DESCARTES : EPITOME OF SCIENTIFIC REVOLUTION

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1. The Tradtion

(a) The publication of Newton's *Principia* in 1687 inaugurated the era of supremacy of science. But the great scientific revolution had been accomplished in the first half of that century. For, it was during that period that the scientific thought was systematically organised and given its now-familiar shape. Descarte's (1596 - 1650) life spans those glorious fifty years.

An incalculable transformation in man's view of the world and his relationship with nature occurred in that wonderful half century. The scientific thought has, since then, been dominating our intellect completely. It is now well nigh impossible to imagine that there once was a totally different world-view and a foolproof and comprehensive Philosophy. The domination of this per- scientific world-view was so pervasive that the struggle of the incipient scientific thought against it appeared as hopeless as that of a tender blade of grass against a slab of stone.

(b) The tradition pictured the man as being central to, the scheme of things. His immediate surrounding, the nature, was open to his direct, scrutiny and ready to serve his ends. The prima facie experience of nature, full with colour, fragrance, sound, warmth, and beauty was authentic and indubitable. There was no need to go behind it. His farther surrounding was the finite cosmos, which revolved round the earth, man's abode, with its stars and planets.

Science changed all this. The immediate experience of nature with its colours, fragrance, sound, and warmth was a subterfuge which hid the real

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working of nature. One had to go beyond it and discover the mathematical formulae that governed the process of nature. Nature was immediate yet apart and did not serve man. His farther surrounding was an infinite universe without any centre. Man occupied an insignificant planet which orbited round a minor star called the Sun. Nature and nature's processes, the universe and its vast clockwork went on relentlessly paying the least heed to man and his aspirations.

This immense change in outlook developed over two-hundred years, and several generations of thinkers contributed to it. Descartes was a prominent leader in the final phase of the new movement. Like many of his contemporaries, he worked in many areas from optics to anatomy and from mathematics to metaphysics. But his immortal fame rests on the well-organised and succinct presentation of the scientific revolution in his such mature writings as *The Principles of Philosophy*. Here we are going to appraise Descartes as an epitome of the scientific revolution.

2. The Classical Thought in the Middle Ages:

(a) Extreme religiosity and repressive Christian dogmatism are characteristics of the society of the middle ages. It is, therefore, puzzling to find that the scholastic education was saturated with the Greek Philosophy which was a product of a pagan civilization. The puzzle, however, becomes less inscrutable when we realise that the classical philosophy was skillfully appropriated by the Church very early after Christianity reached Europe.

The early priests believed in the Gospel ; but they wanted to justify their belief on rational grounds in their debates with non-Christians. They, therefore, had to study the Greek philosophy to achieve their polemical ends. St. Augustine (354-430) is one of the first theologians who attempted a synthesis of Christian doctrines with Platonism and neo-Platonism [1].

The excuse was that they were grafting on the Christian belief those sprouts of Greek philosophy that were worth preserving.

Until the twelfth century, Christianity did not have a worthwhile contact with Aristotle's thought and the Christian philosophy was more Platonic and neo-Platonic. In the twelfth and thirteenth centuries Aristotle's writings became fully available in Latin translations and many of the most famous exponents of

Scholasticism set themselves the task of achieving a synthesis of Aristotle's philosophy and the Christian doctrine. The most famous of these Aristotelian Schōlars is Thomas Aquinas[2].

(b) However, very few read Aristotle in the original or even in Latin translation. Much of the scholarship was based on commentaries written by medieval scholars like Toletus (1532 - 1596), Fonseca (1528 - 1599) and by the Faculty of the University of Coimbra in Portugal. Many of the commentaries put so free a construction on the original Aristotelian doctrine that it verged on distortion[3]. Descartes observes "they (i.e, commentators) frequently corrupted the sense of his writings and attributed to him (i.e, Aristotle) various opinions which he would not recognise as his own were he now to return to the world"[4].

The school curricula were exclusively based on Aristotle's teachings. Out of ten courses, five used Aristotle's treatises as texts. Thus the alumni of the schools were soaked in Aristotelian philosophy. Naturally, most of them became staunch followers of Aristotle and even those who were critical of Aristotle used him as the reference point to measure their divergence. Descartes observe, "Those who did not follow him (i.e, Aristotle), among whom are to be found many of the greatest minds, did not yet escape being imbued with his opinions in their youth, as those from the staple of instruction in the schools"[5].

3. *The Traditional World-View :*

(a) The tradition had a well-knit set of theories which explained everything from the structure of the cosmos to the motion of a falling stone. Moreover, these theories conformed to immediate experience. Thus, it was consistent with experience to ascribe motion to planets and stars and to keep the earth stationary. Both those features of the traditional cosmology, namely, a well-woven scheme of ideas and their conformity with experience, made it a formidable target to its opponents. Here we shall mainly discuss those parts of the tradition that deal with motion.

According to the tradition the cosmos was a series of spheres centred on the stationary earth. The sphere nearest to the earth contained the moon and the farthest sphere that formed the boundary of the cosmos was studded with the fixed stars. The space between the lunar sphere and the boundary was called the celestial sphere; while the space enclosed by the lunar sphere was called the terrestrial sphere.

In the celestial sphere were the spherical shells on which were studded the planets, namely, the Mercury, the Venus, the Sun, the Mars, the Jupiter, and the Saturn. The space between the planetary spheres and the boundary sphere was filled with what were called the reagent spheres. The boundary sphere was kept rotating by God and the reagent spheres carried that motion to planetary spheres. All celestial bodies were formed of 'the fifth element', which was a type of matter that was transparent and weightless.

The matter in the terrestrial sphere comprised four elements, namely, the earth, water, air, and fire. The earth stood at the centre and was enveloped in layers of water, air and fire, in that order. Thus, matter in the cosmos was of five types, and each type of matter had an assigned or natural place.

(b) Motion in the sense of displacement of a body was called the 'local motion' and constitued just an instance of the wider concept of motion which was defined as the actualisation of that which was potentially as such[(6)]. Thus, education of a child, blooming of a bud, and fall of a stone were all instances of motion (in this wider sense), while the last instance was of local motion.

The placing of local motion in the locus of the wider concept distorted it in several directions. Firstly, motion is taken as a process of change and, therefore, it becomes transient and terminable. Secondly, a change is either due to an internal source as in the case of blooming of a bud or may be due to an external as in the case of schooling of a child. The same applies to local motion also. Thirdly, change produces a transformation in the body that undergoes a change and, therefore, the local motion is also expected to produce a change in the body that is displaced. Hence, the model for motion, including the local motion, is biological and not mechanical[7].

Let us see what kind of understanding there can be of a local motion, like the fall of a stone, in this set-up. When a stone falls its motion is terminable on reaching the ground. It is a process which exhausts when the stone reaches its assigned position. The source of motion is inside the body of the stone, namely, its desire to regain the natural position. The motion produces a change in the body for the desire to regain the assigned position that resided in the body is removed at the end of the motion.

The fall is a natural motion and the stone rests permanently on the ground, unless it is removed by an external cause. The motion thus generated is a violent motion. In this case, too, as in the case of natural motion, the source of motion must act in contact with the body in motion, e.g. in the case of a flying kite, the breeze acts in contact with the kite.

In studying local motion in this set-up we are more interested in the source of motion than in the speed or path of motion, i.e., we are interested in kinetics and not in kinematics. Further, what attracts our attention more is the change that occurs in the body and not the change in location.

(c) We have seen that orginally the Christian Tradition was strongly influenced by the neo-Platonism. Neo-Platonism had a potent component of Pythagorean philosophy, which emphasized that the world was made of numbers and physical phenomena could be expressed in terms of mathematics [8]. But in the later middle ages Christianity became thoroughly informed by Aristotelian philosophy, and then the attitude of the tradition to mathematics became very ambiguous.

Aristotle postulates three classes of entities. Physical entities lead an independent existence but are subject to change. Metaphysical entities have independent existence and are unchanging. Mathematics studies objects that are abstracted from sensible things. Such objects have dependent existence and are immutable. Principles governing entities belonging to one genus cannot be expressed in terms of the principles that govern entities in another genus. hence, mathematics cannot be used to express physical phenomena.

Every corporeal body comprises matter and form, and physics studies both. The form gives the body its qualities such as colour, fragrance, weight, shape, etc. Therefore, physics studies material body with all its properties. Mathematical concepts are incapable of capturing a body with all its physical properties. In particular, mathematics cannot explain qualities and motion of a body for "there is no quality and no motion in the timeless realm of figure and number" [9].

Nevertheless, Aristotle proposes a category of mixed and subordinate sciences such as optics, where one may use the geometrical principles to study the path of light. Other sciences that fall in this category are harmonics and astronomy[(10)].

4. The Revolution :

(a) Descartes' *Principles of philosophy* was published in 1644. These principles succinctly summarise the scientific thought of the sixteenth and seventeenth centuries. The principal architects of the scientific thought were the great thinkers like Copernicus (1473 - 1543), Kepler (1571 - 1630), and Galileo (1564 - 1642). But several less known figures like Gassendi (1592 - 1655), Mersenne (1588 - 1648), and Beeckman (1588 - 1637) also made significant contribution to the development of science.

The main theme of the new thought was the concept of motion. There were three approaches to the centrality of this concept. Firstly, the study of physics was reduced to the study of motion. Secondly, the motion was shorn of its trappings which it had acquired as a part of the wider concept of change. Thirdly, the motion became expressible in mathematical terms, and this set the trend for subsequent development.

(b) The scientific thought presented a rival world-view right at its inception. The Copernican theory replaced the finite cosmos by the infinite universe and, instead of the earth, took the Sun and the fixed stars as its points of reference. The cumbersome system of planetic spheres and reagents had been replaced by equally complicated system of epicycles and equants. It now gave way to elliptical orbits of planets. The new world-view had devastating implications for the traditional conception of motion and these implications are methodically worked out by Descartes.

In the twenty-first principle Descartes declares "the extension of the world is indefinite".[(11)] This means that the universe has no centre and elements have no assigned places. In the twenty-second principle Descartes asserts "the matter of heavens and earth is the same".[12] This repudiates the traditional division of the world in the celestial and the terrestrial spheres. It means that the motion of the celestial bodies and of the terrestrial ones are at par.

According to the tradition, physics was concerned with the nature, i.e. the matter and the forms of corporeal bodies. under the new theory form alone became important, since there was only one kind of matter. Descartes states in the twenty-third principle that the diversity of form is due to the motion of matter. "All properties of matter....can arise from the motion of its parts." [13] Thus, the central theme of physics is the study of motion.

(c) Tradition regarded the local motion, i.e. the displacement of a body, as an instance of change. Descartes dismisses this wider conception and says that by motion he understands "nothing more than the action by which a body passes from one place to another".[14] The classification of motion into natural and violent motions loses its rationale when the notion of the assigned place of an element is rejected. Since motion is only the displacement of body and not a change in it, motion is treated as a mechanical phenomenon and not as a biological process.

A consequence of this reasoning is that *motion and rest* become parallel phenomena. Motion is no longer a process, in that it does not exhaust on its own. If a motion ends, then there must be an external source for it. The same is true of rest. Rest does not end on its own; there is some external source that moves a body out of rest. It means that rest and motion are states of a body, and a body does not change its state on its own. This is the famous law of inertia, which Descartes states as the thirty-seventh principle.

An objection to the Copernican theory was that it did not mention the source that kept the planets moving round the Sun. The tradition had worked out the source of the motion of planets round the earth, to God. The law of inertia provides a neat answer to the objection against the Copernican theory. The planets move because there is no source that stopes them. In fact the question of source of motion becomes insignificant under the new dispensation. Instead of kinetics it is the kinematics of motion that assumes importance. Descartes takes both, the circular as well as the rectilinear paths as the paths of inertial motion.[15]

5. *Primacy of Mathematics :*

(a) The medieval tradition originally carried the stamp of neo-Platonism.

Neo-Platonism had a kind of mysticism at its core and this mysticism was in close affinity with the belief of the Pythagoreans in the mathematical structure of the world.[16] It was therefore, believed that mathematics was the key to understanding of the world.[17]

Later, the Christianity appropriated the Aristotelian philosophy, and the neo-Platonist slant in the early tradition disappeared. Mathematics was replaced by logic. In the curricula of schools, logic formed an important part. Logic was supposed to serve two purposes. One, it was a science of demonstration, that is, of proving conclusions from the premises. It was believed that the syllogism was an instrument of deriving factually new information. Two, logic was supposed to provide a nomative theory of thought. Commentators on Aristotle regarded it as a psychological theory giving an account of how mind should function.[18]

In spite of the oficial suppression of the original mathematical current in the tradition, several schools in Europe had kept the belief in mathematics alive.[19] The scientific thought that began with the Copernican theory was informed by this faith in mathematics. Indeed, there was no basis for the postulation of a heliocentric universe and for Kepler's laws of planetary orbits except that they displayed a beautiful mathematical harmony. There was no empirical evidence that supported the heliocentrism.

Galileo was a great exponent of mathematical demonstrations of physical phenomena. He continuously expressed his astonishment at how natural events followed principles of geometry.[20] Galileo created the mathematical science of local motion. For him it was "a simple and natural extension of the exact mathematical method to a field of somewhat difficult mechanical relations".[21]

(b) We have noted earlier the two objections that tradition raised against the use of mathematics in physics. The first was that the mathematical concepts were inadequate to capture the qualities in corporeal bodies. Galileo observes that a distinction must be made between that which is absolute, objective, immutable, and mathematical on the one hand, and that which is relative, subjective, fluctuating, and sensible, on the other. He then declares that only the former can be the object of knowledge. Number, figure, magnitude, position, and motion are intrinsic to corporeal bodies, and hence, the primary qualities.[22] Descartes puts this in a nutshell when he states : "the nature of body consists not in weight, hardness, colour, and the like, but in extension alone".[23]

The second objection was that the subject matters of mathematics and physics belonged to different genera. Descartes meets this objection by saying "all sciences form an organic unity and that all must be studied together and by a method that applies to all. This method must be that of mathematics".[24] In the sixty-fourth principle, Descartes emphatically states that in physics one need not use any principles other than those of mathematics.

Not only the underlying structure of the world was mathematical but the method of discovering facts was also mathematical. In this connection Galileo and Descartes repeatedly express their dissatisfaction with logic, especially with that logic that was taught in schools. For logic merely "teaches the mode of expounding to others what we already know".[25] The new facts can be discovered only by the mathematical method.[26]

(c) The scientific revolution accorded primacy to mathematics. It repudiated the authenticity of experience if it was not consistent with mathematical calculations. The qualities of bodies like, fragrance, colour, or taste were ignored, and only extension was declared as essential, because it was amenable to mathematical treatment. One may rightly ask if we are justified in paying so much of price to buy mathematical consistency. Is mathematics more credible than experience ?

The imdubitability of mathematics was questioned by Descartes also in his early researches in mathematics. The problem was one of expressing solution of an algebraic equation in terms of a line-length. A line-length was "clear and distinct", and, hence, indubitable. But Descartes found that except in very simlple cases it was not possible to express a solution of an equation as a line length.[27]

There was a deeper objection, too. It may be convenient and fruitful to assume that there is a mathematical structure that underlies the phenomena. In more concrete terms, it may be expeditious to accept heliocentrism because it simplifies calculations and presents a harmonious picture of the universe. But this does not mean that the world is in fact heliocentric. It will be intellectual arrogance to insist that, because we understand the world in mathematical terms, God must have made it so.

Descartes himself entertained such an objection. God could have created exactly the same world as the one we have and yet have made different things true in it. As an illustration he suggests "God was free not to make it true that the radii of the circle are equal." [28]

These objections became alarmingly real when Galileo was condemned in 1633 by the Church for holding heliocentrism as factually true instead of as a mere expediency. Descartes, therefore, turned to metaphysics for the justification of science.

6. Justification of Science :

(a) Right from antiquity there had been two opposite attitudes to knowledge. The justifictionists maintained that there was indubitable knowledge and man could attain it. This was countered by the sceptics by a two-fold argument : (i) There was no indubitable knowledge; and (ii) if there was any, it was not attainable. By the seventeenth century the Christianity had answered the first part of the sceptic doubt. Since God created the world in a particular way, He had the objective knowledge of the world. The Church had the answer to the second part also. Though the difference between God's knowledge and rational mode of inquiry was unbridgeable, one could reach it through faith. This latter answer was a complete antithesis of scientific revolution.

Science had discarded the prima facie experience as untrustworthy. It was the mathematical formulations of the experience that carried conviction. Descartes had started with the belief that mathematical ideas were clear and distinct. But this belief suffered a set-back when he failed to express solutions of an equation as line-lengths. Further, though mathematical formulation of the world might appear convincing to us, there was no reason to believe that it conformed to the actual structure of the world. It was, therefore, necessary to find a justification for the scientific enterprise.

(b) We can give here only a brief outline of the arguments that Descartes advances to meet this difficulty. There are two reasons for this. Firstly, a full sketch of the argument will take much space; and, secondly, we are familiar with it because it informs our scientific activity even today.

The criterion that Descartes applies to test the veracity of a knowledge claim is of clarity and distinctness. An idea is clear when it lets itself be seen, but it is distinct when it thrusts itself upon our attention,[29] i.e., when it is convincing. This criterion has a long and complicated pedigree in the tradition. Aristotle believed that there was a natural way of functioning of our sense organs, which revealed the nature of the world to us. By the seventeenth century this doctrine came to be described as the "natural light of reason". Descartes adopted it as the criterion of clarity and distinctness. An idea was indubitable if it was perceived clearly and distinctly.

But this criterion was under cloud now; because, what we may find clear and distinct in the natural light of reason, may not objectively exist. For, our ideas may not be in conformity with God's design.

(c) Descartes begins by taking on the sceptics. Let us start by doubting each and every opinion. But this doubting involves one indubitable fact, namely, that there is someone who doubts. "Accordingly, the knowledge that *I think, therfore I am* is in fact the first and most certain that occurs to one who philosophises orderly".[30] This entity *I* which thinks, is not a corporeal body. It is the thinking mind.

The thinking mind reviews all the different ideas it has. When it starts to explore the idea of perfection, it concludes that the mind itself is not the most perfect; for, *to know* is more perfect than *to doubt.* Now the mind by itself cannot contemplate of something more perfect than itself, it can only think of something less perfect than itself. therefore, there is something more perfect than the mind that gives the mind this idea. This something is God, the most perfect. Because, He is the most perfect, He exists.

God gives us the sense organs and through it the knowledge of the world. "He is absolutely veracious and the source of all light, so that it is repugnant for Him to deceive us". Therefore, "all that we clearly perceive is true" [31] Thus God is the guarantor of the criterion of clarity and distinctness. True, we do make errors and our knowledge of the world is incomplete. But our errors are due to our privations and our eagerness to pass judgments before we have clear and distinct idea of a phenomenon, while incompleteness of our knowledge is due to our finiteness and God's infiniteness. But, in spite these shortcomings, there is hope. We have clear and distinct ideas about some phenomena and we can build upon this knowledge. Though we may never attain complete knowledge, there is a possibility of progressing towards it indefinitely.

(d) In this study of Descartes we had to pass over some of his important contributions to mathematics, to optics, and, the most important, the separation of mind from body. We also ignored some of his ideas, such as his theory of vortices, which were later proved to be erroneous.

My intention was to appraise Descartes as an epitome of the scientific revolution. I picked up a few prominent ideas in Descartes' philosophy such as the new world-view, the distinction between primary and secondary properties, the primacy of mathematics, and the criterion of clarity and distinctness, and showed that these ideas can be used as milestones in mapping the development of the scientific revolution.

NOTES

1. Wedberg, Anders : *A History of Philosophy* (Vol I), Clarendon Press, Oxford, 1982, p.15.
2. *Ibid.* p. 150
3. Gaukroger, Stephen : *An Intellectual Biography of Deseartes,* Clarendon Press, Oxford, 1995, p. 57.
4. Descartes, René : *A Discourse on Method,* I.M. Dent & Sons, New York, 1912, p. 151.
5. *Ibid.* p. 151
6. Ross, Sir David : *Aristotle,* Methuen & Co. Ltd., London, 1960, p. 81.
7. Koyre', Alexander : *Metaphysics of Measurement,* Chapman & Hall, London, 1968, pp. 5-6.

8. Burt , E. A. : *The Metaphysical Foundations of Modern Physical Science,* Routledge and Kegan Paul, London 1925, p. 42-43.
9. Koyre', Alexander, *op.cit,* p. 8.
10. Gaukroger, Stephen : *op. cit,* p. 57.
11. Descartes Rene' : *op. cit,* p. 209.
12. *Ibid.,* p. 209.
13. *Ibid.,* p. 210
14. *Ibid.,* p. 210.
15. Gaukroger, Stephen : *op. cit,* p. 245.
16. Burtt, E.A. *op. cit,* p. 40.
17. Wedberg, Andres : *op. cit,* p. 48.
18. Gaukroger, Stephen : *op. cit,* p. 54.
19. Burt , E. A. : *op. cit,* p. 42.
20. *Ibid.* p. 64.
21. *Ibid.* p. 62.
22. *Ibid.* p.73.
23. Deseartes, Rene' : *op. cit.,* p. 200
24. Burt, E. A. : *op. cit,* p. 98.
25. Descartes, Rene' : *op. cit,* p. 15 and p. 156.
26. Burt, E. A. : *op. cit,* p. 65.
27. Gaukroger, Stephen : *op. cit,* p. 179.
28. *Ibid :* p. 205.
29. Gaukroger, Stephen : *op. cit,* pp. 122-123
30. Descartes, Rene', *op. cit,* p. 167.
31. *Ibid.* p. 177