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الحمد لله رب العالمين والصلاة والسلام على أشرف الأنبياء والمرسلين
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The Duality Principle:

A Quranic Approach to an Integrated Science Curriculum

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The following paper is based on the Quranic verse 51:49 which describes the nature of all created things. The English transliteration of the verse is, "Wa men kulli shayen khalqna zawgyne la'alakum tadhkaroon." This translates into English as, "And all things have We created in pairs in order that you may reflect on it.

ومن كلّ شيءٍ خلقنا زوجين لعلّكم تذكّرون

The word 'zawgyne' is consistently translated into the English language as 'pairs.' In scientific literature its meaning is extended to incorporate such concepts as 'duality', 'complementarity', 'opposites', 'inverses' and several other concepts reflecting conjugate and/or reciprocal properties. Terms will be listed below, within their respective disciplines, from the natural, biological and social sciences.

We find mentioned in the Tafsir of Ibn Kathir the following pairs of creation: the heavens and the earth, the sun and the moon, light and dark, night and day, the land and the oceans, life and death, jannah and narr. Ibn Kathir elaborates on the meaning of this verse (BY) saying that, "Every aspect of creation has the pair characteristic, extending even to the animals and plants. This is the case in order that we may reflect and know that Allah, The Creator, is One and there is nothing that can be associated with Him." In addition to verse 51:49 there are five other Quranic verses which include the term zawgyne. They

are: 11:40, 13:3, 23:27, 53:45, and 75:39. The pairs in these ayat reference all pairs at the time of Prophet Noah, male/female, all vegetation, and all fruits of creation. Besides the dual form, zawgyne, the singular and plural forms, zawj and azwaj, appear in multiple verses of the Quran.

Throughout the 20th century scientists have been on a quest to devise models of the universe which present accumulated knowledge in an integrated, coherent and unified manner. This paper will examine historical attempts to produce unified models for the natural and physical sciences. Continuing in the Einstein tradition, this paper will also look at contemporary efforts to find a model that describes all forces in nature. Recalling the words of Mendeleev, in a lecture to his chemistry class, "It is the function of science to discover the existence of a general reign of order in nature, and to find the causes governing this order. And this refers in equal measure to the relations of man, social and political, and to the entire universe as a whole..."

Finding the causes which govern the general reign of order in the natural sciences has traditionally been accomplished through observation and experimentation, followed by theorizing about the results of the experiments, testing the predictive ability of the theory, reporting the findings, rewriting the theory to accommodate any anomalies, and further experimentation. This process, generally referred to as the scientific method, has served the academic and science-based communities in the past when the traditional disciplines were compartmentalized with well-defined borders and boundaries. The technological applications of new discoveries have produced new sub-disciplines, the sub-disciplines further dividing into sub-sub-disciplines. Neuro-psychology, bio-physics, geo-chemistry, bio-geo-chemistry are a few of the new research areas. Findings from these fields are published in over 70,000 journals, reporting on 25,000 research fields. Over forty new scientific journals per week have been published, on the average, since 1978. The explosion of information and subsequent 'knowledge' in all disciplines, scientific as well as non-scientific, has increased dramatically. Students of science are expected to learn a babble of tongues and theories. Attempts to "integrate" the various science disciplines into a coherent whole have mainly fallen by the wayside and, in some cases have themselves developed into new scientific disciplines themselves. A classical example of an interdisciplinary science, created from two distinct scientific fields is that of cybernetics -- the comparative study of biological and electromechanical systems, which includes the study of machines that imitate human behavior and artificial intelligence. Technological applications, improvements and innovations have contributed substantially to the exponential growth in scientific knowledge.

An abundance of scientific information has resulted not only in an inability to keep up with new scientific discoveries, but worse, in an inability to teach science in a coherent fashion. Over 200 national reports on the status of science education today describe the present science curriculum as obsolete. Applying scientific principles to the knowledge-base of information would, in my estimation, contribute significantly to the evasive goal of a unified perspective on science.

Let's look at some of the attempts to organize the methods of science and some of the arguments against the possibility of achieving such a goal. UNIFIED SCIENCE, GENERAL SYSTEMS, REDUCTIONISM, consilience (a consolidation of theory) and SYNTHESIS are some of the key terms used to characterize the efforts of natural and social scientists to develop a unifying principle for all the sciences. The structure of the atom and Mendeleev's Periodic Table of Chemical Elements are classical examplesof unifying principles in physics and chemistry. Newton's integration of Kepler's and Galileo's theories into the law of gravity is another example of a unifying model which, depending on one's orientation, can be called a theory in unification, reduction, synthesis

or general system. The process of reducing or incorporating one theory into another is also characteristic of the scientific method.

Theories that explain or reduce existing facts into a complete and consistent descriptive model are used to make predictions about future events and investigate related phenomena. When new results from experiments and observations render the existing model obsolete or when anomalies and deviations from the predictive pattern of the model are found, a new model must be created. The development of new models happen in many ways. The two most well known methods of model creation are rearrangement and generalization. for instance, during Copernicus' time a geocentric model of the universe was in use. His rearrangement of the planets, which placed the sun at the center of the planetary system, resulted in a more complete and consistent solar model. The new model incorporated the older model that could no longer explain the current observations.

Generalization of the Newtonian concept of gravity, which included the notion of space, was used by Albert Einstein in his generalized principle of gravitation. Reduction and replacement of the principle of inertial mass with gravitational mass led to a more comprehensive theory. Reordering objects into other accommodating relationships or expanding a theory to reflect previously unaccounted-for facts, has been an integral part of the scientific method since the time of Aristotle.

In contrast to the natural sciences, theories in the social sciences are less easily verified. Social scientists oftentimes devise social models which aren't validated until after their death. The social and economic models of philosophers such as Bacon, Spengler, and Marx, for instance, have been tested in various political and socio-economic settings. Many of these models had failed to explain the events of their times, and were replaced by modified or resurrected older models. Failures, however, have never inhibited the desire or drive to devise models that give an orderly picture of the environment in which we live.

The first sociologist, Ibn Khaldun based all of his analysis on the Quranic revelations. His models have never been shown to be incorrect and, in fact, have been refurbished and imitated. Social scientists, unlike the natural scientists, are skeptical of the great unifying visionaries from among their ranks whether they are philosophers, religious leaders, political leaders, or even statesmen. Natural scientists, on the other hand, expect that older models will always be replaced with enhanced and all-encompassing newer models. New discoveries, resulting in the manipulation and control of matter and energy, always lead to newer models. Organizing or controlling social systems---whether economic, political, philosophical, or religious---has been more difficult, from the quantitative point of view, for the social scientists than it has been for their counterparts in the natural sciences. We have all witnessed the opposition that exists towards the idea of establishing a single world government, or a unified global economic system. For this reason, social scientists express strong reservations about ever finding a unifying model for their disciplines. They are content in revising, generation to generation, all sociologically-based theories.

Social scientists are not the only skeptics, however. The biologist Popper [5] argues that all "explanatory (reductionism) science is incompletable; for to be complete it would have to give an explanatory account of itself." Using an example taken from map drawing, he argues that an attempt by any formalized system to explain itself would prove futile. He submits a stronger argument for the incompleteness of science by appealing to the famous incompleteness theorem of Godel [2]. He argues that since all the natural sciences use arithmetic and since arithmetic is incomplete, therefore all natural science is, therefore, rendered incomplete. Popper is not the only one to

challenge the ability of science to "complete" itself. Physicists themselves challenge the ultimate completeness of physics when they argue that "theoretical physics will never admit terminal disciplines." [6]. Another significant problem is highlighted in Santilli's monograph. He points out that he attempt to use quantum mechanics to explain the atomic, nuclear and hadronic (sub-nuclear) layers of microscopic reality has produced models which "an increasing number of physicists believe to be in conflict with physical reality." The atomic layer has produced one single effective model. The nuclear layer lacks a single effective model and the hadronic layer has produced a proliferation of models!

Natural and social scientists express skepticism about the ability to devise a unifying modus of operation. An alternative approach is "the common good" model by Hurd [3]. It is an argument for charging science with a higher-order thinking model. It argues for the use of a model that presents scientific and technological concepts in their relation to social concerns, personal development and the common good. "To change the perspective of science instruction from a historical one to a focus on 'learning to learn' projects a future context. The goal is not to predict the future, however, but to use what we have learned and direct the future." The so-called "scientific method" is unknown in the scientific community, insists Paul DeHart Hurd, Professor Emeritus at Stanford University, and there are multiple ways of doing science. "Patterns of thinking shown by researchers in physics, ecology, cognition, molecular biology, and computer science, for example, differ in style and vary with the investigator. The reform movement of the 1990s calls for an integration of school subjects: a conceptual convergence of the natural sciences, mathematics, and technology with the social and behavioral sciences and humanities into a coherent whole. A unity of knowledge will make it possible for students to take learning from different fields of study and use it to view human problems in their fullness from several perspectives."

The idea of integrating the disciplines around a model of common good, social concerns and personal development, focuses on the human problems created as a result of the extremes to which mankind has gravitated in the use and manipulation of his 'power.' Monopolies, slavery, pollution, ethnic cleansing, nazism, poverty, nuclear intimidation, prejudice, and abuse of power and wealth are the excesses of human nature. In order to counterbalance a tendency towards these extremes, a view of science is needed which that alerts us to the boundaries beyond which, if we trespass, leads to these same abuses. A view of science based on the concept of duality would indeed accommodate Prof. Hurd's common-good model in a natural and humanistic way. Extreme modes of operation within the social realm should be analyzed within the context of the extremes of forces in the natural realm. A balance occurs between the extremes.

Another approach to the proliferation of scientific and non-scientific knowledge is the concept of 'consilience' that is proposed by the biologist Edward O. Wilson. Over the course of his long career, he has made contributions to population genetics, evolutionary biology, entomology, and ethology. He has also had a serious interest in philosophy, the humanities, and the social sciences. In his 1998 book, *Consilience: The Unity of Knowledge*, he makes us aware of the gaps and problems in his thesis to integrate all knowledge. First introduced by the English philosopher William Whetwell in 1840, the concept of consilience is the search for proof of "the alignment (literally, the 'jumping together') of knowledge from different disciplines." Wilson argues that through consilience, we can rethink some of the Enlightenment's long out-of-fashion goals: "the surprising orderliness of the universe, the possible intrinsic consilience of all knowledge concerning it, and the ingenuity of the human mind in comprehending both." By bridging the gap between traditional divisions of human inquiry -- specifically the chasm between the arts and the sciences -- Wilson believes that we will at last 'understand' the way our

world works. Prof. Sam Samanta of Finger Lakes Community College (Canandaigua, NY) has a web site dedicated to Wilson's efforts in consilience but focuses on dualities which need to be reconciled.

The duality principle...
The preceding remarks imply that it is impossible to establish a unifying conceptual model from which we can view all of the scientific disciplines. Some would argue that we need to seek convergence beyond the domain of science itself. The arguments against successfully producing a unified model appear to be rather strong. The Quranic verse 51:49, however, seems to be a clear principle which can be applied to, not only, the scientific disciplines, but also, to the social and behavioral sciences.

This principle I shall call "The Duality Principle." The duality principle characterizes several of the laws and operations found in almost all areas of study labeled as science. Duality is also a principle observed in the humanities. Terms like complementary, dialectical, opposite or inverse are sometimes used to indicate the idea of dualism. Dualism is often times used to refer to two opposing forces, two operations or two characteristics. The dual pairs might be observed functioning alone in a given phenomenon but, more frequently, can be distinguished and separated and labeled with their distinct properties. Other times, the two distinct elements act in such close proximity that they cannot be distinguished, except with precise measurements, such as the high and low pressure areas in atmospheric and climate patterns of the clouds or the barrier between fresh and salt water of the ocean.

Many times the duality principle can be identified immediately by the very terms that are used to define these interacting elements, e.g. action and reaction, particle and anti-particle, inhaling and exhaling. In general, however, terms that are in a dual relationship cannot be identified without knowing the science behind their definitions. For example, chlorophyll-hemoglobin, electron-proton, evaporation-condensation stand in a dual relationship with one other but their descriptive terms do not disclose that relationship!

In mathematics, often called the queen of the sciences, all 'operators' and 'operations' are studied only in a dual relationship. One rarely learns an operation in mathematics without also learning its inverse operation. Addition and subtraction, multiplication and division, raising to a power and taking roots, the distributive law and factoring, all come to mind immediately as examples of dual operations. Calculus is nothing more than the study of two dual operators that are, in fact, inverses of each other, viz. integration and differentiation. In physics, action and reaction, positive and negative charges, and particle and wave theories are known as dual and/or complementary principles. In economics, supply and demand, and profit and loss are connected in a dualistic manner. In biology the functions of chlorophyll and hemoglobin, inhaling and exhaling, muscle contraction and extension, anabolic and catabolic, osteoblasts and osteoclasts, lymphatic and myeloid elements are known to have opposite functions. In philosophy and political science the concepts of liberalism and conservatism, thesis and antithesis (Hegelianism) are dialectical, or opposites, and also fall into the dual category. In chemistry, Lavoisier's theory that every definite compound consists of two parts having opposite electrical activity was the basis for Jacob Berzelius' dualistic formulas [4]. In a book on the philosophy of language, the linguist Eco [1] describes duality as a structure from which language derives its meaning. Life and death, mind and matter (dualism of Descartes), space and time, subsistent forms and spacio-temporal objects, subjective ideas and objective reality, good and evil, yin and yang, the list is endless. In the humanities John Milton is referred to as the "Poet of Duality" [7], because of his focus on the concepts of good and evil and the ultimate paired destiny to which mankind will be delegated, heaven or hell.

Application of the Quranic verse 51:49, in the form of the Duality Principle, will greatly simplify and unify the structure from which we view all human knowledge. As the common assessment gauge we can analyze knowledge databases in the humanities, the social, behavioral, mathematical, and natural sciences . Duality should be considered as an axiom of the world in which we live. Our study of the respective instances of duality in language, biology, poetry, physics, music, economics, psychology, mathematics, political science, geology, history, chemistry, and in all the other well-defined disciplines will give us a view of the world which is more simplified, organized, unified and "scientific. This in turn will make it possible to accommodate the humanities, and to view the "human problems in their fullness from several perspectives." The general reign of order within science and the humanities may well be founded in this principle and may even satisfy Medeleev's invocation.

Islamic elementary and high schools can establish a science curriculum based on the duality principle. If Islamic elementary and high schools were to establish a science curriculum based on the duality principle, the principle could be introduced in the early stages of the educational process. If we were to teach the principle at the beginning school levels, and to identify those activities in our lives to which duality applies, we could then extend the principle to the more subtle dualistic relationships that exist in mathematics, science, language and ultimately, to each of the other disciplines. Inhaling and exhaling, the waking and sleeping states, night and day, hot and cold are all activities and observations that every one of us, consciously or unconsciously, witnesses daily. The extension of these observations to more sophisticated and scientific could thus be handled in a natural way. If students were to be presented with the structure of duality, and shown how it applies to each of us in our daily lives before they began studying the theories of any scientific discipline, they would have the opportunity to incorporate this knowledge into their understanding of the disciplines.

Recall the, sometimes, heated debate over whether light was to be classified as a particle or a wave. After many decades the debate finally ended with the full acceptance of the dual nature of light. Scientists acknowledged, over 70 years ago, that light has both a wave and a particle nature.

Modern-day physicists no longer argue about the complementary characteristics of matter and energy---they accept duality. They claim that for every force is an associated particle. Gravity is a force. So its complementery partner is a particle called the graviton. The graviton has not been has not been detected in laboratory experiments. Similarly the existence of a strong force, which binds the protons together in the nucleus of atoms and called the gluon, has not been demonstrated experimentally. While the gluon's existence has not been demonstrated experimentally, its theoretical existence is accepted, as is the theoretical existence of every particle that has a 'force' associated with it. What has been adopted here is, in fact, the duality principle described in the Quranic verse 51:49. In physics this theory is called "supersymmetry." This theory has lead to a more advanced theory, still being developed, which is being dubbed the TOE (Theory of Everything). TOE is based on a concept called "dual-spaces," which depends on the theory of supersymmetry. A summary of the ideas behind dual spaces, including several articles on TOE and the Mathematics of Duality, can be found in several past issues of Scientific American http://www.sciam.com/ including http://www.sciam.com/1999/1299issue/1299weinberg.html.

Grand Unification Theory and Spacetime Dualism

The General Theory of Relativity was published by Albert Einstein in 1916. It is a geometrical theory which postulates that the presence of mass and energy causes

spacetime to be curved, and this curvature affects the path of free particles and even deflects the path of light. In Newtonian mechanics gravity is a force. In General Relativity, however, gravity is no longer a force but is a consequence of the curvature of space-time.

Modern physicists have reduced all forces to four basic ones: the gravitational force, the electromagnetic force, the strong nuclear force, which binds the protons together in the nucleus of the atom, and the weak nuclear force, which causes spontaneous radioactive decay in atoms. In 1979, Sheldon Glashow, Steven Weinberg, and Abdus Salam combined the theories of electromagnetic and weak interactions into the electroweak theory. Attempts to unify all known forces began in earnest with Maxwell's successful 19th century unification of electricity with magnetism. Einstein's equivalence and relativity theorems continued this tradition of Maxwell. The effort, to unify all known forces into a comprehensive theory, is called the Grand Unification Theory (GUT). While some success has been made in unifying the gluon force between quarks with the electroweak force, problems arise when the force of gravity is included. In order to accommodate gravitational forces a new theory, called string theory, was developed in 1996. It is atheory of elementary particles which incorporates relativity and quantum mechanics. The particles are viewed not as points but as extended objects called strings. String theory is a theoretical framework for constructing unified theories which include both the microscopic forces of the atoms and macroscopic gravitational forces. The theory is sometimes referred to as the Theory of Everything (TOE).

The unification of all forces, however, is an impossibility according to the Quranic verse 51:49. The Duality Principle asserts that if a unified force, uniting the strong, weak, electromagnetic and gravitational forces is found, then a complementary, or dual force, would also be discovered! If this were not the case then the verse would be false and more seriously, from the Islamic point of view, the concept of tawheed (Oneness of Allah, azza wa jal) would be compromised.

There are also more recent arguments by physicists for the case of duality. Dualism is known to be a general property of matter. It is used to explain one of the long-standing puzzles in the hierarchy of masses of the fundamental fermions [8]. The history of particle physics shows that if a regular pattern is observed in the properties of matter then it could be explained by invoking some underlying structures. An explanation for the pattern of the fermion masses is based on the conjecture of spacetime dualism in the form of two reciprocal manifestations of space unified through an "inversion" region. Physicists are considering a dualistic view of spacetime to explain seemingly contradictory interpretations of quantum effects.

The zawgyne nature of creation described in the Quranic verse 51:49 and, in the principle that I call the Duality Principle, appears to be the general characteristic which scientists integrate into all of their theories. For Muslim Educators it should be accepted as a fundamental truth as the basis of reasoning and applied in all scientific investigations.

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