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ISLAMIC PERSPECTIVES ON SCIENCE AND TECHNOLOGY

AN ESSAY ON INTERRELATIONS BETWEEN SCIENCE AND TECHNOLOGY IN ISLAM

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Toshiyuki Akiyama
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Preface

Scientific discoveries and achievements by medieval Muslim scholars in the field of both natural and theoretical science are said to have made great contributions to the development of modern science in the western world. It is often said that the western Christian world had sunk into the tenebrous abyss of intellectual stagnation in contrast with the brilliant efflorescence of Islamic civilization in the Medieval Ages.

I am not sure whether this commonplace contrast is right to the point or not. People in the Medieval Christian world might have been more intelligent and brighter in their own way than the western historians of the 19th century imagined. However, from the viewpoint of contribution to the development

of modern science and technology, Islamic science and technology in the Medieval Ages are considered to be superior to those of the Medieval Christian world.

This idea of the superiority of Islamic science over the Medieval west is actually based on the yardstick of the modern western academics. The western version of science history is based on the theory of evolution which still exerts a great influence on the way of thinking of modern scientists in general in spite of the recent criticism raised by many scholars against it. In the position of the evolutionistic view of science history, modern western type of science are considered after all to be the final type which has been shaped by the evolutionary process of scientific development. Therefore, Islamic science have been evaluated by the degree of contribution to modern western science in the science histories written by western academics possessed with the evolutionistic idea.

Such evaluation, however, seems to be misleading, for Muslim scholars in the Medieval Ages never expected such evaluation. They used to work for their own purpose based on the Islamic world view. They never

imagined the present pollution and environmental contamination caused by chemical materials when they discovered them. They never thought of the so-called Star wars at all when they developed their simultaneous equations. Islamic science and technology might have been a different view of science and technology developed in their own peculiar way and purpose. They should not be measured by the yardstick of degree of contribution to modern western science.

If Islamic science and technology continues to be evaluated in this way, we cannot reach the real understanding of their meaning and value in the total view of human culture. I feel it is an urgent task for our contemporaries to re-appraise Islamic science and technology in the face of the present state of the modern western science.

The author of this volume, Mr. Akiyama, makes a great contribution to illuminate the real meaning and value of the Islamic science and technology from the standpoint of a value-free approach to the subject. Readers of this volume will be able to have a correct understanding about Islamic science and technology.

Mr. Akiyama is a research fellow of IMES. He is a promising researcher of Islamic sciences and technology with a background of natural sciences and expertise in handling Arabic materials.

Akiro Matsumoto
General editor

Introduction

On the brink of a nuclear armageddon, beset by the crises of overpopulation congestion and pollution, and faced by the prospect of exhausting his non renewable resources, man, today, stands to face a new enemy himself. Where only a couple of centuries ago he sought to save nature, today he has overwhelmed it. Eric Ashby put it across so succinctly when he said, "What we are experiencing is not a crisis; it is a climacteric."(1) A frivolous rate of consumption perpetuated by an inept and short sighted political elite has contributed to the crises. Scientists should be held responsible for permitting the conversion to a technology which wastes by not establishing a balance between exhaustible resources and necessary consumption. What is worse, the crisis is now evident as a menace to all intellectual freedom.(2)

Some factors that can be asserted to have produced the crises are economy, politics, and civilization. Actually, the decisions of leaders or policy makers sometimes cause the problems. However, considering the fact that contemporary society is strongly influenced by the modern science-technology, we feel the intimate connection between the society and the technology, and we cannot attribute all of the crises to politics and economic factors. There is an opinion that the level of decay of an environment depends upon the economic system. However, this assumption is wrong as long as the economic system of a country is based on the development of industrialization. This can be proved by the case of the USSR where the destruction of the environment is as serious a problem as that of the West.(3) As a matter of fact, the one thing that influenced environmental crises directly is modern science and technology.

Modern science and technology have brought many ruinous factors. At the same time, they have contributed to some positive elements to our lives. We should not ignore the contribution of modern technology and the significance of development. For a more comfortable life, we now depend on the progress of science and technology. For example, modern medicine

has brought mankind freedom from many diseases. Due to the discovery of antibiotics and new vaccines, methods of treatment have progressed remarkably and infectious diseases have decreased. We can now enjoy a longer life. In the respect of natural disasters, we need not suffer as much as before because modern civil engineering defends against some of them. It contributes to increase of provisions as well. Human beings have conquered enemies with the help of science and technology.

The modern world is connected by an increasingly efficient communication system, therefore, we can know what happens around the globe almost immediately. One can choose between topics which interest him from the vast amount of informations currently available. This pleasure owes to the development of computers and information networks. Automobiles which appeared at the end of the nineteenth century, spread all over the world, and they have made human movement easier. Moreover, airplanes enable us to take longer strides and to move much faster and further. Today, such technology of transportation has become indispensable for our lives. Technology has succeeded in bringing about a more convenient life. And now is the age of rockets. They will give us dreams to travel to the moon in the

future.

However, under the name of development, human beings have been so absorbed in cultivating new science-technology and so hasty in their quest for industrialization, that they have not noticed the negative aspects of science-technology. Rapid progress in technology and industrialization has brought the contamination of air, rivers, and the sea, and noise of industrial plants and transportation. Pollution such as this has destroyed the environment and has given ill influence to the health of human beings. Today, unnecessary technology and systems are made not because they are proved scientifically to be good or because they are accepted for human benefit, but because some institution and areas devoted to the promotion and development of vested interests want to have them.(4)

When we consider modern crises we cannot turn a blind eye to ecological problems. In the past, all existence on earth were co-existing successfully, but today, human beings break part of this co-existence. That is to say that the "God-given equilibrium is being destroyed by modern man in revolt against Heaven and against his own inner nature."(5) Nature and environment have become more and more artificial. Therefore, we feel alienated from the environment.

The Ocean is considered so large that scientists did not think that human activities would affect it badly. We have dumped oil, soap, chemical wastes, and radioactive wastes without consideration of the environment of the ocean. As a result, a large amount of oil put plankton to death. Small fish are effected by the plankton, next large fish are effected by the small fish, next human beings .... . One malevolent breaks the ecological chain.(6)

We are living in a large scale production-consumption society and modern technologies have progressed with this system. Therefore, what is needed with the technology is high speed, high quality, in large amounts, and an one-way structure from resources to wastes. To bring resources by using large amounts of energy from distant places is cheaper than to change raw material near at hand into resources. And it is thought to be more rational to make no-window buildings for ventilation than to open windows and introduce wind into rooms. That is an idea not from resources but from technology.(7) Therefore, some forms of technology are rather expanding the energy crisis.

Due to an increase in population, a rise in the average life span, and an improvement in our life-

styles, a large production of food is demanded. However, both the lands and the ocean are facing an ecological crisis because men have pursued foods rapidly and greedily. As a result, the devastation caused an expansion of desert lands and a decrease of fish.(8) The more we subdue nature, the more deeply we fall as a lonely subjugator on earth.

In order to conquer these serious crises, not only ecological ones, but also those caused by modern science and technology, we must not deal only with the technology aspects involved. To do so would be a short-term countermeasure. We have to grasp what the science and technology should essentially be and reconsider our attitude towards and view of nature. For that purpose, history of science is useful. Seyyed Hosein Nasr suggests that,

> If we wish to use the history of science beneficially to solve the acute problems modern science and its applications have brought about, we cannot be satisfied merely with the current method of studying the history of science. We must also study the sciences of nature of other civilizations and periods, independently of their contribution, or lack of it, to modern science. We must consider these sciences as being independent views about nature some of which may be of considerable aid in the solution of contemporary problems and as providing a background for the criticism of certain aspects of modern science.(9)

The purpose of this thesis is to scrutinize and discuss the characteristics of Islamic science and technology and to describe the knowledge and values and perspectives appearing through them. To explain the peculiar manifestations of Islamic science and technology, they will be compared to the modern ones. The Islamic region has been regarded as being very complex and unknown. Indeed, we can admit a lack of knowledge about its culture, society, and religion. The same can be said about Islamic science and technology. Although a brilliant culture with progressive science and technology existed in the past, many scholars have not touched or understood them. Even though some scholars mention science and technology in the Middle East, they regard them as only the mediation from Greek civilization to modern European civilization. This history seems to be produced from a Europe-centered view. Scholars see the Islamic world still from the standpoint of "Orientalism".(10) We should not follow this standpoint. Removing prejudice, we have to understand what the values of Islamic people are. The following is emphasized in the sequential chapters.

Chapter I examines the characteristic of modern science and technology and the Western view of nature which affects modern science and technology. It is

important to examine the situation of modern technology for comparing Islamic values as well as for understanding of the uniqueness of science and technology in Islam. This chapter tries to prove that science and technology are not always universal or value-free, because both, how a man recognize science, and how he approaches scientific truths will be affected by his priori perceptions, which are shaped by his surroundings and culture.

Chapter II attempts to point out Islamic essential knowledge, Islamic values, and scientific subjectivity which are related to Muslim's recognition of science and their final scientific product. Islamic science is a facet of a multi-dimensional world of nature, so Islamic ethics and values which have a definite perspective have naturally penetrated into the science and technology.

Chapter III concentrates on the traditional Islamic science and technology. The Islamic world had a high level of these indeed, and behind them lay essential Islamic knowledge and values. The Islamic principle of the harmony and equilibrium between man and nature can be understood through an understanding of Islamic perceptions and application of technology. This chapter is useful to understand how Muslim

scientists saw science and how they actually treated nature in the past.

Conclusion discusses the reason why Islamic science and technology stagnated after its Golden Age, and attempts to answer the question of whether Islamic society refused westernization or not. Finally, modern crises are contrasted with Islamic values in order for us to get some hints to fight with these crises.

Note

(1) Eric Ashby, Reconciling Man with the Environment, (London: Oxford University Press, 1978), p.3. He mentions the reason of his definition that a crisis is a situation that will pass; it can be resolved by temporary hardship, temporary adjustment, technological and political expedients.

(2) Michael Polanyi, Science Faith and Society , (Cicago: The University of Cicago Press, 1964), p.74.

(3) John A. Livingston, One Cosmic Instant, Trans. Tositaka Hidaka and Setsuko Haneda, (Tokyo: Bunka Hoso Development Center Co., Ltd, 1974), p.234. He refers to the thesis of Dr. Goldman, Marshall I, ("The Convergence of Environmental Disruption," Science 170: 37-42, 1970), Goldman concludes the thesis that if the study of environmental disruption in USSR means something, it shows that it is not private companies but industrialization which causes the environmental disruption. This indicates that the nationalization of all resources is not a panacea and the change from private greed to public greed does not improve the disruption so much.

(4) J. R. Ravetz, "Science and values," The touch of Midas, (London: Manchester University Press, 1984), p.53.

(5) Seyyed Hossein Nasr, Islamic Science, (London: World of Islam Festival Publishing Company LTD., 1976), p.227.

(6) Seiki Sha, Atarashii Kagakushino Mikata, (Tokyo: Koudansha, 1978), pp.217-218.

(7) Tadoru Kato, Shigenkarano Hasso, (Tokyo: Chuokoronsha, 1979), pp.214-215.

(8) see Erick P. Eckholm, Losing Ground, Trans. Hiroyuki Ishii and Kenichi Mizuno, (Tokyo: Sojyu Shobo, 1978).

(9) Seyyed Hossein Nasr, The Encounter of Man and Nature, (London: George Allen and Unwin Ltd., 1968), p.52.

(10) Edwad W. Said mentions in his book Orientalism (New York: Vintage Books, 1979) that Orientalism is the corporate institution for dealing with the Orient--dealing with it by making statements about it, authorizing views of it, describing it, by teaching it, settling it, ruling over it: in short, Orientalism is a Western style for dominating, restructing, and having authority over the Orient.

Chapter I.

Modern Science and Technology

A. Characteristic of modern science and technology

Modern science and technology have developed with the assistance of each other. Now we come to understand the modern technology as science-technology. Many societies have overestimated technology in its contribution to the development of society, and they have believed excessively that science and technology gave many societies absolute truths about all aspects of nature. Science and technology have attracted societies for hundreds of years. We have been so fascinated by science and technology, that we have been apt to sacrifice religious persuasion, cultural heritage, and historical tradition to high alter of modernity.(1) Although, modern science-technology brings glory, wealth, happiness, and convenience to

people, it is only a few limited people that benefit from it. Most of the other people do nothing but surrender to the great power of science-technology.

Modern science and technology has three characteristics. The first characteristic is a strong connection between science and technology. Judging from the history of science, technology had, for a certain period, progressed without help from science, and even when technology was sure to benefit from science, technology actually dared to ignore the help of science. Rene Descartes and Francis Bacon first insisted that the co-operation between them was possible. It was in the eighteenth century, when the union between them was realized.(2) Science flourished and scientists devoted themselves to the discovery of new theories for technology to adapt them to human use.

Technology developed with the assistance of science and it also contributed to the progress of science. At the first stage, science was applied to land surveying, the technique of calculation, and weighing machines. Meanwhile, technique of pumping contributed to the study on the elasticity of air. Universities began to have subjects concerning these applications.(3) In this way, science and technology proceeded together.

Today, the connection is so strong and close that science has no direction without technological help. If a scientist abandons the technological aids, he can not establish even a hypothesis. At the turn of the century, a physician discovered the efficiency of penicillin but he had no technical means for its production, so the discovery was not practiced. Jacques Ellul asserts,

> today all scientific research presupposes enormous technical preparation as, for example, in atomic research. And very often it is some simple technical modification which allows further scientific progress. When the technical means do not exist, science does not advance.(4)

Now, the border between scientific activities and technical activity is not clearly defined, or rather scientific activities have been replaced by technical activities to such an extent that science can no longer be conceived to be without a technical outcome.(5)

Moreover, nowadays scientists need more complex techniques for research. For example, the research of elemental particles is achieved by the complicated cyclotron. The enormous amount data coming out of advanced huge equipment is dealt with by a super-

computer, formulated, and at last compared with analyzed results. This process becomes routine, therefore, there is no room for flashes of wit and rapid progress of an idea. In this case, human elements are less needed. Man's idea is isolated. The routine work is all for the research.

The second characteristic is the lack of actual proof. Modern science has the methods of analyzing and relating the processes of nature by quantitative methods. The quantitative method has penetrated into our lives and also advanced the technology to the limit. Blind adherence to it puts aside what F. Bacon advocated that actual proof equals experimental methods.(6) Modern technology removes the space where trial-and-error should stay, because it is belived that the trial-and-error can be replaced by some quantitative analysis.(7)

Two problems occur. One is that new technologies of production are easily put to instant use. As soon as a scientist finds a scientific discovery, new application to technology will be sought. The application enters society before someone checks and reckons its impact on society and how people will react to it. Scientists are hesitant about regarding what carefully calculated findings would launch in the

world, but they are not able to resist to its application.(8) Damages by agricultural chemicals are a typical case in point. It was used before its effect on environment was researched. Lack of the actual proof of technology to the society enables human beings to establish dangerous technology for themselves easily.

The second problem is that the ignorance of actual proof makes human beings establish complex and uncontrollable technology easily. For it can exist without decisive examination by men. The most glaring example is atomic technology. It is not too much to say that atomic plants are made by computers, because possible cases including accidents in a plant are calculated, and as a matter of fact, radiation prohibits actual proof. However, many accidents happen which are not possible to predict through calculations.

The last characteristic is production-oriented technology. J. R. Ravetz defines two types of technology. One is that people will try out the innovation of technology according to a market, which automatically decides what will happen and what will be the best thing to happen. The other is, so to speak, the technological imperative which consists in the faith that everything possible is obligatory.(9) The former technology is more related with modern Western

societies and has led to the more wide-spread bewilderment such as resource exhaustion, increasing outputs of waste matter, and the contámination of the environment.

Production seeks a steady output, efficiently and with great speed. The combination of machines is a typical characteristic. Production does not admit the isolated machines. In order to obtain maximum profits, machines must remain in full-time operation and must not make irregular commodities. Under the condition that the more the goods produced, the more that can be sold, "much faster and much more" is the slogan and automation has been pushed to the limit.(10) The technology has been controlled by external mechanisms to which individual intention and consciousness are extraneous. Works are systematized and become scientific. Man's exploitation of man is a prominent manifestation of this mass produced economy.(11) This system demands human beings to be a wheel and expects them to be an impersonal implicit process which raises the basic question of whether it is society that controls technology or technology which shapes modern society.

In contemporary society, where the economy is highly autonomous, the role of both consumption and

production is complicated. John O'Neill mentions that "it is obvious that consumer needs are generated in the production sector rather than in the consumer's body."(12) As a result, society is filled with more secondary and unnatural needs than primary and natural needs. Modern technology follows the excessive needs. It is appropriate to think that the original purpose of the automobile was a means of transportation. What, however, is the task of smaller and more fuel-efficient cars? Is the automobile just a symbol which promises us youth, beauty, and social mobility? We have got, in compensation for noise, pollution and loss of life. O'Neill advises,

> We need to think of the work of consumption in order to begin to understand what is required of us in the collection, display, and disposal of commodities that service the collective representation of a scientific and technical culture.(13)

B. View of nature in the modern West

In the following section, I will look into the modern Western people's thoughts and attitudes toward nature. A large number of crises, especially ecological crises, are man-made destructions of nature. Modern civilization breaks the harmony between man and

nature and has succeed in putting him apart from nature. This view of nature has enables us to not only destroy nature, but also contaminate the environment under the name of development. The techno-scientific culture takes pride in overcoming nature and aquiring ultimate power over nature. We have long offered the apology that the destruction and poison spread by modern civilization is for peace, civilization, and the maintenance of our life-styles.

The most remarkable is the view of "domination over nature", domination over the fish of the sea, over the fowls of the air, and over all creatures living on the earth.(14) There is a tendency represented by Bacon and Descartes who advocated the social value that we can enjoy "effecting all things possible" and "rendering ourselves the master and possessor of nature".(15) Influenced by their thoughts, modern civilization has fought against the physical and natural forces with which through human history, man has been flurried. Parvez Manzoor mentions, "No longer helpless before the capricious might of untamed nature, modern man, having already subdued his whole terrestrial milieu, is now casting his covetous glances at the start."(16) A primitive man identified himself with the environment through the belief of animism and

kept the balance of nature. However, this time, a modern man has identified himself with the environment only through the evidence of science. S. H. Nasr warns us that this view of nature has caused various problems.

> It is precisely the domination of nature that has caused the problem of over-population, the lack of breathing space, the coagulation and congestion of city life, the exhaustion of natural resources of all kind, the destruction of natural beauty, the marrying of the living environment by means of the machine and its products, the abnormal rise in mental illness and a thousand and one other difficulties some of which appear completely insurmountable.(17)

Contemporary man regards nature as a restriction he should overcome. There is a history of battle between man and nature. The enemies were sometimes, intense heat, cold and hard rain and wind, and sometimes bad illness. He regards even the physical condition of his body as a limit to be conquered. He has thought that nature is able to be replaced eternally by his ability rather than its own process. Mankind has put labor between himself and nature as an object, and has made tools by way of controllable things.(18) Human beings have tried to fly higher and faster than birds and run farther and faster than

tigers. For that purpose, they have created symbols of tools and made machines. That is the very history of science and technology.

It is possible for the Western people to possess nature. Nature is the source of wealth and profit, so private ownership seems natural. The benefit of nature exists for their use. Sea water, air, land and plants, therefore, come to be valued as a commodity. Now, Japan has a very serious problem of the increasing land prices, which is caused by several resales of land. The price has doubled or tripled in a couple of years in the metropolitan areas. Only limited few can earn large amounts of profits from nature.

Private ownership has reached the peak when human beings have succeeded in exacting energy by breaking the shell of atoms. It was never thought possible in the past. Technology progresses to the stage where it can use a lot of energy from atomic power plants and nuclear bombs. This technology has been developed to the non-earthly level.(19) However, we cannot imagine how much this energy technology has injured nature and mankind.

Human beings justify the man-centered view of nature in the name of progress regarding the view as a display of their subjectivity and expansion of freedom.

They had an ideology of rationalism that the action of controlling, dominating, and applying nature developed themselves as real human beings and spread their freedom. This ideology might bring up the man-centered view of nature more than the ideology of the practical utility of nature. There are some trends to reconsider the view of nature, owing to the increasing destruction of nature and the limitation of growth of science and technology, thus harmony between the economy and the environment are claimed. However, these trends mean that men try to settle a matter with, and to approach nature more, as they cannot dominate and control nature as they did in the past, but they have not yet abandoned the man-centered view.(20)

The view of nature affects modern man's means to observe nature. Nature is an object to be made clear by human reason. Western people insist on the superiority on nature and distinguish themselves from it completely. They view nature objectively and make it another world apart from themselves. On this condition, human beings as a subject can touch, observe, and theorize nature as an object. Simple conformity of the subject with the object, or simple unity of thinking with reality is very easy to confute. Cognitive objects have existed in a form completely

independent from the cognition of the subject. This distinction of subject and object is essential to the scientific enquiry of the modern Western style. Modern science has grown up on this separation.

The fact is that human beings hold nature in themselves, that is within the human body. Therefore, in order to conquer nature, they have to keep even the body apart from their consciousness. Conversely speaking, they hold the spirit independently from the body. The dualism of spirit and body thus appeared. The concept of this dualism conforms to Christianity. Christians in the past tended to think of themselves as not being in their organic body but in their spirit. The spirit seemed to control the body and thus a hostility of intention to instinct sometimes broke out. In the Middle Ages, there were some conflicts between Christianity and science. The basic aspects of the conflict seemed the dualism of spirit and matter, of the sacred and the secular, and of the spirit and flesh. S. Parvez Manzoor mentions;

> Christianity, the most anthropocentric religion the world has seen, sanctified man's conquest of nature and, in fact, was instrumental in the engenderment of natural and physical science.(21)

Christianity holds the concept of hierarchy among God, human beings, and nature. Human beings and nature are created by God, and God exists transcendently. Each exists for the upper class. Human beings exist for God and nature exists for the human beings. The human beings stay between God and the nature. They know nature by reason and recognize God by intelligence. It is possible to say that an intellectual endeavor in the Christian world has been pursuing how the hierarchical order of God, man, and nature should keep in harmony.(22)

C. Science and values

Some of the Western style technology was introduced to the Third world. Did, however, all these transferred technologies take root in the developing countries? The answer would be in the negative. Conversely, the transferred technology sometimes caused several social and cultural disturbances. These countries could not have the same merits in application of the technology as the Western service proposed. Rather restrictive aid practices prevented the Third world from building up any indigenous technological capability.

We have thought long that science and technology is universal and value-free, therefore, they can transcend geographic borders without resistance. But facts prove this assumption wrong. Philipine introduced revolutionary agricultural technology from Japan in 1970's. Nevertheless, some of them did not take root in Philipine and perished. This resulted from the exporter's ignorance of the peculiar climate and fact that whether transference of technology succeeds or not depends on the situation of a receiver.

In general, science has two parts. One is, needless to say, the objective investigation of the matter of nature. Another is, new understandings of science--subjective recognition.(23) It is said today that the consciousness of the latter part is inevitable for the recognition of science and must not be made light of or ignored. The importance of subjective recognition in scientific activities certifies that modern science is not always value-free or universal.

Science has been regarded as a cognitive system which observes what exists on the earth and brings what is investigated into the area of human consciousness. However, this idea seems superficial. According to the previous concept of science, there was no question or no uncertainty about the objective fact. The objective

world was a group of laws. Scientists believed that if they could imitate the laws correctly, they would be able to reach scientific truths. They did not deny the evidence produced by science which indicated that laws were impersonal.(24) Michael Polanyi mentions past ideal natural science as follows;

> Yet the prevailing conception of science, based on the disjunction of subjectivity and objectivity, seeks--and must seek at all costs--to eliminate from science such passionate, personal, human appraisals of theories, or at least to minimize their function to that of a negligible by-play. For modern man as set up as the ideal of knowledge the conception of natural science as a set of statements which is 'objective'.(25)

Actually, truth is truth everywhere and in every period. Every scientific question has only one right answer among many wrong answers. In former times, scientists thought that everyone could recognize science correctly. But "correctly" has various meanings in accordance with those in the know.

Although science is based on the world of sense, it is expressed by indifferent linguistic systems. The ultimate style is a quantitative expression. Because of this quantitative expression, the science seems abstract and alien for men. Thus, man feels absolute

with the quantitative expression that they cannot touch.(26) Actually, the quantitative expression gives us the impression that a figure can express the most objective fact. However, the impression coming from the figures is not always the same and it depends on the perception of an individual. People living in a tropical zone feel cool in temperature of 20 degrees Celsius but for people living in a zone of cold weather this would seem warm. Likewise, patients in a hospital feel that 60 phones create a considerable amount of noise, but not so for operatives working in a factory. We look, hear, feel, and smell something through our senses directly, but at the same time, we compare it with our emotions. The quantitative expression is not absolute. Formulation by a figure is available for the quantitative expression, but not for clear expression of a phenomenon. Hence, it is possible to say that modern science which quantifies everything cannot explain the subtleties of nature.(27) How man feels or recognizes the figures provided by science depends on the situation in which he stands. Science is not always impersonal. Ziauddin Sardar mentions,

> The currently accepted view of scientific objectivity treats observation as a direct sensory experience--touch, smell, colour, taste, and the like. Scientific positivism in fact regards these experiences as fundamental to scientific method. However a man's emotional condition at a particular moment may play as important a role in determining his conclusion as his sense of sight. In certain situations emotions will be a scietist's most powerful weapon. To ask him to ignore his feelings, emotions and sympathies is to ask him to deny his nature. This is neither possible nor desirable.(28)

We have to reconsider the theories as well. Science consists of various theories, so it gives us a sense that it has no uncertainty. Some poor scientists still believe that theories can explain whole aspects of nature, and then they obtain accurate knowledge from the theories. They try to put theories together in order to build up a new theory. What is more, they have kept the tendency to regard that what relies on theory is more objective than what relies on immediate sensory experience. They would depend on theoretical guidance for the interpretation of their experience and would reduce the status of direct impressions.(29) David Bohm, however, warns us that behind this action lies the worship of theory but the worship sometimes becomes an obstacle in due quest for knowledge. Most of the theories are of one particular insight and of one vision, but not the knowledge about

the reality of the phenomena. The theories are clear in a certain field, but must not be applied over boundaries.(30) The recognition of a theory is different among scientists. While the Japanese, for example, are very careful and sensitive in dealing with the theories of nuclear physics and the scientists pay a lot of attention to their application. However, Americans are not so careful and many American scientists are quite enthusiastic about studying nuclear bombs. Theories show us one side of reality not the whole. The theories are not an absolute. How a man understands a theory is influenced by his subjectivity. This proves that science supported by theories does not give the same sense to us.

Everett Mendelsohn states;

> The human approach to understanding, explaining and interacting with nature has certainly not been uniform through time, nor across cultures. It has not even been the same for all groups or classes within a single culture or society. Indeed, these very differences, appropriately studies, can provide the basis for a deeper understanding of the role of science within a society or culture.(31)

In summary, science is not the reflection of existing matter. How do scientists observe truth and how do they get their objectivity? Where is a

scientist's subjectivity? Science stands on the dynamic relationship between humans as a subject and nature as an object. This is to say, a scientist can know the reflection of an object through his subjectivity, so it is impossible to separate the subjective side from the objective side even in science.(32) The subject and object are not opposed to each other, on the contrary they are closely related. We can define that scientific recognition is a personal recognition. Perception of one science varies according to the people involved.

I mentioned above how we see, how we feel, and how we understand a scientific object and how these are influenced by subjectivity. Because subjectivity is not to be separated from science, perceptions of science differs between groups. How Western people see modern science is evidently different from how, for example, the Middle Eastern people see it. Next I will examine about what scientific problems we take, how we approach them and what knowledge we obtain. I want to show that science is firmly rooted in cultural and social influences, so one culture or society has its own science. Mendelsohn defines science as social activity as follows;

> Science is an activity of human beings acting and interacting, thus a social activity. Its knowledge, its statements, its techniques have been created by human beings and developed, nurtured and shared among groups of human beings. Scientific knowledge is therefore fundamentally social knowledge. As a social activity, science is clearly a product of a history and of processes which occurred on time and in time and in place and involved human actors. These actors had lives not only in science, but in the wider societies of which they were members.(33)

In the process of establishing one scientific answer, the choice of problems, the choice of design of solving, the choice of explanation, all involve values of society. As a premise of all decisions, the basic priori implicit perceptions a scientist has beforehand are important. The basic knowledge has been built mostly by education. The syllabus in teaching is presented as if there is no question about the choice of subjects. However, when a teacher wishes to take a subject, his principle of selection are determined partly by consideration of feasibility, but even more by the consideration of value and ethics prevailing in a society.(34) Eventually, even primary scientific knowledge is somewhat influenced by society.

When a scientist chooses a problem, which is not at the level where answers are easily attainable through calculations and/or collection of data, but are

rather at a level where questions remain unanswerable, like energy problems or organic transplant problems, social and cultural values come in. Members of a social and cultural group may have their own basic problems of man vis-a-vis their particular circumstances to some degree. The selection of areas for research are socially and idealogically influenced in various degrees. The case where a problem is serious for a group but not for others is common in the scientific world. The scientific choice of problems involves dimensions of values, some of which are intrinsic to an individual and some of which are external of neighbouring fields such as culture and society.(35)

The methods of reaching the answer also vary. Mendelsohn indicates that the techniques for the proper study of science as a human activity will encompass the historical, sociological, and socio-psycological factor and be comparative in mode.(36) How a scientist thinks about a problem decides the design of experiment. If a scientist thinks a problem is important and serious, he needs a higher significant level of examination. He has to take a larger size of sample and probably go through a more lengthy, laborious, and careful testing procedure. And the style of solving a problem

influences the final scientific products a great deal.(37)

I mentioned the process of sciénce from basic knowledge and the selection of problems, to the design for solution. In every stage, the presence of some values is undeniable. After all, what scientists find is peculiar to themselves. In scientific investigation, the subjectivity cannot be put aside in the final analysis. Therefore, it is natural that people within a particular culture and society have their original science and technology. However high and abstract a level scientific activities reach, they begin and grow up in the society. Science, values, and institutions are related deeply and build the framework of civilization and the civilization is one of adjusted systems. Sardar mentions the influence of culture on science as follows:

> Science is a cultural phenomenon. Every culture has a view of the natural world, of society and of knowledge--be it conscious, or unconscious, well-articulated or incoherent. As all cultures consider the basic problems of man and exhibit rationality to some degree, they have some kind of science. It would seem that occidental culture contains the most rational of sciences. But other cultures have had their sciences at the zenith of their civilization.(38)

It is also useful to review the collapse of value-free feature of technology which has been dominant until so recently. Technology is not neutral. Technology reflects and defines the relation of producers to products, of workers to their works, of an individual to groups and society, and of human beings to the environment.(39) An example illustrating violating value-free characteristic is the failure in industrialized countries' transforming technology to developing countries. Spengler thought that modern technology was the original product of the Occidental civilization and an expression of its culture, so it was difficult essentially to transfer the Occidental technology to different cultural areas. If the other world had some similar development process of culture to the European one, he thought European technology would develop there to a certain extent. However, his concept seemed to be heresy in his day.

Is his concept still unacceptable today? Careful import of technology seemed to promote the fulfillment of needs of the Third world. However, we know some cases that the Third world countries did not accept some Western technology because it did not coincide with their cultural background. These countries were aware that they could not become familiar enough with

technology of other cultures. That is because science and technology are essentially a cultural activity.(40) For example, the scientific development pursued with an intent to perpetuate certain bigotry, like eugenics and sociobiology will never be accepted in the Islamic world(41), because that developments are extraneous to the Islamic culture. Al-Attar advises engineers in the Middle East as follows;

> Today, it is no longer sufficient for technological problem-solvers to consider only the technical aspect of problem they are facing, they must integrate them with the social and cultural dimensions of the problem.(42)

In both scientific recognition and investigation, the subject side is inevitable. The subjectivity is social and cultural bound because human subjectivity is established socially and culturally. Understanding, knowledge, methodology, process, technique, culture, society, and environmental context cannot continue to exist separately as far as scientists are concerned.(43) There is no divorce of science and technology from the values of a society and culture and never has been. Particular theoretical ideals and particular types of knowledge are consistent with particular social arrangements.(44) It is impossible

for a scientist to put science apart from social concern.

I will introduce the thinking of a science-philosopher, Michael Polanyi. He deals with personal coefficient in area of science, in the book of "Personal Knowledge." The personal coefficiency shapes all factual knowledge and bridges the disjunction between subjectivity and objectivity. It means "that a man can transcend his own subjectivity by striving passionately to fulfill his personal obligations to universal standards."(45) He deals with object-subject matter more deeply and clearly in his other book "The Tacit Dimension." Generally speaking, human beings can know something by language. So, it seems impossible to recognize something without language. However, Polanyi touches the importance of non-linguistic knowledge.

His premise is that we know more than we can tell. One example which proves it is the distinction of face. Suppose one knows someone's face, he can find that face among some thousands of pictures. Nevertheless, he can not tell how he recognizes it, and he cannot express this in words. This unrepresentable knowledge is the tacit knowledge Polanyi defines.

It has been declared that the purpose of modern science is to establish objective knowledge which does

not include subjectivity at all. The process not following this ideal seemed to be a temporarily permitted imperfection which we had to make efforts to remove. Polanyi states,

> But suppose that tacit thought forms an indispensable part of all knowledge, then the ideal of eliminating all personal elements of knowledge would, in effect, aim at the destruction of all knowledge. The ideal of exact science would turn out to be fundamentally misleading and possibly a source of devastating fallacies.(46)

When we want to know something, for example, a frog in detail, we have to grasp the image and feeling of frog in mind through experiencing it through by tacit knowledge first. The scientific and mathematical meaning of frog exist in the relation between the theory and the understanding of frog by tacit knowledge. Similarly, "a true knowledge of a theory can be established only after it has been internalized and extensively used to interpret an experience."(47) Theories can be acquired meanings depending on prior tacit knowing, and can function within an act of tacit knowing which consists in our attending from the theories to the previously established experience on which it bears.

The most important concept that Polanyi contends

is that one knows more than he can express in words. Most of this tacit knowledge was formed through his experience and such knowledge has a great role in the understanding of scientific objects and theories.

Next, I will examine some aspects of Islamic culture which provides a socio-cultural set up for Islamic science.

Note

(1) S. Parvez Manzoor, "Environment and Values," The touch of Midas, (London: Manchester University Press, 1984), pp.150-151.

(2) R. J. Forbes and J. E. Dijksterhuis, A History of Science and Technology, Trans. Testu Hiroshige, Hisashi Takahashi, Shigeko Nishio, and Aiko Yamashita, (Tokyo: Misuyu Shobo, 1977), p.2.

(3) Ibid., pp.241-242.

(4) Jacques Ellul, The Technological Society, Trans. John Wilkinson, (New York: Vintage Books, 1964), p.8.

(5) Ellul mentions more that the relation between science and technique becomes even less clear when we consider the newer fields, which have no boundaries. In modern psychology and sociology, what can we call technique since in the application of these sciences everything is technique? But it is not application which characterizes technique, for without technique, science has no way of existing. If we disown tecqunique, we abandon the domain of science and enter into that of hypothesis and theory.

(6) Susumu Sato, Kagaku Gijutsutowa Nanika, (Tokyo: San'ichi Shobo, 1982), p.84.

(7) Yoshiro Tamanoi, Seimeikeino Economy, (Tokyo: Shinpyoron, 1982), pp.122-123.

(8) Ellul, p.10.

(9) J. R. Ravetz, "Science and Values," The touch of Midas, p.47.

(10) Sato, p.69.

(11) Ellul, p.114.

(12) John O'Neill, Five Bodies, (Ithaca: Cornell University Press, 1985), p.95.

(13) Ibid., p.102.

(14) Manzoor, p.152.

(15) Eric Ashby, Reconciling Man with the Environment, (London: Oxford University Press, 1978), p.4.

(16) Manzoor, p.150.

(17) Seyyed Hossein Nasr, The Encounter of Man and Nature , (London: George Allen and Unwin LTD., 1968), p.18. Furthermore, it is the same dominion of nature, limited to external nature and coupled with giving complete freedom to the animal nature within man, that has made the problem of war so crucial, war which seems unavoidable, yet because of its total and almost cosmic nature brought about by modern technology, must be avoided.

(18) Tamanoi, p.15.

(19) Jinzaburo Takagi, Imashizen'o Domiruka, (Tokyo: Hakusuisha, 1985), p.20.

(20) Ibid., pp.20-21.

(21) Manzoor, p.152. He refers to the thesis of Lynn White Jr, ("The Historical Roots of Our Ecological Crisis," Science 155:1203-7, 1967). White puts forward the thesis that the roots of our ecological problems are to be found in the Judaeo-Christian ethics. Man, in the Biblical tradition, is above nature. He is a special creation of God and has been commanded to have dominion over nature.

(22) Syuntaro Ito, Bunmeiniokeru Kagaku, (Tokyo: Keiso Syobo, 1976), p.29.

(23) Kei Takebe, Kagaku Shiso Joron, (Tokyo: Hakubunsha, 1967), p.153.

(24) Sato, p.27.

(25) Michael Polanyi, Personal Knowledge, (Chicago: The University of Chicago Press, 1962), pp.15-16.

(26) Sato, p.25.

(27) Ibid., p.25.

(28) Ziauddin Sardar, Science, Technology, and Development in the Muslim World, (London: Croom Helm, 1977), p.23.

(29) Polanyi, p.4.

(30) David Bohm, Fragmentation and Wholeness, Trans. Masahiro Sano, (Tokyo: Kosakusha, 1985), pp.20-23.

(31) Everett Mendelsohn, "The Social Construction of Scientific Knowledge," The Social Production of Scientific Knowledge, (Boston: D. Reidel Publishing Company, 1977), p.4.

(32) Sato, p.101.

(33) Mendelsohn, p.4.

(34) Ravetz, p.46.

(35) Ibid., p.46.

(36) Mendelsohn, p.4.

(37) Ravetz asserts the influence of values in the contents of knowledge. It may be easy to argue for what I have called the social construction of ignorance. Ignorance is socially constructed very easily, very commonly, in terms of the values and political forces which determine what is desirable to know and also what is fit to print.

(38) Sardar, p.28.

(39) Andre Gorz, Ecologie et Politique, Trans. Taketomo Takahashi, (Toko: Gijututo Ningen,

1980), p.28.

(40) Mohamed S. Al-Attar, "Forword," Technology Transfer and Change in the Arab World, (London: Pergamon Press, 1978), p.xi.

(41) Ziauddin Sarder, Science and Technology in the Middle East, (London: Longman, 1982), p.23.

(42) Al-Attar, p.xi.

(43) Mendelsohn, p.3.

(44) Richard Whitley, "Changes in the Social and Intellectual Organization of the Science," The Social Production of Scientific Knowledge, p.143.

(45) Polanyi, p.42.

(46) Michael Polanyi, The Tacit Dimension, (New York: Doubleday & Company INC., 1966), p.20.

(47) Ibid., p.21.

Chapter II.

Knowledge and Values of Islamic Science and Technology

In the Middle Ages, the whole Islamic world reached its apogee and built high levels of science and technology. Islam abolished the borders isolating countries so that the whole area had one religion, world view, and scientific language. Indeed, Arabic which spread from Baghdad to Cordoba was not only the language of Revelation but also of science.(1) Glyn Ford mentions,

> If science is not the unique intellectual construct and if the history of science is not the history of iterative movements toward the truth about the natural world but rather the history of various social construction of reality mediated through science, scientists and society, then there exists the possibility of an Islamic science that will be one facet, or more likely a series of facets, of a multi-dimensional world of nature, all of which are imbued with the very essence of Islamic society.(2)

Cultural strength must be one factor in a strategy for science development. Moreover, Islam, without which probably the Arab Renaissance might not have occured, is another factor promoting science. Islam is a total system. It is a religion, as well as a culture, a civilization all at once. Furthermore, it is a holistic system touching every aspect of human behavior. Islamic ethics and values penetrated all human activity including science and technology.(3) Nasr says,

> No serious study of the Islamic science can thus be carried out without some reference, no matter how brief, to the principle of Islam and conditions, created intime and space by Islam for the cultivation of the science.(4)

Islam is a very strong supporter of original science and has a definite philosophical and methodological perspective on science and technology.

Islam has different assumption about the relationship between man and nature, universe and space from modern science so science based on Islamic assumptions would be an entirely different proposition. In this chapter, I will inquire into Islamic philosophy, thoughts, criterion, view of nature, and scientific subjectivity which affected how Muslims perceived

science and technology, and what kind of science and technology they built.

A. Islam and science

In the Middle Ages, there was the apparent conflict of science and religion in the West. Some of the causes are thought to be the ignorance of Christianity to science and enclosure of religion by itself. Christianity had a dualistic grasp which led to the advancement of religion vis-a-vis science. An inmate of a monastery could not read a book about nature until the thirteenth century in France.

Such historical experiences were indifferent to Islam because science and religion are two sides of the same coin in the Islamic world-view.(5) Islam does not differentiate between matters of state and matters of religion. The pursuit of knowledge in Islam can prove the link between science and religion. The Qur'ān has many topics on scientific interest to persuade Muslims to think and to investigate nature. On every page the verses suggest that mankind gained knowledge through critical recognition of God's sign.(6) The Qur'ān for example, says

> Say: "Behold all that is
> In the heavens and on earth"
> But neither Signs nor Warners
> Profit these who do believe not. (7)

Muslim felt that they had to open the door of ignorance by widening knowledge. "The pursuit of studies, research, application, practice, or management of an Islamic science or technology must be recognized as being as Islamic."(8) Prophet Muhammad demanded all Muslims to make efforts to pursue knowledge as religious duty('ilm). He said that the Muslim had to look for "'ilm" from birth to death because a man who made such efforts prayed to God and he was regarded as very faithful in the eyes of God. Making a study is as valuable as fast, and teaching is as valuable as praying. To study the wonderfulness of creatures is to deepen one's faith in God as a Muslim.(9) Franz Rosenthal expresses the concept of "'ilm" when he says that;

> Qur'ãnic 'ilm has the religious connotation of acknowledgment of the premises of religious existence and acquaintance with the religious duties of Muslim, and the word soon came to refer specifically to knowledge of Islamic religious doctrines and obligations.(10)

The object of man's appearance in the Islamic world is

in order to obtain total knowledge of creatures and to become the universal man. What a Muslim gains through intellectual endeavors is power over natural phenomena. It is one of God's greatest gifts that He created man with a spiritual love for science and technology.(11)

Islamic teachings have moreover exhorted Muslim people to exceed their previous visions of technological and scientific narrow confines. Therefore, wherever knowledge came, a Muslim could receive it. The teachings helped Islam attain various sciences and technologies from other civilization like Greece, China and India, even though the religions were different. Muslim were very generous toward heretics. The translation and the technology transfers contributed to the cultural development. The translation of classical science, philosophy and humanistic-social science were one of the primary vehicles of Islamic assimilation of alien science and technology. The central position of "'ilm" in the Islamic world and the faith to religion made the translation and the transfer activity scholarly and effective.

According to Qur'ān, it is not for everyone to be able to read the "book" of the universe. The Qur'ān regards only men of knowledge as being able to discern the majesty and magnificence of God's creation and as

having the humility provided by their knowledge of Divine power and greatness.(12) Moreover, Qur'ān emphasizes the study of natural phenomenon and scheme of creation, because the knowledge of the laws of nature and feature of things can be useful in improving the condition of human life. It allows believers to use knowledge to uncover riches and resources in nature and to achieve material advacement through his scientific discoveries.(13) The indisputable fact remains that traditional Islamic science and technology would not have existed if it had not been for Islamic persuasion for Muslims.

The central theme of the Qur'ān is the Almighty and His Creation and the Book of ethics and values concerning humanity and social science. It also touches on scientific facts concerning geophysics, biology and other natural sciences and technology not by abstract philosophical argument but by very scientific explanations. There is no essence of God in a human being but God indicates to him that God has direction for his intentions. Similarly, Qur'ānic verses remind readers that God has given them all the ability and the necessary faculties to understand and evaluate natural phenomenon.(14) The verses are regarded as a "Guiding Light" leading Muslims to the

right path of knowledge.

Some of the verses concerning scientific topics in the Qur'ãn are as follows:

> It is He who made the sun a radiance,
> and the moon a light,
> and determined it by stations,
> that you might know the number of years
> and the reckoning.
> God created that not save with the truth,
> distinguishing the signs to a people
> who know.
> In the alternation of night and day,
> and what God has created in the heavens
> and the earth-surely there signs
> for a god-fearing people.(15)

We can understand from the above verses that although God is the central theme He never gives us a definite and figurative description. However, the Qur'ãn speaks of His ãyats, signs, around us and bestows scientific values to ãyats. Ãyats are a clue to contact with creatures and an indication showing what truth is. Muslim scholars touched and understood the truth when they did not neglect or make little of the ãyats but rather observed, investigated, and analyzed ãyats with scientific attitudes.

On the Qur'ãnic approach to science, Islam has not asked man to pursue knowledge for only science's sake, nor only to believe that pursuit is an end. The Islamic scientists were not allowed to stop a science

even when they found a good answer, because scientific activity is also a means for the attainment of higher and more enlightened goals. Knowledge was far from being enjoyed as an end in itself. In Islam, there is no difference between the means and ends of science. Both are subject to the ethical and value aspects of Islam. M. Husain Sadar remarks;

> the opinion of those who argue that science must be allowed to pursue its own course, without any consideration for the problems of mankind or ethical and value criteria cannot be reconciled with Islamic dictate that both means and ends of science must submit to Qur'ãnic ideals.(16)

From this point, the pursuit of knowledge could not be abused nor lead to harmful effects in the Islamic world.

All Islamic activities have both personal and social aspects in its world. Muslim have to keep knowledge not only for gain of an individual but also for that of Ummah, the entire Islamic community.

Ummah is a Muslim community where a number of individuals come to together in harmony with the intention of advancing and moving toward a common goal. Most important is the interrelationship between each existence.(17) All Muslims are linked in a single bond

within the Ummah. The definition of "us" for a Muslim, with respect to others within the Ummah, goes beyond the link of family, race, or geography.(18) Islam holds vertical relationship between man and God, that is worship, as well as a horizontally organized relationship among believers which ties each together in a tight binding. A Muslim is responsible even for others' fate in a Ummah. The relation between an individual and Ummah is that an individual does not suffer from domination or corruption of the Ummah and that he is not allowed to destroy the harmony of the community. Islam requires Ummah to settle the humane and fair public order and to give the chance for an individual to achieve all kinds of developments. Islam requires an individual to construct a dynamic and harmonized community of Ummah.(19)

M. Ali Kettani remarks about the role of knowledge as follows;

> Knowledge was considered by scientists to be a trust of God to a person, who should use this conscientiously. This meant that their knowledge had to be used for the good of the community and had to be transmitted to others. As such, both their ways of doing science as well as the final product of their endeavor were dictated by the value system of Islam.(20)

The pursuit of scientific knowledge is not only to understand nature through signs but also to serve the community and to protect and promote its ethical and moral institutions. Although science is an essential activity for Islam, Muslim cannot use science simply to observe and understand nature, but at the same time, they make use of it for the community. A scientist belonging to an Ummah has to consider what his study contributes to the Ummah. A personal life's quest for science is the same as that of the whole Ummah. The purpose of a scientist in an Islamic approach is to bring benefit to himself as well as to the community. Kettani mentions;

> In using science for the development of ways and means to controlling the forces of nature, the guidelines to Muslim is to seek the good of the community.(21)

B. Wide knowledge

Christianity in medieval times not only subordinated matter to the spirit and condemned the secular, but also discriminated against the real world with a segmented view. Philosophy which seemed to hold an upper class to science, was interested in the sacred and spiritual aspect, meanwhile, science which was

quite distinct from philosophy, was interested in the secular and material aspect. Unlike Christianity, Islamic theology of the same period did not have the concept of dualism and hierarchy so that reaching the truth of the matter was not divided from that of spirit. No wall can be seen between both studies. The continuity from natural science to metaphysics is firmly supported by Islam. The reason is that all existing things hold the same origin, originating from God, and hold the same qualification. This idea is the concept of tawhīd which I will define later.

The continuity was to be found in the past culture of Islam. The unity of spirit and matter was a basic perception on which the knowledge of science sought to co-exist with theology and philosophy. Scholars, in the Middle Ages, were interested in science and technology as well as in philosophy. As the purpose of man's appearance is to gain a wide knowledge of all things, according to Islam, science could not develop without involving philosophical accomplishments. It was not unnatural for a scholar to be a scientist as well as a philosopher. Some of the scholars were acknowledged for succeeding in the study of both spirit and matter. "The physician, for example, might also be a mathematician, a poet, an astronomer, a

musician, a linguist, a chemist, a philosopher, or a theologian."(22) For instance, Ibn-Sīnā was most illustrious in Arabic medical annals but he was also a famous physician, a philosopher, and a poet. A modern bibliography lists under his name over two hundred titles, dealing with philosophy, medicine, geometry, astronomy, theology and art.(23)

Medieval technology and science in Europe advanced independently so technology had not been interested in the result of science, nor had science been interested in technology. On the other hand, at the same time in Islam, there was no hostility between practical technological studies and real theoretical studies, rather they were in close connection.(24) The Arabs thought of technology as a legitimate branch of science. "Muslim scholars did pay due respect to all kinds of practical knowledge, classifying applied science, and technological subjects alongside theoretical studies."(25) Mathematics was applied to methods of calculation. Surveying was much developed by the contribution of geometry and astronomy so much so that astronomers performed great operation of measuring the length of a terrestrial degree.(26) It is common to find scholars who made their name as both scientists and engineers. For example, Al-Kindi was a

physicist as well as a metallurgist and an engineer, and Al-Razi was a chemist and an engineer as well as a physician, and Ibn al-Haytham was a mathematician, physicist and engineer.(27)

Science was useful for testing technological inventions. Muslim engineers were not left free to innovate technology in their own way but were required to consult with scientists. Furthermore, technological developments were always examined in full and discussed enthusiastically by doctors and philosophers.(28) The link of science and technology was necessary for Muslim scholars to inspect whether innovations were desirable or not for the community.

The Arabs aquired ancient Greek sciences and advanced them. The methods of experiment had been disdained in Greece, because the Greeks had prejudice against people who performed physical labor. There was a hierarchy. However, Islam was successful in rising above it. Islamic civilization developed objective experimental and operational procedures. In the Middle Ages, especially knowledge concerning chemistry and alchemy were increased with the help of experimentation. Muslims made new scientific methods by reforming old theories and adding, examining, and experimenting with traditional procedures. Muslim

scholars not only maintained ancient sciences, but also brought about new methods and opened the ways for modern science.

Here, I will state the concept of tawhīd, the most basic principle. In Islam, tawhīd remains at every level of Islamic civilization so science and technology hold also the concept of tawhīd. It is said that the Islam is the religious teachings of tawhīd. This spirit prescribes the absolute existence of God and means the absolute unity of God. All creatures are created by God and have the same origin. No creature on the earth can exist alone and each existence is caused by the others. The most important point is that all creatures are equal before God. Thus, it is not allowed for one creature to be superior to or to discriminate against others. God is the direction toward which creation moves, and He determines the goal of the universe.(29) Tawhīd also encompasses the unity of man's personality. The personality can not be divided into temporal and spiritual phenomenon. Both are only two facets of one single aspect. More important is to put this concept of tawhīd into practice. Because Islam has no concept of dualism and pluralism there was no separation between the preachings of theology and philosophy and what science

invented. Both studies have different roles and functions and complement each other. The same rank of spirit and matter was the essence of continuity of philosophy and science. Tawhīd does not admit hierarchy either. The lack of hierarchy between scientists and physical labor made the co-operation of science and technology possible.

I will look into typical Islamic philosophy which indicates Muslim's essential attitude to nature next.

C. The unification of the cognition and the cognizable

Modern Western scientists' attitudes to nature is that they objectify nature apart from themselves. Enclosing themselves, they try to observe aspects of nature. Nature is an object for a human being to be solved by his reason, and to be used for his benefit. As regards the matter of the cognizant and the cognizable, the knower and the known, the cognitional object exist completely independent of the cognitional subject. This position cannot guarantee the conformity of the knowledge and the knowable, "because cognition in the cognitional subject is dependent on the cognitional object, while this cognitional object is standing ontrogically outside the consciousness of the

cognitional subject."(30) Applying this idea to science, scientists can not conform what they know about nature completely because their consciousness stands apart from reality. This separation leads to the alienation of man and nature so evident in toaday's world.

In contrast to the Western view, Islamic philosophy embraces ontological continuity between the subject and object in the theory of the unification of the cognizant and the cognizable based mainly on Allamah Qazwini's philosophy. In his philosophy, the unification can happen between the cognizant and "the essential cognizable" which is understood as the form identical with the external reality on the level of its own essence. The unification means the unification of two things which are a continual state like the identity admittable between a thing in potentiality, and a thing in actuality. When the essential cognizable occurs in the soul of cognizant, the cognizant changes into the state of actual cognizant from possible cognizant.(31) Qazwini insists that those who maintain the unification of the cognizant and the cognizable in the intellection of the reality of things, are right, because both the concept of the cognizant and that of the cognizable exist

together in an external existence as well as in a mental existence. "In the consciousness, the representation of the concept of the cognizant and the representation of the concept of the cognizable will be achieved at the same time and to the same one degree."(32) They are always corelative.

From view of Qazwini, it seems that Islamic philosophy preserves the continual relation between human beings and nature. The relation leads to the union of consciousness and reality. In Islamic science, an observer does not see nature as only an object nor has he recognized it as something which he should conquer, rather he feels nature close to himself. As faithful Muslims conforming to the basic principle have not regarded nature as apart from themselves, they have not destroyed or exploited nature rapidly. What Muslims found is accumulated intellectually in themselves to improve themselves as a human beings, whereas since the holder of knowledge is separated from nature in the West, what is scientifically found is easily applied to industrialization. As Islam and nature have compensated for each other in the real Islamic world, the Muslims have not felt the alienation which is so common in the Western world. The philosophy of Allamah

Qazwini is suitable for understanding Muslim's thought and attitude towards nature.

D. View of nature in Islam

Islam has had its own view of nature in its association with nature and this has influenced Islamic activities. Especially some of their sciences and technologies were completed and complimented by their view of nature.

The most remarkable feature of their view is the harmony and equilibrium between man and nature. The tawhīd in its very essence says that God, nature, and man have the same will, self-consciousness, thought, purpose and life, and that these three are unified.(33) Ali Shariatis states,

> Tawhīd is to be interpreted in the sense of unity of nature with metanature, of man with man, of God with the world and with man. It depictes all of these as constituting a total, harmonious, living and self-aware system.(34)

In Islam, there is no contradiction between man and nature. This idea affected the Muslims' attitude toward nature. We can find the harmony between man and nature in the particular Muslim traditional technology

of their habitat, agriculture and energy technology. Their technology in the Middle Ages does not give us a sense of aggressive destruction of nature and unilateral reaping of natural resources. Rather they were trying to establish harmony with nature and with the environment. Most of the houses maximizing the use of natural material, were keeping balance with the landscape and using natural forces such as wind, light, and water for life. With the respect of resources, Muslims keep in mind to preserve as much resource as possible so as not to disturb the environment. From this sense, re-cycling was a prevalent theme in old the Islamic world. Forests were destroyed and topsoil was removed in agriculture, but this tendency was on a small scale and seemed unusual in the Middle East with the prevalent manner of living in harmony with nature.(35)

The traditional sciences also impress us with the equilibrium of man and nature. There are many applications of cosmological principles. Nasr states Islamic sciences as follows:

> If Islamic sciences serve the various needs of man's terrestrial life and make possible his living in harmony with his natural environment, they are also means whereby man can journey across the level of cosmic manifestation to attain ultimate freedom.(36)

Based on this view, Islamic medicine defined the health, as the condition which is keeping the balance between human body and nature, and between the body and spirit. Interests of a physician was thus how to keep the balance and how to lead to a natural recovery.

The value of harmony defines human roles vis-a-vis other creatures. The basic pattern of the will of God is manifest in the whole order of nature.(37) Muslim regard the God-made cosmos as a harmonized unity under which every existence has to accomplish its own role. All creatures should live harmoniously constituting the total cosmos. A Muslim is not allowed to destroy other existences, but rather he must live in harmony with them. As man and environment are indivisible, to keep symbiosis with nature takes roots in the Muslim mind. The traditional cosmological science provided view of nature as well as helped in a direct manner to protect nature by letting Muslims know where they are in the cosmic order.(38) In the past, scientists devoted themselves to studying plants and animals not because they wanted to know how they eat or how they use effectively, but because they wanted to discover how they exist together in a harmonic balance.

Western people think it possible to possess nature

in general, and have changed it for commodities for long. However, in Islam, ownership in its usual meaning is rejected. As it is God who gives creatures to the world, He is recognized as the owner of the world. Natural resources, land, and crops are all consigned goods from God. Human beings are only an administrator of these benefits, socially and personally. The Ummah plays an important role in dealing with things in society. In the case that it is necessary to protect social benefit, Ummah puts some limits on the individual's desire to possess things, because to complete a dynamic Ummah is the Muslims' final goal.(39) An individual has freedom to own something, but society sometimes limits his exercise of this freedom. The Islamic perspective is interested in the welfare of the individual as well as society. Ayatullah Sayyid Mahmud Teleghani explains about ownership of natural resources as follows;

> The right to the ownership and distribution of products made from natural resources is based on the right to the disposition and distribution of natural resources, so as to ensure that the earth and all its natural resources belong to everyone. These rights are upheld only insofar as they do not injure the general welfare.(40)

To put some kind of a limit is the most striking

difference concerning ownership.

An individual can own nature, but this right is controlled by society. What he can obtain from nature should be beneficial both for him and his society. For a Muslim, to protect himself means to protect others and the environment. From this point, the situation of unilateral reaping of resources does not arise. The machines which consume large amount of energy were indifferent to traditional Islamic technology. Faithful Muslim do not assert the exhaustion of resources.

Note

(1) Edward J. Jurji, "The Course of Arab Scientific Thought," The Arab Heritage, (Connecticut: Hyperion Press, INC., 1981), p.224.

(2) Glyn Ford, "Rebirth of Islamic science," The touch of Midas, (London: Manchester University Press, 1984), p.35.

(3) Ziauddin Sardar, "Islamic and Western approaches to science," The touch of Midas, p.4.

(4) Seyyed Hossein Nasr, Islamic Science, (London: World of Islam Festival Publishing Company LTD., 1976), p.3.

(5) M. Husain Sadr, "Science and Islam," The touch of Midas, p.15.

(6) S. Waqar Ahmed Husaini, Islamic Environmental Systems Engineering, (London: The Macmillan Press LTD., 1980), p.6.

(7) Quran [10: 101]

(8) S. Waqar Ahmed Husaini, Islamic Science and Public Policies, (Kuala Lumpur: City Reprographic Service, 1986), p.22.

(9) Sigrid Hunke, Allahs Sonne Über Dem Abendland, Trans. Toshikazu Takao, (Tokyo: Misuzu Shobo, 1982), pp.202-203.
Furthermore, M. Husain Sadr mentions, as follows: (The

touch of Midas, p.18.)

> The Prophet Muhammad repeatedly and very eloquently emphasized the importance of acquiring knowledge. Some examples from Hadith are as follows: Acquire knowledge, it enables its possessor to distinguish right from wrong; it lights the way to heaven. It is our friend in the desert, our company in solitude and companion when friendless. It guides us to happiness, it sustains us in misery, it is an ornament amongst friends and an armour against enemies. To seek knowledge is a duty of every Muslim.

Similarly

> the forth Calif Ali Ibn Talib, advocated as follows: Knowledge is the legacy of the prophets, wealth is the inheritance of the pharaohs. Therefore knowledge is better than wealth. You are to guard your wealth but knowledge guards you. So knowledge is better. A man of wealth has many enemies, while a man of knowledge has many friends. Hence knowledge is better.

(10) Franz Rosenthal, The Classical Heritage in Islam, (Berkeley: University of California Press, 1975), p.5.

(11) Ibid., p.63.

(12) Mahdi Gulshani, "Science and the Muslim Ummah," Al-Tawhīd, A Quarterly Journal of Islamic Thought and Culture, Vol.I, No.1 (Teheran: Islamic Propagation Organization, Muharram 1404), p.122.

(13) Ibid., p.124.

(14) Sadr, p.20.

(15) Quran [10: 5-6]

(16) Sadr, p.24.

(17) Hideko Iwai, Islamic Society and Woman in Islam, (Niigata: The Institute of Middle Eastern Studies, International University of Japan, 1985), p.29.

In the same way, the Universal Islamic Declaration of 1980 describes the importance of establishing Ummah as follows:

> Whereas Islam enjoys the Muslim Ummah to establish a just and humane world order, providing every

opportunity to the all-round development of man and society in an environment free from all forms of exploitation and inequality; and
Whereas the Muslim Ummah is duty-bound to fulfill its covenant with Allah by establishing the Islamic order and translation into practice the ideals and translation into practice the ideals and principles of Islam in its own life, thus presenting the message and model of Islam to others. (Allahbukhsh K. Brohi Islam and Contemporary Society, London: Longman Group, 1982 p.255.)

(18) Ali Kettani, "Science and technology in Islam," The touch of Midas, p.85.

(19) Ziauddin Sardar, Science, Technology, and Development in the Muslim World, (London: Croom Helm, 1977), p.53.

(20) Kettani, p.86.

(21) Ibid., p.67.

(22) John S. Badeau, "The Arab Role in Islamic Culture," The Genius of Arab Civilization, (Massachusetts: The MIT Press, 1983), p.173.

(23) Philip K Hitti, History of the Arab, (London: The Macmillan Press LTD., 1970), p.368.

(24) Syuntaro Ito, Bunmeiniokeru Kagaku, (Tokyo: Keiso Syobo, 1976), pp.36-37.

(25) Ahmad Y. al-Hassan and Donald R. Hill, Islamic Technology, (Cambridge: Cambridge University Press, 1986), p.263.

(26) Ibid., p.263.

(27) Ibid., p.265. He mentions other examples that the Banu Musa brothers were mathematicians and astronomers in addition to being engineer and al-Biruni as astronomer, physicist and engineer.

(28) J. D. Bernal, Science in History, Trans. Yasuo Shizume, (Tokyo: Misuzu Shobo, 1976), p.273.

(29) Iwai, p.24.

(30) Akiro Matsumoto, "On the Theory of the Unification of the Cognizant and the Cognizable," Bulletin of the Institute of Middle Eastern Studies, (Niigata: The Institute of Middle Eastern Studies, International University of Japan, 1986), pp.38-39.

(31) Ibid., pp.42-44.

(32) Ibid., p.52. in Appendix of op. cit "A treatise on the Unification of the Cognizant and the Cognizable" by Sayyed Abu-Hassan Rafii Qazuwini.

(33) Ken'ich Hayama, Dr. 'Alī Sharī'atī's Revolutionary Ideology and the Role of the Rouahanfekr in Social Change, (Niigata: The Institute of Middle Eastern Studies, International University of Japan, 1985), p.13.

(34) 'Alī Sharī'atī, On the Sociology of Islam, Trans. Hamid Alger, (Berkeley: Mizan Press, 1979), as mentioned in Iwai, p.24.

(35) Nasr, p.227. He mentions that, there is, in fact, a feeling that, had it not been violently disturbed from the outside, the system inter-relating man and his environment in the Islamic world could have continued indefinitely, that the relations between nomadic and sedentary life, between agriculture and technology, between using the resources of nature and catering to nature's needs formed the life-providing rhythm within a living organism whose stability was guaranteed by the order, harmony and complementarity of these elements.

(36) Ibid., p.235.

(37) Husaini, Islamic Environmental System Engineering, p.2.

(38) Nasr, p.237.

(39) Takuma Abe, A Comparative Study of Islamic Ownership, (Niigata: The Institute of Middle Eastern Studies, International University of Japan, 1987), pp.52-53.

(40) Ayatullah Seyyid Mahmud Taleghani, "Society and Islamics," Campell, (Berkeley: Mizan Press, 1982), as mentionsed in Abe, p.27.

Chapter III.

Traditional Islamic Science and Technology

Islam attained its most brilliant period of cultural life and a very high level of science and technology in the Middle Ages, while European countries had to wait some centuries to catch up with the precedent culture. What made this age especially famous is the fact that it expressed the most momentous intellectual awakening in the history of Islam and one of the most significant in the whole history of science and technology.

People in the Middle East did not have prominent science and technology until Islam was presented. Starting with little heritage, Muslims developed their own culture with a keen sense of intellectual curiosity and an appetite for pursuing knowledge.(1) The curiosity and appetite went beyond the boundaries of Islam, and Muslims studied other cultures such

as Greek, Indian, and even Chinese cultures. Islam succeeded for the first time in the history of human thought, in harmonizing and reconciling monotheism with other cultures. It is possible to say that the Muslims became the beneficiaries of older and more cultured people whom they encountered and concurred with.

Although Muslim accomplished the very rich in science and technology, their great works have been largely neglected in historians of science and technology. The Euro-centric views of the history of science was that science had its origin in ancient Egypt, Babylonia and Phoenicia, and that from these science passed through Greece and returned to the Middle East in the form of Hellenism. This flow was then re-diverted into Europe through the Arabs.(2) It is evident from history that peculiar science and technology existed in the Middle East and that it contributed much to the Renaissance in Europe. It was not a mere mediation of civilization from Greece to Europe. Whoever has touched the history of the Middle East ought to know that the Abbasid Dynasty, reigning from the eighth century to the eleventh century, was the most celebrated and longest-lived Islamic dynasty and the highest level of Islamic civilization. Actually, Islam created the Golden Ages,

in contrast, favorably, with the Italian Renaissance.

In spite of the existence of Islamic science and technology, most historians of science ignore the Arab contributions. Ahmad Y. al-Hassan states;

> Admittedly, such historians have acknowledged the progress achieved by Muslim scientists in mathematics, astronomy and the exact sciences, but they have for the most part been harsh in their judgement of Islamic technological innovation.(3)

There has been a general tendency for occidental scholars to trace the genealogy of science from the Greek civilization to the European civilization with a sense of superiority based on the fact that Europe had already dominated the world since the nineteenth century. This seems a very European centered view of history. These scholars disliked Asian factors entering their own history of civilization. They tried to make the non-Western factors as small as possible.(4) Today, some scholars study the Islamic science and technology, but their interests are basically to trace how Muslims transmitted Greek sciences to European science: that is, so to speak, embezzling a part of Arabic science. Meanwhile, Islamic scholars see their own science as one of an expression of their own culture.(5)

There is no reason for us to follow the Europe-centeric view. Rather, we have to understand the fact of world history without prejudice. We also should not take the position of only admiring Islamic science and technology. What I have to do in this thesis is to examine how values and perspective of culture and society, some concepts of religion, typical styles of knowledge, view of nature, and scientists' subjectivity all got interweaved, and how these factors influenced Muslim recognizing science and establishing original science and technology. I will look over above purpose through traditional practical science and technology in this chapter.

A. Science

It is said that the paradigms of Islamic science are the concept of tawhīd, khīlafah and 'ibādah to promote 'adl and istislāh. The Stockholm seminar on "Knowledge and Value," which studies the cultural differences and commonality between Islam and the Occident, identified these values with science. Tawhīd was mentioned in the last chapter. Khilāfah is the concept that a man is responsible and accountable to God for his scientific activities, and that he has

to preserve the integrity of living. 'Ibãdah implies contemplation which serves as an integrating factor for scientific activity and the system of Islamic value. The pursuit of knowledge for the benefit of an individual and a community is the major role of 'ibãdah. 'Adl is social justice. Istislãh is public interest. Scientific activity in Islam that promotes 'adl draws legitimacy from istislãh, which is the chief supplementary source of Islamic law.(6)

The issues of traditional science should be treated within a framework of these concepts that forms the goals of an Islamic society. Judging from the connections between the above concepts, I can say that Islamic science has promoted Qur'ãnic revelation of science and what they found would be influenced by Islamic ethics. Moreover, as it has kept social relevance, it has brought great helps and profits to the society and to individuals.

1. Medicine

In accordance with the Islamic principle which sees creation as signs (ãyats) of God, the study of the human body, that is medicine, was the focus of attentiion in the Middle Ages to understand the wisdom of God. For mankind recapitulates the whole of exis-

tence and is the key in understanding the whole. The theory of Islamic medicine was connected to Islamic metaphysics, cosmology, and philosophy. Muslim physicians saw a human body closely relatedto its soul and spirit. Moreover, the interrelation and the effect of cosmic forces seemed to affect a human body. The physicians were also aware of the empathy between all orders of existence and the mutual action and reaction of one entity to another.(7)

These physicians imported much from ancient Greece because it coincided with the Islamic conception of Universe. The Islamic conception was the balance and harmony of the whole existence and was related with the idea of the harmony of physical parts in Hippocratic and Galenic medicine.(8) If the perception and theory of medicine in Islam had been different from that of Greece, Muslim would not have accepted Greek medicine.

Islam indicated some topics about health and various questions concerning personal hygiene, dietary habits, ablutions, other elements affecting the body, and the relation of the spirit and body through the Qur'ān and Hadīth. Modern medicine does not define the meaning of health in its own terms, while the definition of health and sickness had already been settled in Islamic concept. Health meant the harmony

of inner constitutions of a human body and considered what one ate and drank in view of each one's constitution. Moreover, it is a question of living in harmony not only within oneself, but also within the environment.(9) Ibn Sīnā stated at the beginning in his famous medical book, Canon, as follows:

> Medicine is the science by which we learn, (a), the various states of the human body, (i) in health, (ii) when not in health, (b) the means by which, (i) health is likely to be lost, and (ii) when lost, is likely to be restored to health. In other words, it is the art whereby health [the beauty of the body--long hair, clear complexion, fragrance and form] is conserved and the art whereby it is restored, after being lost.(10)

The role of medical treatment in classical Islamic world was the preservation of the equilibrium and of harmony. Traditional Islamic medicine is inferior on the point of analysis with modern medicine, but it holds the all-embracing point according to the concept of health. A physician investigated how a patient restored the health of the whole body in order to cure one disease. He attached much importance to natural recovery. Islamic medicine set to make an important contribution to health policies. In contrast to this, modern medicine seems to be interested in what is the cause of sickness and how to conquer it. Contemporary

excessive medical treatment seems not to restore health but rather to improve health itself.

The practical Islamic medical treatments came from the Islamic tradition. Muslim used to emphasize the importance of diet as far as hygiene was concerned. Muslim thought that the kind of food consumed and manner to which it was consumed were connected to health, so that the effect of diet was more powerful than that of drugs on both health and illness.(11) Physicians, hence, kept close watch on what a patient ate and drank. Traditional medical baths were also commonly used as medical cures in the Islamic world. As body purification has been demanded by Islam, baths have been built and we cannot find even a small village without a public bath. Therefore, the bath was attended regularly for hygienic as well as ritual purposes. The use of hot and cold water and air, the rub-down, and massage have been used by Muslim physicians for all kinds of medical cures ranging from overcoming headaches to reviving sexual energy.(12)

Whatever the technical idea might be, Islam never permitted the dissection of a human body because it seemed to be a violation of respect to the most lofty existence. Therefore, some medical studies like the circulation of blood did not progress. Muslims

depended the knowledge for the areas in which they lagged behind on Greek scholars.(13) This fact illustrates that religious climes sometimes opposed scientific development.

Islamic pharmacology, as a branch of Islamic medicine, has had a balanced concern with the effect of drugs on human physiology, whereas traditional ones coming from outside Western culture were one-sided and over-concerned.(14) Pharmacology was the depository of experience and observation of numerous generations of human beings extending over to prehistory. Muslim rejected drugs which had not been tested and was forced upon the public without a close study of long-term result on the human body. This tells how much importance past Muslims attached to long observation and actual proof.

Although Western medicine has brought about remarkable successes today, it cannot still overcome even simple headaches or common colds better than medieval physicians. Today, Western physicians become increasingly interested in traditional remedies like, acupuncture, and herbs, and now a greater degree of attention is being paid to traditional Islamic medicine.

2. Mathematics

Muslim loved mathematics because it was directly connected with the central idea of Islam which is the doctrine of Unity, tawhīd. God is one. First of all comes the Unity of God. God is unique; the Creator and Sustainer of all. Unity, in itself is concrete. Therefore, the number One is the most direct and intelligible symbol. Numbers are important because Muslim can relate multiplicity to Unity through the numbers and bring to light harmony, the principle of the Universe.(15) Seyyed Hossein Nasr expresses typical science as follows:

> Mathematics in the Islamic perspective is regarded as the gateway leading from the sensible to the intelligible world, the ladder between the world of change and the heaven of archetypes.(16)

The major contributing cultures to Islamic mathematics were Greek and Indian, and particulaly the Pythagorean concept of numbers and geometric figures were significant. They had similarity to the intellectual perspectives of Islam, since Pythagoras also had a blinding message of One as the symbolic role of numbers and figures. Pythagorean mathematics helped the Arabian people express the message which

came from the very core of Islamic teaching.(17) The mathematical knowledge Islam received from India was the series of numbers which was also indispensable to the Islamic development of mathematics. Hindu mathematicians began usin numerical systems that is the decimal positional system from zero to nine, probably a few centuries before the rise of the Islamic civilization. However, Hindus did not extend this system anymore but Muslim first represented parts of the unit by decimal fractions and they represented numbers as we do now.(18)

The fundamentals of the mathematics were applied to arts and architectures and it played a special role in art forms. Its role can be recognized more in the descriptive geometry of art from patterns on carpets to ornaments of Mosques. They have been deeply influenced by the concept of Unity. Nasr mentions as follows:

> Mathematics in Islam has been able to aid in the realization of a harmony, balance and awareness of the effusion of multiplicity from Unity and return of all multiplicity to Unity which characterize Islamic spirituality and are manifested in the most direct manner in Islamic art and architecture. Nowhere is the sacred character of mathematics in the Islamic world view more evident than in art, where with the help of geometry and arithmetic matter is ennobled and a sacred ambience created wherein is directly

> reflected the ubiquitous Presence of the One in the many.(19)

Mathematics was so essential that it was applied to not only scientific areas but also some technological areas. Muslim used their mathematical knowledge from business accounting, land surveying, mechanical devices, and astronomical calculations to optical instruments.(20) These technologies could attain a high level with the aid of the mathematics. This is one case of the connection between science and technology which is a characteristic of the Middle Ages.

3. Astronomy

Medieval astronomy developed in parallel with mathematics. Astronomy was one of the branches of the application of mathematics and could not have progressed without the aid of geometry. Muslim astronomers could accomplish computation techniques for determing the motion of the planets, thus, were able to achieve greater precision in their measurement of planets.

Astronomy included religious stimulus, so it attracted Muslim's interest. Astronomy was very useful for their life to know the exact time and direction.

The Prophet settled some rules of praying. If a person practices them conscientiously, God will accept a believer's prayers. Requests from Islam made it necessary for believers to know the time for daily worship and the season for Ramadān, fast and Hajj, pilgrimage. Islam was spread world-wide in various geographical locations differing in the length of day and climactic conditions. Therefore, the man whose role was to tell the time and season had to depend upon astronomy. He was called to be a quasi-astronomer. He needed to calculate the start and the end of the season of Ramadān and to predict sunrises and sunsets which defines a space of time of daily fast. He also had to be careful concerning solar and lunar eclipses.

To find the direction was also indispensable for their lives in order to pray toward Mecca. To determine the direction, an astronomer had to observe the fixed stars and planets, calculate planetary motion and construction, and pay attention to latitude and longitude which had been measured in the Middle Ages.

Islamic medieval astronomy was developed to a level of remarkable accuracy. What made this accuracy possible was the vast amount of actual observation

which was in fact much larger in volume than what the Greeks had done. The observation covers all aspects of astronomical phenomena, such as: traditional constants were made more precise, many stars were discovered, the inclination of the eclipse was measured, the motion of solar apogee was observed, and other important discoveries of movements of planets were made. The improvement of instruments simplified the observation. To make and improve instruments was unusual for Greek scientists, owing to their consciousness of hierarchy to hand-craft workers, meanwhile, Muslim engineers were advanced in making minute conveniences for the sake of science. Muslim scientists succeeded in developing transferred theories and innovated new instruments.

4. Physics

In contrast to modern physics, there was natural philosophy in Islamic disciplines which includes the life, the earth science and physics. Many of the Muslims were eager to the study of the laws of simple machines.(21) Classical treatises of Islamic physics most contributed to its practical technology, windmill, architectural elements, irrigation systems, chemical processes, and so on. Islamic civilization studied

physics to utilize nature usefully. One field in which physics made great progress was the study of gravity and the making of machines which applied it effectively. Muslim knew that the acceleration of a body falling due to the force of gravity would not depend on its mass and quality. They also knew that the power between two things increases when its distance decreases and mass increases. They used the theory in work with balance levers and, wheels and mills by falling water.

The ethics that the physicists accomplished from the total structure of Islamic principle was that "Muslim did not secularize the cosmos they were studying because they never lost sight of the totality in order to gain knowledge of the past."(22) They did not make all what they knew apply to this domain. They felt danger instinctively of some application like making metal, which was thought to be alien to the natural environment and to lead the destruction of the balance of nature.

5. Zoology

Medicine was most developed in this medieval era because the object of it was human beings, the center of all existence. In the same way, animals,

and creatures nearest to human beings were studied seriously. Animals were sacrificed for food to support human existence and some were used for husbandry. But the main purpose of zoology was to understand the animals' roles to gain greater knowledge of Divine Wisdom and to know better their own inner nature. Nasr indicates as follows;

> Through the study of animal kingdom man is therefore more fully able to realize his vice-regal role and become aware of the great responsibility he must exercise as the central being in the terrestrial environment vis-a-vis the animal and plant kingdoms.(23)

Animals performed important tasks in the Islamic paradise and as the symbols of various spiritual realities.

Classical Muslim studies on their animal kingdom were seen both in the arts and in literature. Some scholars illustrated the animal world to express philosophical aspects of the animals' religious and juridical status and to capture the inner qualities and the genius of species in question. Their arts did not occupy the place as modern arts holds. The arts in Islamic zoology played a role which was artistic as well as scientific in nature. A sacred art enabled man to contemplate the visible cosmos as an icon revealing

the spiritual world.(24) In Islamic literature, animals can be found as symbols of cosmic qualities and spiritual attitudes and as well as symbols of moral teachers.

All creatures including human beings in the Islamic world are made for a particular purpose with each fitting within the harmony of the total order of nature.(25) The arts and literatures indicate that men do not have the right to dominate and destroy the animal kingdom indiscriminately. Animals will respond to obey and to serve man, if man fulfills his duty as one of the creatures in the animal kingdom. Islamic zoologyis very suggestive to modern man's attitude towards animals which has broken co-existing conditions by the unilateral exploitation of animals.

B. Technology

Qur'ãn emphasizes that mankind is related to nature and that human ability to control the forces of nature should not exploit the unrighteous desire for domination but should be in the nobler interests of a free upward movement of spiritual life.(26) From the teaching of Qur'ãn, the most evident characteristic

of the Muslim view of nature, the harmony and equilibrium between man and nature, arise. God makes all creatures live co-operatively and each has their own role. He commands the whole order of nature. Believers cannot disturb another existence. This essential view of nature affected the establishment of Islamic traditional technologies.

The policy of the technology was, hence, to utilize natural forces within the environment in question, to make the maximum use of human skills, and to cause the minimum amount of disturbance within the natural environment.(27) Muslim did not take the steps which would mean making and using technology out of harmony with the environment. They thought even metals and fire were alien to the natural environment and would ultimately cause the loss of equilibrium with nature.(28)

The works of Islamic technology are to be found on practical devices and machines which dealt with a variety of subjects from agricultural and transportational devices used in everyday life, to other complicated devices like clocks. Furthermore, it is clear that technology involved improvements for the material aspects of the civilization of Islam such as the standards of living, the type and diversity of

products used or consumed, the level and extension of agriculture, and arms used in warfare.(29) As technology is, as mentioned above, also one expression of a society and its culture, some cultural and social factors of Islam permeated their technology. I will look over the traditional Islamic technology from various points, not only from the standpoint of machines and devices but also from the realm of civilizations.

1. Habitat

What most exhibited the equilibrium between man and the environment in Islamic traditional technology was a human habitat and physical layout of the classical Islamic town. They had succeeded in preserving the equilibrium and harmony with the natural environment, and the natural forces and elements in spite of hard weather of intense heat. Architecture in the old towns was congruous with the landscape and in harmony with nature. Cities like Fez, Sana'a and Isfahan give examples of just how such cities accorded with various types of landscape which created living units for settlement. They are beautiful and in equilibrium with nature.(30) These cities included nature within them. The environment ethic permeated

the Muslim cities as well.

Architecture and town planning attempted to use natural materials as much as possible to create harmonious urban environments. The material that Muslim builders used depended on the area where they were working. For example, in the region of present Lebanon, ceder wood was plentiful for roofing and ashlar masonry was common in Egypt and in Tunisia. Syria (i.e. modern Syria, Palestine and Jordan) held to the tradition of building in dressed stone because Syrian limestone is a splendid building material; easy to work, resistant to weather, and has a beautiful amber tint on exposure.(31) Using natural material did not produce the alienation and atomisation of cities from landscaping. A faithful Muslim's respect for nature was so deep that he made maximum use of material provided by nature.

Egypt faced urban housing shortages in 1975. Egypt was seeking help to solve the problem through contracts with foreign companies which specialized in highly industrialized prefabricated houses. However, this caused negative factors. The final products were less appropriate for Egypt's climate and culture than public housing blocks already built.(32) These buildings are ugly, expensive, and energy-intensive.

Modern technology broke what Egypt had kept in housing plan based on the principle of harmonizing with the environment. Traditional architects turned the glare of the desert sun into pleasing patterns of light by the use of lattics, but modern technology took this beauty away. We cannot be impressed by Cairo's congruity with nature anymore, rather it seems to resist the natural beauty because of its reliance on designs of steel and cement. The same undesirable situation can be admitted for some modern large towns in the Middle East today.

Past Muslims endeavored to make maximum use of power and factors provided by nature. Islamic architects in a desert area did not apply large glass windows through which the maximum radiation was led, and as buildings were made of earth and tiles they were cool in summer and warm in winter. It was also common that many houses had several stories and a large windcather on the roof carrying cool air to each story. Muslim used ventilators to lead wind to deep basements for refuge against high temperatures. The Egyptians made the openings in their houses suitable for winds from the north and equipped the houses with ventilators without fail. These ventilators were still common in Cairo until a century ago.(33) Natural

forçes were applied to other elements of city life such as streets, markets, and the arrangements of houses. Nasr mentions;

> Where there are hot deserts, narrow streets were built to protect the cool air of the night during the day-light hours. Where the temperature became very warm, such as around the central desert of Persia, use was made of wind towers to ventilate homes, of deep basements to serve as places of refuge for the summer and of deep underground cisterns to provide cool water. The use of wind towers in the central cities of Persia, such as Yazd, Kashan and Kerman, is particularly instructive and shows how the science of man has made maximum use of existing natural elements to create an architecture which is at once beautiful and efficient, one which reflects the principles of Islam.(34)

Islamic traditional technology of habitat and city planning demonstrated how the Islamic people made maximum use of natural forces, at the same time, they kept the beauty and equilibrium with nature.

2. Re-cycling and high durability

Production which exists for only consumption is seen as being wasteful of God's creations and thus, a profanity to Him in Islam. What a Muslim possesses must always be put to practical use most effectively. It should not be hoarded, maintained carelessly, wasted with one's taste or simple vanity in Islamic principle.

These actions are not allowed at any level of an individual, a society or a nation. To produce unnecessary, short-lived and vanity goods as well as to squander natural resources have seemed to destroy the elaborate mechanism of living.

In the Islamic world, something which is able to be utilized by more than one person has been transferred from one person to another. What makes the transfer possible is one of the values of the Islamic society; caring for neighbors. Muslims have kept a custom which encourages the exchange of articles of everyday use among neighbors. The Qur'ān condemns those who refuse lending household articles to neighbors. The Western attitude of self-sufficiency for everything in life is unusual to the Islamic people.(35) Therefore, they have not regarded the transference of articles, especially re-cycling or Zakāt, a pooling for social distribution.

The idea of a natural cycle dominated the traditional technological theories and practices. Life is based on the connection between units and continuous use and reuse of energy and materials through the chain of life in Islamic world. Therefore, themaximum possible re-cycling of all materialswas natural to, and a rule of, the traditional technology. Re-cycling

has been integrated with the reverence towards all material bounties and a strong moral sense against waste and squandering of the gifts of nature.

Islamic economy has general principles which has kept the request for consumables subdued by encouraging the production of highly durable commodities and discouraging obsolescence owing to changes in tastes and fashion. Muhammad Akram Khan states;

> Since the values of an Islamic society hold goods of high quality and durability in high esteem, the entrepreneur should produce articles of high durability, so that replacement is not demanded after a short time. Moreover, the entrepreneur's efforts to create demand by creating psychic dissatisfaction and inspiring change of fashion would violate the ethical norms of the society.(36)

It was necessary for an entrepreneur to keep the technology which could make high durability goods. Technology concerning products of tough household items, such as furniture, crockery, cutlery, and small tools progressed and reached higher levels in the medieval period. It was in a sense a social technology to make resources for more productive uses.

3. Small technology

In the modern world, industry is so multiple

and specialized that the transportation of raw material and the production of the final product is inevitable. This system requires large amounts of energy and labor. Meanwhile, although some cities in the Middle East flourished in the trade of spice and silk in the past, each city aimed at a self-sufficient economy at best because the basic concern of the Islamic economy is the fulfillment of basic needs. Islamic civilization had the principle of providing the maximum amount of happiness on earth but not to seek after the maximum amount of production for own sake. Even today, small industries like carpet weaving are valid and still have a function in total local efficiency.(37) Under this principle, the Muslim society did not need a large scale of production to provide superfluous goods. Nor did it need complex technology and large amounts of labor forces. Only small technological units were necessary. When the Muslim society carries out local efficiency plans, a "community can live at peace with its immediate natural environment with the minimum amount of external perturbation and the maximum amount of self-sufficiency."(38)

Cairo is now suffering from the uncontrollable and rapid expansion of its population. The population

quandrupled or quintupled in several decades. This caused a lack of breathing space, the coagulation of city life, and contamination of the environment. Many reasons can be put forward, but one of the causes presented recently is the structure of the economy which pursues the same rapid industrialization as developed countries did. The same situation is to be seen with other cities, but there is some tendency to reconsider the essential Islamic society. Nasr mentions;

> After the tragic flight of the population during the past century to big cities, causing the strangulation of many cities and the falling into ruin of many villages, several Muslim governments which had been discouraging this tightly integrated economy and were encouraging specialization on farms and in villages have now began to return to the traditional Islamic idea.(39)

Human beings have changed various natural materials into resources and used them. The abundant materials around one could be used as the finest resources. But this was possible only in a small or middle scale economy and with use of local level technology, not with huge mass produced technology. A moderate scale of technology has a certain capacity according to the demands of a community. Andre Gorz

points out that methods of a middle scale production are more efficient, more economic, and more abundant with technical innovations and revolutions. It can, moreover, avoid large amount of wastes and pollution.(40) Human scale techniques can fortify family and other human ties. The medium and local level technology in Islamic society could create an atmosphere of peace and beauty in balance between the community and the environment.

4. Agriculture

Both the Qur'ān and Hadīth have commanded Muslim to progress, improve, and intensify agricultural activity. The Hadīth would bless the act of planting a tree even if it be one day before the end of the world.(41) Muslims found their religion concerning the importance of agriculture for human life.

Extensive use of agricultural land could be traced to the revolution of agricultural technology in the Middle Ages. Muslim agriculturists thought land should be used to its full capacity, even the inferior land which had never been thought of as cultivable. Revolutional knowledge of crop-rotation schemes, land cultivation, and soil expertise made the margins of farming penetrate into near desert lands which had

been used only for sporadic grazing before.(42) Lloyd Timberlake mentions;

> Past Muslim cultures showed great skill at controlling this syndrome, desertification, with intricate crop-rotation schemes, complex irrigation systems and systems for controlling and rotating the grazing among tribes over ast areas of delicate, arid grassplants.(43)

In the case of trying afforestation, harmony of nature and environment was kept and biological resources were not excessively exploited. Even in the desert, no attempt was made to change the environment but rather to complement it.(44)

Other remarkable technological innovations included the process for the production of sugar. Sugar-cane was first known in India, but it was not eaten there. Sugar became a foodstuff as well as medicine in all Muslim countries. Sugar-cane plantations spread from Persia, Egypt, and Sicily to Spain and sugar-refining followed. Sugar required a chemical refining process which was a difficult technique having several steps, so the assistance of science was needed.(45) The typical relation between science and technology in the medical ages allowed the process of refining to develop. Sugar-cane plantations

spread to Europe from Spain and Sicily, but it was not until the thirteenth century that the sugar industry itself came to be known in Europe.

Growing fruit trees, a branch of agriculture, had special meaning related with Islam. Fruits had an important and significant role in the daily diet of Muslim which was important for their health and medical use. Moreover, as paradise in the Qur'ãnic image holds the symbols of fruit, the cultivation and use of fruits have had religious significance. Therefore Muslim were absorbed in improving the quality of fruits and developing new seeds.

C. Characteristics of Islamic science and technology

I discussed several branches of traditional science and technology and relations between these different branches and the values of the Islamic society. The Islamic values and principles decided the layout of traditional science and technology. Even when Muslims absorbed some of the scientific heritage of other cultures, ideas entering Islamic thought were transposed into a new spiritual and intellectual forms which were capable of meshing into the Islamic world picture.(46) I will next examine the characteristic

covering the whole field of traditional science and technology.

The first characteristic is the development of experimental and operational methods. There was a belief in the Islamic scientific view that scientists could know the essence of things through human operations. The nature had order created by God and could be treated and understood through positive interference by human beings. Nature did not stand apart from human positive management but rather both were united. The structure of nature was made clear by the operational procedure.(47) Meanwhile, the ancient Greeks were speculative and contemplative in nature and apt to scrutinize figures and laws of nature through thought. Astronomy in ancient Greece was, therefore, to recognize laws among phenomena and to make the phenomena related to the whole cosmic order. Its interests were how to make a contemplative cosmos but not how to observe heavenly bodies carefully. Islam modified the astronomical theory of ancient Greece and then added practical and useful techniques for observation because it had already established the importance of operative methods for observation in scientific studies. Muslim's imaginative ability in astronomical technology helped

develop transferred instruments and exploite innovations. New instruments enabled Muslim astronomers to have more accurate observations and systematic studies.(48)

The success in chemistry in the Islamic medieval world was attributed to experimental procedures. Several theses show that Muslim chemists were familiar with experimental technology handling drugs, metals, and perfumes. Chemistry, different from other science, needs many materials and processes. In order to become one science, Chemistry has to do all processes and to find some general rules proved by experiments. The Arabs succeeded in practicing these experiments to some degree. The Arab world had a large-scale chemical products process for soda, saltpeter, and alum in the late Middle Ages. Islamic traditional science emerged from the rational, mathematical and theoretical science of Greece and became a more experimental and operational practical science.

Muslim scientists emphasized actual proof not only by experimental procedures but also by experiential methods coming from a large amount of accumulated data. Because the study of chemistry is advanced as a result of extensive and time-consuming processes, much first-hand and accumulated data was needed. The development

of medicine was also based on experiential procedures, so drugs without long-term tests on human bodies were not used.

The second characteristic is the prevalence of energy-saving technology. One characteristic of modern technology, production-oriented technology, is a one-way system from resource to waste, so we are now suffering from an increasing output of waste and are threatened by the exhaustion of resources. A market economy effects resource allocation. However, in the Islamic economy, resource allocation is figured out primarily by market forces, but more importantly it is determined by social considerations. Three general principles in the economy appear in the ideas of M. A. Khan.

(1)The preferences in the Islamic economy have internalized the social and moral goals of Islam. Because social and moral behavior influences the resource allocation, it cannot be predicted by mere market analysis. Demands for socially undesirables, like alcohol or gambling gadgets are not acceptable. Once Muslim knew that the transportation of produced goods required large energy, so minimizing restrictions on transportation were agreeable in classical Islamic society.

(2) The fundamental object of resource allocation is not the maximazation of utilities but the fulfillment of needs. Therefore, resources should be primarily devoted to the production of necessities, and only surplus resources, to the production of comforts and luxuries.

(3) The opportunity costs of different choices involves a non-market moral element. The resources spent for Hajj, pilgrimage, seems to be irrational involving high opportunity costs in the materialistic sense. But from Islamic perspective it is rational and profitable.(49)

In Islamic the society, the concept of a successful life does not need maximum acquisition of material goods but rather a simple and religious life implies more satisfaction and self-fullfillment.(50) The philosophy of resource allocation which has characterized some parts of the Islamic life will not give us a sense that traditional technology sought an aggressive and unilateral reaping of resources. Actually, there is a lesson on wasting resources to be learned from the technology of re-cycling and high durability. Furthermore, there are economic principles for the fulfillment of basic needs behind simple technology. Both concern the Islamic attitudes towards resources.

The Middle East has been highlighted on the international scene especially since the oil shock, as it influenced the energy policy of the entire world. The price of petroleum rose rapidly and the Western countries got aware of the importance of natural energy and renewable energy sources. Traditional Islamic technology is fairly advanced in utilizing natural forces and in saving energy. The Islamic world not only supplies petroleum but also is able to give advice concerning a rational energy policy to nowadays society.

Islam had two basic philosophies in using various forms of energy. One is "to preserve as much energy as possible in any process," and another is "to use the most easily available form of energy requiring the minimum amount of disturbance to the environment."(51) The former principle exhorts us not to exhaust in a few hundred years the reserves which nature has taken millions of years to form. The exhaustion of all natural resources has seemed to Muslims to be equal to the extinction of human life, so the Islamic faith has advocated the preservation of resources for a long time. The latter principle explains how to obtain the best possible result from the limited resources. It expresses also the concept of equilibrium between man

and nature which indicates that man should use energy on earth without destroying the harmony of nature. Muslim scientists and engineers in medieval times made efforts to save energy consumption in line with these principles. As traditional technology has indicated, Muslim used natural sources wisely. They employed wind to cool houses through ventilators and light to heat them through windows. At night, cool air was retained in narrow streets to help combat the intense heat of the daytime. The other practical use of nature was found in turning mills through the use of wind and turning wheels using falling water. According to Glyn Ford, on energy technology, Islamic states are still emphasizing small-scale renewable energy sources such as solar energy and ocean thermal energy conversion rather than emphasizing fossil fuels and nuclear energy.(52)

In Islamic philosophy, the concept of tawhīd suggests that all the resources on earth are the creation of God, and only He has the right to determine how the resources are to be used. What a Muslim has belongs essentially to God. An individual under God, is an administrator of the resources who does not have the right to waste or hoard existing things. As all resources come from God, they are not to be squandered

or hoarded. Furthermore, the Islamic perspective has been interested in the welfare of individual as well as that of the Ummah. Even though an individual has freedom to hold some resources, the Ummah sometimes limits his exercise when the welfare of the Ummah is threatened.

The last characteristic of traditional Islamic science and technology is that it is a religious stimulus. The most typical case is astronomy. Islam requested believers to keep a strict prayer routine. The practical need of the religion that is the season for Ramadān and Hajj, the time for the daily prayer, and the direction of Mecca gave religious impetus to the Muslim's study of astronomy. Muslims depended on the phenomenon of the heavens to decide the seasons, the time, and the direction. Practical religious needs supplemented metaphysical reasons related to the nature of the Qur'ānic revelation to make astronomy a main concern of Islamic scientists and to enable them to produce a vast corpus.(53)

Geography, which is not the branch of science or technology, was also developed with religious requests. Philip K. Hitti mentions;

> The institution of the holy pilgrimage, the orientation of mosques towards Mecca, and the

> need for determining the direction of the Ka'bah at the time of prayer gave religious impetus to Muslim study of geography. Astrology, which necessitated the determining of the lattitudes and longitudes of all places throughout the world, added its scientific influence.(54)

Agriculture has been encouraged as a direct religious activity. Agriculture was recommended by the Qur'ān and Hadīth and practiced by many eminent saints and religious scholars. Similarly, many prophetic traditions have recommended agriculture to a large extent.(55) As Islamic teaching advocated the importance of agriculture, Muslims were eager to progress and improve agriculture. Therefore, after the spread of Islam into three continents in the seventh and eighth centuries, a remarkable revolution affecting agricultural production, incomes, and population levels took place.(56)

As I mentioned before, Islamic science was not divorced from religion owing to the concept of tawhīd. Islam demanded that men should pursue scientific knowledge, because science itself is thought of as a divinely established system. Moreover, Qur'ānic themes have given readers the keys to understand and touch natural phenomenon. There are accurate Qur'ānic accounts and interpretations of scientific principles

and disciplines. This link between religion of Islam and science enabled religion to provide science with some impetuses and to promote scientific developments.

Note

(1) Philip K. Hitti, History of the Arab, (London: The Macmillan Press LTD., 1970), p.306.

(2) Ibid., p.307.

(3) Ahmad Y. al-Hassan and Donald. R. Hill, Islamic Technology, (Cambridge: Cambridge University Press, 1986), p.28.

(4) Syuntaro Ito, Bunmeiniokeru Kagaku, (Tokyo: Keiso Shobo, 1976), p.49.

(5) Syuntaro Ito, "Bunmei Iten, Arabiato Seiou," Chuto Kenkyu, Sep., (1984), pp.9-10.

(6) Ziauddin Sardar, "Islamic and Western approaches to science," The touch of Midas, (London: Manchester University Press, 1984), pp.7-8.

(7) Seyyed Hossein Nasr, Islamic Science, (London: World Islam Festival Publishing Company, 1976), p.159.

(8) Ibid., p.159. Nasr adds that,

> It is not accidental that the theoretical background of Greek medicine belongs to the same schools of Greek philosophy which were easily assimilated into the Islamic perspective and not to those which the Muslims rejected. ...Had Greek medicine possessed a theoretical background related to the anti-metaphysical school of late Antiquity it is very doubtful whether it would

have been integrated so perfectly within the Islamic intellectual universe.

(9) Ibid., p.162.

(10) O. Cameron Gruner, The Canon of Medicine of Avicena, (London: Luzac & Co., 1930), p.25.

(11) Nasr, p.166.

(12) Ibid., p.157.

(13) Ibid., p.163.

(14) Glyn Ford, "Rebirth of Islamic Science," The touch of Midas, p.37.

(15) Seyyed Hossein Nasr, Islamic Cosmological Doctrines, (Massachusetts: Harvard University Press, 1964), p.45.

(16) Seyyed Hossein Nasr, Science and Civilization in Islam, (Massachusetts: Harvard University Press, 1968), p.146.

(17) Nasr, Islamic Science, pp.75-77. Pythagoras was Islamicized rapidly, for there existed already in the Islamic universe a dimension which could be described as Abrahamic Pythagoreanism one in which the symbolic role of numbers and figures appeared in dazzling clarity, illuminated by Islamic gnosis which is precisely a blinding message of the One.

(18) J. L. Berggren, Episodes in the Mathematics of Medieval Islam, (New York: Springer-Verlag, 1986), p.36.

(19) Nasr, Islamic Science, p.88.

(20) Goldshmidst Arthur, A Concise History of Middle East, (London: Western Press, 1983), p.107.

(21) Nasr, Islamic Science, p.135.

(22) Ibid., p.150. He mentions that Muslims were aware that a certain amount--and only a certain amount--of science in the modern sense can be developed within the traditional cosmos provided this science knows its limit and does not expect to progress indefinitely in a domain which is by nature finite.

(23) Ibid., p.71.

(24) Ibid., p.66.

(25) Nasr, Islamic Cosmological Doctrines, p.123. This idea of "economy" in nature--considered not simply anthropomorphically but with regard to the Divine plan--is closely allied to teleology; for if there were no purpose in things it would be meaningless to speak of waste of utility.

(26) M. Husain Sadr, "Science and Islam," The touch of Midas, p.23.

(27) Nasr, Islamic Science, p.147.

(28) Ibid., p.150.

(29) Ahmad Y. al-Hassan and Donald R. Hill, Islamic Technology, (Cambridge: Cambridge University Press, 1986), p.280.

(30) Nasr, Islamic Science, p.228.

(31) Ahmad Y. al-Hassan and Donald R. Hill, p.73.

(32) Lloyed Timberlake, "The emergence of environmental awarness in the West," The touch of Midas, p.131.

(33) David A. King, "Architecture and Asrtronomy: The Ventilators of Medieval Cairo and Their Secrets," Journal of the American Oriental Society, Vol.104, No.1, (1984) pp.97-98.

(34) Nasr, Islamic Science, p.229.

(35) Muhammad Akram Khan, "Resource Allocation in an Islamic Economy", The Islamic Quarterly, 4th, (1985), p.245. He mentions it was customary in Muslim societies that only some of durable articles need be obtained by every family and others should be shared with neighbors. In this way, not only the indispensability of neighbors was emphasized but this also increased the use-time of household articles.

(36) Ibid., pp.245-246.

(37) Nasr, Islamic Science, p.233.

(38) Ibid., p.233.

(39) Ibid., p.233.

(40) Andre Gorz, Ecologie et Politique, Trans. Taketomo Takahashi, (Tokyo: Gijututo Ningen, 1980), p.80. He thinks that machins' increasing in size is not technological inevitability but is one of political choices. Middle scale production whose employees are less than five hundred can avoide some waste and pollution.

(41) Nasr, Islamic Science, p.209.

(42) Ahmad Y. al-Hassan and Donald R. Hill, p.207.

(43) Timberlake, p.131.

(44) Ford, p.37.

(45) Ahmad Y. al-Hassan and Donald R. Hill, P.221.

(46) Ford, p.35.

(47) Ito, Bunmeiniokeru Kagaku, pp.36-37.

(48) Sigrid Hunke, Allahs Sonne Uber Dem Abendland, Trans. Toshikazu Takao, (Tokyo: Misuzu Shobo, 1982), p.71.

(49) Khan, pp.241-242. In an Islamic economy, the real life phenomenon of resource allocation has to be studied by taking into consideration of human behavior, which is motivated by non-exchange and non-market forces.

(50) Ibid., p.243. The Prophet emphasized a simple and rigorous life, which implied maximization of satisfaction with minimum resources. The source of pride in early Islamic society was self-imposed deprivation for the welfare of others. The Prophet taught contentment and thanks-giving and subdued demand for material resources.

(51) Nasr, Islamic Science, p.37.

(52) Ford, p.38.

(53) Nasr, Islamic Science, p.93.

(54) Hitti, History of the Arab, p.383.

(55) Nasr, Islamic Science, p.209.

(56) Ahmad Y. al-Hassan and Donald R. Hill, p.203.

Conclusion

A. Stagnation in Islamic science and technology

Several centuries have passed since a genuine Islamic science and technology existed. Once, Muslims were teachers, but they have had to become students once again. The history of science continued from Greece to the Middle East. Now, the stream has diverted to Europe. Islamic science has been out of touch with the main stream of science for over four centuries, and in this period, Islamic civilization degenerated to reach its nadir.(1)

Some inner aspects of the Islamic world led to Islam falling behind today's science and technology. One significant reason for the decline is, without doubt, the gradual loss of interest in scientific and technological subjects. After the twelfth century, the

movement of religious fanaticism against science was an outstanding tendency. In the age of decay, pursuing scientific knowledge was reduced to acquiring religious knowledge. The interest in science and technology was decreasing in proportion to the respect that society had for science. The scientific inquiry of knowing God and His creations stopped. Scientists and technologists have devoted themselves to only learning the work of their great ancestors and to copying their achievements. As a result, scientific subjects were dropped from universities, which became more and more absorbed in religious studies. A few who wished to study science had no choice but to go to Western universities.(2)

The reason why the interest was lost in science and technology was the change in the interpretation of Islam. When science flourished, it was related with philosophy and harmonized with the Qur'ān. The scientists tried to approach the cosmos of Qur'ān through its teachings. Traditional Islamic science could accept the Greek science and developed it because certain Greek philosophies behind science coincided with that of Islamic science. However, it gradually came to be said that the harmony between Qur'ān and science was difficult and futile. The stream of Islam

was changing gradually. One of predominant theologians who warned of the futility was al-Ghazahli who wrote a well-argued refutation of philosophy and alerted against exposing the Muslims to potentially misleading thoughts of basically innocuous rational science.(3) He divided truth into two, one was religious truth and another was rational truth. He defined the pursuit of the former truth as being an obligation for all but that the latter truth as being an obligation for those with such professions as physicians, mathematicians, or philosophers. Ghazahli elucidated that the former obligation could make the relationship between human beings and God very strong and give a Muslim hopes to receive rewards in the hereafter. His thoughts spread in Islam and gained currency steadily. As a result, science lost its dignity. Although Ghazahli was often blamed for the decline of science and philosophy, he believed and declared that the study of religious science and jurisprudence could be more useful and important.

The change in the interpretation of Islam does not lead to the question of whether it was beneficial or not. Ghazahli extracted other aspects of Islam and developed them.(4) Scientific knowledge could not be connected with the perpetual Islamic value system.

This fact led to the decay of science and the cultural and intellectual stagnation at the end of the Islamic Middle Ages.(5)

The fact that Ulama could not catch up with the passage of time and was left from Islamic revelation resulted in the stagnation of science as well. Ulama is the body of specialists, the possessors of knowledge and the term is variously translated as scholars, doctors, savants and divines. They are the carriers of the literate memory of the Islamic culture.(6) The early Ulama had resisted the corruption of Islamic law by letting authorities keep the law. However, they began to ignore Islamic teachings and to be content with keeping a conventional usage.

The power and influence of the Ulama weakened, which is related with the underdevelopment of the Islamic culture. The Ulama used to hold great power in protecting Islam from the secular. However, it obeyed authorities and accepted proposals from them easily. Authorities gained more confidence in their abilities, and began to feel superior toward the rest of mankind only because they were Muslim. The Ulama also became conservative enough to adjust themselves to the authorities and complacent enough to have established a great civilization. The Ulama devoted

themselves to studying the traditional accomplishments. Eventually, this hardening of thoughts and complacency caused the loss of ideas and at last, the continuous retardation of the Muslim society. The Islamic law had been able to adapt itself to the alternations in Islam, but owing to the decline of the Ulama, it could not advanced well. Indeed it has not been changed for more than a thousand years. The stagnation of law is evident. The Ulama's attitudes to other fields of science and technology were the same and the attitudes effected the stagnation of science. Dogmatism found its way in the thinkings of the Ummah concerning science and technology. Science become complacent which led to the loss of ideals and objectives. It also lost creativity and imaginative vigor.(7)

Muslim had held universalism among themselves apart from the rest of the world. Ali Kettani defines universalism in relation to science as follows:

> This universalism combined with tolerance made the exchange of ideas and acceptance of foreign talent possible. As a result, Islamic scientific community was distinctively cosmopolitan in race, language and even religion. They were all bound by a common view of the world, a common cultural language and were indeed part of a common scientific milieu.(8)

Scientists were free to move within Muslim world and were treated as citizens of all Islamic countries. However, the political division within the Islamic world brought about the disunion of the Ummah. The identity within the "us" of the Ummah started giving more its space to other identities such as national groupings, the region or the tribe within the nation, the clan within the tribe and the region, and at last the family. This disintegration led to the dominance of the individual who is only devoted to himself. There happened revenge among identities. The Muslim world had held a united power under one universalism and much knowledge had grown up. But gradually they lost their own universalism. This fact handicapped the movement of people, ideas, and goods.(9)

While Islamic civilization reached its peak, Europe remained in the dark ages. However, this position reversed. The West freed itself from under-development, and established its own ideals and the modern Western civilization. As Western civilization succeeded in creating a man-centered view, the trend of studying various facts of matter was taken seriously. Europe flourished culturally and economically throughout the Industrial Revolution, and attained its highest stage of prosperity and power.

It was a real shock for the Islamic people to meet the Western civilization while they were suffering from cultural and social stagnation. The social and cultural differences were so novel that the Muslims were eager to absorb Western thoughts, institutes, and technology. It has been long thought that westernization is modernization. Many third-world countries accepted this definition of westernization for their countries development. Similarly, the Middle Eastern countries' introduced westernization without exception. At the same time, the Western countries aimed at spreading their domination over much of the surrounding areas while concurrently earning profits from the third world. Certain countries entered the Middle East one after another, and imposed some kind of colonial rule over most of the Islamic lands.

The technological colonization is a recent outer aspect which prohibits the Muslims from pursuing an indigenous course in technology. Western industrialization contributed to some degree to economic growth and the fulfillment of some needs in the Middle East. However, it is now evident that Middle Eastern countries can do nothing but depend entirely on European technology and finished products. The transfer of technology and plants have taken place

under turnkey contracts. In such cases, technology come in a packaged form, which perpetuates technological dependence on Europe. The process of transfer of technology has also been accompanied by investment activity of foreign enterprises, so the transfer has effected licensing agreements with local companies.(10) The objects and concerns of the exporting countries, the Western countries, do not necessarily coincide with those of the importing countries. As the exporting countries aim at maximizing profit and making technical chains by reflecting their countries interests, they sometimes ignore research and feasibility studies related to local needs and requirements of the Middle Eastern countries.(11) Therefore, importing packaged technology leads to certain problems such as the difficulty in adapting it to local conditions, the exclusion of local participation, and high costs.(12) The Middle Eastern countries do not have the advantage of setting, adapting and improving technology. The choices opening to the countries are restricted. Due to the dependence on and restrictions from the West, Muslims cannot make similar progress to Europe. The technological gap between Europe and the Middle East is widening.

Some scholars pointed out that the underdevelop-

ment of the Middle East was due to the fact that it did not succeed in accepting westernization effectively. It is true that westernization led to some industrialization. However, is it possible to say by looking matter from a new perspective, that the Middle Eastern countries refused westernization? In the Middle Ages, the Muslims positively introduced external culture into the Islam world, due to Islamic tolerance, and made great progress in technology. But this time they did not. This is because Muslims found Western thought and values too different from theirs. Christianity affected Western culture and thoughts with emphasis on spiritual superiority and the separation of church and state, while Islamic teachings unify them. Moreover, a Muslim has to be responsible to the Ummah he joins while a Christian has to be responsible for himself.(13) As a Muslim attaches importance to the profits of his community, he does not approve of the Western people's ideas. Similarly, the relief of material poverty is desirable for Muslim people, so material fertility of goods and systems is unusual to the Muslims who still maintain their religious traditions. Modernization threatened the Muslims with the destruction of their spirit.(14) This danger exceeded the tolerance of Islam. The Middle East

kept its spirit and independence by refusing westernization.

As Spengler has mentioned, modern technology was the original product of Western civilization and an expression of its culture. Western culture is evidently different from the Islamic culture. How Western people see their own technologies is obviously different from how the Islamic people see them. As Western style modernization seemed to Muslims to carry the potential dangers of destroying their society and culture, they did not accept all of the available technologies. It is thus natural that self-abnegation within the Islamic world took place against this westernization.

As the Middle Eastern countries have imported only technology for industrialization, there lies a separation of technology from science. In the Arab world, between the development and the community of science, there is no transaction or communication. No discussion between scientists and engineers, to decide whether a project is desirable or not for the environment, has taken place. University professors of science are not consulted.(15) The fact that the connection of science and technology is desirable for development is forgotton in today's Middle

Eastern countries. Abdus Salam, a Nobel prize-winner criticizes the Arab worlds failure to the service of science. He indicates as follows;

> there is too much emphasis on technology transfer. Science transfer must also be considered. It is the basis for technology. Technology is a dead loss without this. Technology is just an episode in the history of nature.(16)

Now, the Middle East is facing the same environmental problems as the West. In the oil rich Gulf region, industrialization has progressed with little respect to the environment. Most Gulf countries produce at least double the refuse per capita of affluent Western countries. Oil waste, plastic, and sulphur dioxide use results in various kinds pollution.(17) Glyn Ford mentions modern Muslim's life as follows;

> many of the town planning schemes implemented in the Middle East pay no attention to Islamic mores. The extended family is inevitably destroyed as Western-style urbanization takes its toll with its ubiquitous and alienating tower blocks and express ways. The sense of community is atomised as improved communications lead to an insistence on mobility and the production of the flat-dwelling, capital-hopping 'gypsies' of the twentieth century.(18)

The creeping of the deserts is also serious. It is a result of ill-designed buildings and industrial pollution. Desertification threatens the homes of 80 million people.(19)

The reason of this problem is thought to be a clear rift between the theory of Islam vis-a-vis environment and its practice. Lloyed Timberlake thinks that the leaders and political elite in the Middle Eastern countries are completely separated from their religious cultural roots and from own people. As development is synonymous with industrialization and the importation of foreign equipment for the leaders, the Arab world falls into the same pitfalls as the industrialized countries have. The leaders are indifferent to Muslim solidarity and value their own profit more than the Ummah's. They ignore the problem of fitting modernity into the deep traditions of the Islamic culture. Western technology is forced to spread among the Islamic society but it is essentially impossible to take root in the Middle East. A leadership divorced from culture is also divorced from the environment of the people.(20)

B. Conclusion

I examined Islamic science and technology as an expression of its culture and society. I will, in conclusion, contrast modern crises with Islamic values. It seems paradoxical to consider the crises through the Islam world because it is now suffering from a cultural and social lag. Of course, science progresses rationally, but it is undoubtedly politics which defines the framework of rational progress. The Islamic world isolated from progress still has responsibility of contributing to the development of the world we all live in. It is never anti-science nor is a step back to the old days. The world is affected by Islamic ideas in which the element of stability and totality dominate. The value of the Islamic world will provide us with new paradigms and some hints to solve the current day crises.

The lack of totality is attributable to the defects of modern science. Scientists do not deal with the whole reality. They deal with only one facet of it. What they deal with is an arbitary abstraction of reality as symbols.(21) Problems, for example, on ecology are complex. In the past, a large amount of agricultural chemicals were used for

increasing provisions. Noxious insects were wiped out and the food levels increased temporarily. However, this plan destroyed a corner of the ecology with some useful insects. Agricultural chemicals became the cause of food pollution. This illustrates the failure of science which lost the total world view.(22)

The specialization of disciplines is to some degree, inevitable for the advancement of research, because today's studies are subdivided and widely spread. It is easier for a scholar to consider reality by braking it down because he will be overwhelmed by the reality if he attempts to treat it in totality. However, David Bohm mentions that today, fragmentation is extended widely from a society to an individual. Art, science, and technology are divided into several special fields. Each field seems to have no connection with the other. It is illusive to believe that all fragments are disjointed. According to Bohm, illusions such as these have brought about the contamination of the environment, overpopulation, and economic and political confusion.(23) In spite of some necessity of specialization in a discipline, it is also a fact that some interdisciplinary changes are taking place recently because of the dissatisfaction with excessive specialization.

There was philosophy, metaphysics and the cosmos behind traditional Islamic sciences and technologies so science and technology did not fall into this same lack of totality. A Muslim's scientific knowledge, in general, had to be used well for an individual as well as for the community. A Muslim must bring profit to and contribute to the community through his knowledge. In Islam, as the Ummah has a priority over the individual, science and technology were not abused freely.

The continuity from science to philosophy was approved of and encouraged by Islam. It is thought that the object of man's appearance in Islam is to obtain a total knowledge of things to become a Universal man. The Islamic unifying principle did not allow various forms of knowledge to be cultivated. Moreover, scientific knowledge represented the trust given by God to a scientist who used it conscientiouly. We can prove, for example, through their pharmacology that faithful Muslim scholars did not lose totality. Islamic pharmacology was based on experiences and observations of generations upon generations. Islamic values did not allow Muslim to use drugs until they were tried out in the long-term for a body as a whole. Therefore, traditional medicines did not have

the same dehumanizing influence as modern medicines sometimes do.

It is said that to overcome the crises of nature and society, especially the ecological crises, it is necessary for us to understand our view of nature and reconsider it contrasting with other views. The Islamic view of nature is suggestive because it does not have a sense of an imminent collapse and of continuous disorder of the natural environment. A Muslim can live in peace and feel at home on earth because;

> He has lived in equilibrium with his environment because he has submitted himself to the universal laws which dominate all levels of existence and which are the metaphysical source of the laws governing the natural world.(24)

The Islamic view of nature is based on the interrelation of all existing thing. The most essential view, the harmony and equilibrium between man and nature is in direct contrast to the view in the West: that nature is a donation to and can be used freely by man. This attitude is destroying the equilibrium because it isolates each component, namely man and nature, rather than harmonizing them together, as is done in the Middle East. Our justification of the man-

centered view of nature by our regarding the view as an expansion of freedom is not comprehensible to Islamic thought. Moreover the philosophy of the "Unification of the Cognition and the Cognizable" exhibits well the Muslim scientist's attitudes to and observations of nature, while modern scientists cannot conform what they know with nature completely because their consciousness stands apart from reality. Many Muslim scholars are rediscovering their own spiritual roots now. It is not accidental that Muslim intellectuals were the first to rise-up against the abuse of nature in the name of science and progress. Their Islamic conscientiousness makes them suitable partners in a debate of the ecological crises.(25) Nasr states;

> Modern science has grown during the past few centuries by forgetting the interrelation between things, by isolating a particular phenomenon, by analyzing and finally generalizing the results of this analysis. In contrast, the traditional cosmological sciences, especially those of Islam, are based on the interrelation between things, on the unicity of nature, on synthesis and the vision of the whole within which alone the parts gave meaning. This is precisely what ecology aims to study, even if it limits its scope to the physical word. That is why it is so closely related to the philosophy of nature embedded in Islamic philosophy and science and is so alien to the prevalent philosophy of nature in the West.(26)

In spite of the fact that energy problems and resource exhaustion has been cried, natural forces and elements are still objects to be conquered not to be utilized for energy in our society, and the modern economic system is fixed in a one-way system from resource to waste. Contemporary people spend their lives in pursuit of material and sensuous pleasures. How happy a man is depends on how many luxury items he holds. Emulation in consumer behavior occurs. The Middle East stands at a crucial point--not only because it exports the main source of energy used today, but also because it has a responsibility to help the industrialized worlds more in solving energy problems by providing guidelines for the ingenious use of natural forces and elements.

As natural resources in Islam have been used effectively from ancient to modern civilization, the full ecological survey of energy in the Middle East seems of a doubtful value.(27) In the past, Muslims were wise to use wind for cooling houses and turning mills. Now, they are interested in how they can obtain maximum energy from light and sea water. In Islamic principles, resources should be allocated for the production of necessities at a low cost and in plenty, in order that most of the population can avail of

these necessities.(28) The traditional belief in the technology of re-cycling and high-durability is the technology of saving energy. The Islamic principles of resource allocation and traditional technology are instructive for dealing with the crisis of the exhastion resources facing modern society.

Islamic physicians defined health in their own terms. An interest in medicine was how they maintained this level of health and thus the harmony of their whole existence. They attached importance to hygiene and the natural recovery process of human bodies. Traditional Islamic pharmacology also had a balanced concern. In contrast to the Islamic medicine, Ivan Illich criticizes modern medicine in his book, Medical Nemesis.(29) According to Illich, medical care as a social system has responsibility to ease the pain of a patient when he is not suitable for his social role. The society does not make people aware of the basic and continuous reasons of diseases by means of forcing them to consult doctors. Medical care today hides structural reasons for diseases, which is essentially social, economic, and political, by treating the disease as an accidental and personal abnormality. As a matter of fact, diseases appear and disappear according to factors originating in the environment,

condition of habitat, custom of diet, and hygiene. The extinction of malaria and cholera owed not to the progress of medical care but to the progress of the above factors. Judging from the cause of a particular disease, it seems possible to say that the purpose of modern medicine is not to restore people's health but to improve over-all health itself. There is no limitation for the improvements, so manufactures of medicines have an infinite market and medical treatment becomes more and more accessible.

Several implications, in order to improve science and technology, crushed by careless investigations are found in other practices and in the living institutions of the traditional Islamic world. Examples are plentiful. Because Western physicians still cannot overcome simple headache, they come to study traditional remedies like acupuncture and herbs usage and a great degree of attention is being paid to Islamic medicine. Though we are apt to overhunt animals, Islamic zoology serves as a good reference to know how we can contribute to the maintenance of the ecological cycle. The urbanization in the present day world is the center of disorder and the basis of the ecological crises. But the planning and construction of the past cities in the Middle East remain a worth

while study. The specialization of modern industries made the transportation of final products unavoidable in the modern economy and caused the population to concentrate themselves in towns, whereas classical Islamic societies emphasized local-efficiency and local-level technology. Turning forests into deserts and the lowering of the water table are features of modern agriculture, on the other hand, the teachings of traditional Islamic agriculture become even more significant against the rapid destruction of top soil, and suggestive in the spread of cultivable lands.(30)

It is a mistake to declare that, as modern technology leads to contemporary crises, more development within the present framework is not necessary. In new civilizations, a lot of technology in the modern world today will not be available and almost all of it will have to be re-developed from ground-one under the conditions.(31) We need to establish a new paradigm of technology before we meet the catastrophies coming from the accumulating crises. We cannot ignore the inescapable conclusion that modern science and technology do not have the capacity of overcoming all of the crises. We have to reexamine the value of modern science and technology deliberately. As Seyyed Hosein Nasr mentioned, we need to study how

science of other civilizations and periods contributed to and lack for modern science.

In this thesis, I discussed the Muslims' views of science and the basic thoughts which established their own science and technology. Furthermore, I pointed out some characteristics of traditional Islamic science and technology. In the Islamic world, as in the West, science was used to obtain unimaginable riches and to improve life. However, the nature of scientific enterprises is quite different. There is a great deal to be learned and new insights to be gained, from the study of how the Islamic culture perceived science and its role in society.(32) For new civilizations, in order to fight against the crises and to make another paradigm, the study of Islam seems to be effective and helpful, in suggesting the course the world will have to take in the near future in order to minimize the drastic situation we find ourselves in.

Note

(1) Ziauddin Sardar, Science and Technology in the Middle East, (London: Longman, 1982), p.19.

(2) Ali Kettani, "Science and Technology in Islam," The touch of Midas, (London: Manchester University Press, 1984), p.87.

(3) A. I. Sabra, "The Scientific Enterprise," The World of Islam, (London: Thames and Hudson, 1976), p.183.

(4) Syuntaro Ito, "Bunmnei Iten, Arabiato Seiou," Chuto Kenkyu, Sep., (1984), p.12.

(5) J. D. Bernal, Science in History, Trans. Yasuo Shizume, (Tokyo: Misuzu Shobo, 1976), p.169.

(6) Azz Al-Azmah, Arabic Thought and Islamic Society, (London: Croom Helm, 1986), p.251.

(7) Toshio Kuroda, Islamuno Kokoro, (Tokyo: Chuokoronsha, 1980), p.168.

(8) Kettani, p.85.

(9) Ibid., pp.86-87.

(10) R. Graaf, "The Status of Science and Technology in the Western Asia Region," Technology Transfer and Change in the Arab World, (London: Pergamon Press, 1978), p.56. He states packaged technology constitutes not only the finished plant but also embodies the work that has gone into its design,

the selection of parts, processes, purchasing, erection and commissioning. Continued packaged technology importation, which is particularly strong in the oil-producing countris, will perpetuate technological dependence.

(11) Bichara Khader, "The Role of Technology in the Development and Integration of the Arab world," The problem of Arab economics development and integration, (London: West view, 1984), p.131. The transfer of technology is basically commercial transaction between buyers and sellers, an agreement upon a certain price for the transfer and operation of technology based on arranged contract.

(12) Ibid., p.133.

(13) Kuroda, p.30.

(14) J.R. Ravetz, "Science and Values," The touch of Midas, p.43.

(15) A. B. Zahlam, Science and Science Policy in the Arab World, (London: Croom Helm Ltd., 1980), pp.19-20.

(16) Abdus Salam, "The falling of Arab Science," The Middle East, No.140, (1986), pp.63-65.

(17) Lloyd Timberlake, "The emergence of environmental awareness in the West," The touch of Midas, p.131.

(18) Glyn Ford, "Rebirth of Islamic science," The touch of Midas, p.37.

(19) Timberlake, p.131.

(20) Ibid., p,133.

(21) Eric Ashby, Reconciling Man with the Environment, (London: Oxford University Press, 1978), p.33.

(22) Seiki Sha, Atarashii Kagakushino Mikata, (Tokyo: Koudansha, 1978), p.224

(23) David Bohm, Fragmentation and Wholeness, Trans. Masahiro Sano, (Tokyo: Kousakusha, 1985), pp.14-15.

(24) Seyyed Hossein Nasr, Islamic Science, (London: The World of Islam Festival Publishing Company LTD., 1976), p.234.

(25) S. Parvez Manzoor, "Environmental and Values," The touch of Midas, p.154. He mentions,

> Besides S. H. Nasr, other Muslim thinkers who have addressed themselves to the problem of modern scientific culture, have discovered in Islam a tradition particularly congenial to ecological harmony. Cf. for instance, Ziauddin Sardar, his earlier Science, Technology and Development in the Muslim World, and also S. W. Husaini, Islamic Environmental systems Engineering. Husaini's attempt to elicit environmental thought from Islamic sources forced him to trek the whole terrain of Islamic intellectual tradition--for such is the ubiquity of environmental concern in Islam.

(26) Nasr, pp.227-228. He mentions more,

> Islamic sciences may be said to be based on the profound intuition of the interdependence and interrelation of all things in the Universe, let alone the terrestrial environment, and their message for the modern world is, among other things, to remind man of the necessity of keeping in mind the central role of this harmony and equilibrium between opposites and the interrelation in every legitimate science of nature if this science is not to lead to the destruction of its own object of study.

(27) E. B. Worthington, Middle East Science, (London: Oxford University Press, 1946), p.83.

(28) Muhamad Akram Khan, "Resource Allocation in an Islamic Economy," The Islamic Quarterly, 4th, (1985), p.245.

(29) See. Ivan Illich, Nemesis Medicale, (Paris: Editions du seuli: 1974) as mentioned in Andre Gorz Ecologie et Politique.

(30) Nasr, p.223.

(31) Tadoru Kato, Shigenkarano Hasso, (Tokyo: Chuokoronsha, 1979), p.218.

(32) Ford, p.35.

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