Lecture: 19

Course Title: Science, Technology and Society

Science and Technology, and their Human Roots: Philosophy of Science and Technology

Socrates said that the unconsidered life is not worth living. The question about science, technology and their human roots is therefore more relevant today than in any other time in history. But what a philosopher can do here? Is there anything to discuss in an area by one who is not an expert in that field? Whether modern technology and the world it had created, contained issued of theoretical importance beyond their mere technical challenges? Why a philosophical approach to technological solutions of the issues mentioned here? This lecture is designed as an answer to some such questions.
Before we discuss such issues, we need to clarify certain terms about the proper meaning of which there seem to be certain confusion. Does science have the same meaning as the term technology? And what about the new term technocrat? What is the relationship of these terms to science on one hand and the central protagonist in history of technology, the machine on the other?

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As per the dictionary meanings of the terms science and technology are indicative of the following**:**
sci·ence
1. a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws: *the mathematical sciences.*
2. systematic knowledge of the physical or material world gained through observation and experimentation.
3. any of the branches of natural or physical science.
4. systematized knowledge in general.
5. knowledge, as of facts or principles; knowledge gained by systematic study.
tech·nol·o·gy
1. the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.
2. the terminology of an art, science, etc.; technical nomenclature.
3. a technological process, invention, method, or the like.
4. the sum of the ways in which social groups provide themselves with the material objects of their civilization [1]

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The term science means "special knowledge." It comes from the Latin word, "scire," "to know." The corresponding Sanskrit word '*vigyan*' meaning higher knowledge seems to be appropriate for its meaning. A scientist asks the question "why?" to a phenomenon in nature, and proceeds to research and find the answer to the question. Thus a scientist is one who has higher specialized knowledge. Apple falls from trees all the time, but it took a genius like Newton to ask the question 'why?' and he discovered the Laws of Gravity and became a scientist.
Science is not just a necessary adjunct of technology; it is indeed a branch of free enquiry. Gonad Piel observes;' Science is a value to be cultivated for its own sake. …The curiosity, the initiative, the imagination, the persistence, the patience, the frustrations, that must be experienced and endured in science, but must be founded on the belief that all this toil is justified as an expression of the superior faculties of moral and as a contribution to the value of man as a whole.'[2]

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Definition of science and technology

While the words **science** and **technology** are often used interchangeably, they actually have different meanings.

Science from the Latin *scientia* (knowledge) is a system of acquiring knowledge based on the scientific method, as well as the organized body of knowledge gained through such research. Science as defined here is sometimes termed pure science to differentiate it from applied science, which is the application of scientific research to specific human needs. [3]

Technology is a broad concept that deals with a species' usage and knowledge of tools and crafts, and how it affects a species' ability to control and adapt to its environment. In human society, it is a consequence of science and engineering, although several technological advances predate the two concepts.

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Differences in Etymology

The word **science** comes through the Old French, and is derived from the Latin word scientia for knowledge, which in turn comes from scio - 'I know'. From the Middle Ages to the Enlightenment, science or scientia meant any systematic recorded knowledge. Science therefore had the same sort of very broad meaning that philosophy had at that time. In other languages, including French, Spanish, Portuguese, and Italian, the word

corresponding to science also carries this meaning. Today, the primary meaning of "science" is generally limited to empirical study involving use of the scientific method.

Technology is a term with origins in the Greek "technologia", "τεχνολογία" — "techne", "τέχνη" ("craft") and "logia", "λογία" ("saying"). However, a strict definition is elusive; "technology" can refer to material objects of use to humanity, such as machines, hardware or utensils, but can also encompass broader themes, including systems, methods of organization, and techniques. The term can either be applied generally or to specific areas: examples include "construction technology", "medical technology", or "state-of-the-art technology". [4]

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Science refers to a system of acquiring knowledge. This system uses observation and experimentation to describe and explain natural phenomena. The term science also refers to the organized body of knowledge people have gained using that system.

Fields of science are commonly classified along two major lines:

1. Natural sciences, which study natural phenomena (including biological life),

2. Social sciences, which study human behavior and societies

These groupings are empirical sciences, which mean the knowledge must be based on observable phenomena and capable of being tested for its validity by other researchers working under the same conditions. [5]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

Introduction.

One of the most popular problems in the area of philosophy of technology is the characterization of science-technology relationships. One source of confusion is the undoubted relationship that exists between science and technology and Sparks pointed out that even though science and technology overlap in an area which might be referred to as “applied science”, there are a number of important differences between the two, even though these differences might not be self-evident to an average member of the general public who, through neglect and through repeated use of the phrase “science and technology” has lost the distinction between “science” and between “technology”. The two cannot be told apart, which is hardly surprising given that, as Mayr put it: “ . . . practical usable criteria for making sharp neat distinctions between science and technology do not exist.” [6]

“ Is Technology related to Science?

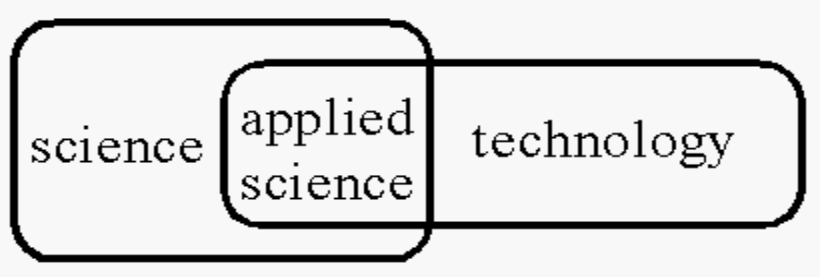

fig. 1 ” [7]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

“Bigelow’s phrase “*the practical applications of science*” points to the root of much of the current confusion as to the meaning of technology. In using this phrase to describe technology he effectively placed technology beneath the umbrella of science to such an extent that science and technology are now, as Rose described, seen by many as an “*indivisible pair*” with technology as the subservient and dependant partner. Thus, for much of the time the pair are wrapped together into a single conceptual package known simply as “science”. This point is emphasized when surfing the Internet for technology-related teaching resources. A plethora of lesson plans exist at sites dedicated to science education. The problem is, though, that many of these lessons should properly be termed “technology” but are all too often referred to as “applied science”. [8]

One source of confusion is the undoubted relationship that exists between science and technology. …. ”[9]

Dr. Hsien-Hui Lee observes : “Sparkes illustrated this relationship (fig 1) and pointed out that even though science and technology overlap in an area which might be referred to as “applied science”, there are a number of important differences between the two (table 1), even though these differences might not be self-evident to an average member of the general public who, through neglect and through repeated use of the phrase “science and technology” has lost the distinction between “science” and between “technology….” [10]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

Following Dr. Hsien-Hui Lee we may explore the following pattern of science-technology relationship in a novel way :

TECHNOLOGY	**SCIENCE**
Goal: the creation of artifacts and systems to meet people's needs	**Goal:** the pursuit of knowledge and understanding for its own sake
Key Technological Processes	Corresponding Scientific Processes
Design, invention, production	Discovery (controlled by experimentation)
Analysis and synthesis of design	Analysis, generalization and creation of theories
Activities always value-laden	Making virtually value-free statements
The search for and theorizing about new processes (e.g. control; information)	The search for and theorizing about cause (e.g. gravity; electromagnetism)
Pursuit of sufficient accuracy in modeling to achieve success	Pursuit of accuracy in modeling
Taking good decisions based on incomplete data and approximate models	Drawing correct conclusions based on good theories and accurate data
Design, construction, testing, planning, quality assurance, problem solving, decision making, interpersonal and communication skills	Experimental and logical skills
Trying to ensure, by subsequent action, that even poor decisions turn out to be successful	Using predictions that turn out to be incorrect to falsify or improve the theories or data on which they were based

Table 1 " [11]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

Various models try to explain these relations from different points of view. Some of these descriptions talk about either an application from scientific knowledge to technological innovation, or from new technological artifacts to new scientific discoveries.

This application model was once a largely widespread opinion among historians and philosophers, but criticisms from economics, sociology and history have exposed good reasons for re-consideration. The critics have given rise to new interpretations and models, which extend from those which consider science and technology to be two different systems, to others that uphold that there are no significant differences between science and technology.

This idea has been maintained by both scientists and engineers. The famous report of Vannevar Bush (an engineer in the Manhattan Project) came to the conclusion that basic research leads to new knowledge, and this creates the fund from which the practical applications of knowledge must be drawn (Bush, 1945, p. 13). Without basic research there is no possibility of technological progress.

This linear or hierarchical model has its roots in economic and prestige factors. Scientists, for fear of technological outcomes overshadowing scientific research, wanted to establish a linear dependence between scientific discoveries and technological innovation. On the other hand, engineers were happy to obtain status: the reputation of applied scientist was better than technician. [12]

Perspectives on Science – Technology Relationship: Hierarchical,Symbiotic and Coalescing

The most sophisticated version of this thesis in philosophy was produced by Mario Bunge (Bunge). Bunge defined technology as applied science Bunge defined technology as applied science Technology creates new scientific possibilities.

The hierarchical model.

It is possible to characterize two versions of the same idea: there is a relationship of subordination between science and technology. Without some developments in one area there is no possibility for the other to develop. There are two different versions: one maintains that technology is the outcome of the application of new scientific knowledge. The other one holds that without a special technological infrastructure there is no new scientific knowledge.

The hierarchical model also moves in another direction, one from technological innovation to scientific discoveries. For instance, Derek de Solla Price (1984) argues that there are some technological innovations (arising within normal technological evolution) that yield new scientific possibilities. Price gives as an example the development of the

telescope by Galileo. Galileo wasable to change the cosmology of his time thanks to telescopic observations. This new instrument led to the acquisition of new data, which made possible new scientific knowledge. Such relationships between science and technology occur in the field of experimentation**.** [13]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

Technology as the application of basic scientific knowledge.

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dependence between scientific discoveries and technological innovation. On the other hand, engineers were happy to obtain status: the reputation of applied scientist was better than technician.

The most sophisticated version of this thesis in philosophy was produced by Mario Bunge (Bunge, 1966). Bunge defined technology as applied science: "The method and the theories of science can be applied either to increasing our knowledge of the external and the internal reality orto enhancing our welfare and power. If the goal is purely cognitive, pure science is obtained; if primarily practical, applied science" (Bunge, 1966, p. 329). [14]

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" There are two ways for applying science to produce technology: (i) in substantive theories, which are applications of scientific theories to nearly real situations—for example, the theory of flight as an application of fluid dynamics. The other possibility is (ii) in operative technological theories, which apply the scientific method. The primary objective of technology here is to establish "stable norms of successful human behavior, that is, rules" (Bunge, 1966, p. 338). These rules ought to be based on scientific laws to warrant their efficiency. A law, a nomological statement, is translated into a nomopragmatic statement, which provides the basis for a pair of rules. These rules prescribe a course of action and indicate "how one should proceed in order to achieve a predetermined goal" (Bunge, 1966, p. 338).
There were many critics in economics, sociology, history and philosophy, opposed to these ideas.The first reactions against the linear model were published in the late 60's and early 70's in twostudies initiated with the aim of showing the economic benefits of scientific research: TRACES(produced by the Illinois Institute of Technology Research

Institute, 1968); and Hindsight (seeIsenson, 1969), and both concluded that "we cannot see that it is possible in any systematic way totrace important industrial applications of science back to basic work of the kind that the ResearchCouncils support in a way which could help in determining how much support is justified" (see
Gibbons and Johnston, 1974, p. 220)." [15]

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These two studies had in common one methodologicalassumption: that "innovation could be considered as composed of a series of specifiable events inresearch and development", so that "the contribution of science to technology could be assessed bytracing the origin of these events" (Gibbons and Johnston, 1974, p. 222). However, they concludedthat the transfer from new knowledge to new artifacts is an extremely complex process; therelationship between the academy and industrial research is not obvious nor direct, and innovation

demands knowledge from internal and external sources. Similar studies to those produced byMichael Gibbons and C. Johnston were published by W. Faulkner, J. Senker, and L. Velho (1995).
The conclusions were similar: the great majority of knowledge used in innovation originates withintechnological sources and is associated with design and R&D activities. The main external sourcecomes from the public sector." [16]

Perspectives on Science – Technology Relationship: Hierarchical, Symbiotic and Coalescing

A. Emerson Wiens writes about the The Symbiotic Relationship of Science and Technology inthe 21st Century :

The obvious connection between scientific principles and practical applications (technology) developed during the scientific revolution and was expanded in the industrial revolution. In recent times, many leaders and the public have developed an unflagging faith in the science-technology enterprise. Pytlik, Lauda, and Johnson (1978) asserted that this faith led the public to believe that "every flaw affecting the human was definable and could be solved through science and technology. To many, science seemed infallible, making people tolerant of its byproducts but unable to assimilate its true meaning." [17] Rustum Roy (1990), a leader in the National Association for Science, Technology, and Society, argued that historically, technology led to science more often than science led to technology. Surprisingly, recent studies have indicated that most technological knowledge is still built, not on science, but on previous technological knowledge". [18]