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THE MODERN SCIENTIFIC REVOLUTION:
A PHILOSOPHICAL INVESTIGATION

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Introduction: Meaning of "Scientific Revolution"

Generally, scientific revolution means a turn away by early modern scientists from the "scientific" systems of the ancient philosophers and medieval scholmen to their own empirical system – the modern experimental system. It is a separation from both philosophy and theology. It is the triumphant, interative, and drastic transformation of the scientific enterprise. Alexander Koyre records the profoundness of this scientific transformation thus:

What the founders of modern science...had to do, was not to criticize and combat certain faulty theories, and to correct or to replace them by better ones. They had to do something quite different. They had to reshape the framework of our intellect itself, to restate and to reform its concepts, to evolve a new approach to Being, a new concept of knowledge, a new concept of science. ¹

For instance, the ancient geocentrism, the physical model that the earth is the center of the universe bequeathed by Claudius Ptolemy was overturned by modern heliocentrism, the model that the sun is the center of the universe – the revolution wrought by Copernicus. In the same vein, the physics of Aristotle was supplanted by those of Galileo and Descartes; and the anatomy and physiology of Harvey and Fabricius were replaced by those of Galen. The New Encyclopedia Britannica presents an overview of the scientific revolution as:

...the re-education of common sense in favour of abstract reasoning; the substitution of a quantitative for a qualitative view of nature; the view of nature as a machine rather than an organism; the development of an experimental method that sought definite answers to certain limited questions couched in the framework of specific theories; the acceptance of new criteria for explanation, stressing the 'how' rather than the 'why' that had characterized the Aristotelian search for final causes. ²

But how are we to understand the term "revolution" in the expression "scientific revolution"? At what point does evolution become revolution? Ordinarily evolution is a process of quantitative change accompanied by
aspects of qualitative change. A unity of quantitative and qualitative changes. A revolution is a fundamental qualitative change. A complete change or transformation. These are the two senses one can understand the "revolution" in the "scientific revolution", the evolutionary or "continuity sense" and the discontinuity sense. In the latter sense, scientific revolution denotes a radical and total break with the "scientific" activities of the past; and the inauguration of a completely new scientific enterprise without any roots in the past. Such a thing, according to Loren Eiseley is not possible in science. "... in science there is no such thing as total independence from one's forerunners." The sense of "revolution" in scientific revolution is the revolution prepared by evolutionary changes. The "continuity sense". According to this view the modern scientific revolution occurred as a result of a recovery from ancient science; but that the pervasiveness and profundity of this recovery were so fundamentally novel and unprecedented that it amounts to a revolution. Herbert Butterfield who "popularized" the expression "scientific revolution" painted a vivid picture of what it means. He is quoted as saying that the scientific revolution:

Overtuned the authority in science not only of the middle ages but of the ancient
word -- since it ended not only in the
eclipse of scholastic philosophy but in
the destruction of Aristotelian physics -- It
outshines everything since the rise of Christianity
and reduces the Renaissance and Reformation
to the rank of mere episodes, mere internal
displacements, within the system of medieval
Christianity. Since it changed the character of men's
habitual mental operations even in the conduct of
non-material sciences, while transforming the whole
diagram of the physical universe and the very texture
of human life itself ...

It was nothing short of a revolution; and it was consciously brought about by
the leading scientists of the time. They were conscious that they were
inaugurating a revolutionary regime of science, a complete new and unprecedented idea
of the scientific enterprise. Hence, they consciously and punctiliously applied
the term "new" in the titles of their work. Recall Bacon's Novum Organum,
and New Atlantis; Kepler's New Astronomy; Galileo's Two New sciences;
etc. That term "new" common among the protagonists of the scientific
revolution had revolutionary significance.

There is, however, this other unique but not completely different
conception of the "scientific revolution" by Thomas Kuhn. To explain
the scientific revolution, Kuhn sought a parallelism between the 'metaphor'
revolution in scientific and political developments. And he submitted that just
as political revolution occur when the existing institutions cease to
adequately solve the problems of the social group, so scientific revolutions
occur when a "paradigm" or "normal science" ceases to be an adequate puzzle-solution to the "scientific community." To further his explanation, Kuhn introduces concepts like "normal science", "paradigm", "anomaly" or "crises in science", "scientific community", etc.

"Normal science" is the prevalent scientific activities of a scientific community; the science that answers their questions, solves their problems and dominates their attitude. It "means research based upon one or more past scientific achievements. Achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice." A "paradigm", on its part in ordinary usage, means a "model" or a "pattern". Kuhn appropriated this common usage in his explanation. According to him, "paradigm" is a scientific "achievement". A scientific achievement that possesses this essential characteristics; it is an unprecedented achievement that has attracted an enduring group of adherents from other models; it is also an achievement that is open-ended so as to give room for all sorts of problems to be solved by the community. In Kuhn's words, a paradigm is either the:

- entire constellation of beliefs, values, techniques and so on shared by the members of a given community.
- On the other, it denotes one sort of element in that constellation, the concrete puzzle-solution which, employed as model or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science.

The first sense of the word is the "sociological", while the second is the more "deeper" sense. One notices that "paradigm" and "normal science" in Kuhn, closely relate to each other.

Kuhn explains "scientific community" to mean adherents to a paradigm; men and women who share a paradigm. The persons who share one "scientific speciality". People who have one "scientific subject matter." And a scientific subject matter corresponds to a scientific community, e.g. physical optics, electricity, heat etc. "Anomaly" or "scientific crises" is the immediate precipitate of a scientific revolution. Some time normal science or a paradigm fails to answer the questions or to solve the expected problems of a community, this is called anomaly. And when anomaly persists, scientists and practitioners take different attitudes towards the existing paradigm as they begin extraordinary research and even a recourse to philosophy, this is crises. This leads the community to a new basis for practicing science — this shift to a new basis of practicing science is what Kuhn calls scientific revolution. For instance: the anomaly and the crises in copernican astronomy brought about copernican revolution in astronomy.

In Kuhn, therefore, a scientific revolution is not a cumulative universal change, but "... those non-cumulative developmental episodes in which an
older paradigm is replaced in whole or in part by an incompatible new one.**

Apparantly, Kuhn equated revolution with any major scientific changes not something that happened at a particular time, like in the modern period, as we won’t to argue in this dissertation. However, our two senses of revolution are not incompatible. Even Kuhn recognizes that scientific revolution became intensive during the modern period, for he says: what distinguishes the modern scientific revolution from earlier revolutions or transformations in science is that for the first time, science acquired a universally accepted paradigm contrasted with earlier times when there were equal competing modes.†† Consequently we will continue to expound the “modern” concept of the scientific revolution, the more popular in the historiography of science.

STATEMENT OF THE PROBLEM
Every age possesses a worldview, an ideology or a “philosophy”. Basic to every worldview is an explanation of “man’s relation to his natural environment.” The perspective of modern men, the worldview of our age is science. From the time of the scientific revolution to this day, science has dominated other worldviews like religion, mysticism, mythicism, etc. Science has become a kind of religion - scientism. Contemporary man, governments, and institutions, are science-possessed. Science touches upon all facets of life: health, wealth, communication, politics, war, and religion. In the intellectual realm, science has dominated other currents like metaphysics, epistemology, politics, philosophy, etc. And despite of protests, its dangers and shortcomings science is still flourishing and waxing. Yet science lies beyond the intellectual grasp of most people. Its operative concepts are alien to great majority of even the educated people. Science has become a specialised endeavour, an immense labour of observation, learning and analysis. It is no more a game for amateurs. Science has become mysterious to all but scientists. Science is increasingly being distanced from non-scientists. This is the problem.

PURPOSE OF THE STUDY
This paper, therefore, is the analysis and clarification of the scientific revolution. The scientific revolution is science at its best; science at its maturity; science at its golden age; science at the height of its development; science modernised. It follows that the analysis of scientific revolution necessarily involves an analysis of the revolutionary development of science. But this short paper will not go into the long, historical evolution of science. It will rather concern itself with the internal mechanism of the scientific revolution; that is, it will concern itself with how the revolution was effected in different science-fronts. The purpose is understanding, demystifying science, a kind of science-education. It is making science intelligible. If we have to live with science we need to understand it. For professional and amateur scientists, this has significant import for doing science as it exposes the internal operation of science.
MAJOR SCIENCE-FRONTIERS OF THE REVOLUTION

The revolution in science occurred in three major science-fronts. These are in the conception of certain scientific concepts, in the method of science, and in the application of science.

Three started occurring radical transformations or revolutionary shifts in the conception of certain concepts with which science is done: there was a new model of the world; there was a new conception of physics; and there was a new conception of gravity.

A model of the world is a coherent picture of everything known about the world. Every people have it: the ancient Egyptians, the ancient Greeks, etc. The last popular one in the history of Western civilization was the medieval model of the universe described in the 13th century by Alighieri Dante (1265-1321). This model was in actual fact ancient Greek model as formulated by Aristotle, Hipparchus, Ptolemy, and christianized by the theologians of the church.

This is the geocentric model. A model consisting of a stationary Earth at the centre of nine transparent and revolving spheres. An outstanding feature of this model is the distinction between the terrestrial and celestial realms. This radical break between the two realms occurred at the moon. Beneath the moon is the realm of imperfection, corruption, and generation. Everything in this realm is composed of the four elements of ordinary matter.

From the moon outwardly, the celestial or heavenly realm is a plenum of a more quintessential or perfect type of matter—a fifth element—the aether. The plenum of this realm carry a number of spherical shells and by their nature (composed of aether) move in uniform circular motion, with some fixed stars and planets. The motion here is not completely self-caused; ultimately the spheres were moved by Aristotle's First Cause or God; and sometimes Aristotle posited the existence of Resident Intelligences as movers of individual spheres.

Intimately involved in this model are the doctrines of natural places and motion. Terrestrial matter and Celestial matter behave radically differently. Terrestrial matter is always seeking its natural place in the centre of the universe: earth, the most humble element, seeks to be at rest in the lowest place possible—the centre of the Earth; water seeks to be above earth; air to be above water; and fire above air. Earthy bodies such as stone have a tendency to fall towards the centre of the Earth; whereas fiery bodies tend to rise. If a body is not at its natural place, then unimpeded, it will move towards it.

Horizontal (oscillatory) motions on Earth are always a result of applied force.

Celestial matter, on the otherhand, is not subject to change or decay and obeys a radically different law of motion. Being in its proper place it has no tendency either to rise or fall out of the sky. It moves sideways in perfect circles around the centre of the Earth. In this way, the nine celestial spheres, carrying everything we see in the sky, rotate about the Earth, each at its own speed. Each sphere at the care of a Resident Intelligence, a sort of Angel; and is driven by the love of God or in a later development of the theory, by impetus imparted by God.

The major revolutionary transformation of the Ptolemaic geocentric model was launched in 1543 by a canon of the Roman Church Nicholas Copernicus. In his book De Revolutionibus, Copernicus revised Ptolemy's mathematical model by eliminating equal points and by taking the sun to be the centre of planetary motions. Copernicus theory is a
mathematical demonstration that Heliocentrism is, in a principle, a simpler and more workable model than the Ptolemaic one.

Fully developed, however, Copernicus model was as complicated as the Ptolemaic one; it failed to predict the positions of the sun, moon and planet with any greater accuracy. The main reason for this failure was that Copernicus had retained the ancients’ idea that celestial bodies must move in perfect circles at uniform speed. Because of its technicality, Copernicus theory was regarded for over 50 years as a mere convenient computational device to save the appearance (calculate planetary positions).

That notwithstanding, his theory survived because of the simplicity of his model.

The astronomical revolution started by Copernicus raised three questions that must be successfully answered before his new model or any other one could stand. The questions are:

1- If the planets are not really carried round the earth by transparent spheres driven by the love of God or by impetus, then what makes them move? 2- If they are not held in place by transparent spheres or guided by Resident Intelligence, then what holds them in their orbit? 3- If, as Aristotle taught, a heavy body falls to earth because it is seeking its proper place near the centre of the universe, how are we to explain its behavior if the centre of the earth, and therefore the centre of the universe, is moving?

Tycho Brahe (1546-1610) contributed in the revolutionary inauguration of a new model of the world by attacking Ptolemaic geocentric model. He collected a lot of data through a great deal of astronomical observation. In a little published book De Stella Nova, Brahe carefully recorded the sudden appearance of a bright star in the constellation of Cassiopeia in 1572. For a short time it shone as brightly as Venus and by 1574 it had disappeared. This implied that something was wrong with the idea that celestial bodies are incorruptible and unchanging. Brahe also showed that the comet of 1577 was at least three times as far away as the moon as such beyond the terrestrial realm of change and decay, and well into the supposedly unchanging celestial realm. The comet raised two disconcerting questions:

1- How was change possible in the celestial realm? 2- How did the comet travel through the supposedly solid translucent spheres?

The next blow on Ptolemaic model of the world was struck by Johannes Kepler (1571-1630). In his book Commentaries on the Motion of Mars (1609), he analyzed the enormous and accurate observations bequeathed to him by Tycho Brahe. Kepler’s contribution is an induction and verification of three laws which eventually formed the foundation of Newton’s astronomy. Kepler’s three laws are summarized as follows:

1- The Planets travel paths, which are ellipses with the sun in one focus.
2- The areas swept out in any orbit by the straight line joining the centres of the sun and a planet are proportional to time.
3- The squares of the periodic times which the different planets take to describe their orbits are proportional to the cubes of their mean distances from the sun.

Kepler’s law implies it is impossible to represent the motion of a planet by a circle or combination of circles because its orbit is an ellipse. This is a reversal of the ancient notion that celestial bodies move in perfect circles. Kepler also advocated that in order for a body to behave as the planets apparently behave in space, there must be some kind of force to hold them in their curved paths. This implies discarding the translucent or plenium spheres of ancient model. Consequently, Kepler’s law of planetary motion marked the decisive break between the ancients’ tradition of speculative astronomy and
the birth of a new physio-mathematical field — celestial mechanics. This new model was finally fairly established by Newton.

The most popular polemics for the destruction of the ancient model and the establishment of the new model of the world was made by Galileo Galilei. In his book *The Two Chief World Systems* (1632), he presented arguments that ostensibly favoured the new heliocentrism against the ancient geocentrism. He showed that the copernican system was not a mere computational device to save the appearance. He advanced proofs for the physical truth of the Copernican system. With his telescope turned to the sky, he showed anyone that cared to look that there were mountains on the moon and spots on the sun which change from day to day. He also showed that there were moons which circle about Jupiter and not about the centre of the Earth.

Added bits of attacks on the Polemica model came from more scientists. Rene Descartes (1596-1630) forwarded the idea that a body will continue in a straight line unless it collides with another body. Robert Hook (1635-1703) suggested that there must be a force of attraction between all bodies which holds the planets in their orbits and cause things to fall to the Earth. But no one could show how powerful this force on the planets would have to be nor how it would vary with distance in order that they would have thei Kepler’s ellipses.

Sir Isaac Newton (1642-1727) solved these puzzles and his solution is contained in his great book, *The Mathematical Principles of Natural Philosophy* (1687) known for short as the *Principia*. In part 11 of the book captained “The System of the World.” Newton completed the Copernican revolution and thus gave the world a new working model of the solar system. He demonstrated mathematically how the motion of everything we see in the sky — stars, sun, moon, planets, and comets — can be explained and predicted by three simple laws of motion and one law of universal gravitation. He also showed that the motions we see on Earth, from the rise and fall of the ocean tides to the behaviour of projectiles and the fall of apples, are governed by these same laws. Thus Newton’s System of the World answered the key questions.

The first question what makes the planets move? Newton answered with the first law of motion. It states: Everybody preserves in its state of rest or of uniform motion in a straight line, except in so far as it is compelled to change that state by impressed forces. The other two questions were answered by Newton’s second law of motion (change of motion (i.e. change of momentum = mx) is proportional to the moving force impressed, and takes place in the direction of straight line in which such power is impressed) and by his law of universal gravitation. This law holds that the planets and the moon are held in their orbits by the force of gravity. To account for all this and for the acceleration of falling bodies on Earth, Newton showed that there must be a force of attraction between two bodies proportional to the product of their masses and inversely proportional to their distances apart. He also demonstrated mathematically that the force of attraction exerted by the large body, like the Earth, acts as though all of its mass is concentrated at its centre. A falling apple is really attracted to the centre of the moving Earth.

Newton’s system of the world broke the ancient barrier between the heavenly sphere: divine and incomprehensible, and the terrestrial sphere: imperfect and changing. And in so doing, united terrestrial and celestial mechanics. This new System of the World is a radical change from the geocentric planar model of the ancients with its
A NEW CONCEPTION OF PHYSICS

There were also effected similar revolutions in the conception of certain scientific concepts. For instance, the ancient concept of \textit{physis} (nature) or the existent thing as that composed of matter and form radically changed to the view that \textit{physis} (nature) or the physical existent thing is matter.

The seventeenth-century new conception of nature as matter radically diverged from antecedent thought in a number of respects. In the first place antecedent thought took the concept of matter to be merely a principle, a correlative of form, that which takes form. Matter was not something capable of separate existence. It could only exist as formed. In itself, matter lacked definiteness. In the seventeenth century, the revolutionary step was taken of conceiving matter as the independent physical existent; as the actual existent; as the self-subsistent stuff. Matter became fully "being"; that is, it was no more subject to "becoming". Matter is and always is what it is. That is, matter is completely without any capability of internal change, either by itself or of being changed by anything else. Matter in itself is entirely unchangeable. As Newton says, matter is movable but it cannot move itself.

Thus, in the seventeenth century as in antecedent thought, matter retains its passivity but diverged from antecedent thought in its relation to the concept of motion. For Aristotle, \textit{kinesis} (motion) was the internal process of change involved in becoming, in the process of actualization of potentiality. Also in Aristotelian thought, change is either qualitative alteration, quantitative alteration or \textit{phora} (change of place). In the new conception, because matter is fully actual, just what it is, not involved in any process of any natural change and passive, only \textit{phora} (change of place) is the possible motion for it. Thus in the new conception, motion becomes synonymous with locomotion.

A New Conception of Physics

With the new conception of motion, came a new conception of \textit{physics} (the science or knowledge of nature). In the modern conception as in Aristotelian, \textit{physics} is grounded in \textit{kinesis} (motion). But while Aristotle's \textit{kinesis} (motion) pertains to the physical as inner process of change, of becoming or actualization, that is, for Aristotle, physics is inseparable from metaphysics; for the seventeenth century scientific revolutions, \textit{kinesis} (motion) pertains to the physical existent only as a change of place (locomotion). Thus the science of physics is in terms of the motion, the change of place of bodies. In the seventeenth century the science of physics was thus pure \textit{kinesis} or \textit{phoronome}. This still entails a connection between physics and metaphysics but it does not make physics dependent on metaphysics as Aristotle made it.
more highly than probability. This underpins the high value placed on reason by the ancients. And this appeal to reason as sole arbiter constitutes the sharpest distinction between ancient method of science and the new one of the seventeenth century. In order words deduction in the hands of the ancients implied that facts were deduced and obliged to conform with an authoritative and rational synthesis. That is, deduction being a priori attached little or no significance to observation and experimentation.

At the beginning of the seventeenth century three men consciously laboured to revolutionize the method of doing science. They are Galileo Galilei, Francis Bacon and Rene Descartes. Of these three heroes of the revolution in the method of doing science Bacon was the most dramatic. Asserting this fact the first members of the Royal Society wrote:

If we must select some one philosopher as the hero of the revolution in scientific method, beyond all doubt Francis Bacon must occupy the place of honor.18

Bacon's new method of science is presented in his book the Novum Organum (New instrument or new method) 1630. Novum Organum is a conscious allusion to Organon - a corpus of Aristotle's logical treatises especially the part entitled "Posterior Analysis" dealing on method which Bacon intended to supersede.

Bacon generally accepted the main outlines of Aristotle's inductive-deductive theory of scientific procedure: the progression from observation to general principles and back to observations. But Bacon's new method was essentially inductive for he writes in the Novum Organum, Book 1, aphorism 19:

There are and can be only two ways of searching into and discovering truth. The one flies from senses and particular to the most general axioms, and from these principles, the truth of which it takes for settled and immovable, proceeds to judgement and to the discovery of middle axioms. And this way is now in fashion. The other derives axioms from the senses and particular, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried.19

In opposition to the Aristotelian, Bacon's new method is also experimental. He writes:

Why sit around waiting for the chance happening of phenomena? Speed up the process by creating the situation you wish to investigate? In this way nature can be coerced into unmasking her secrets at a more rapid rate.20

Bacon believed that making all possible observation and performing all feasible experiment, collecting and tabulating the results will yield a great mass of facts from which new more general laws of nature would almost automatically be extracted by a process of induction. Thus for Bacon, a pyramid of scientific theory would be built up
At first he who invented any art, whatever that went beyond the common perceptions of man was naturally admired by men, not only because there was something useful in the invention, but because he was thought wise and superior to the rest.

But as more arts were invented, and some were directed to the necessities of life, others to recreation, the inventors of the latter were naturally always regarded as wiser than the inventors of the former because their branches of knowledge did not aim at utility. Hence, for the ancients generally speaking, the pursuit of knowledge was an end in itself. It will be wrong, however, to assume that the utilitarian ideal of the end of knowledge was completely non-existent among the ancients. Many ordinary ancient people, that is, the folks, the non-scientists, valued the practical arts. The evidence is seen in a passage in the Republic. Glaucon was asked whether astronomy should be included in the education of the guardians, he replied: “I certainly agree, skill in perceiving the seasons, months and years is useful not only to agriculture and navigation, but also just as much to the military art”. Socrates replied to him: “I am amused that you seem to be afraid lest the many suppose you to be recommending useless studies”. The point of this dialogue is that Plato is aware that “the many” valued the practical utility of any inquiry. But these are the ordinary uninformed people.

Of the modern scientific revolutionaries, Francis Bacon again was outstanding in advocating the addition of what he called “the experiments of fruits (the application of knowledge to practical affairs)” to “the experiments of light” (the knowledge of the causes of things). Bacon’s moral imperative and grand design was to “restore and exalt the power and dominion of man himself, of the human race, over the universe”. The power and dominion which according to him man lost during the fall. Bacon proposed that the truth and value of any system of knowledge is utility. Both faith and science should be judged by their works. And the value of work is “for the glory of God and relief of man’s estate”. Bacon, and Descartes too, regarded their effort as a calling for the redemption of mankind in its material existence.

Bacon decided the science of his day for its wrong method and for being of very little practical use. He says earlier science was carried on by earlier scientists “seldom sincerely to give a true account of their gift of reason, to the benefit and use of men”. He remarked that earlier scholars substituted talk for experiment and contemplation for action. They were satisfied with purely verbal solutions to real physical problems. They confused science with religion and were always seeking final causes and doctrines which would explain physical phenomena.

The call by Bacon for the redemption of mankind in his material existence as the motive of knowledge was revolutionary. But more revolutionary was his equating the betterment of mankind with the glory of God. That is, for Bacon, material power was the means to the divine sanctified end. This markedly contrasted with the ancient view that the highest motive of knowledge was the cultivation of wisdom, contemplation, knowledge for its sake, or even a religious experience. This emphasis on the control of natural forces set Bacon’s philosophy in opposition to Aristotelianism.
For the purpose of advancing and applying science, Bacon proposed the establishment of a scientific academy, "House of Solomon" in his New Atlantis (1627). The academy was to be not just a learned society but a research and teaching institute equipped with laboratories, gardens, a library, workshops, and power houses. The members of the academy were to collect information from foreign lands, from books, from craftsmen, and from their own experiments and observations. The information so collected was to be arranged into the form of an encyclopedia from which a new theory or new system of natural philosophy could be derived, a system that would be of great use when applied to the common needs of mankind. In this regard Bacon writes:

The end of our Foundation is the knowledge of causes, and the secret motion of things, and the enlarging of the bounds of the Human Empire, to the effecting of all things possible.  

It was indeed revolutionary Bacon's call for the motive of knowledge to be to give power. He had a Faustian belief that knowledge was power; but his legal and scientific mind could not equate science with magic. Bacon was not an utilitarian in the base or narrow sense of the word. He more than any other revolutionary in the application of science inveighed severely against the evils of the purely "luciferous" (money-grubbing) motive of knowledge. He admonishes:

Lastly, I would address one general admonition to all: that they considered what are the true ends of knowledge, and that they seek it not either for pleasure of mind, or for contention, or for superiority to others, or for profit, or fame, or power, or any of those inferior things; but for the benefit and the use of life; and that they perfect and govern it in charity. For it was from last of power that the angels fell, from last of knowledge that men fell; but of charity there can be no excess, neither did angel or man come in danger by it.  

What Bacon advocates was "luciferous" (enlightening) knowledge. This, he believes, gives power; the power to improve the lot of mankind, and to increase the sum total of human happiness.

The Definition of Science

These sectoral revolutions in different science-fronts culminated in the birth, formalization and professionalization of modern science. Significant also in bringing these about were the scientific societies. The establishment, objective, structure, funding and membership of the scientific societies defined science.

There were earlier scientific societies but a definitional turning point in the life of science came with the establishment of the Royal Society in 1660. In 1645, in England, a group began to meet at the Gresham College in London under the name of the Philosophical or Invisible College. In 1648, most of the members moved to Oxford due to the Civil War. With the restoration of Charles II in 1660, London again became the centre for scientific activity and it was felt that an official scientific organization should be founded in England. Consequently, the scientists in London met at
Gresham College on 26 November 1660 and formally proposed the foundation of a "college for the promotion of physico-mathematical experimental learning". Two years later in 1662, Charles II sealed the charter which formally incorporated the institution as the Royal Society for the Improvement of Natural Knowledge, called the Royal Society.

The statute of the Royal Society drawn up by its founder Robert Hook in 1663 was instrumental in outlining and defining its nature, scope, concern, and method of science. Hook wrote that the "business and design" of the society is:

- to improve the knowledge of natural things, and
- all useful Arts, Manufactures, mechanic practices, Engines, and Inventions by Experiments – (not meddling with Divinity, Metaphysics, Morals, Politics, Grammar, Rhetoric, or Logic). To attempt the recovery of such allowable arts and inventions as are now lost. To examine all systems, theories, principles, hypotheses, elements, histories and experiments of things natural, mathematical, and mechanical, invented, recorded or practiced, by any considerable author, ancient and modern. In order to the compiling of a complete system of solid philosophy for explicating all phenomena produced by nature or art, and recording a rational account of the causes of things."

Its Chartering in 1662, with a replacement in 1663, made the Royal Society more permanent and formal. This was in part due to the influence and support of influential individuals such as King Charles II.

The Academy Royal des Sciences otherwise popularly called the Paris Royal Academy of Sciences was founded by Louis XIV in 1666. The Academy was founded and funded by the French government. It was also centered in Paris. This centralization has the singular effect of forging a consensus among the experimental community as a fundamental principle in doing natural philosophy (science). Before now experimental philosophers were ideologically heterogeneous, having a variety of physical philosophies and even divided as to the purpose and form of experiment. By the start of the eighteenth century, the experimental community shared a homogenous ideology with the same experimental methods. The consensus was that the only plausible natural philosophy was the one based on mechanistic principles, with the idea of a mechanistic principle not Aristotelian qualities. By early eighteenth century, the mechanistic view was shared by both laymen and clerics alike; and even by experimental philosophers passionately affiliated to Aristotle. And mathematical physics — eventually dynamics — was the leading model of human knowledge.

The Royal Society of London and the Parisian Académie des Sciences helped to establish science as a recognized profession. This they did by being models to the "specialized" scientific societies that proliferated in the nineteenth century. Scientific societies were specialized only in the sense that they belonged to a particular place. In the nineteenth century, they became specialized in the topic they discussed. In Great Britain, between 1800 and 1900, societies were founded for surgery, geology, astronomy, zoology, geography, entomology, botany, microscopy, pharmacy, there was a Societe
Chemique de Physique de Paris (1873). These provided, so to speak, "the social services of science"; they arranged meetings, conferences, publications, and they fostered professional standards by arbitrating in scientific matters. It was against this backdrop and about this time that William Whewell invented the word "scientist" thereby completing the professionalization of science. In 1840 Whewell wrote:

*We need very much a name to describe a cultivation of science in general. I should incline to call him a scientist. Thus we might say that an artist is a Musician, Painter or Poet, a Scientist is a Mathematician, Physicist or Naturalist.*

Before this date, the word science invited confusion and was used only for conveniences and to avoid constant recourse to the more cumbersome expressions "natural philosophy" and "experimental philosophy" both of which have authentic ring of the new learning of the seventeenth century.

The scientific societies anticipated the new rhetoric that praised the usefulness of science; its positive contribution to social and material progress; and its detachment from the value-laden realms of politics and religion. They also provided the standard of what could go by science.

**CONCLUSION**

We began with explaining that the scientific revolution is a radical turn away by early modern scientists from the scientific systems of the ancient philosophers and medieval scholars to their own modern empirical and experimental systems. From the time of this revolution, science became the dominant worldview so much so that it became a kind of religion - scientism. Individuals, institutions, governments are today science-possessed. There are protests to the dominance of science; but in spite of this, science is still wowing. The problem confronting people today is that in spite of its pervasiveness, science is unknown, mysterious, and distanced from a great majority of even educated people. There is the need, therefore, to understand science. To understand science, one had better start with an understanding of the revolution that brought it about.

The revolution in science occurred in three science-fronts: in the conception of certain concepts with which science is done; in the method of science; and in the application of science. The revolution in these science-fronts in real terms means a new conception of knowledge, a new approach to the way through which this knowledge is acquired; and a new motive for acquiring knowledge. This new enterprise also got a new definition, science. And the cultivators are called scientists.