Palmer & Colton, 274).

As the idea of merging the tradition of science with that of craft was catching on about this time, scientists sought to carry out experiments and to do this they needed new tools. Inventors met this need with new inventions. Some scientists produced inventions themselves. The Italian physicist Galilei Galiloe (1564-1642) readily comes to mind in this connection. He invented an improved sector, an instrument for drawing and measuring angles. In 1608, he also constructed improved telescope with which he observed the heavens and discovered many new facts demonstrating that the heavens were not different of a kind from the earth, as held by traditional learning. In 1644, another Italian physicist, Evangelista Torricelli, wrote a description of the barometer, which he invented. About 1700, Jethro Tull, an English farmer invented the seed drill for sowing seeds. These inventions aided scientists and underscored the practical value of science, something hitherto inconceivable; and so suggested a convergence of the traditions of science and technology. Yet the interpenetration of science and technology which Bacon so forcefully proposed would not occur until the Second Industrial Revolution. What did follow immediately in the 17th century, however, was the rapid advancement of science, the scientific revolution. Scientist was determined to direct science to useful ends.

Industrial Revolution, the mechanization of industrial operations, the widespread adoption of inanimate (steam engine) sources of power, was an indication of the union between science and technology during the modern period. It should be noted, however, that the First Industrial Revolution (1750-1850) did not clearly show evidence of this union. Technical innovations during the First Industrial Revolution were brought about by inspired tinkerers, with limited or no contact with scholars, such as Peter Newcomen who invented the steam engine (1705) and James Watt who improved it (1764). The First Industrial Revolution resulted more from the tradition of technology than that of science. The reason the role of science as the source-spring of technical innovations of the First Industrial Revolution was not evident was that science then was undifferentiated from natural philosophy. Science then was at its infancy and had nothing to show in terms of the utility it could offer.

The role of science as the source-spring of the technical innovations of the Second Industrial Revolution (1850-1914) was, however, very obvious. At this period, scientific information was readily available to industrialists in a way that it stimulated the Industrial Revolution. Physicists and Chemists such as Franklin Black, Priestly, Dalton and Davy were in intimate contact with leading figures in British industry. Scientific information was more widely and broadly diffused as a result of the existence then of numerous institutions, associations, academies and discussion groups established for such social purposes as lectures, production of journals, and generation and dispersal of scientific information. In this way, the scientific ideas of scientists were first applied in industry. Newton's laws of motion published in the *Principia* (1687) aided the invention of jet propulsion and rocket engines in the late 1900's. Galileo's scientific theories saying that in a perfect fiction-free machine there is no loss of force, such that the effort put in must equal the useful effect obtained, made possible the design of 18th and 19th measures as "duty", "horse power", and the development energy, generally. The theoretical ideas of Hans Christian Oersted, Andre Marie Ampere, Michael Faraday and George Simon Ohm combined to make possible the linking of magnetism and electric current into electromagnetism, the application of which led to electric lamp in 1820, telegraphy in 1836, and industrial electrolysis in 1837. Later Maxwell linked optics and electromagnetism, the application of which led to wireless telegraphy. Justus Von Liebig's scientific theories made possible the development of synthetic dyes, high explosives, artificial fibres, and plastics. Thus scientific ideas stimulated industrial innovations.

Science was able to positively and directly stimulate innovations during the Second Industrial Revolution because by then science had taken firm root. Science was matured and bigger. By this time it was possible to distinguish within what were previously natural philosophy autonomous areas of research like physics, chemistry, geology, etc. By this time, science was becoming a profession with professionals (scientists) engaged in it and making a living out of it.

The main feature discernable in the relationship of science and technology at this period is that in their union, science is perceived as generating technology which results as a corollary. The definition of technology as applied science stems from the conception of the relationship of science and technology at this period. Writing about the nature of science-technology relationship at this period, Mario Bunge writes: "Ever since theoretical mechanics began, in the eighteenth century, to shape industrial machinery, scientific ideas have been the main motor and technology their beneficiary. Since then, intellectual curiosity has been the source of most, and certainly of all important, scientific problems; technology has often followed in the wake of pure research, with a decreasing time leg between the two" (Bunge, 29). This decreasing time lag is what we are saying has vanished from the twentieth century.

Science-Technology Relationship from the Twentieth Century:

From the 20th century, science and technology have so much converged and interpenetrated each other that they have formed a logical matrix which cannot be easily separated except for the purpose of conceptual analysis. And even at that conceptual level, the separation could only be arbitrary and confusing. In the ancient and most of modern worlds, inventions were made by individual inventors who worked alone relying on their knowledge and skills. Today, inventions are made by groups of scientists and technologists working together in government or industrial research laboratories (World Book Encyclopedia, I Vol.10, 355). Science has become a professional and specialized endeavour. It has a distinct origin and historical background from technology. Science and technology each takes place in different social institutions: science in the free setting of the universities and technology in industries and business settings. Thus, both enjoy some autonomy from each other. Science, however, today, also contributes to the development of technology and technology is contributing to the development of science. Consequently, there is today no more fine line separating science and technology (Gibbons, 100). Indeed, precisely from the second help of the 20th century, as the experience of the Second World War demonstrates, science and technology are involved in a synergistic and symbiotic relationships and the result is a hybrid enterprise called *technoscience*. In this hybrid union, science and technology mutually stimulate and re-enforce each other. This is the true nature of science-technology relationship today; a relationship of two disparate and autonomous but mutually interdependent areas of endeavour.

The cases of steam engine and thermodynamics, astronomy and larger reflecting telescopes, and aerodynamics and aerospace engineering, will help to prove this synergy. The case of steam engine and thermodynamics – the science of heat energy, of the relation between heat and other forms of energy (light, electricity, magnetism, chemical, mechanical), and the conversion of energy from one form to another – illustrate the synergy in science and technology from the 20th century. The development of the science of thermodynamics by Sodi Carnot and Clapeyron resulted from their study of the principles upon which the steam engine worked. The steam engine was invented many years earlier in 1705 by Peter Newcomen and was improved by James Watt and Smeaton in 1764. Both inventors and those who improved the steam engine were practical men, engineers working to solve practical problems. Thermodynamics is therefore the outcome of Carnot's effort to solve the problem of the inefficiency of the steam engines. Thermodynamics is therefore an instance where practice led the way and theory followed; Thus the development of the science of thermodynamics is a serious challenge to the view that technology is applied science for in thermodynamics the practice was in existence many years before the theory. But it must be added that once the science was developed, it provided the theoretical basis for the improvement of the steam engine and the development of other heat engines. This is a good illustration of the synergistic and symbiotic unions between science and technology today.

Again the relationship between aerodynamics and aerospace engineering illustrates the synergy in science and technology in the 20^{th} century. The principles of aerodynamics aid aerospace engineers in the construction and maintenance of guided missiles, aircrafts, and spacecrafts. With spacecrafts and cameras, the age-long dream to explore space was re-enforced. Unmanned spacecrafts equipped with cameras provided so much Lunar data: that the moon has little or no atmosphere, that its surface is strong enough to hold a spacecraft on landing etc (World Book Encyclopedia **M**.Vol.13, 794). Landing on the moon provided other data and stimulated the exploration of outer space by acting as a launching pad for the exploration of outer or deep space.

In the 1900's, observational astronomy considerably increased through the construction of larger reflecting telescopes. In 1918, the 100 inch reflecting telescope was mounted at Mount Wilson. This helped to measure stellar distances. In 1949, the 200-inch reflecting telescope was set up at Mount Palomar. This helped to estimate the life time of the universe. This swiftly corrected the difficulties which the continuous creation theory has been labouring to effect. There was the new radio astronomy which could reach further into space than the Mount Palomar telescope (Mason, 565). There were other technical innovations that stimulated other branches of astrophysics – "the study of the physical and chemical nature of celestial bodies, their origin and evolution." Astrometry aided accurate measurement of the positions of celestial objects. Photometry made possible the measurement of the intensity of radiation coming from a celestial source. Spectroscopy made possible a more detailed study of the radioactive output of a celestial source. The synergy between astronomy and larger reflecting telescopes was foreshadowed by Galileo's, Tycho Brah's and Kepler's telescopes. These telescopes were constructed by Dutch spectacle makers, Hans Lippershy and Zacharias Janson both of them practical men working to solve practical problems. But Galileo and Kepler applied this technology to improve their astronomy.

CONCLUSION

This paper set out to demonstrate that a new kind of relationship, different from the types that existed in the ancient and modern worlds, exist today between science and technology. In the ancient world, the relationship between science and technology was mainly one of separation. With the exception of isolated cases, there was no contact between science and technology. Science and technology had parallel courses of development. In the late Middle Ages, as a result of the utility which the craft tradition was able to confer, scholars began to be attracted to what craftsmen were doing. During the Age of Reason, scholars started advocating for contact between science and technology. This advocacy resulted in the 17th century modern Scientific Revolution. By the Second Industrial Revolution, the contact between science and technology were obvious. Science and technology were by this time perceived to be involved in a relationship in which science breeds or engenders technology which follows as a corollary, hence the definition: "technology is applied science". Today, from the 20th century, precisely from the second half of the 20th century, a new kind of relationship exists between science and technology. This is the synergistic kind of relationship. In this relationship, even though science and technology are independent and autonomous areas of endeavour, they have interpenetrated each other and formed a logical hybrid which we can call *technoscience.* In this interdependent relationship, science and technology mutually stimulate and re-enforce each other.

The productivity of scientists and technologists is determined by the existing science and technology policy. Science and technology policy, to a large extent, depends on the conception of the relationship between science and technology which policy makers hold. The ancient and modern models of relationship are warn out and have been responsible for policies about science and technology that did not yield positive results. The synergistic model is the most comprehensive picture of science-technology relationship. If it is adopted, it promises to generate comprehensive policies that would take science and technology to new frontiers.

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