The Philosophy of Nature and

Modern Science:

A Study of Motion

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Preface

Philosophy of nature occupies an important part in the Thomistic synthesis, and, in the order of educational development, is prior to other philosophical considerations. Yet the philosophy of nature, if not outrightly rejected, generally receives the least amount of consideration of all areas of philosophy.

The rise of modern science seems to have vanquished the philosophy of nature; at least many philosophers have accepted its demise in practice if not in theory. Basic contradictions between modern science and the philosophy of nature are pointed out. Yet the mind says there is but one material world and there must, therefore, be but one truth.

Having some background in both science and the philosophy of nature and convinced of the value and importance of both, this problem seemed of especial importance to the writer. It was with the intention of investigating into this question that the topic for this thesis was chosen.

The work has been personally rewarding and it is hoped that the reader may gain some insight into this problem and its solution.

Table of Contents

I. <u>Introduction</u>

Since the rise of modern science in the seventeenth century a conflict with the philosophy of nature has raged -- usually to the latter's disadvantage. The reasons are many and varied. It is the purpose of this paper to provide a background in which these problems may be considered and the possibility of any solution be explored. Two things will be basic to the inquiry; the nature of the two sciences and the proper relationships between them that follow from their natures.

The inquiry will proceed along the lines of an empirical investigation to <u>determine</u> what <u>is</u> the case rather than to decide what it <u>should</u> be. Accordingly both the philosophy of nature and science will be taken as they are with no attempts being made to conform one to the predispositions or prejudices of the other.

The first step in determining their natures will consist in observing them a t work to see how they actually operate. The work of Aristotle, the founder of the philosophy of nature, will be studied as it is contained in his writings. Modern science will be considered from the t ime of Newton, the founder of the physical-mathematical sciences, as it has developed up to modern times.

With this background the discussion of the natures of the philosophy of nature and science becomes much clearer. Conclusions as to their nature must follow and be in accord with the sciences as observed in their operations in the second section. The basic principle governing the procedure in the third section will be to determine what scientists consider science to be and what philosophers consider the philosophy of nature to be. Each field will be accepted as it is. The basic validity of both the philosophy of nature and science is presumed and will not be considered as such.

The relationship between the philosophy of nature and science will be investigated in the fourth and last section. Conclusions here must follow from the previous considerations. Some of the "conflicts" and their origins will be discussed in the light of what has been determined about the nature of the two fields and their relationship to each other.

Philosophy of nature is used here to designate the branch of Thomistic philosophy called cosmology, which considers the material world. Psychology, or the study of living things, is not included. Science is used to designate primarily the mathematical-physical bodies of knowledge arising with Newton in the seventeenth century. The names as used here, have no significance beyond terminology.

Briefly then, the method will be to proceed from the treatment of motion by these two disciplines to implications of their natures. The consideration of their natures should shed light upon their relationship to each other. At this point the difficulties and "conflicts" can be examined.

II. Motion

The Philosophy of Nature, Aristotle Background

Contemporary Philosophy and Science

The area here called "philosophy of nature" had been a primary concern of Greek philosophers. While Plato, indeed, had great influence on Aristotle, the latter articulated a philosophy of nature distinctly his own.

Aristotle had to depend on sense experience and more especially his own sense experience for his starting material. Science, as understood today, was almost totally lacking in Aristotle's time. Beyond a few simple observations, there had been no progress except as regards the practical problems involved in living. Highly speculative theories were plentiful and certain older and erroneous theories were accepted by Aristotle and were used in the elaboration of his philosophy. Two important examples are the theories of geocentricism and the four elements.

Consequently, Aristotle constructed his remarkable philosophy of nature based upon the principles of matter and form by observation and reasoning, starting with almost nothing except for what "knowledge" was available from previous thinkers. He developed and expounded his theory chiefly in the _Physica_ and _De Caelo_.

The _Physics_ deals with more general considerations (motion in general): "our first task will be to try to determine what relates to its principles."[1] The De Caelo considers more specific applications, i.e. local motion.

In deriving his concept of matter and form Aristotle first observed change or becoming. He saw that something changed in every "becoming," but something also remained, "an unmusical man becoming a musical man."[2]

> Now in all cases other than substance it is plain that there must be some subject, namely, that which becomes. ...
>
> But that substances too, and anything else that can be said 'tobe' without qualification, come to be from some substratum, will appear on examination. For we find in every case something that underlies from which proceeds that which comes to be; ...[3]

Aristotle has arrived at the determined and determining, the principles, matter and form. "I say everything comes to be from both subject and form."[4]

The various forms of determining or the modes of being were classified by Aristotle in the Categories. Essential predication refers to substance. Non-essential predication is either intrinsic or extrinsic. Quantity, quality, and relation belong to the intrinsic. The extrinsic is divided into what is common to all things and what is common to man, i.e. habitus. What is common to everything is predicated according to efficient causality, action and passion or according to measure, quando and ubi.

On this basis Aristotle begins to consider the notion of motion in Book III of the Physics.

Aristotelian Motion

Since Aristotle defined nature as "principle of motion and change," motion must be understood for the correct understanding of nature or the material world. For this reason he treats of motion in some detail.

Then Aristotle proceeds to classify things in three ways, "(1) what exists in a statement of fulfilment only, (2) what exists as potential, (3) what exists as potential and also in fulfilment...in each of the other modes of the predication of being."[5]

Motion must take place in things. "Again there is no such thing as motion over and above the things."[6] Since the Categories according to Aristotle adequately divide all reality, all things, motion must then take place with respect to the categories."It is always with respect to substance or to quantity or to quality or to place that what changes changes."[7]

Aristotle then defines motion: "The fulfilment (activation) of what exists potentially, in so far as it exists potentially, is motion."[8] Several examples are used toillustrate the definition. In the beginning an object actually cold is potentially hot. In the process of heating the object becomes hot but is not yet actually hot. The object potentially hot is not in motion nor is the hot object. Only the object imperfectly heated, ordered to further act in the form of heating can be said to be in motion. Thus motion is an activation and the object in motion is partly activated in respect to the term of the motion, but still on the way.

Motion "cannot be classed simply as a potentiality or as an actuality"[9] or "privation" as others have attempted to do. The only possibility remains the suggested definition.

Local motion then is the actualization of an object according to the predicament, "ubi," insofar as an object is not yet present to the "ubi" which is the term of the motion, but is "on the way" or "part way there."

After presenting and explaining the essential definition of motion, Aristotle treats of various directly related questions.

Every physical mover, as it acts through contact, is itself acted upon and therefore moved <u>per accidens</u>. The object in motion is moved <u>per se</u>.

The question was considered as to where the motion lay, in the mover or the moved. The answer given is that the mover is such because it actually gives, but it is the moved which receives the actuation. "Hence there is a single actuality of both alike," but considered in diverse ways. "For insofar as motion is from the agent it is called action, and insofar as it is in the patient it is called passion."[10]

In Book IV Aristotle discusses the related aspects of motion, place, void, and time.

Place is known through replacement; where one object is now, another is later. That out of and into which they pass must be something different from both. Place also exerts a certain influence, Aristotle concluded, in that each of the four elements is carried up or down to its own or its natural place unless hindered. Consequently place must exist.

Various observations and reasonings lead him to give place these essential characteristics: it contains, is not part of the contained, is equal to the contained, is separable from the contained, is distinguished according to up and down according to the natural places of things.

By proposing and rejecting various definitions he concludes that "the innermost motionless boundary of what contains is place."[11] Place must be considered because of a special type of motion according to space or the predicament, "ubi."

He then concludes that past the middle point between earth and the edge of the universe is "up" and below the midpoint in the direction of earth is "down." Further, "If then a body has another body outside it and containing it, it is in place, and if not, not."[12] Therefore everything which is in place (contained) is subject to motion.

After much discussion and analysis, time is defined to be the measure of motion. "Time is a measure of motion and being moved, and it measures the motion by determining a motion which will measure exactly the whole motion, as the cubit does the length..."[13]

In Book VIII Aristotle considers the species of locomotion. "The motion of everything that is in the process of locomotion is either rotatory or rectilinear..."[14]

Rectilinear motion since it is subject to contraries, up and down, forwards and backwards, left and right (the coordinates of the s phere of place) must stop to reverse direction and therefore cannot be continuous.

Rotatory motion, however, is continuous, "for rotatory motion is a motion of a thing from its place to its place,"[15] rectilinear motion being from its place to another place. Only for rotatory motion does the starting point and term coincide, and so this is the only perfect motion.

Further, rotatory motion is the primary locomotion being simpler and more complete. Rotatory motion can be eternal, but no other. Rectilinear motion cannot reach its starting point except by turning back, in which case there are two motions.

Aristotle also considers the phenomenon of momentum, how a thing continues in motion when the mover has ceased to move. His solution:

> the original movement gives the power of being a movement either to air or to water or to something else of a kind, naturally adapted for imparting and undergoing motion... The motion (of the object) begins to cease when the motive force produced in one member of the consecutive series is at each stage less than that possessed by the preceding member, and it finally ceases when one member no longer causes the next member to be a movent but only causes it to be in motion.[16]

A series of consecutive movers is postulated to explain the continuing motion of an object.

In the <u>De Caelo</u> Aristotle considered the universe composed of heavenly and sublunary bodies. He practically deduces the necessary character of the entire universe as he knew it. Some of the more interesting and pertinent details are the following.

The heavenly bodies were essentially different from the sublunary and were composed of a fifth incorruptible element. This followed as a conclusion of and explanation for the eternal, changeless motion observed in the heavenly bodies. He says, "then there must necessarily be some simple body which revolves naturally and in virtue of its own nature with a circular movement."[17] As simple bodies theyare not subject to generation or corruption.

All sublunary bodies have levity or gravity in proportion to the relative composition of the four elements. Much earth increased the gravity; fire on the other extreme makes for levity with the other two elements in between. This is the basis of natural and violent motion and natural place.

The natural place of heavy bodies is down, that of light bodies being up. All tend by nature to their natural place. Such motion is natural motion. Violent motion is characterized as motion away from natural place because of some hindering force. "For naturally a thing moves in one way, while its unnatural movements are manifold."[18]

Aristotle had some concept of certain proportions involved between the various factors in motion.

Thus the basic dynamic formula which we might deduce from the scattered statements of Aristotle

> is the "speed is proportional to the ratio of the motive force to the resistance (of the medium), provided the force is sufficiently great to overcome resistance and produce movement." Now suppose that we had a natural movement in a vacuum. The density of the medium would obviously be zero and thus the movement would take place instantaneously.[19]

Instantaneous motion according to Aristotle was a contradiction and therefore a vacuum did not exist. An additional implication:

> He also remarked that the speed of a falling body would be proportional to its weight, and that it would increase as the body was further removed from its point of release and came closer to its natural place. Hence the velocity would be proportional to the distance fallen.

This in outline is Aristotle's consideration of the phenomenon of local motion, its basis or nature and related implications. He has proceded on the basis of others' and his own elementary observations or experience.

In many instances it is clear that the conclusions drawn from unprecise (that is not to say <u>false</u>) sense observations or experience are incorrect. At Aristotle's time no changes had been observed in heavenly bodies. There were no accurate means to measure time or accelerations, etc.

Further, Aristotle drew no distinction between philosophy of nature and science in the modern sense. He simply proceeded from the general to particular using what observations and reasoning was necessary to draw his conclusions.

Introduction

Physics, the study of motion (at its inception), began with Kepler and Galileo in the seventeenth century. The early successes in this field consisted as much in overturning preconceptions and prejudices from earlier times as in positive contributions.

Isaac Newton in 1687 published Mathematical Principles of Natural Philosophy. Newton following upon the contributions of others, Kepler in particular, arrived at the basic laws of motion of classical mechanics which he expressed in this work. His work was extended successfully to many other physical applications.

Until recent times his basic conclusions went unchallenged. Modern developments, however, show that these laws of motion are inadequate to explain the cosmic and micro-levels of nature. Relativity and quantum or wave mechanics respectively have replaced Newton in these areas.

These three developments are considered below to see at first-hand how science actually operates and reaches its conclusions.

Newtonian Mechanics:

In Mathematical Principles of Natural Philosophy, Newton defines various concepts, establishes laws, scholiums, lemmas, and proves theorems in a manner similar to the foundation of any mathematical system. He describes his work and aims:

> But our purpose is only to trace out the quantity and properties of this force from the phaenomena, and to apply what we discover in some simple cases as principles, by which, in a mathematical way, we may estimate the effects in more involved cases; for it would be endless and impossible to bring every particular to direct and immediate observations.
>
> We said in a mathematical way, to avoid all questions about the nature or quality of this force, which we would not be understood to determine by any hypothesis;...[21]

Among the definitions at the outset of Book 1, a very important one concerns what is termed momentum (which Newton considered motion in the proper sense.[22]) "Definition II. The quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjunctly."[23]

Newton's "Axioms: or Laws of Motion" follows the introductory section. "Law I. Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon."[24] "Law II. The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed."[25] "Law III. To every action there is always opposed an equal reaction: or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."[26]

On the basis of these definitions and laws arising from his own empirical experimentation and observation and that of others he considers the centripetal (directed to a c enter) force of gravity. By gravity he meant any attraction by which bodies approach each other. The centripetal force on a stone whirling on the end of a string is ultimately generalized to the law of universal gravitation prevailing over the earth, sun, and stars. He derived by analysis that the centripetal force of gravity is inversely proportional to the square of the distance between the objects.

In Book III, Newton laid down four rules of reason as a part of his method and as its justification (the last being against the purely hypothetical speculation of Descartes which was in vogue on the continent).

1) Admit no more causes of natural things than are true and sufficient to explain the phenomenon.
2) To the same natural effects we must as far as possible assign the same causes. (uniformity)
3) Qualities of bodies which admit of neither intensification or remission and which are found in all bodies are to be esteemed universal qualities.
4) We should hold truth established by induction until further perfected by induction or exceptions are found.

The development of his laws of motion was based upon the following concepts as Milic Capek points out:

1) That of substantial corpuscular entities preserving their identity through time.[27]

2) That of space, which, while it contains material corpuscles, remains distinct from them and does not participate in their motion, remaining in Newton's words, always immovable and self-identical.[28]

3) That of homogeneous time, whose function with respect to motion is comparable to the function of space with two bodies; it is an unchanging receptacle of motions, "space of motion," as Barrow said.[29]

4) That of spatiotemporal continuity of motion, which follows directly from the homogeneity of both space and time, and which guarantees the possibility of identifying corpuscular entities in different points in space and different instants in time.[30]

Newton's work based upon the above postulates, concepts, etc. which he perceived by empirical observation and experimentation form the basis of all classical mechanics. Newton's theories of motion were generalized to include many other classes of phenomena.

The following section will outline the treatment of motion in the classical sense presented in the typical college text of physics.[31]

Examples of various types of motions are given, such as a falling cup, boy on a swing etc. In the course of the discussion each type of motion is analyzed into its own particular mathematical description.

Uniform motion in a straight line may be expressed as $v = \frac{s}{t}$ where "t" is elapsed time, "v" the velocity and "s" the distance traveled.

Acceleration is the time rate of change of velocity and is expressed $a = \frac{v - v_0}{t}$ where "a" is acceleration, "v"the final velocity, and "v "the initial velocity. The average velocity is expressed $\frac{s}{t} = \frac{v_0 + v}{2}$. By multiplying the two equations and simplifying: $v^2 = v_0^2 + 2as$. From the first equation $v = v_0 + at$, and by substitution for "v" in the second equation: $s = v_0 t + \frac{1}{2} a t^2$. These are the basic equations of motion considered in the introductory text.

Applying differential calculus, a mathematical tool developed by Newton, makes the mathematical expression much easier to consider. The law of motion may be represented by the function, f(t) s. The first derivative, $D^1 f(t)$ is equal to the instantaneous velocity at time "t", and the second derivative, $D^2 f(t)$ equals the acceleration. Given one of these expressions and the conditions at a given time, all of the other conditions at any time can be mathematically derived.

Motion is a vector quantity or quantity in a particular direction. When a number of forces in different directions act simultaneously, one resultant force is produced. The resultant force may be calsulated in various mathematical procedures.

In projectile motion two effects must be considered, the forward motion and the motion toward the earth due to the acceleration of gravity. Mathematically the resultant motion is analyzed into its horizontal and vertical components which are considered separately.

With this introduction to simple motion, dynamics are introduced. This includes force, momentum etc. Statics follows. Newton's laws are expressed mathematically: the second as net F mawhere "F" is force, "m" mass, and "a" acceleration. These laws are explained and applied to problems by means of the mathematical expression for simple motion.

Much of the rest of the matter considered is an elaboration or derivation from these laws and relations. The equations governing circular motion, simple harmonic motion, the general gas law can all be derived from the basic equations.

In general, the study of additional topics follows in a similar manner. The forces, motions, etc. are considered quantitatively and expressed in mathematical relationships. These equations are then applied to particular problems to be solved.

Quantum Mechanics[32]

In the nineteenth century Newton's laws had been extended to many fields including phenomena on the atomic scale. Despite the sacrosance character of these laws, it became clear that many phenomena of the atomic scale could not be explained within the framework of Newton's system.

Black-body radiation, which did not follow the postulates of classical mechanics, gave birth tothe new mechanics of atomic phenomena. To explain the distribution of radiation of various frequencies Planck found it necessary to postulate the quantum. Electromagnetic waves are emitted and absorbed only in units of energy equal to $h \times v$ where "h", Planck's constant, is 6.624×10^{-27} erg. and "v" the frequency of the wave. Using the same principle the photoelectric effect and variation of specific heats was able to be explained.

Niels Bohr used this theory to explain the structure of the hydrogen atom. The spectrum of hydrogen was composed of series of certain frequencies. By making certain postulates about the atom's structure, the spectrum could be explained as the energy difference between orbits emitted by the electron in passing from one orbit to another.

The basic postulates:

1) The electron of the hydrogen atom revolves around the nucleus in a circular path or orbit.

2) The angular momentum of the electron equals $(h/2\pi)n$ where "n" equals 1,2,3,...

3) The electron loses no energy in moving in its orbit. Loss and gain of energy is due to a change of orbits.

However, the inadequacies of the theory soon became clear. Besides the arbitrary character of its postulates, the theory proved incapable to explain much beyond the simple hydrogen atom, molecular bonding, larger atoms, etc.

In 1924, de Broglie proposed a wave-particle duality for matter. From this time the modern wave mechanics developed very rapidly. Heisenberg in 1925 formulated a system of quantum mechanics in terms of matrices. In 1926, Schroedinger proposed a differential wave equation. This second mathematical treatment is generally accepted and used at the present, chiefly because it is easier to consider.

A very simplified form of the equation would be $H\Psi = E\Psi$. "H" is the Hamiltonian operator and represents a set of operations to be performed on "Ψ" in much the same way as "$\div$" is an operator. The probability of finding the electron in a particular position equals Ψ^2. The energy of an electron in a particular level is represented by "E" This equation is basic to all wave mechanics in much the same way as $F = ma$, Newton's second law, is basic to his mechanics.

This basic equation can be used theoretically to represent the state of the electron in any state of conditions by means of suitable alterations. When describing the electron ina relatively simple three dimensional potential box situation the equation in the long form becomes

$$\frac{-h}{8\pi^2 m}\left(\frac{\delta^2\Psi}{\delta X^2} + \frac{\delta^2\Psi}{\delta Y^2} + \frac{\delta^2\Psi}{\delta Z^2}\right) + V(X,Y,Z) = E\,\Psi$$

In practice, however, the mathematics necessary to solve the equation became so complicated that no attempt has been made to apply the equation beyond the simpler cases.

The square of the "Ψ"-function as mentioned above represents the probability of finding the electron in a particularplace. Consequently, $\int\int\int (\Psi)^2 dx\, dy\, dz = 1$, the probability integrated (added) over the three dimensions will be unity.

More recently Jordan and Dirac have proposed the Transformation Theory. The Schrodinger wave equation is interpreted as representing the probability amplitude of an electron in a position when its energy is known.

While the probability of being in a particular place is considered, there are no functions to represent simultaneously the proper position and the probable momentum or velocity of a wave-particle. Heisenberg has expressed this as the Uncertainty Principle whereby knowledge of position is inversely proportional to knowledge of velocity. This follows from the limitations of observations. Any means (light waves etc.) used to observe such atomic phenomena will affect what is observed. This then is the physical basis for the probability of the mathematics.

On the macro scale such statistical probabilities do not have to be considered because observational limitations or the difference from averages of massive aggregates and what would be "absolute" are such as to be negligible and unmeasurable. Physically the probability of the wave-particle "nature" of the electron is interpreted as electron density and is pictured as a cloud enclosing the nucleus. The graph of electron density (or probability) of an electron in a 1s orbital would be . The 2p electron -- , and so on.

The discontinuity of space and time (or phenomena discontinuous in space and time it may be argued) are also physical implications of the mathematics. When a quantum or photon is emitted by an electron, the mathematics implies an instantaneous motion to an orbital of lower energy. There is no allowance for the gradual formation of the photon as the electron is passing to another orbital. This discontinuity as was the probability is negligible on the larger scale. These effects cannot be observed when a large aggregate of atomic phenomena are considered together.

Because of these considerations many would consider quantum or wave mechanics as the basis of natural phenomena which on the macro scale simplify (through the averaging of great aggregates of atomic phenomena) into the more familiar laws of Newtonian mechanics and ordinary experience.

<u>Relativity</u>:[33]

The Special and General Theories of Relativity represent a great synthesis of a tremendous number of facts in electrodynamics, hydrodynamics electricity, etc. By means of relativity a number of phenomena, baffling to previous scientists, have been explained.

Various features and predictions of the theories have been experimentally checked and have confirmed the predictions or deductions which had been made.

Einstein's theories of relativity are almost entirely mathematical and while successful in its synthesis, is questioned as validly representing objective reality, as being something more than a purely mathematical system.

Because of the complexity of relativity due to its mathematical nature, the treatment here will be limited to a cursory consideration of the most important conclusions and implications of the theory. The mathematical reasoning behind the story will not be considered, but it should be remembered the mathematical reasoning is there.

Special Theory:[34]

The special theory of relativity was primarily concerned with the correction of the difficulties in measuring the position and velocities of objects.

The "ether" considered by scientists in the nineteenth century, was a descendent of Newton's absolute space. Both commodities, if not fictions, proved unknowable to science. Michelson and Morley, two American physicists, wanted to determine the speed of the earth through the ether. Taking advantage of the earth's rotation, they measured the velocity of light when the observer is moving toward and away from the light source. They had expected the velocity to vary, but it did not.

Lorentz and Fitzgerald to explain these negative results proposed that bodies contract in the direction of its motion just sufficiently to account for the constant velocity of light according to $l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$ where "c" is the speed of light. At small velocities the effect is negligible. Where $v \longrightarrow c$, $l_v \longrightarrow O$. A related equation, $m_v = \frac{m_e}{\sqrt{1-v^2/c^2}}$ where $v \longrightarrow o$, the mass in motion approaches infinity.

A related consideration is that of absolute time. There is no way in which two observers at different places may synchronize their "clocks." Since the velocity of light is not infinite, a time lapse would occur between observer and the observed and prevent synchronization between different locales. Time, as mass, is affected by great velocities and approaches zero as the velocity approaches that of light. Consequently "clocks" synchronized in one locale upon being moved, i.e. acquiring velocity, would lose their synchronization. Consequently the concept of absolute time is not valid. There are simply "local" times in the root sense of the term.

Einstein applied these considerations to X-ray radiation and photoelectric phenomena and his predictions were confirmed. The increase in mass at great velocities is "that the electron picks up energy in its acceleration and that this energy is converted into mass."[35] These considerations are an application of $E=mc^2$.

The special theory of relativity, considered above, is a theory of measurement whose basic feature are the constancy of the velocity of light, the lack of an absolute frame of reference (motion is relative), and the relationship or equivalence of massand energy.

General Theory:

The general theory extends the relativity of time, space, etc. to the entire universe. What is the basis of measurements on this scale?

The more important conclusions in sequence (less the underlying mathematics) are as follows.

The universe must be finite or otherwise the force of gravity would be infinite so that matter would be radiant energy according to $E=mc^2$ and the universe would be a blaze rather than composed of bodies.

Matter is distributed randomly rather than uniformly in the universe. Since Euclidean geometry is based upon uniform distribution, the validity of it and Newtonian mechanics based upon it is questioned.

Because of random distribution of matter, there are denser and rarer locales. Gravity, which Einstein considered a function of position, would differ according to locale. The concept of universal gravitation then gives way to local gravitation. In locales of greater gravitation the action of matter is predicted to be proportionately slower. Spectroscopic studies of the sun and stars have confirmed this prediction.

This seemed to verify the theory that curvature geometry best described the distribution of matter; that a curved line (rather than a rectilinear) is the natural path. It must be remembered that on the ordinary scale any difference would be indetectable.

The previously detected and unexplained rotation of the elliptical orbit of Mercury confirmed the theory. The gravitational pull of the sun accounted for the bending. Jeans suggested the bending of light of the stars passing close to the sun to be measured during an eclipse as a test of the theory. This was also confirmed. Had universal gravitation held true, light fillowing the line of least resistance would travel in a straight line.

Universal Field Theory:

The consideration of local gravitation led Einstein to his universal field theory first proposed in 1949. He "concluded that gravity is constituted by a body as its source."[36] Since the field is constituted by objects, space is not responsible for the position of bodies. On the contrary, space is the effect of the position of bodies.

Implications For Local Motion:[37]

Relativity fuses the concepts of space and time into a single continuum. The analogy of a right triangle with hypotenuse, r, may be used. "R" may be considered as the objective distance between two events in the space-time continuum with "a" and "b" (the other sides of the triangle) comparable to space and to time. Their relationship, $r^2 \quad a^2 \; b^2$ is such that "r", the objective distance, remains the same while "a" and "b" or space and time may vary. Time is another variable, a fourth dimension.

Einstein's field theory was generalized in such wise that the concept of well-defined localized thinghood had to be reconsidered;

> matter became a local deformation of the spatio-temporal medium. More accurately what was called a material body is nothing but a center of this deformation; the deformation itself spreads out in all directions with decreasing intensity, producing thus the phenomenon of gravitational and... electromagnetic fields.[38]

Now the radical transformation of Newtonian motion can be seen. Newton's basic postulates have been challenged: "thinghood" preserved in motion; space the absolute, separate container; homogeneous time; spatiotemporal continuity of motion. "It makes no sense to speak of a movement of material parts as a transport of things; what takes place is a traveling process of condensation comparable to the movement of a wave in matter (by way of a rough analogy)."[39]

Motion in the classical sense had been transformed completely. Motion was not of something or in something, but simply a motion. In one region a spatiotemporal distortion disappears or is reduced and appears in a neighboring region whose curvature was originally "regular."

It should be noted, however, that the Theory of Relativity on the terrestial scale, the world of (relatively) slow speeds and small distances, simplifies to Newtonian mechanics as is evident from the few equations presented above. Newtonian mechanics can be considered as a special case of the Theory of Relativity which governs the world of ordinary experience.

III. The Nature of the Philosophy of Nature And Modern Science

Before any discussion of the relationship between the philosophy and the natural sciences, the essential characteristics of each must be known. The previous discussion of motion as treated by Aristotle and by modern science has already shed some light on the problem insofar as the operations of the two sciences in action has been observed along with some of their conclusions.

The modern sciences will be considered first because it is the more familiar of the two to the modern man and the consideration of the philosophy of nature as a separate field becomes simpler.

Each science will be considered primarily from an empirical basis, what it actually is and does, rather than from any preconceived views as to what it should be or should do.

The Modern Mathematical-Physical Sciences

The question here is what does the scientist consider his science to be and to do. Philosophical considerations will be offered as they follow from this.

Accordingly then, what do scientists say of science, when introducing science as a certain discipline to other scientists and the student?

Various introductory physics texts were examined.

Following are several typical introductions:

> In order to formulate valid relationships between physical quantities, accurate measurements must be made. Thus physics is a qualitative science.[40]
> In making measurements of physical quantities, we ordinarily perform a series of operations which involve the comparison of an unknown quantity with an accepted standard of the same kind.[41]

In a second text;

> It is the function of science to correlate precise measurements of physical quantities. By such correlations basic laws are discovered.
> Physics deals mainly with the more fundamental aspects of energy and non-living matter. Physical knowledge comes to us through the application of scientific methods: The gathering of data, formulation of hypothesis, and testing of hypotheses by means of controlled experiment.
> Mechanical quantities are expressible in terms of three fundamental dimensional quantities such as mass, length, and time; or force, length, and time.[43]

Later he continues; science answers the question "What is matter?" by describing its properties such as inertia.

An yet again in another text?

> The laws and facts of physics are concerned broadly with matter and energy, together with such related quantities as force and motion.
> A definite knowledge of natural phenomenon, and of the precise relations between them, is based upon experimental information concerning the quantities involved. ... Clearly, the evidence obtained must be quantitative in order that it may have definite meaning. Evidence of this type is obtained by measurement, one of the most important elements in all scientific work.[44]

The basic elements mentioned above are four. The subject matter of this science is the material world. Science starts or begins with the material world. Secondly, the science is quantitative (mathematical?) in its nature.

Third, general statements (given many names) are formulated to explain or relate the quantitative aspects observed of the material world. Last, science returns to the material world, to scientific data, for verification, to test its general statements.

The discussion of "scientific" motion illustrates these principles very well. Newton and later scientists who were to supercede him began with observations of the phenomena of the material world either directly or indirectly. Ultimately, whether proceding from their own observations or others, the ultimate source of their scientific work came from observation of material phenomena. The phenomena are such that they are quantifiable and are able to be measured. These particular data are the starting point of science.

The quantitative or mathematical nature of science is most obvious. Observations are expressed immediately in mathematical terms. Hence it is that science attains the material world under the aspect of quantitative phenomena or better "quantifiable" phenomena. Relativity and quantum mechanics have been almost completely "mathematicized." Biology too may soon be a mathematical science. Middle terms of science are mathematical or at least expressed mathematically.

The general statements of science have been discussed widely. Various names have been assigned to these statements generally according to the degree of their verification, proceding from hypothesis to theory to law. This is not of concern here. The validity or value of these general statements is of importance and will be treated below.

These general statements arise in two ways. The data observed by science may suggest a certain conclusion or general statement or it may present a problem to be solved. The former case may be well considered as Bacon's induction. By sufficiently correlating and juggling the pieces of data they will fall into place as a scientific law. The latter case is most often the matter of facts in modern science. In answer to the problem presented a tentative general statement or theory is formulated. The theory or explanation is much broader and more universal than the scientific data leading to the problem. The theory is not so much deduced from the data of the problem as it is a product of the mind. For example, this is precisely the situation of Bohr and the spectrum of hydrogen which he attempted to explain. In either case these laws or general statements must be verified.

The verification is for science a return to the material world which was its source. Deductions are made from the general statements proposed. These deductions or predictions are tested experimentally. Additional scientific data is gathered and compared to the predictions of the general statements. Data in disagreement or unexplained by the theory or its predictions disproves the theory and vice versa.

Einstein's theory of relativity is an example of the case in point. Predictions logically deduced from his theory such as the bending of light, conversion of mass and energy have been tested and confirmed.

The question of the validity and value or worth of the general statements or scientific theory must now be discussed.

The last thirty years has marked the beginning and development of the "operational" approach to scientific concepts and laws. The approach is now generally though not universally accepted in science.

P.W. Bridgman has been the originator and chief exponent of operationalism and his point of view, representative of the approach, will be outlined here.

Its origin lies in the tremendous scientific revolution of Einstein and the theory of relativity. Concepts of Newton and classical science such as absolute time and space were overthrown, as was seen above. These concepts had long been endowed with reality or entity. Their demise necessitated a complete readjustment of scientific thinking in regard to the validity and value of concepts and general statements or theories of science. Bridgman remarks:

> there can be no doubt that through these theories physics is permanently changed. It was a great shock to discover that classical concepts, accepted unquestioningly, were inadequate to meet the actual situation, and the shock of this discovery has resulted in a critical attitude toward our whole conceptual structure which must at least in part be permanent.[46]

The basic principle of the new "critical attitude" according to Bridgman equates the concept or law with the set of operations, the measurements, from which it took its origin. It is no more and no less than the corresponding operations. The concept is as general, as valid, etc. as the related operations. Bridgman says, "the concept is synonomous with the corresponding set of operations."[47] Further he says, "To determine what the concept means in any particular instance, an examination must be made of the operations by which the concept was made."[48]

Operationalism, with a few dissenters, is generally accepted and practiced in science. In physical chemistry, for example, free enthalpy and entropy are of greatest importance. Yet they are not given a physical or real definition. They are defined by their mathematical notation and the operations required to measure these quantities. Entropy or ΔS, as an example, equals $\int \frac{\delta q_{rev}}{T}$. This notation, practically speaking, <u>is</u> entropy or represents the operations necessary to measure it. Such examples are typical of the operational approach.

Eddington in the same vein declares,

> Every item of physical knowledge must therefore be an assertion of what has been or would be the result of carrying out a specified observational procedure.[49]

The implications of this approach are important. The terminology of science must be considered very carefully. Many times terms used as if univocal may not be so. Length for example on the terrestial scale is equivalent to "In the mks system ... the distance between two marks on a carefully protected bar of platinum-iridium alloy preserved at..."[50] and methods of comparing this standard to other quantities. Soon the standard will be "defined as exactly 1,650,763.73 wavelengths of a certain orange line in the spectrum of the krypton isotope of atomic mass number 86."[51] Bridgman notes, "if the operation in determining a concept, say length, differs the concept is different."[52] Is length or motion the same concept on the macro level as on the micro level where the speed of atomic particles is determined by a series of complicated mathematical operations?

Bridgman elaborates on this point:

> These new operations are so chosen that they give, within experimental error, the same numerical results in the domain in which the two sets of operations may be both applied; but we must recognize in principle that in changing the operations we have really changed the concept and that to use the same name for these different concepts over the entire range is dictated only by considerations of convenience, which may sometimes prove to have been purchased at too high a price in terms of unambiguity.[53]

A second and more important implication of the operational approach are the inherent limitations of science, granted the operationalism is valid. First, the concepts of science are limited in their meaning and scope. "If meaning is sought for concepts outside the domain in which they have been defined, the task is impossible."[54] The concepts of motion and mass and so on, cannot be used indiscriminately, but must be carefully restricted to the meaning and scope of the operations by which they are defined.

Secondly, science as a whole is limited in what it can do, in what is able to treat and discuss. Any question or consideration which cannot be treated operationally simply cannot be treated. Bridgman discusses meaningless questions as far as science is concerned and calls them, "those for which a suitable operation for answering it cannot be found."[55] Science cannot consider all things, but only those which it can reach in its operations. All else is strictly speaking meaningless -- to science.

Finally science is restricted in the manner in which it can treat the phenomena of the material world such as do fall within the range of its operations. To the extent and in the manner its operations reach these phenomena, to the same extent and manner must science discuss these phenomena. This is clearly the case with regard to Heisenberg's uncertainty principle discussed above. Because the very nature of the operation interferes with what is observed, these phenomena must be discussed by science in terms of probability and statistical average. So too in relativity, since there are no operations to determine absolute time and absolute space, science must and has discarded such concepts as meaningless (for the scientist).

The tentative character of scientific laws also follows from operationalism. Bridgman says, "all results of measurement are only approximate."[56] Consequently the laws and concepts following such operations or measurements are approximate or tentative. Bridgman continues:

> ...any statement about numerical relations between measured quantities must always be subject to the qualification that the relation is valid only within limits... but all our experience is surrounded by a twilight zone, a penumbra of uncertainty, into which we have not yet penetrated. ... and we must hold no preconceived notions as to what will be found within the region. The penumbra is to be penetrated by improving the accuracy of measurement.[57]

He concludes, "It is a general consequence of the approximate character of all measurement that no empirical science can ever make exact statements."[58] Scientists consider their results to be more than a mental construction or Procrustean bed but at the same time recognize that their validity is limited to the accuracy and degree in which their operations reach material reality.

The scientist is interested in coordinating and explaining the relationship of the myriads of phenomena of the material world in accordance with what was said above.

Science must be accepted by the philosopher as it actually is. Science must not be downgraded or adapted for the convenience of other considerations. This discussion has proceeded in accord with this norm, what is science to the scientist.

What is of interest to the philosopher of nature is precisely the "meaningless" of the scientist.

> Natural science rests upon certain fundamental presuppositions. ...it must take some things for granted... -- knowability of the physical world...

uniformity of nature...the principle of causality.[59]

Various problems arise in this regard. What lies beyond the range of science? Is it and what is it? Pierre Duhem, a historian of philosophy remarks:

> Now these two questions -- Does there exist a material reality distinct from sensible experiences? and What is the nature of this reality? -- do not have their source in experimental method, which is acquainted only with sensible appearances and can discover nothing beyond them.[60]

This precisely is the sphere and realm of philosophy of nature.

Philosophy of Nature

There are very many opinions about a philosophy of nature. The less complimentary start with "there is no such thing" or "petrified antique." Others would make it a preparatory stage of science, an extension of science, a philosophical or logical analysis of science and so on.

The philosophy of nature at point here is the cosmology or hylemorphism as originated by Aristotle and developed by St. Thomas Aquinas and later "Thomists."

The specific doctrines or validity of the philosophy of nature is not of moment here. The question to be considered is its nature, scope, and method from a philosopher's point of view. Like science,the philosophy of nature must be considered as it actually is and operates and not from any preconceptions, scientific or otherwise.

The various texts of philosophy of nature offer generally parallel definitions. Typical are:

> Philosophia naturalis definitur: scientia perfecta (propter quid) entis mobilis. ..., corpus naturale est Philosophiae naturalis objectum materiale; objectum autem formale "quod" est ens mobile seu mobile ut sic.[61]

and:

> Cosmology seeks to render the universe of mobile being intelligible in the light of its first causes and principles which are the necessary sources of mobile beings, of their coming into being and our knowledge of them.[62]

He continues -- the subject is the universe of mobile being, the being found in sensible matter and motion. Its object is the first principles of mobile being and its method is inductive (procedes from sense knowledge) and deductive.

The special characteristics of the philosophy of nature, which are included in the definitions above, are its material and formal object, its method and its term or conclusions. These characteristics will be considered respectively below.

The material object of the philosophy of nature is the material world. It shares this characteristic with science. However the aspect by which the material world is considered (its formal object) is not the "quantifiable" phenomena of science but is rather the "mobility" of the material world. Its formal object is then mobile being. According to St. Thomas, "And because everything which has matter is mobile, it follows that mobile being is the subject of natural philosophy."[63]

It is important to note what "mobile being" or under the "aspect of mobility" connotes as opposed to the "quantifiable" phenomena of science. The philosophy of nature is concerned with properties belonging to all mobile being or bodies under the aspect of mobility. The philosophy of nature is concerned, for example, with the fact that bodies change into other bodies with different qualities etc. It is concerned with the fact that certain properties or phenomena observed in bodies admit of variation. It is not, however, interested in the "particularity" of such changes. It is not interested that hydrogen as hydrogen and oxygen as oxygen combine in the ratio of two to one to form water with its properties of boiling point equals 100 degrees, etc. Nor is it concerned with the fact that water has a specific heat of one as opposed to other specific heats.

Philosophy of nature is interested only in the <u>generality</u> of such events; that things may be changed into other things with their own differing permanent properties, that there are certain proportions in chemical combinations, that material bodies exhibit certain permanent characteristics.

This fact accounts for the importance of sense knowledge in the philosophy of nature. The elaborate equipment and precise methodology of science is not generally needed to obtain the "generality" of an event. It is, however, of absolute necessity in science to discover the "particularity," the "quantifiable" phenomena upon which science is based.

Koren of Duquesne remarks, "most of these data are so readily available in experience that usually a simple statement of the starting point is sufficient and there is no need to conduct a formal process of induction."[64]

The formal objects of philosophy of nature and science, therefore, are definitely distinct, but not totally unrelated.

The method of the philosophy of nature is reason or deduction. From the "generalities" observed of mobile being, implications which must necessarily follow are deduced. Aristotle, for example, observed the change of things into another. His problem was what is necessary for such a change to take place. He was not interested how this particular red apple with the worm hole was changed into himself, nor how apples in general change into men. He was concerned with the "generality" of the event and what must necessarily be involved for things to be able to change into other things. His answer was matter, the principle of the determined, and form, the principle of determining.

By the same procedure Aristotle tried to deduce the necessary implications of motion of things which he observed as a "generality" and so also the locomotion of things as was outlined above.

Philosophy of nature differs from science in yet another respect. The conclusions are not directly verifiable from the data. The concepts such as causality, substance, matter, are not to be observed as such in the material world.

Predictions are not deduced from its conclusions to be tested empirically as does science in its return to the material phenomena. The verification of the work of the philosophy of nature, therefore, must be a reconsideration of its starting point or "generality" and the reasoning. Granted the validity of the starting point and correct reasoning, the conclusion must be valid.

With regard to this point Koren declares:

> Verification is still possible here, but in a way that differs considerably from the method used in experimental science. It will have to consist in 1) a careful search to see whether the experiential starting point is true and not subject to reasonable doubt; 2) strict observance of the laws of reasoning. For, if the starting point is true and the reasoning process correct, it follows of necessity that the conclusion must be true.

Maritain confirms the point. Because the conclusions of the philosophy of nature cannot be observed in sensible things they cannot be directly verified.

> The other proceeds from the visible to the invisible, to what is <u>in itself</u> outside the bounds of all sensory observation, for the principles which are the aim of the philosopher are pure objects of intellection, not of sensible apprehension or imaginative representation.

In summary, the method of philosophy of nature is to deduce from the "generalities" observed in mobile being its necessary implications.

The term or conclusions of the philosophy of nature are, as indicated above, the deductions made from the "generalities" observed in mobile being. In this way then, the philosopher of nature comes to the term of his work, the ultimate causes or principles of nature.

One philosopher of nature provides a fairly typical description:

> Philosophy views all things in their most general and fundamentalaspects. ... And while certain types of bodies have properties and activities which are characteristic of the types, all types have definite properties and activities which are common to all types, because they pertain to bodies as such. The particular sciences are concerned with the special types of bodies, but philosophy deals only with bodies as such and with their most general properties and activities.[67]

With regard to the elaboration of the more specific details there remains much disagreement. However, the specific doctrine of the philosophy of nature is not the case at point, but rather the general structure and nature of this philosophy.

IV. Conclusions

Several important conclusions may be drawn from the considerations above about the relationship between science and the philosophy of nature.

Mutual Independence

The two disciplines are essentially independent. There has been much controversy as to where and how the philosophy of nature fits into St. Thomas' three degrees of abstraction. This formal approach, however, is not necessary to see that these two disciplines are basically independent of each other and indeed, must presuppose this fact to some extent.

Historically their independence is easily seen. The basic principles of the philosophy of nature had been outlined centuries before modern science had appeared on the scene. The non-mathematical sciences were, however, confused with the philosophy of nature and were thought to be an elaboration of the latter.

Modern science, which began in the seventeenth century, not only developed independently of the philosophy of nature, but had oftentimes expressly repudiated it. In Maritain's words, "The sciences have, however, no dependence whatever on philosophy with regard to their own intrinsic development."[68]

Besides the historical argument it is clear from the natures of the two disciplines that they are distinct and independent of each other. They differ in their formal object, methods, and conclusions.

Maritain, who has considered at great lengths their respective positions and natures, describes it:

> Having totally different formal objects, entirely different principles of explanation and conceptual technique, and in the subject i self requiring fundamentally different intellectual virtues or qualities of discriminating illumination, the proper domains of philosophy and science are not translatable. An explanation of a scientific order can never be displaced or replaced by a philosophic one or *vice versa*.[69]

In this sense there is little disagreement over their mutual independence. Van Melsen, a philosopher and a scientist, remarks in a somewhat long but very pertinent quotation:

> From the sharp distinction existing between science and the philosophy of nature, it will be understood that the respective methods of consideration do not have much bearing on each other. The specific results of science do not contribute to the philosophy of nature because those results are obtained by methods which already presuppose the starting-points for the philosophy of nature. Consequently the results of science do not throw any *new* light on these starting-points. No more can the results of philosophy of nature be of any direct value for science. For the philosophy of nature is concerned with such features of matter as science, by using methods built entirely on the presupposition that matter has those features, has already reckoned with.[70]

The Complementary Relationship between Science and the Philosophy of Nature

While the philosophy of nature and science are mutually independent, they cannot be said to be totally unrelated. Previously, in the examination of the formal objects of both, it was observed philosophy of nature is interested in the generality of an event and science the precise particularities.

As a result, neither can grasp the whole of reality. The philosophy of nature can explain the principles of nature, the causality necessary to it, the reality of substance and species, along with other fundamental characteristics of the nature of the material world as material. Yet it cannot dealas such with the particularity of the material world.

Looking to Maritain once again; "But because of its very structure, this ontological type must forego explaining the detail of phenomena, exploiting the riches of natural phenomena: an important point which was not at all clear to the ancients."[71]

By the same reasoning science too cannot reach the whole of the material world. As explained above it is limited to the scope of its operations. The work of the philosophy of nature cannot be attained by science, and, hence, science must presuppose the reality and causes of material and formal object.

At times the question can be raised whether science even reaches the material world as it actually is. For example the principle of uncertainty points out that the velocity and position of an atomic element cannot be attained simultaneously by the operations of science and does not state that such is necessarily the case in reality. The problem is similar with homogeneous time in relativity. These and many other questions are meaningless to science because they exceed the scope of its operations.

The presuppositions of science are generally granted, although the view of their nature and extent will depend upon how one considers the philosophy of nature. Werner Heisenberg remarks, "In short any theory of physics makes more physical and philosophical assumptions than the facts alone give or imply."[72]

From the viewpoint of John Russell, a philosopher of nature,

> Some of these (substance, cause, etc.) must be presupposed by all scientific discourse, but they cannot be investigated by scientific method since they cannot be given a univocal meaning, or fitted into the simplified logical schema which the scientist uses to express his laws."[73]

The conclusion follows, therefore, that the philosophy of nature and science in their respective roles of explaining the material world are complementary to each other. Russell adds, "Each supplements the other..."[74] Whitehead points out "the fallacy of the misplaced concreteness," the error of assuming either science or philosophy of nature contains the complete picture of reality.

Another aspect of their relationship follows from the limitations of science and the more universal and basic character of the conclusions of the philosophy of nature.

Maritain points out the fact that insofar as the philosophy of nature does explain the fundamental principles and nature (in the philosophical sense) of what comprises the material and formal object of science, which may be taken as the "presuppositions" of science, to this extent, science is in a restricted sense dependent upon the philosophy of nature.

He elaborates on the point:

> We have the right to hold that thomist philosophy rather than any other is in the position to supply the sciences with the metaphysical framework where they can follow out at ease the necessities of their own proper development and which will do them no violence: not only because it is essentially realist and critically justifies the extra-mental reality of things and the value of our faculties of knowledge, which all science implicitly presupposes, but because it guarantees the autonomy, the specific quality of each, and its metaphysical elucidations of the real imply in consequence no necessary systematic definitions despotically imposed upon science.[75]

It may be concluded that science in a restricted sense is dependent upon the philosophy of nature in that the latter supplies to it its "metaphysical framework." As regards species or essence they remain mutually independent.

An important result of determining the independence and proper spheres of science and the philosophy of nature is to restrict each to its own sphere outside of which neither discipline has any competence.

In past days no distinction was made. The "philosopher-scientist" skipped between the two fields with the greatest of ease. Their independence became more clear with the rise of science and the demise and revival of the philosophy of nature in the last three centuries.

No longer can the philosopher of nature risk solving scientific problems with a philosophic method and hope to escape the righteous wrath of scientists. The task is sufficiently hazardous at the present while remaining within his own field.

This relationship applies in both directions. The scientist aware of his own limitations will not try (or should not try) to dictate to the philosopher.

Leo Schumacher, a philosopher of nature, remarks:

> However if a physicist puts a special interpretation upon an experimental result and then asserts this interpretation has a one to one correspondence to reality he is liable to meet some opposition from philosophers.[76]

Benefits will follow in both fields from knowing and observing their respective limitations in form of the validity of their conclusions.

<u>The Material Dependence of the Philosophy of Nature upon Science</u>

The value of scientific data to the philosophy of nature has long been debated. Some would have the philosophy of nature rely solely upon sense knowledge or experience and discard scientific knowledge as an alien and contrary element. Others propose an almost exclusive use of scientific knowledge, the <u>only</u> valid knowledge as far as they are concerned.

The attempt here will be to determine to what extent, if any, the philosophy of nature depends materially upon science, granted the validity of what has been said previously about the nature of the two disciplines and the validity of the disciplines themselves.

It is a basic principle of Thomism that all knowledge must originate or come through the senses. Such knowledge is called experience or experiential. Granted this fact, all knowledge whether scientific or philosophical must be experiential in origin. Scientific data, however, includes much which falls beyond the direct range of the senses. Such "beyond-the-senses" phenomena are brought within the range of the senses by means of numerous scientific instruments so that this data may be observed experientially. Does the "indirectness" or use of instruments constitute an essentially differenttype of knowledge which on this account or for some other reason is invalid and cannot be used in the philosophy of nature?

There does not seem to be any valid basis for such a position. It is immediately apparent that no strict dividing line can be drawn between the two, both because of the ultimate experiential nature of all knowledge and because scientific data comes in degrees. For example is the man wearing glasses obtaining scientific or sense knowledge the man with a low power magnifying glass? the microscope or electron microscope? Is there a basis for considering such indirect experiential knowledge as the line on a graph from nuclear-magnetic-radiation an essentially different type of knowledge? Such a basis has not been offered by those rejecting all scientific knowledge.

This position, which may have arisen because of the defensive position of the philosophy of nature since the rise of modern science, is often justified on thebasis of the "incomplete or purely provisional" character of scientific data or the unreliability or unpredictability" of scientific views. This objection is valid to a degree. Much scientific work lacks the character of strong certainty (more in respect to theory than scientific data) and as such cannot be used by the philosophy of nature.

Yet to extend the objection to all scientific knowledge is a gross error and arbitrary rejection of much certain knowledge attained by science in the interest of an <u>a priori</u> prejudice. Certain scientific knowledge must be accepted as certain, for example some of the basic data as electromagnetic radiation, atoms, etc. Science is neither totally certain nor totally tentative and the certain results of science must be accepted as such.

On the contrary, the non-opposition of sense and scientific knowledge has been pointed out by many. Norbert Luyton declares;

> The fundamental mistake of this solution is, we think, the incorrect assumption of a radical and basic difference between spontaneous and scientific data. ... On closer inspection there is no question of contradiction, but only of rendering more perfect and complete.[77]
>
> If one insists upon speaking of opposition, it will have to be the opposition of the rudimentary and refined, but not that of

false and true.[78]

Accordingly scientific experience is an organization and expansion of spontaneous experience, but not its negation.[79]

Sir James Jeans remarks about sense and scientific data, "Science has of course provided us with methods of extending our senses both in respect of quality and quantity."[80] He adds that with the aid of instruments man can see a range of light 64 times that of the unaided eye.

Julius Seiler, a well-known philosopher of nature sums up:

> Yet it cannot be denied that science has expanded the field of our knowledge in a startling manner. It has through numerous "artificial senses," introduced us to wholly new realism of nature: the microcosm, the macrocosm, and the non-perceptible realities of immediate dimensions. But all these worlds together form together with the world of direct experience a whole of mutually reacting parts.[81]

It follows therefore that scientific data may be of use to the philosophy of nature in two ways: it may clarify sense knowledge and can open new areas to philosophic speculation.

It was noted previously that the philosophy of nature is interested in the "generality" of an event in distinction from all the "quantifiable particularities" of that event. It was because unaided sense experience could reach the basic generalities of the material world such as motion, generation, individuals, that he was able to deduce from them the basic principles of the philosophy of nature. Yet it is clear from what has been said previously that

Aristotle was not able to perceive all the "generalities" of the material world nor was his knowledge of "generalities" completely correct. The fact of the "eternal, unchanging" motion he perceived in heavenly bodies is an example of this. Granting the "generality" he thought he had perceived, his "absurd" conclusions are not so absurd.

Scientific conclusions are sometimes "generalities" which may prove very useful to the philosophy of nature. For example, the fact that atoms combine in certain combinations has implications for the philosopher of science in regard to properties. The principle of conservation of momentum has led to the modification of the concept of local motion so that the actuation of the thing in motion, according to some, need only be tending toward an end in the way of an other locus. It neither must reach an end or retain the same end. The principle of conservation of mass-energy also has philosophical implications. The point at issue is that Aristotle by 300 B.C. had not exhausted all facts for speculation, but that many are coming to light under the aegis of modern science.

The philosophy of nature, therefore, is to a certain extent materially dependent upon scientific knowledge both to clarify the sense knowledge which is its starting point and for new areas of speculation. Philosophers, Thomist and otherwise, emphasize this point.

Pierre Duhem, a noted historian of philosophy, declared over fifty years ago:

> Does it follow that the knowledge of physical theory is useless to anyone working for the progress of cosmology? ...
>
> We are not asking whether the cosmologist can without harm be ignorant of physics; the answer to that question would be too obvious, for it is plain that a cosmological system cannot be reasonably constituted without any knowledge of physics.[82]

Thomists too have recognized this fact. Jacques Maritain writes: "There is most certainly, a strong material dependence of philosophy on the sciences."[83] Joseph Sikora writing in the Thomist declares, "The philosophy of nature is exceedingly poor unless it enriches itself with the knowledge of the sciences, infusing its own light into the mass of knowledge provided it by these sciences."[84]

In summary, the philosophy of nature depends chiefly upon what is called sense knowledge from which it can most directly obtain the "generalities" from which it proceeds. It is also materially dependent upon scientific knowledge for clarification of sense knowledge and for new areas of speculation.

The great mass of scientific information cannot be used in the philosophy of nature most often because of its particular character, because the operations leading to such knowledge are inherently unable to reach reality as such, or because the knowledge may yet be uncertain and tentative.

<u>Conflicts between the Philosophy of Nature and Science</u>

Theoretically there can be no conflict because both the philosophy of nature and science are describing the material world and its truth must be one. However "theory" and "practice" have perhaps never been so far apart as here. Modern science had all but buried the philosophy of nature until Leo XIII prepared the way for its revival.

The reasons for such strife are several, most of which have already been discussed at least implicitly so that a rather brief treatment will suffice.

A basic difficulty is that of communication. The same words more often than not are used in different ways by the philosophy of nature and science. Matter for example in the philosophy of nature is the potential principle or principle of the determined. Mass (matter) for science according to its operational definition is that which offers resistance to acceleration. While mass and matter have much in common in both fields it cannot be assumed that they are identical. Vincent Smith in discussing and attempting to solve the difficulties of the philosophical implications of the mass-energy equivalence of science makes this particular point.[85]

Both philosophers and the few scientists interested in the philosophy of nature are aware of the problem. James Coffey writes:

> Unfortunately there exists no sound, stable tradition of communication between philosophers and scientists. As a result the conclusions of one group are not easily accessible to the numbers of the other. Until this problem of communication is solved, the philosopher cannot hope to present an adequate cosmology.[86]

A scientist from Maryland University, Charles Herzfeld, comments on the terminology aspect of communication:

> One question concerns the relations between terms used in philosophy in a technical manner and the same terms used in physics in a different technical manner. The correspondence cannot be a simple equality, and some redefinition can be called for, but this has not yet been done to the satisfaction of all parties.[87]

All problems of communication and terminology will perhaps never be completely solved because of the different natures of each field, nor can all problems be blamed upon the lack of communication. Yet when both the philosophers of nature and the scientists understand what the other is saying for what is with all its limitations, many occasions of conflict will be eliminated.

A second source of conflict may arise because the results of either the philosophy of nature or science are assumed to be absolutely final and valid and cannot be modified. Hylosystemism was proposed precisely in this framework, that the initial work in the micro-world was absolute and true. Soon science itself dealt the death blow to the "philosophy" which had tried to "justify" science.

No scientist would hazard to say that science has reached the promised land, nor should the philosopher claim the elaborations based only upon the "generalities" Aristotle saw or thought he saw represents the sum total of what the philosophy of nature can be, and is valid to the last detail. The philosophy of nature should benefit from the advance of science. Yves Simon points out Maritain's conclusion with which he is in accord:

> Maritain is quite aware of the great improvements in knowledge which can be expected from the cooperation of the philosopher and scientist; but he does not believe that such a cooperation can even work smoothly and without frictions.[88]

Another source of difficulty arises when the philosopher attempts to solve the other's problems by means of his own method. Bridgman has, for example, proposed extending "operationalism" to all fields of knowledge. This attempt would be doomed to failure just as surely as Aristotle had to fail when he attempted to explain the entire universe by his philosophic method. Newton himself repudiated any broad philosophical meaning as such in his work:

> We said _in a mathematical way_, to avoid all questions about the nature or quality of this force, which we would not be understood to determine by any hypothesis; ...[89]

Yet the whole edifice of mechanism was built on this foundation so that when Newtonian mechanics proved inadequate, the edifice fell. Science cannot do the work of philosophy or vice versa.

For this reason Aristotle's "scientific" work failed and it was on this basis most of his philosophical work was also rejected by many. Both fields have much to gain by knowing and observing their own limitations.

V. Author's Comments

Granting the basic validity of the philosophy of nature and science, there seems to be good reason for rejecting the absolute conflict of the two which some would propose.

It is naive to dismiss all disagreements between the two with a wave of the hand as due to "misguided" scientists or "antiquated" philosophers. There has been contention and will continue to be as an inevitable consequence of the different attitudes and natures of each field.

Yet, by taking into account the different natures of the philosophy of nature and science, the difficulties of communication, the limitations of each, etc., much needless sterile quarreling can well be avoided in the future.

By following the guidelines of their relationship, material dependence in the one instance and a metaphysical framework in the other, by proceeding with the caution indicated by the difficulties in communication and the past tendency for one field to invade the domain of the other, etc.; progress can be made by both. Science will not be encumbered by any restrictive prohibitions. The philosophy of nature will find opened up for itself new fields of speculation not possible just a few years ago.

FOOTNOTES

1. Aristotle, *Physica*, trans. R. P. Hardie and R.K. Gaye, *The Basic Works of Aristotle*, ed. Richard McKeon. New York: Random House, 1941, p. 218.

2. *Idem*. p. 231.

3. *Idem*. p. 231.

4. *Idem*. p. 232.

5. *Idem*. p. 253.

6. *Idem*. p. 253.

7. *Idem*. p. 253.

8. *Idem*. p. 254.

9. *Idem*. p. 255.

10. Thomas Aquinas, *Commentary on Aristotle's Physics*, trans. Richard J. Blackwell, Richard J. Spath, and Edmund Thirlkel. New Haven: Yale University Press, 1963, p. 147.

11. Aristotle, *Physica*. p. 278.

12. *Idem*. p. 278.

13. *Idem*. p. 295.

14. *Idem*. p. 380.

15. *Idem*. p. 387.

16. *Idem*. p. 392.

17. Aristotle, *De Caelo*, trans. W.D. Ross, *The Student's Oxford Aristotle*. New York: Oxford University Press, 1942, p. 269.

18. *Idem*. p. 300.

19. Carl G. Hempel, *Fundamentals of Concept Formation in Empirical Science*. Chicago: Chicago University Press, 1952, p. 170.

20. George Sarton, A History of Science. Cambridge: Harvard University Press, 1952, p. 517.

21. Sir Isaac Newton, The Mathematical Principles of Natural Philosophy, trans. Andrew Motte, Vol. III. London: Knight & Compton, 1803, p. 3.

22. Cf. Henry A. Perkins, College Physics. New York: Prentice-Hall Inc., 1945, p. 32.

23. Sir Isaac Newton, Vol I. p. 1.

24. Idem. p. 14.

25. Idem. p. 14.

26. Idem. p. 15.

27. "IV. Absolute motion, is the translation of a body from one absolute place into another;" Idem., p. 7.

28. "II. Absolute space, in its own nature, is without regard to anything external, remains always similar and immovable." Idem. p. 6.

29. "I. Absolute, true, and mathematical time, of itself, and from its own nature flows equally without regard to anything external, and by another name is called duration:" Idem. p. 6.

30. Milic Copek, The Philosophical Impact of Contemporary Physics. New York: D. Van Nostrand, Inc., 1961, p. 262-263.

31. Cf. Franklin Miller, College Physics. New York: Harcourt, Brace & World, Inc., 1959, pp. 30-65.

32. Cf. J.H. Van Vleck, "Quantum Mechanics," Encyclopedia Britannica. Chicago: William Benton, Publisher, 1961, Vol XVIII, pp. 813-828; and Leonard I. Schiff, "Quantum Mechanics," Collier's Encyclopedia. New York: P. F. Collier & Son Corporation, 1959. Vol. XVI, pp.492-499.

33. Cf. Andrew G. Van Melsen, The Philosophy of Nature. Pittsburgh: Duquesne University, 1954, Chapter 5, "Quantity," pp. 154-198.

34. Cf. Leo Albert Foley, Cosmology. Milwaukee: The Bruce Publishing Company, 1962, "Relativity," pp. 140-158.

35. Idem. p. 150.

36. Idem. p. 158.

37. Cf. Milic Capek, _The Philosophical Impact of Contemporary Physics_, "The Transformation of the Concept of Motion," pp. 262-288.

38. _Idem_. p. 266.

39. H. Reichenback, _Relativitatstheorie und Erkenntnis_. Braunschweig, 1950, p. 98 as quoted by Milic Capek, p. 265.

40. Alpheus W. Smith and John N. Cooper, _The Elements of Physics_. New York: McGraw-Hill Book Compahy, Inc., 1957. p. 4.

41. _Idem_. p. 4.

42. Franklin Miller, _College Physics_. New York: Harcourt, Brace & World, Inc., 1959, p. 6.

43. _Idem_. p. 11.

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45. Cf. P. W. Bridgman, _The Logic of Modern Physics_. New York: MacMillan Co., 1958.

46. _Idem_. p. 1.

47. P. W. Bridgman, _The Logic of Modern Physics_. p. 5.

48. _Idem_. p. 4.

49. Sir Arthur Eddington, _The Philosophy of Physical Science_. Ann Arbor: University of Michigan Press, 1958.

50. Franklin Miller, _College Physics_. p. 6.

51. _Idem_. p. 7.

52. P. W. Bridgman, _The Logic of Modern Physics_. p.3.

53. _Idem_., p. 23.

54. _Idem_. p. 23.

55. _Idem_., p. 28.

56. _Idem_. p. 33.

57. _Idem_. p. 33-34.

58. _Idem_. p. 35.

59. Celestine N. Bittle, _From Aether to Cosmos_. Milwaukee: The Bruce Publishing Co., 1941, p. v.

60. Pierre Duhem, _The Aim and Structure of Physical Theory_, trans. Philip P. Wiener. Princeton, N.J.: Princeton University Press, 1954, p. 10.

61. Josepho Gredt, _Elementa Philosophiae_. Vol. I; Barcelona, Spain: Herder, 1958. p. 193.

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63. Thomas Aquinas, _Commentary on Aristotle's Physics_, p. 13-14.

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65. _Idem_. p. 4.

66. Jacques Mariatin, _Degrees of Knowledge_, trans. Bernard Well. New York: Charles Scribner's Sons, 1938, p.59.

67. Celestine N. Bittle, _From Aether to Cosmos_, p. 13.

68. Jacques Maritain, _The Degrees of Knowledge_. p. 60.

69. _Idem_. p. 59.

70. Andrew G. Van Melsen, _The Philosophy of Nature_, p. 15.

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76. Leo S. Schumacher, "Comment on Dr. Herzfeld's Paper," _American Catholic Philosophical Association Proceedings_, Vol. 23, 1952, p. 61.

77. Norbert M. Duyton, "De actueele stelling der traditioneele naturphilosophie," Tijdschrift voor Philosophie, VIII. Louvain, Belgium, 1946, pp. 219-225 as quoted by Henry Koren, Readings in the Philosophy of Nature. The College Reading Series; Westminster, Maryland: The Newman Press, 1958.

78. Idem. P. 39.

79. Idem. p. 39.

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81. Julius Seiler, "Physics and the Scholastic Theory of Form and Matter," Cross Currents. IV (Summer,1954) p. 173.

82. Pierre Duhem, The Aim and Structure of Physical Theory. p. 299.

83. Jacques Maritain, Degrees of Knowledge. p. 63.

84. Joseph J. Sikora, "The Philosophy of Nature and Natural Science from a Thomist Viewpoint," Thomist. XX (July, 1957) p. 346.

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