A sharp knife is neither true nor false, but
whoever grasps it by the blade is truly in error.

Anonymous (found in fortune cookie)

Chapter 2
A PROBLEM OF KNOWING

Knowledge about economic phenomena is imperfect. This is not a problem unique to economics. An understanding of the methods by which knowledge is accumulated aids in the identification of potential biases or weaknesses of any discipline or field of study. The study of processes by which knowledge is acquired has been recognized as a challenge in philosophy and science from the time of Greek philosophers to the present. Countless philosophers and scientists have struggled with the problem. As knowledge is gained, it produces new science and technology. In turn, new knowledge alters the process of knowing and may alter its course. It is impossible to adequately cover the topic in a single book, much less a single chapter. However, any understanding of the methods of economists requires some introduction to a few important contributions to the literature on the process of knowing. It is a fundamental part of cultural literacy in a world dominated by "science" and the "scientific method." Brief summaries of some of the major contributors and technological changes are presented.

METHODOLOGY AND EPISTEMOLOGY

There is a long history of various approaches to the study of the economy. These approaches are not self contained, isolated bits of knowledge; they are extensions of and reactions to earlier approaches in economics and other fields. The process of "knowing" is difficult. Two questions that should be paramount are:

- What do I know?
- How do I know?

Epistemology is the study of the origin, nature, methods and limits of knowledge. There are several disciplines that study the processes that contribute to knowing; the history of science and the sociology of knowledge are two closely related fields. Methodology is one aspect of epistemology. **Methodology** is generally seen as the system of values, beliefs, principles and rules that guide analysis within a given discipline. The methodology(ies) that prevails within a discipline plays a major role in the nature of questions that are asked as well as the answers that are offered.

There is a large and growing body of literature on methodology in philosophy and the sciences (both natural and social). This trend has also influenced economics. Many economists have participated in the explorations into methodology and epistemology. One explanation for a renewed interest in methodology in economics is that the basic processes created to explain the development of market systems and mature industrial economies may need to be adjusted if there are significant structural changes in the economy. The study of the history of economic thought and methodology adds to the question "What do I know?" the question of "What do I believe?" This necessarily leads to the question of "Why do I believe?"

One of the most difficult tasks in any discipline is to understand the nature of knowledge and the process by which it is acquired within the discipline. In this matter, economics is no different from any other body of knowledge. The methods used to study the phenomena influence the phenomena we select to study and the conclusions we draw.

Facts, Information, Knowledge and Wisdom

In any period of history, there is a problem of determining the nature of what we think we know. **Facts**, **information**, **knowledge** and **wisdom** are not the same things. It is possible to engage in long arguments about the meaning of these words. For our purposes, we will accept facts in the spirit of its Latin roots. *Factum* is something done; *factus* is done; *facere* is to do. Information implies a gathering and organization of facts in to an order or system of categories. It may also include the communication of those facts. Knowledge implies an understanding of the nature of relationships among the facts and information. Wisdom is more complicated and suggests a system of values and the judgement to evaluate and apply knowledge. These definitions are superficial and subject the reader's interpretation.

Knowledge held at any time may be "true" or "not true." Knowledge that is true may or may not be useful. Knowledge may be useful whether it is "true" or not. Before the **Copernican Revolution**, a common belief was that the Earth was a stationary center of the universe. This was the Ptolemaic system attributed to Claudius Ptolemy [127-151 AD], a Greek mathematician and astronomer who lived in Egypt. In this system, the sun, stars, planets and moon circled the Earth in repeated patterns. Complex models were constructed to explain and predict the paths of the objects. These models worked with reasonable accuracy and were useful to plan for seasons, planting of crops, and to prepare for floods. The models were useful, but "wrong." New information obtained through observation and measurement showed there were simpler explanations for the paths of the celestial bodies. The Copernican or **heliocentric** view gained dominance. Galileo [1564-1642] verified the Copernican system with a new technology (the telescope). Johann Kepler [1571-1630] improved on Galileo's findings and calculated equations to

explain the elliptical orbits of the planets about the sun. As we accept "new knowledge" about the cosmos and subatomic matter, we replace old truths with new truths.

Explanation, Prediction and Storytelling

Explanation and **prediction** are two of the objectives of science. These two goals are not symmetrical; it is possible to explain an event or phenomenon without being able to predict the probability of its occurrence; at the same time, it is possible to predict an event without being able to explain its nature or causes. Mark Blaug identifies two problems that arise from the "Symmetry Thesis." First is problem 1; "*the history of science contains a number of theories which appear to explain natural phenomena, without however predicting them even in a statistical sense."* [Blaug, 1986, p 274] Darwin's theory of evolution is cited as an example. Second is problem 2; "*…science, and particularly social science, abound in rules-of-thumb that yield highly accurate predictions about both natural and social events despite the fact that we may have absolutely no idea why these rules-of-thumb work as well as they do.* [Ibid.]

Whether explaining or predicting, science places value on precision and rigor of the process. However, one should avoid using the same criteria to evaluate scientific models with different objectives. It is also necessary to avoid attempts at precision and rigor that are not possible. Thomas Mayer cautions economists (the warning applies to all disciplines):

> *"…we should draw a much sharper distinction that is usually done between two types of economic theory. One, formalist theory is abstract theory that is concerned with high-level generalization and looks towards axiomization. The other, empirical science theory focuses on explaining past observations and predicting future ones. While both are perfectly legitimate, applying the criteria appropriate to one to evaluate the other generates confusion and misunderstanding. (Mayer's book)…is a plea for a more modest economics that recognizes the inherent difficulty of making precise and indubitable statements about the actual world, accepts that there is a trade-off between rigor and relevance. I certainly agree that one should be as rigorous as one can be: I just oppose trying to be as rigorous as one can not be."* [Mayer, p 7]

An emphasis on rigor and precision may result in attempts to develop theories or models that are esoteric and of little interest to anyone other than the scientist-author.

In addition to explanation and prediction, science and the stories of science also create, shape and transmit individual and social values. Often this is an unintended effect rather than a conscious objective. The study of the evolution of methods in a discipline, such as economics, will hopefully create a greater awareness of this role and a greater understanding of one of the important effects.

Reasoning

There are several processes that can be used in the discovery, creation and justification of knowledge. Instinct, intuition, abduction, deduction, induction and authority are examples of sources of knowledge. Appeals to authority as a justification for acceptance of knowledge is common but typically must be supported by empirical and rational reasoning. Instinct, intuition and introspection were once of great importance, but are not often seen as credible as "science" when seeking justifications for "knowledge" in Western, industrial societies. Most discussions of methods in science place primary emphasis on inductive and deductive processes.

Inductive Reasoning

Inductive reasoning is the process of inferring information from empirical observations. If several glasses of water were taken from a lake and each glass of water was shown to be safe to drink, it might be "inferred" that the water in the lake is safe to drink. Because all the water in the lake was not (and possibly could not) be tested there is some probability that all the water in the lake is not safe to drink. Empiricism is rooted in the inductive process and is based on empirical observations. Statistical inference is an application of the inductive method.

While inductive methods are useful, there are pitfalls to avoid. Observations might be incomplete or the interpretation of the observation(s) could be incorrect. The selection of which phenomena to observe and the sequencing of the “facts” can alter the conclusions reached. The application of inference and inductive methods requires judgement and caution in the interpretation of data.

Deductive Reasoning

Deductive reasoning is a process that starts with a set of premises (or *a priori* truths) or general principles and through rules of logic, “deduces” a conclusion about a specific case. This process is sometime called "rationalism." If the general principle or premise were that all the water in the lake was safe to drink, then deductive reasoning would conclude that a specific glass of water from the lake is safe to drink. The internal logic could be correct but if the premise or general principle were false, correct deductive logic would not yield true conclusions.

Abductive Reasoning

Abduction is a creative process from which hypotheses arise. Abduction is similar to induction. The differences are that abduction is less formal process that consists of a combination of intuition, experience, observation, deductive reasoning and generates hypotheses which could be wrong. Abduction is the insight that occurs with less conscious formal reasoning than either induction or deduction. It is the purpose of

inductive and deductive reasoning to test the hypotheses that emerge from the process of abduction.

A BRIEF DESCRIPTION OF APPROACHES TO KNOWING

The history of Western civilization records a variety of approaches to the process of "knowing." These different approaches have been shaped by many factors. The process of knowing can be thought of as a technology. As contributors react to or extend earlier approaches, new approaches are created. Those approaches that conform to expectations and produce results that conform to or are consistent with social values have a greater probability of being accepted and integrated into the culture of the society. The techniques used to communicate the process and ideas will influence the nature of the process and ideas. In the *Axemaker's Gift*, James Burke and Robert Ornstein give a brief account of evolution of the Western system of "knowing." Burke and Ornstein write that the axemakers[1] are:

> *"... the people who gave us the world in exchange for our minds." ..."Each time the axemakers offered a new way to make us rich or safe or invincible or knowledgeable, we accepted the gift and used it to change the world. And when we changed the world, we changed our minds, for each gift redefined the way we thought, the values by which we lived, and the truths for which we died.". . ."And because each axemakers' gift was so attractive, not evil or ugly, we always came back for more, unmindful of the cost."* [Burke, p xiv]

In a 1978 book, *The Common Sense of Science*, J. Bronowski identifies three ideas that are fundamental to the Western perception of science. These three ideas are:

- "*the idea of order.*" [Bronowski, pp. 12-55]
- "*the idea of causes."* [Ibid. pp. 56-78]
- "*the idea of chance*." [Ibid. pp. 79-96.]

Order

Bronowski states that, "*Science is not an impersonal construction*." [Ibid. p 13] This human construction of knowledge begins ordering of things and events or phenomena. Aristotle saw order in the "nature of things." Things fall to the earth because it is in their nature to do so. Bronowski mentions that one of the contributions made by the philosophers of the middle ages is that there is a hierarchy to the system of order. [Ibid. p 23]

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[1] "The Axemaker" is a metaphor for the people who produce new knowledge, science and technology.

The notion of order is implicit in the classification of phenomena. Taxonomy (the art and/or science of identification, naming and categorization of phenomena) is fundamental to the process of science and the acquisition of knowledge. To classify events or things requires the recognition of the way in which things are alike or different. Taxonomy implies observation of the phenomena and some recognition of specific characteristics.

Causes

Bronowski argues that both Da Vinci and Newton were great inventors and mechanics. They both recognized patterns of order in the universe and were able to describe these patterns. The difference, according to Bronowski, is that while Da Vinci's work displayed an interest in variety and infinite adaptability, Newton was focused on unity and the singleness of nature. [Ibid. p 24] Bronowski comments;

> *"We could say that the Middle Ages saw nature as striving towards its own inner order: and that the Scientific Revolution overthrew this order and put in its place the mechanism of causes. … On the one hand, all science, and indeed all thinking starts from and rests upon the notions of order; what marks the Middle Ages is that their order was always a hierarchy. And on the other hand what marks the scientific view is not that it turned to the mechanism of causes, but that it saw the world as a mechanism at all – a machine of events."* [Ibid. p 25]

Chance

If the world of events were truly a machine subject to the law of causes, events would be deterministic. Bronowski argues that the recognition of the law of chance is central to the method of science. It adds "*statistical law"* to the concept of "*causal law*." [Ibid. p 82] Causal law states that event B is caused by event A and therefore, event B will follow event A 100 times out of 100 occurrences of event A. Statistical law is based on the notion that event B will "*probably*" follow event A. The process is described as one where;

> *"We look for a trend or systematic difference. But the line of this trend will itself be blurred by the unsteady hand of chance or random fluctuation. We cannot get rid of this random scrawl. But we can from it determine a measure of random variation, and use that to draw round the trend an area of uncertainty. If the area is small enough by standards which are agreed between us, then the trend is established, and we know the limits within which it is likely to lie.* [Ibid. p 92]

The concept of probability provides the method by which observations of an extraordinarily complex world can interpreted. It gives us information and knowledge that may not be "true" but is useful.

While any summary of the evolution of the methods of Western knowledge is necessarily an over simplification, some periods, contributors and events seem worthy of note. While these summaries of contributions are of necessity brief and simplified, they are intended only to introduce a bare outline of ideas. To understand the subtleties of the contributions of any person requires dedication and discipline to study their works. The purpose here is to contribute to the awareness and cultural literacy of the reader. Some acquaintance with the architects of the Western perception of the world aids our understanding of economic theories and their relation to society.

Greeks

Discussions of Western Civilization often begin with the Greeks. The Greeks contributed to the development of economic thought as well as to the methodology of Western knowledge and perceptions of knowing. Their contributions to economics will be considered in a later chapter. There were several events and contributors that helped to shape the Western approach to knowledge.

The Alphabet

Some time during the 9th century BCE, the Greeks altered the Phoenician alphabet to represent the sounds of speech. [Burke, p 67] Burke and Ornstein hypothesize that this had several effects. It shifted the acquisition of knowledge from oral material that is "fluid and living" to written material that is "dated and fixed." [Ibid. p 69] It provided a way of expressing knowledge in abstract terms; "A" is nothing specific in nature but it provides a means to express reality in abstract terms. The use of the alphabet enables a society to record its evolution: "*Herodotus was not so much the father of history as the child of the alphabet*." [Ibid. p 69] Three other important effects of this contribution were:

- "*External storage also publicizes thinking, so that it can be considered, commented on and criticized.*" [Ibid. p 70]
- "*With the aid of writing, the brain can manipulate symbols and ideas without having to expend the effort necessary to reproduce them. In modern cultures, people who are engaged in abstract thinking use external material, like writing, as their 'working memory*" [Ibid. p 70]
- *and, in turn, this influences the way we perceive the world. "the alphabet helped them get away from the old, polytheistic way of thinking and to produce rational and general laws based on sequential cause-and-effect explanations for natural phenomena.*" [Ibid. p 73]

These changes brought about by the alphabet influenced the process of knowing in the West. More specifically, the effects of these changes can be seen in modern

economic theory; particularly the critical analysis of abstract ideas to describe and analyze economic processes. The ability to use abstract symbols has been an important influence on the patterns of Western thinking and economic theory.

Burke and Ornstein also speculate that the patterns in which symbols are written or read can alter the methods by which information is processed. Language can be read from bottom-to-top, top-to-bottom, left-to-right, right-to-left or some combination.

> *"Left-to-right orthography is read differently. The eye movement control, moving to the right is run by the left hemisphere of the brain. So left-to-right letters are first seen in the right-hand field-of-view of each eye and then processed in the left hemisphere of the brain, which is specialized for sequential, bit-by-bit processing and the analysis of chunks of information.* [Burke, p 72]

The technologies associated with language may well influence the form of what is perceived as knowledge. The relationship of knowledge and language is an important question.

Mathematics and Mechanics

Archimedes [287-212 BCE], Euclid [about 300 BCE] and Pythagoras [570?-495? BCE] were mathematicians who produced the tools that allowed the Greeks and Western culture to conceive of an ordered, mathematical universe. Archimedes gave us the lever and Pythagoras and Euclid gave us geometry. The lever is a mechanical device that has widespread application. The metaphor of the lever has been applied in a variety of circumstances including the social sciences. Geometry is a mechanical process that emphasizes linear, sequential thought patterns to "prove" an argument.

Algebra is attributed to the Arabic scholars. One of the characteristics of algebra is that it is a formal, structured language with a precise syntax. It is very useful in stating precise, causal relationships between dependent and independent variables. These relationships are referred to as **functional relationships.** The process of stating theories or models in an algebraic format tends to encourage a mechanical perspective.

Calculus is an even more powerful mathematical tool that was not developed until the late 17th century. Isaac Newton [1642-1727] and Gottfried Leibniz [1646-1716] are the two most closely associated with the development of calculus. It provides a means to find maxima and minima of functions and to state precisely the rate of change caused in a dependent variable by a change in any independent variable.

Most of the tools of mathematics require measurement and quantification of phenomena. This encourages those in pursuit of knowledge to dwell in the realm of those things that can be measured and quantified. For better or worse, ultimately the

mechanical, mathematical perspective of nature and social behavior triumphs. Modern economics relies on statistical and mathematical tools to construct and communicate models of economic behavior. The geometry of the Greeks, the algebra of the Arabic world along with Newton and Leibniz's calculus form the core of a powerful tool to develop and communicate ideas and knowledge.

Democritus of Abdera [460-370 BCE] was one of the first contributors, that we have any knowledge about, to the conception that our universe is composed of atoms moving in a void. These atoms are material "things" which cannot be divided. For Democritus, these atoms were homogeneous and unchangeable. Democritus' position is summarized:

> *"In sum, Democritus' reason for asserting that reality consists of atoms moving in the void is that this statement can be deduced from the promises: (1) nothing can come from nothing, (2) change really occurs, and (3) motion requires a void. That explanation must be mechanistic also follows from these assumptions if it is further allowed that all interactions are impacts. Democritus' mechanism was also the culmination of the rejection of animistic and supernatural will-forces by all his philosophical predecessors."* [Magill, p 19]

The perception that events are material phenomena that follow mechanistic rules rather that the will of gods is the basis of the potential for modern, mechanistic, empirical science. While the mechanical view does not mature until the late 17th century, Democritus planted the seed.

Debate and Democracy

The Greeks are credited with the introduction of democracy to Western civilization. The ability to present, criticize and debate ideas is a fundamental requirement of democracy. This tradition of debate and democracy not only influenced the forms of governance in Western societies but also shaped the nature of inquiry and knowing. As with all history, we must select what we believe to be relevant events and contributions. So it is here. While the contributions of the Greeks are complex and rich, it is necessary to be selective and summarize. In this simplified analysis, there seem to have been two major contributions to the concept of democracy; the **Sophists** and the reforms of Solon.

The Sophists were teachers for hire and taught their methods of reasoning for pay. They included ethics as well as a concern about the physical world. They tended to emphasize the relationships between laws and customs [*nomos*] and nature [*phusis*]. Protagoras of Abdera [490-420 BCE] and Gorgias of Leontini, Sicily [c.483-376 BCE, sometimes spelled Georgias] were both Sophist contributors to Western thought.

Protagoras' view of "truth" lay in the process of "overthrowing" another person's arguments. He believed that there is no objective truth but rather that the world is the

result of each person's perceptions. The purpose of argument is to alter the other person's perceptions. Laws and customs are the result of agreement of human perceptions. The issue is not in the "truth" of a perception or argument but rather in its usefulness.

Gorgias of Leontini [about 480 BCE] was a Sophist teacher who lectured in the form of debate. Like Protagoras, Gorgias believed that there was no objective truth, therefore, we must rely on opinion. The ability to influence other's opinions was the purpose of argumentation. Gorgias is credited with the realization that:

> *". . .the relationship between speech and 'truth' is far from simple. Speech is not just a matter of presenting the facts, since considerable reorganization of the 'facts' is involved in the way they are selected and sequenced."* [Burke, p 77]

Solon [638-558 BCE] instituted reforms in the 6th century which contributed to the rise of democratic ideals and thought. Many of these reforms were economic reforms that dealt with slavery for indebtedness, limits on the size of land holdings, and economic trade.

In addition to the creation of a tradition of argumentation and debate, the ideas of democracy contribute to a social system that encourages a perception that all participants have something to contribute. The free exchange of ideas is fundamental to the evolution of knowledge. It also contributes to the structure of modern economics which is a description, analysis and defense of the market system. In this role, the relationship of the "**free market**" or economic democracy to political democracy is an important topic.

Plato [427-347? BCE]

Plato was a student of Socrates and contributed both to the philosophy of knowing and economics. One of Plato's major contributions was *The Republic* which focused on the concept of justice. Here we are concerned with his influence on the methods of knowing. Plato believed that the observable world was an imperfect image of a realm of unobservable and unchanging forms. [Audi, p 619] These forms are ". . . *eternal, changeless, and incorporeal; since they are imperceptible, we can come to have knowledge of them only through thought*." [Ibid. p 621] When **Diogenes** ridiculed Plato's concept of forms by arguing that he could "*see a cup but not 'cuppness,' Plato attributed this to his (Diogenes) having eyes but no intellect.*" [Haren, p 10]

In Book VII of *The Republic*, Plato used the parable or allegory of the cave as a demonstration of the nature of knowing, education and ignorance. He imagines humankind living from birth as prisoners in a darkened cave. The individuals are constrained in such away that they can only see the wall before them. A fire casts

shadows of things behind them on to the walls. Unable to see the things, the shadows become "reality." One prisoner is taken into the light and exposed to another reality. What was wisdom in one place was not necessarily wisdom in another. Upon return to the cave if he relates the new reality to his former peers they laugh at him and seek to kill him. The fate of Socrates may well have influenced the lesson of Plato's parable. (For a bit of fun, imagine the modern business corporation as a cave. The modern university should be a trip into the light but in fact, has become an anteroom to the corporate cave and deals in darkness and shadows.)

Plato attempted to develop a unified theory that integrated many branches of learning (law, politics, arts, economics, ethics,…) [Burke, p 79] and tried to describe an ideal. Plato knew and was influenced by Pythagoras [570?-495? BCE], who was a mathematician/philosopher. Plato's position was that:

> *"…only the truths of mathematics endure so that only a theory based on numbers with a geometrical framework would reveal the permanent structure behind the obvious change and decay of the world. He was the archetypal theoretician who believed that the structure of matter could be worked out from logical principles and so there was no need for observation."* [Burke, p 79]

Plato's contributions emphasized a belief in the importance of theory to understanding the world and the ability to consider an abstract ideal. While this abstract ideal may not be achieved, it represents the ability to identify factors and states that represent goals.

Aristotle [384-322 BCE]

Aristotle, student of Plato and tutor to Alexander of Macedon (Alexander the Great) was one of the major influences in the evolution of Western thought. He made significant contributions to politics, economics, philosophy and ethics. His contributions to the methods of knowing shaped the direction and character of Western culture. This was particularly true during the middle ages. During the Renaissance Francis Bacon, Descartes and others devoted some of their efforts to dispelling medieval or Scholastic interpretations of Aristotle; he was reinterpreted for a new era.

Aristotle's development and application of syllogistic logic is perhaps his most important contribution. Syllogistic proper is "…*best seen as a system of valid deductive inferences rather than as a system of valid conditional statements*." [Audi, p 40] The syllogism consists of two premises (a major and middle) and a conclusion or "minor term." It is a system of rules about how to reason. It is essentially a deductive process. A major result of the use of this process is that it submits an understanding of the

universe and ". . . *problems to a sequential rational process*." [Burke, p 81] An example of reasoning by syllogism would be:

- All humans are rational.
- Consumers are humans.
- Therefore: all consumers are rational.

There are many rules to guide this sequential process to ensure there are no fallacies in reasoning. However, if either or both of the premises are false, no amount of correct reasoning will produce a "true" conclusion. Aristotle found it necessary to include a process to establish the premises used in the deductive process. The establishment of these premises was done through induction (or empirical observations) or prevailing beliefs. This inductive process was neither well developed nor formal. Formalization of the inductive process did not occur until the renaissance. Aristotle's process of reasoning juxtaposed the inductive and deductive processes with emphasis on the deductive elements.

In addition to Aristotle's contributions to logic and reasoning, he introduced a new awareness of change. He saw change as a constant process. "*All natural things are subject to change (kinesis). Defined as the actualization of the potential qua potential, a change is not an* ***ontologically*** *basic item*." [Audi p 41] These changes might be quantitative, qualitative or location. The crucial concept was that it was the fulfillment of potential. This implies change as progress; i.e. it is **teleological.** This notion is related to Aristotle's conception of "causes" which he perceives as being in the "nature of things."

Medieval

Terms used to describe specific periods in history are always subject to some error. Because of the difficulty of clearly delineating the dates of most periods in history, there is a question as to the appropriate dates of the medieval era. The medieval or middle ages may be defined as starting as early as the fall of the Roman Empire (476 AD) or as late as the 8th century. The end of the medieval period may be as early as the 12th century to as late as the 16th. The dates from 500 AD to 1350 AD are rough estimates, usable for our purposes. There are no clearly defined boundaries for the medieval era for all areas of Europe. There is no specific moment that it begins or ends; its dates are not the same in Italy as in Germany or England.

While this period is sometimes mistakenly referred to as the "Dark Ages," the advancement of science and efforts to "know" the nature of the world continued. The term Dark Ages implied that learning and development was stagnant. Most historians

now agree that the medieval period was not one of stagnation. As a generalization, one of the problems that had great influence during this period was the reconciliation of Christianity with secular approaches to knowledge and the teachings of the Greeks. The early medieval period was influenced by Saint Augustine [354-430 AD].

Augustine tried to show that the instability of society and the decline of Rome were not caused by Christianity. In the process he provided a ". . . *justification of the role of secular learning for the theologian*." [Haren, p 37] Augustine and his followers encouraged an attitude toward secular training that contributed to the operation of the Church. The ability to read, write and maintain records greatly increased the ability of the Church to maintain power through a hierarchical organization. Aquinas and the Church were the dominant contributors to the preservation and development of knowledge during the middle ages.

Anicius Manlius Severinus Boethius [480-525 AD] was one of the few early Latin scholars with a knowledge of Greek. He tried to make the philosophical ideas of the Greeks available to other medieval scholars. Until the recovery of Aristotle's works in the mid-12th century, his translations were the only available sources of the writings of the Greeks. [Audi, p 78] During the middle of the medieval era, the contributions the Greeks had made were "lost." (Boethius' translations were the primary contact of the Latin scholars with Greek philosophy.) However, the Islamic world had begun to expand (7th, 8th and, 9th centuries) and the literature of the Greek philosophers was maintained and extended by Islamic scholars.

Late in the Middle Ages, the Greeks (Aristotle in particular) were rediscovered by the Western scholars. The fall of Toledo [1085] into Christian control provided a library with a Moslem collection of Greek scholarship to be translated and reintegrated into Western culture. Roger Bacon [1214-1293], Saint Thomas Aquinas [1225-1274] and many other medieval scholars devoted much energy to reconciling Aristotelian philosophy with Christianity.

Roger Bacon [1214-1293]

Roger Bacon [1214-1293] was one of the first medieval scholars to integrate the newly recovered Aristotelian philosophy into his work.

> *"Bacon's major scientific writings were not pieces of natural philosophy but passionate attempts to warn the church hierarchy (in works addressed to the Pope) against suppressing the new learning expressed in Aristotelian philosophy and in all the new literature relating to natural philosophy, mathematical science and medicine. Bacon argued that the new philosophy was a divine gift, capable of proving articles of faith and persuading the unconverted: that scientific knowledge contributed vitally to the interpretation of Scripture; that astronomy*

was essential for establishing the religious calendar: that astrology enabled man to predict the future; that 'experimental' science taught how to prolong life; and that optics enabled the creation of devices that would terrorize unbelievers and lead to their conversion. . . . So theology did not oppress these sciences but put them to work, directing them to their proper end" [Burke, p 118]

Bacon's *Opus Maius* [1267] was a response to the Pope's demand to see Bacon's writings. There are three important points that Bacon makes [Audi, p 61]:

- "*the study of Hebrew and Greek is indispensable for studying the Bible*,
- *the study of mathematics (encompassing geometry, astronomy, and astrology) is, with experimentation, the key to all sciences and instrumental to theology*,
- *philosophy can serve theology by helping conversion of non-believers*." [Audi p 61]

Bacon's approach appears very modern. He was able to have a greater influence because the Aristotelian methods of deduction and the empirical methods he advocated were to be put to the use of religion. An interest in **alchemy** and natural phenomena encouraged the use of experimentation.

*"Bacon's experimental technique, which would give the axemakers a new technique for manufacturing knowledge, became known as '**resolution and composition**.' It was a direct descendant of the mode of thought made possible by the alphabet because it applied the cut-and-control analytical method to the solution of problems. 'Resolution' defined a complex phenomenon and its casual conditions by breaking it down into the elements or principles involved in its appearance. 'Composition' then used this data to show how these causes brought the phenomenon about, thus revealing the conditions that were necessary and sufficient to produce the phenomenon."* [Burke, p 118]

The work of the **Oxford Calculators,** sometimes called the Merton School, in the mid 1300's was an example of attempts at applied empiricism that were made in measurement and quantification of natural phenomena, particularly motion. [Audi, p 553] Ultimately, "knowing" depends on a system of **taxonomy** and measurement. Taxonomy is the process of identifying, naming and categorizing phenomena. The very act of classifying phenomena suggests a form of reductionism; i.e. the process of breaking an event or thing into its component parts for purposes of analysis.

Saint Thomas Aquinas [1225-1274]

Saint Thomas Aquinas [1225-1274] was one of the most important intellectual leaders during the middle ages. Aquinas was concerned with the proper relationship

between faith and reason; religion and secular thought; the Church and Aristotelian methods. His purpose was to reconcile the spirit with matter. He sought to remove or at least alter the role of the Platonic influence.

> *"…the Platonic theory of knowledge… which was regularly beset with the difficulty of accounting for the origin and the truth of knowledge, was translated into a theory of abstraction in which sensible experience enters as a necessary moment into the explanation of the origin, the growth and the use of knowledge, and in which the intelligible structure of sensible being becomes the measure of the truth of knowledge and of knowing."* [Pegis, p 32]

Aquinas made a distinction between philosophical activities and theology. Philosophy was based on natural reason while theology depended on divine revelation. Truth is common to both reason and revelation. [Haren, p 181] However, the human intellect cannot know the nature of God. The "*human intellect depends on sense for the origin of its knowledge*." [Ibid.] "*The principle here is that while the recognition that something is an effect implies recognition – and in that sense knowledge - of the cause.*" [Ibid.] Reason is at best incomplete and fallible; revelation is not. God is the creator of the universe and the order of the elements in that universe. "*What the mind knows it knows by abstraction from the sense experience in virtue of its natural intellectual powers.*" [Ibid.] Aquinas' approach sets the stage for the development of empirical approaches to knowing.

William Ockham [1285-1347 (1349?)]

William Ockham was a Scholastic philosopher and considered the "father of nominalism." [Audi, p 543] Nominalism is the belief that there are objectively existing entities, but that universals are abstractions, words or names. Our ability to "know" reality is constrained by our language and experience. Knowledge is limited to particulars. These ideas appeared in Boethius' work as early as the 6th century and found in logical positivism in the 1920's.

Ockham is also credited with "Ockham's Razor" (sometimes Occam's Razor) or the "principle of parsimony." Ockham's Razor is often invoked in arguments about economic theories. It is the belief the development of theories or models should tend toward simplicity. Fewer **parameters** and simpler models are preferred over explanations that are more complex.

Renaissance

The renaissance is like other periods of history; its beginning and end are not clearly defined. For our purposes, it begins about 1400 [or slightly earlier] in Italy and extends to the 17th century. New perspectives of technology and the universe were

exemplified by such notables as Prince Henry the Navigator [1394-1460], Leonardo da Vinci [1452-1519], Nicholas Copernicus [1473-1543]. Copernicus altered the perception of the universe and the role of humanity by recognizing that the earth was not the center of the universe. Henry the Navigator and da Vinci gave society an awareness of human ability to use the intellect to create technology that enables us to do things and go places. The Western Hemisphere was opened to exploration, conquest and trade.

During this period, art and literature are given a new importance; there is a new attitude toward secular knowledge; and at least two new technologies alter the world. Mechanical clocks and moveable type altered social perspectives of the universe and the methods by which new ideas were communicated. The new technology of moveable type and books contributes to the recognition of nationality through the publication of bibles and books in a variety of languages. Niccolò Machiavelli [1469-1527] published *The Prince* [1469] that reflected and contributed to a new perspective about nations and state building. The Protestant Reformation and a new awareness of national identity reorient the objectives of intellectual endeavors. The Protestant Reformation contributes to the shift of power from the theological realm to the secular. This shift alters the objectives and methods of the acquisition of knowledge.

Mechanical Clocks: A New Perspective on Time and the Universe

During recorded history, time has been of interest to humans. Many of the relics of earlier civilizations were used to mark the passage of seasons or time of day. Astronomy, which helped to produce much of early science and mathematics, may well have begun as an attempt to understand the passage of time. Early human societies depended on daylight and seasons as indicators of time. Daylight and dusk marked the time of day. The ability to predict the cycle of seasons was more difficult and important; seasonal patterns of animal migrations, ripening of fruits and nuts in different geographic areas, times so floods, planting and harvesting were crucial to the well being of groups. Egyptians divided the year into three seasons; flood, sowing, and harvesting. Based on astronomical observation and inconvenience of earlier calendars, by 3000 BCE, the year was divided into 12 months of 30 days each with a special 5-day period. [Derry, 222-223]

As to time during a day, "*Herodotus reports that the Greeks had adopted sundials and the twelve divisions of the day from the Babylonians."* [Dohrn-van Rossum, p 18] The keeping of the hour passed from shadow clocks (about 1450 BCE, [Derry, p 224]) to sundials to water clocks. During the medieval era, the timing of prayer dictated a need for increasingly complex measurements of time. While there is some probability that the mechanical clock was the result of needs and ingenuity of early monasteries (particularly the Benedictines), its history is not known. Some writers attribute its

development to the Moslem world, others to China. [Dohrn-van Rossum, p 46] Whatever its source, mechanical clocks had made their appearance in European culture by the "*thirteenth century AD when they were driven by falling weights;"* [Derry, p 225]

Mechanical measurement of time requires a source of power (Such as a falling weight or spring.), a mechanism to transmit the energy to a display [audio such as chimes or visual such as "hands"), and a means to regulate the speed of the falling weight or spring. It is the escapement that is new to the mechanical clock. The pendulum was added by Galileo's son in 1641. [Derry, p 227] The development of the clock is a fascinating study in the history of a technology. By the 13th century, clocks had become "the objects of daily use in churches and monasteries." [Dohrn-van Rossum, p 64] The location and use of clocks became more "public." Dohrn-van Rossum traces the evolution of the public clock in a variety of cities. [Ibid. pp. 128-172] Clocks became important in civil, military and commercial activities; clocks were placed in central locations in towns and cities; human activities shifted from the natural rhythms of daybreak, daylight, dusk and night to abstract units of time measured by the mechanical clock.

The development and making of clocks encouraged the development of new skills and an understanding of new ways to transform and apply motion. It a created a perception that mechanical motion could be transformed into "time." Clock making provided part of the foundation for the scientific revolution as a way of precisely measuring time. The knowledge derived about the transmission of motion through gears and mechanical devices also contributed to the Industrial Revolution to come.

The clock altered the perceptions of the universe and man's role. Jacques Ellul (perhaps pessimistically) agrees with Lewis Mumford in calling the clock "*the most important machine of our culture*." [Ellul, p 329]

> *"The clocktower, with its public clock, made its appearance toward the end of the century (14th). Until then, time had been measured by life's needs and events. At most, life had been regulated since the fifth century by church bells; but this regulation really followed a psychological and biological tempo. The time man guided himself by corresponded to nature's time; it was material and concrete. It became abstract (probably toward the end of the fourteenth century) when it was divided into hours, minutes and seconds. Little by little this mechanical kind of time, with its knife-edge divisions, penetrated, along with machinery, into human life. The first private clocks appeared in the sixteenth century. Thenceforward, time was an abstract measure separated from the traditional rhythms of life and nature. It became a mere quantity. But since life is inseparable from time, life too was forced to submit to the new guiding principle. From then on, life itself was measured by the machine; its organic functions obeyed the mechanical. Eating, working, and sleeping were at the beck*

and call of machinery. Time, which had been the measure of organic sequences, was broken and dissociated. Human life ceased to be an ensemble, a whole, and became a disconnected set of activities having no other bond than the fact that they were performed by the same individual. Mechanical abstraction and rigidity permeated the whole structure of being." [Ellul, p 329]

Perhaps Dohrn-van Rossum's description is less pessimistic than Ellul's:

"Around the year 1410, at the dawn of Europe's modern era, an anonymous author assumed the role of an English friar and described contemporary innovations in the ways people dealt with time. In his exegesis of the First Commandment, he condemned the art of the astrologers, explaining that God had created the firmament out of light and time like a flawless clock. Light and time, the starry heavens, were meant to serve man, not the other way around. From the firmament as a great clock, he proceeded to the striking clocks, new in his day, and explained that just as the heavenly bodies did not rule earthly creatures, clocks in cities large and small did not rule men. Rather, in cities and towns people ruled themselves by the clock." [Dohrn-van Rossum, p 1]

The mechanical clock became the mother of machines. [Boorstin, pp. 64-78] The clock was one of the first mechanical devices for measuring. It contributed to the social stock of knowledge and awareness of instruments for measurement. "*Clockmakers became the pioneer scientific-instrument makers*." [Ibid. p 64] They were the first group to apply the new knowledge of mechanics to making machines, which revealed information about human's world and altered perceptions.

The integration of the clock altered perceptions of the universe and provided the metaphor of the "clock work universe;" the world constructed by the supreme clockmaker. All that was left for the seekers of knowledge was to discover the mechanics of the great clock works.

Moveable Type

Johannes Gutenberg [?1400-1468?], a goldsmith, began to experiment with moveable type as early as 1439. He and others (a partner Johan Fust and an independent experimenter in Holland) developed moveable type and by 1448 were capable of printing books. [Derry, p 238] Some date the Gutenberg Bible at 1456. Burke states that in "*...1455 there were no printed books in Europe and by 1500 there were twenty million books in 35,000 editions, one book for every five members of the population*." [Burke, p 123] Burke and Ornstein's story of the development of the printing industry in Europe stress the importance of Gutenberg's contribution. It also relates the importance of technological change to perceptions of the world. Moveable type was a double-edged sword. On the one hand:

"Rome realized that printing could strengthen its social authority through the production and dissemination of thousands of copies of identical devotional books, which would make possible liturgical conformity and obedience on an unprecedented scale." [Burke, p 124]

On the other hand, as bibles were printed in a variety of languages, it began to reduce the power of the Church and it created an awareness of national identity. There were efforts to censor the books with ideas not in conformity with the teachings of the Church;

"Endlessly reproducible, small, unobtrusive and portable, for every book seized by customs officers and impounded, another ten could be got to their desired location hidden in bales of cloth…, or under the floorboards of ships… . [Jardine, p 171]

The technology of moveable type and the production of books had profound consequences. Its success was driven not only by an interest in knowledge and scholarly activities, but also by commerce. Early printing was a financial success and encouraged a commercial mentality. [Jardine, p 132, pp. 135-180] The book was one of the first commodities to be a standardized, mass-produced and sold. In addition to the commercial success,

"The printed book revolutionized the transmission of knowledge, and permanently changed the attitudes of thinking Europe. Print brought with it many of the features of a book-based culture which in our everyday lives we now take for granted. The scribally produced manuscript was unique (the pagination of each copy would be different); the printed book for the first time allowed two readers to discuss a passage in a work they were both reading by referring to the precise page on which it occurred. Consistent pagination also made it possible for the author or editor to provide an index. … The comparatively effortless production of multiple copies meant that printed books could disseminate knowledge much more rapidly, widely and accurately than their handwritten antecedents. [Jardine. P 177]

Protestant Reformation

Martin Luther [1483-1546], a university professor, Aristotelian and Augustinian friar, who was trained in nominalism, publicly attacked the sale of **indulgences** by a representative of the Church. In October 1517 he posted 95 theses and began the process that fundamentally altered the answer to the question: "What is the proper relationship between man, God and the Church?" He questioned the role of the monasteries, the papacy, and the conditions of salvation. In doing so, he weakened the single most important institution in Europe. The Church had united Western society and had been a major influence in scholarship and the development of knowing. It had been

the single most important institution in shaping what was regarded as knowledge in the Middle Ages. Luther's position was that man was saved by grace, faith alone justifies man before God. "*Man's conscience, his reason and the Scriptures together became his only norm and authority*." [Ferm, p 284]. Knowledge became a process directed by methods, individuals and the community of scholars rather than being based primarily on authority.

John Calvin [1509-1564], a humanist and French theologian, also contributed to the reformation. Calvin "…perceived the personality as a hierarchy of faculties properly subordinated to reason, which was at odds with his evangelical reason." [Audi, p 99]

> *"Like other humanists, therefore, he was also profoundly skeptical about the capacity of the human mind to grasp ultimate truth, an attitude that rested, for him, on both the consequences of original sin and the merely conventional origins of language." [Ibid.]*

While the Church still had great influence over many scholars like Galileo, the idea that man could know the universe through reason was strengthened.

The Rise of Science

The beginning of the 17th century saw a many changes in the process of knowing. "Science" and knowing were advanced by such figures as Francis Bacon [1561-1626], Galileo Galilei [1564-1642], Johannes Kepler [1571-1630], René Descartes [1596-1650], William Harvey [1578-1657], and Thomas Hobbes [1588-1679], all of whom were born in the 16th century. Robert Boyle [1627-1691], John Locke [1632-1704] and Sir Isaac Newton [1642-1727] followed. These men built upon the contributions of the past and shaped the development of modern, Western thought.

Francis Bacon [1561-1626]

Francis Bacon may be one of history's great scoundrels or a great hero that liberated science from the traditions of the Scholastics and Greek philosophy. His life was more exciting than most novels. He was the son of a prominent family; entered Trinity College, Cambridge at age 12; failed to obtain his inheritance; rose to member of parliament at age 23; fell out of favor with one monarch (Queen Elizabeth); gained the favor of another (James I); practiced law; was knighted; rose to Lord Chancellor; confessed to taking a bribe and was imprisoned for a short time. [Urbach] And still had time to write *The Advancement of Learning* [*AL*, 1605] in English and *Novum Organum* [*NO*, 1620] in Latin.

The Advancement of Learning and *Novum Organum* were the first two parts of a plan to produce a much more ambitious work to be called "Magna Instauratio" [which was never finished]. The objective of *Advancement in Learning* was to rationalize the need

for learning and to show the necessity of advancing knowledge. [J.E. Creighton in Bacon, p vii] *Novum Organum* was to replace Aristotle as the preeminent guide to the process of acquiring knowledge.

> *"Bacon did for inductive logic what Aristotle did for the theory of the syllogism. It is of course, incorrect to say, as has sometimes been said, that Bacon invented the inductive method of reasoning. … What Bacon endeavored to do was to analyze the inductive procedure, and to show what conditions must be fulfilled in order that truth may be reached in this way."* [Ibid. p viii]

Bacon understands individual and social resistance to learning;

> *"That it enervates men's minds, and unfits them for arms; that it perverts their dispositions for government and politics; that it makes them too curious and irresolute, by variety of reading; too peremptory or positive by strictness of rules; too immoderate and conceited by the greatness of instances; too unsociable and incapacitated for the times…"* [Bacon, *AL*, p 7]

Bacon [possibly to appease the established religion] argues that knowledge proceeds from two sources; "*divine inspiration and external sense*." [Ibid. p 76] His focus then is on the use of external senses and empirical methods. Bacon advocates reductionism and objectivity in science. "*Nature shows herself best in her smallest works*." [Ibid. p 77] This seems to imply that phenomena in the universe can be reduced into components and each of the small parts studied individually. Then the knowledge obtained from each of the pieces can be aggregated to reveal truths or information about the whole. Economics uses this reductionist approach in the application of Utilitarianism to microeconomic theory.

With respect to objectivity, Bacon identifies four "idols" and false notions that inhibit the inductive method of science. [Bacon, *NO*, pp. 319-320]

- The "*idols of the tribe are inherent in human nature*." [Ibid.] These are human tendencies to seek patterns and purposes in nature.
- The "*idols of the den are those of each individual; for everybody has his own individual den or cavern which intercepts and corrupts the light of nature, either from his own disposition, or from his education and intercourse with others, or from his reading,…*" [Ibid.]
- "*There are also idols formed by the intercourse and society of man with man, which we call the idols of the market*." [Ibid.] These are based in linguistics and rhetoric.
- "*… there are idols which have crept into men's minds from the various dogmas of peculiar systems of philosophy, and also from the perverted*

rules of demonstration, and these we denominate idols of the theatre." [Ibid.] These are the biases created by the authority of received theories and ways of doing things.

Bacon' influence has reached into the modern era. Scientists from John Stuart Mill [Audi, p 61] to a fictional detective, Sherlock Holmes [Smith, Jonathan] have been influenced by his work. He was a contemporary of William Shakespeare [1564-1616] and was the subject of a controversy (attributed to Delia Bacon [1811-1859]) regarding the authorship of the Shakespearean plays.

Creighton's introduction to Bacon's *Novum Organum* identifies the recognition of the conscious act of the inductive process as an important aspect of Bacon's contribution:

> *"For we must distinguish between using induction more or less unconsciously and thoughtlessly, and employing it with full consciousness of the various steps involved, and under the proper conditions. What Bacon endeavored to do was to analyze the inductive procedure and to show what conditions must be fulfilled in order that truth may be reached in this way. He thus brought the mind to a consciousness of its own methods, and provided it with a sure instrument for reaching certain conclusions."* [Creighton in Bacon, p viii]

This increased consciousness produced a new culture;

> *"But Bacon's services in impressing upon mankind a new idea of culture, and in arousing them to the practical importance of extending their knowledge of nature, are perhaps even more important than his logical theories."* [Ibid.]

While Bacon emphasized the practical applications of knowledge he wished to limit its application:

> *"But here, by use and by action, we do not mean the application of knowledge to* ***lucre****, for that diverts the advancement of knowledge, as the golden ball thrown before Atalanta, which, while she stoops to take up, the race is hindered."* [Bacon, p 23]

Galileo Galilei [1564-1642]

Galileo is one of the best known contributors to the advancement of knowing. His departure from strict Aristotelianism and conflict with the Church ensure his place in history. Galileo had many influences in his life. Two of the important forces were his father and his employment as a mathematician rather than as a philosopher. [Shea, pp 3-7] His father, Vincenzio Galilei (a musician and music was considered a branch of mathematics), engaged in experiments with strings and notes. [Ibid.] His employment as a mathematician rather than philosopher freed him from the need to adhere to the methods advocated by Aristotle. The methods of Aristotle had been dominant since

their rediscovery and defense by Aquinas. Philosophers were expected to adhere to the teachings of the Church and Aristotle. The Inquisition enforced this expectation. Galileo, being a mathematician, had a less clearly defined role. [Ibid. p 5] Galileo turned to Archimedes, Euclid and Copernicus. The lever, motion and the Copernican system were the focus of his study; Experimentation, observation, measurement and the telescope were his tools.

Galileo's approach ultimately created problems for him with the Church and the last years of his life were spent in house arrest. Scott Gordon summarizes the general aspects of Galileo's contributions to the process of knowing;

> *"Galileo's view was that differences of view about natural phenomena are resolvable by observation and experiment, not by appeal to authority." … "Hierarchical order is an effective way of creating intellectual peace, but it is too easy and perfect. People often complain that scientists (especially social scientists) disagree among themselves. One must, however, expect disagreement, since it is not easy to settle differences by empirical investigation. Authority can settle differences very neatly, but it is a questionable way of assuring that what all persons are required to believe is in fact true. Doubt is more valuable than certainty when one may be quite wrong in what one is certain about."*
>
> *Neither Galileo nor any other sophisticated scientist would contend that empirical data derived from the observation of nature speak for themselves. Data must always be interpreted." …*
>
> *"…the secrets of nature are open to investigation by every man who goes about it properly. It is a question of method, not of status."* [Gordon, p 24]

Descartes, Hobbes and Newton, as well as course of science and knowing were directly influenced by Galileo. His major contributions included:

- "*telescopic astronomy,*
- *principles and laws of motion,*
- *the mode of relating mathematics to experience,*
- *and experimental science or the science of experimentation."* [Cohen, pp. 135-136]

Telescope and Microscope: A New View

Bernard Cohen comments that the Copernican Revolution did not occur until the innovations of Johann Kepler [1571-1630] and Galileo Galilei [1564-1642]. [Cohen p 126] Nicholas Copernicus [Mikolaj Kopernik, 1473-1543] worked out a method of calculating the positions of planets with the sun rather than the earth at the center of the universe. The method was published in *De Revolutionibus Orbium Coelestium* [1543]. The

Copernican system appealed to some because the calculations were simpler but was rejected by others because the system did not appeal to their reason or religion. The planetary observations of Tycho Brahe [1546-1601] and the work of Kepler and Galileo eventually established the Copernican system as the prevailing wisdom. It was Tyco who collected observations on planetary motion and hired Kepler as an assistant. Kepler using much of Tyco's data worked out the elliptical orbits of the planets.

> *" He (Kepler) made one of his greatest discoveries by having the good fortune to eradicate the effects of a major mathematical error by introducing a second error which nullified the effects of the first one. Kepler was one of the greatest astronomers of history; yet we could easily assemble a whole volume of his writings that would show how unscientific his thinking and his science were.* [Cohen, p 127]

In May 1609, Galileo apparently heard of a telescope that had been invented by a Dutchman and based on the idea built his own telescope. [Asimov, p 19] From this development:

> *"He used principles of analogy and physical optics to show that the moon is like the earth, craggy and corrugated. He discovered that the earth shines and illuminates the moon, He found that Jupiter has a system of four moons, that Venus shows phases. His telescope not only revealed new information about previously known celestial objects – sun, earth, moon, planets – but also brought within visible range a host of stars (and moons) that had never been seen by human eyes."* [Cohen, p 136]

Galileo's telescope produced visual, empirical evidence to support the Copernican system. Through the telescope, evidence was gathered that showed celestial bodies that orbited other planets and that other planets had some characteristics in common with the earth; it was the instrument that impressed upon the human eye and mind the possibilities of the Copernican system.

The invention and development of the microscope is not known with certainty; it may have been by Thomas Digges' father (about 1571) or Zacharius Jansen (about 1595). Many early writers were aware that single lenses and globes of water magnified print and objects. Roger Bacon notes the use of magnifying devices and eyeglasses were used as early as the beginning of the 14th century. [Wilson, p 73] By the late 12th and early 13 centuries Islamic scholars had worked out a theory of optics that had been

> *"disseminated and studied in Europe through the* Perspectiva *of Ibn-al-Haytham, or Alhazen, who had explained geometrically the plano-convex lens, noting that an object placed in a dense spherical medium between the eye and the center of the sphere would appear larger."* [Wilson, p 72-73]

One argument is that lenses were not systematically used before the early 17th century to gather knowledge others argue that men like Roger Bacon used lens to observe various phenomena. [Wilson, p 215] Either way, Robert Hooke [1635-1703] and Antoni van Leeuwenhoek [1632-1723] are the names most often associated with the compound microscope and the use of microscopes as scientific instruments. Hooke's book, *Micrographia* (1665) was an attempt to turn microscopic observation into a geometry, grammar or alphabet for the expression of complex forms. [Wilson, p 228]

The telescope and microscope allowed scientists to observe phenomena that had previously only been the subject of speculation. In addition to making a wider range of phenomena visible to be measured, quantified and classified, it encouraged a new perspective toward science and scientific instruments. An indication of this increased interest was the founding of Royal Society of London in 1662 and the Royal Academy of Sciences in Paris.

William Harvey [1578-1657]

William Harvey's contributions are narrow but not unimportant, particularly to economics. His major book, *An Anatomical Treatise Concerning the Movement of the Heart and of the Blood in Animals* [1628] influences the perspectives of science and provides a metaphor for generations of economists. His conception of the circulatory system of provided a model for the François Quesnay's [1694-1774][a physician and economist] ***Tableau*** which is considered the foundation of the idea of "circular flow" in economic theory.

With reference to his contributions to the Western perspective of knowing, his contributions were twofold;

- successful use of experimentation and direct observation and,
- the introduction of quantitative reasoning in the study of living organisms. [[Cohen, p 189]

Harvey's work demonstrated that the developing scientific methods could be successfully applied to human and other living creatures. The notion of a circulatory "system" reinforced the mechanical view of life.

René Descartes [1596-1650]

Descartes is often regarded as one of the major contributors to the "Age of Science," or "Age of Reason." Again, the definition of periods in history is often arbitrary and never clearly delineated. It cannot be denied that he was an important influence on the Western perspective. His life was devoted to a search for truth and a definitive method to reveal that truth. He believed that his objective could be achieved through systematic doubt and mathematics.

As many great contributors to history, Descartes has been seen as a hero and villain. His separation of the mind and body has been controversial. A second feature of Descartes' approach was to reduce all phenomena to mechanical explanations. Stephen Gaukroger, a biographer of Descartes, comments about mechanistic views in the context of optics;

> *"The motivating idea behind this, as we shall see, is mechanism: what Descartes is concerned to provide, above all, is an account of how our perceptual image of a mechanistic world is formed, and how the process by which this perceptual image is constructed can itself be accounted for in mechanistic terms. Descartes had been committed to a practical form of mechanism in 1619/20, in his work with (Isaac) Beeckman, and this took the form of a reconstruction of physical problems in micro-mechanical terms.* [Gaukroger, p 146]

Descartes' commitment to mathematics was, in part, due to its certainty. Economists are indebted to Descartes for his contribution of "Cartesian coordinate system" and the development of analytic geometry. Descartes says:

> *"The long chains of simple and easy reasonings by means of which geometers are accustomed to reach the conclusions of their most difficult demonstrations had led me to imagine that all things, to the knowledge of which man is competent, are mutually connected in the same way, and that there is nothing so far removed from us as to beyond our reach,…."* [Descartes, p 52]

He also integrates the methods of geometry with those of algebra to improve the method of knowing that he develops:

> *"I believed that I could borrow all that was best both in geometrical analysis and in algebra, and correct all the defects of one by the help of the other."* [Descartes, p 53]

Decartes lasting legacy has been a mathematical, mechanical perspective of the world about us. He has also contributed to a reductionist approach to knowing. In *Discourse on Method* [1637], Descartes describes the second step in his outline on the procedure for resolving problems of knowing:

> *"The second, to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution."* [Descartes, p 51]

Modern economic theory is characterized by its use of a reductionist, mechanical approach. It has long attempted to emulate the methods used in physics. This approach has encouraged the use of mathematical models and a need to reduce the phenomena to sets of equations. The influence of Descartes on the methods used in economics has been significant.

Thomas Hobbes [1588-1679]

Thomas Hobbes was an English philosopher who spent much of his life on the continent. He briefly served as an assistant to Francis Bacon, but did not "affiliate his philosophy to the Baconian." [Sorley, p 49]. Sorley states that Hobbes and Bacon had similarities:

- "*agreed in opposition to medievalism*" [Scholasticism];
- "*both attempted to elaborate a comprehensive scheme*;"
- "*the vague term 'empirical' can be applied to both; but Hobbes set small store by experiment*;"
- most importantly, "*their acceptance of the mechanical theory*;"
- but Sorley concludes; "*there is ample evidence, external as well as internal, that Hobbes was indebted not to Bacon but directly to Galileo*." [Ibid.]

Hobbes is best known for his contributions to political philosophy which were probably influenced by the events surrounding **Cromwell's** rise. Hobbes, like Bacon, rebelled against Scholasticism and disliked Aristotlianism in the form that had prevailed. Hobbes is best known for his views about the nature of humans and the conditions in a state of nature.

A quote from *Leviathan* [1651] is often use to characterize his political views in a simplistic manner:

> *"Whatsoever, therefore, is consequent to a time of war where every man is enemy to every man, the same is consequent to the time wherein men live without other security than what their own strength and their own invention shall furnish them withal. In such condition there is no place for industry, because the fruit thereof is uncertain: and consequently no culture of the earth; no navigation nor use of the commodities that may be imported by sea; no commodious building; no instruments of moving and removing such things as require much force; no knowledge of the face of the earth; no account of time; no arts; no letters; no society; and, which is worst of all, continual fear and danger of violent death; and the life of man solitary, poor, nasty, brutish and short."* [Hobbes, p 107]

In *Leviathan*, Hobbes seeks a solution to this state of nature; he finds the solution in reason. Humans, being rational, have rational objectives and will work toward these goals using reason. While humanity lives in a state of nature that is "mean, nasty brutish and short," the desire for peace and to avoid violence and death are the objectives of reason. Reason results in morality and a rational construction of law. Schneider, in his introduction to Hobbes' *Leviathan*, says: *"This is the first attempt to construct a*

systematic utilitarian rationalization of natural law." [Hobbes, Schneider's introduction, p xi]

For Hobbes, knowledge is produced by reasoning and reasoning and speech are related:

> *"The faculty of reasoning being consequent to the use of speech, it was not possible but that there should have been some general truths found out by reasoning as ancient almost as language itself.* [Hobbes, p 4]

Hobbes proceeds to categorize knowledge as two types. One is of 'fact' and consists of sense and memory. The second is called 'science' and:

> *""…is conditional, as when we know that if the figure shown be a circle, then any straight line through the center shall divide it into two equal parts. And this is the knowledge required in a philosopher-that is to say, of him that pretends to reasoning.* [Ibid. p 74]

Hobbes presents an early attempt a presenting a system based on reason that allows humanity to identify goals and objectives and to rationally make choices that lead to those objectives.

John Locke [1632-1704]

John Locke was one of the most important philosophers of the era. His interests and contributions were diverse. He was a physician, philosopher, political theorist, economist and scientist. Locke worked with Robert Boyle [1627-1691] whose contributions in medicine and respiration were linked to his use of experimental methods. His contributions in political philosophy have been used to rationalize the American Revolution. *An Essay Concerning Human Understanding* [1689] is one of the foundations of epistemology and the history of knowledge. Peter Nidditch, in the introduction to *An Essay*, comments that:

> *"The Essay presents, for the first time, a systematic, detailed, reasoned, and wide-ranging philosophy of mind and cognition whose thrust, so far as it is in line with the future rather than the past, is empiricist."* [Nidditch in Locke, p vii]

Locke begins his search for knowledge by looking at the mind as a "white paper" [*tabla rasa*];

> *"If we will attentively consider new born children, we shall have little Reason, to think, that they bring many Ideas into the World with them."* [Locke, p 85]

He goes on to accept some faint ideas such as hunger, thirst, warmth and pains may have been felt in the womb but continues:

> *"Let us then suppose the Mind to be, as we say, white Paper, void of all Characters, without any **Ideas**; How comes it to be furnished? Whence comes it by that vast store, which the busy and boundless Fancy of Man has painted on it,*

with an almost endless variety? Whence has it all the materials of Reason and Knowledge? To this I answer, in one word, From Experience: In that, all our Knowledge is founded; and from that it ultimately derives it self. Our Observation employ'd either about external, sensible Objects; or about the internal Operations of our Minds, perceived and reflected on by our selves, is that, which supplies our Understandings with all the materials of thinking. These two are the Fountains of Knowledge, from whence all the ***Ideas*** *we have, or can naturally have, do spring.* [Ibid. p 104]

Locke like many writers often uses words in ways may be different from the common uses. "*Ideas*" is one of these cases. N.P. Wolterstrorff comments on the word as used by Locke:

> *"Exactly what Locke had in mind when he spoke of ideas is a vexed topic; the traditional view, for which there is a great deal to be said, is that he regarded ideas as mental objects. Furthermore, he clearly regarded some ideas as being representations of other entities; his own view was that we can think about non-mental entities only by being aware of mental entities that represent those non-mental entities* [Audi, p 438]

Locke bases the structure of knowledge on ideas that are simple or complex. Simple ideas are those that are uncompounded; uniform in appearance and available through one sense. [Locke, p 121] These simple ideas are contained in a passive mind. [Ibid. p 163] Complex ideas are made up of simple idea**s** and are acted upon by the mind. There are three processes identified by Locke;

- "1. *Combining several simple ideas into one compound one, and thus all complex ideas are made."*
- "2. *The 2d. is bringing two Ideas, whether simple of complex, together; and setting them by one another, so as to take a view of them at once, without uniting them into one; by which way it gets all its Ideas of Relations."*
- "3. *The 3d. is separating them from all other Ideas that accompany them in their real existence; this is called Abstraction: And thus all its General Ideas are made*." [Locke, p 163]

Locke proceeded to attribute sensation and reflection as the processes by which humans acquire experience. [Locke, p 105] Human perception is not infallible. Consequently, certainty of knowledge is not always possible; knowledge and beliefs are both important but not the same. The probability of a truth may be all that we have:

> *"Our Knowledge, as has been shewn, being very narrow, and we not happy enough to find certain Truth in every thing which we have occasion to consider; most of*

the Propositions we think, reason, discourse, nay act upon, are such, as we cannot have undoubted Knowledge of their Truth: …. Probability is likeliness to be true, the very notation of the Word signifying such a Proposition, for which there be Arguments or Proofs, to make it pass or be received for true. [Ibid. p 655]

The greater part of humanity *assents* to conclusions and relations [including cause and effect] without certain knowledge. This becomes an important aspect of human behavior;

" This is all the greatest part of Men are capable of doing in regulating their Opinions and Judgements; … [Ibid. p 658]

Locke's approach to knowing is practical and based on experience and empirical evidence. His training in medicine as well as his association with Robert Boyle probably influenced his views on experimentation. Locke's contributions to political theory were important in rationalizing the revolutionary spirit and were in all likelihood shaped in part by his Protestant upbringing, the English civil war, and his time in the Netherlands. He was one of the early contributors to economic issues such as the quantity theory of money, but we shall turn to economic issues in a later chapter.

Because of Locke's contributions in epistemology, revolution and economics, one additional quote is mandatory:

"Hence I think I may conclude, that Morality is the proper Science, and Business of Mankind in general. [Locke, p 646]

Locke, a major contributor to philosophy in his own right, was impressed by a contemporary and friend Isaac Newton. In *An Essay on Human Understanding*, Locke writes:

"Mr. Newton, in his never enough to be admired book has demonstrated several Propositions, which are so many new Truths, before unknown to the World, and are farther Advances in Mathematical Knowledge:…" [Ibid. p 599]

Isaac Newton [1642-1727]

Perhaps the best known and most important architect of the modern Western perspective was Sir Isaac Newton. Newton, like so many of the other contributors to the process of knowing, was engaged in a broad spectrum of activities. He served as president of the Royal Society, maintained contacts and friendships with Boyle, Locke and other philosopher/scientists. He was involved in public affairs and was at one time the Master of the Mint. He is best known for his ideas on gravity and the effects on tides. During the plague of 1665-67 Newton, as many people tried to do, lived as secluded a life as possible. During this time, he is reputed to have developed the binomial theorem and calculus; discovered the ability to split white light into colours and

began his study of mechanics. [Spielberg, p 71] He is (a co)discoverer of calculus [2] and a general system of motion and matter often referred to as "**Newtonian Mechanics.**" Newton was also well known for his interest in experimentation. He designed and built scientific instruments to aid in the experiments.

Calculus offered a more sophisticated way to deal with relationships between variables. The notion of a differential provided a means to find minima and maxima as well as measure the rate of change in one variable (dependent) "caused" by changes in other variables. For economists who were trying to apply the techniques used in the physical sciences, this new tool ultimately came to play a crucial role. Newtonian mechanics became the standard for physical science and many other disciplines (economics is our concern) tried to apply his methods.

The "Newtonian Revolution" fundamentally altered the way in which we view our relationship with the world. Newton's work, like others, was built on those who came before:

> *"In this sense the Newtonian revolution in science was the culmination of a multiauthored effort, going back to the beginning of the Scientific Revolution, rather than the creation by Newton of something wholly new. Yet the simplest comparison of Newton's* Principia*, with Kepler's* Astronomia Nova*, Galileo's* Two Sciences*, Wallis's* Mechanics*, Hooke's writings on motion, or the treatment of accelerated motions in Huygens's treatise on the pendulum clock shows a difference of several orders of magnitude in depth, scope, and technique. It is because of the size of this quantum jump that Newton's* Principia *is the 'epoch' of a 'revolution in physical science.'"* [Cohen, p 162]

Principia [*Philosophia Naturalis Principia Mathematica*, 1687[3]] was written in Latin and used mathematics extensively. It is Newton's study of matter and motion; it is the formal presentation of Newtonian mechanics. The foundations of this approach are based on three fundamental **axioms** or laws:

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."* [Newton, p 19]

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1. [2]There was some controversy as to whether Newton or Gottfried Leibniz[1646-1716] developed calculus first; see Hall, Rupert. *Philosophers at War*, Cambridge University Press: Cambridge, 1980.

[3] The author's preface was dated May 8, 1686.

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.* [Ibid.]

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."* [Ibid.]

To insure that these laws were used properly, Newton provided us with a set of four basic rules for to guide the process of reasoning:

Rule I

> *"We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.* [Newton, p 320]

Rule II

> *"Therefore to the same natural effects we must, as far as possible, assign the same causes.* [Ibid.]

Rule III

> *"The qualities of bodies, which admit neither intension, nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.* [Ibid.]

Rule IV

> *"In experimental philosophy we are to look upon propositions collected by general induction from phænomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phænomena occur, by which they may either be made more accurate, or liable to exceptions.* [Ibid. p 321]

From these laws, Newton constructs an explanation of the universe. He explains the tides of the oceans and the movement of the heavenly bodies in the skies. Gravity is the force that controls the tides and orbits of planets. It is a mechanical, ordered world explained by mechanics and mathematics.

His ideas and approach explain all manner of phenomena and provides the tools to build an **Industrial Revolution**. Newton's world is the dominant perception that has faded little in 300 years. Albert Einstein's [1879-1955] theory of relativity, quantum mechanics and black holes are at the leading edge of science, but the average person still lives in a Newtonian, mechanical world.

While the Newtonian system has shaped the Western perception and been a primary explanation for most of our universe, on the second to the last page of *Principia* Newton concludes:

> *"Hitherto we have explained the phænomena of the heavens and of our sea by the power of gravity, but have not yet assigned the cause of this power. This is certain, that it must proceed from a cause that penetrates to the very centres of the sun and planets, without suffering the least diminution of its force; that it operates not according to the quantity of the surfaces of the particles upon which it acts (as mechanical causes use to do), but according to the quantity of the solid matter which they contain, and propagates its virtue on all sides to immense distances, decreasing always in the duplicate proportion of the distances.* [Newton, p 442]

Newtonian mechanics fails to explain the nature and cause of gravity. Its effects can be observed but gravity is beyond the realm of Newtonian knowledge. The space-time continuum now explains the probable forces of gravity in a non-Newtonian method.

The infatuation and attempts to apply the new Newtonian mechanical method to a variety of disciplines followed. "*Adam smith devised Newtonian economics, his friend David Hume a Newtonian psychology…and Joseph Black and John Dalton began to apply Newtonian thinking to the problem of chemical affinities."* [Depew, p 93] Newton's system has been and remains a major component in the intellectual structure of the Western industrial world.

David Hume [1711-1776]

David Hume, a Scottish philosopher, might be labeled as a "constructive-skeptic." He built on the teachings of Locke and Berkeley: he attempted to create a science of the human mind as Newton had created a science of matter and motion. While he sought a foundation for all sciences, he did not accept the Cartesian belief that certainty of knowledge could be attained. Hume attempted to "… *introduce the experimental method of reasoning into moral subjects*." [Sorley, p 171] David Norton characterizes Hume's position by quoting Hume:

> *"And as the science of man is the only solid foundation for the other sciences, so the only solid foundation we can give to this science itself must be laid on experience and observation. …* [Norton, p 3; From *A Treatise of Human Nature*]

From Locke Hume borrows the use of simple and complex ideas. Ideas are, in a sense, the memory of "impressions." Impressions are the result of experience, emotion, passion and may be attained from sensation or reflection. Hume argues that the human mind has two tools to deal with ideas and impressions: memory and reason.

According to Hume:

> *"All the objects of human reason or inquiry may naturally be divided into two kinds, to wit,* relations of ideas*, and* matters of fact*. Of the first kind are the sciences of geometry, algebra, and arithmetic, and in short, every affirmation which is either intuitively or demonstratively certain. … Propositions of this kind are discoverable by mere operation of thought, without dependence on what is anywhere existent in the universe. …*
> *Matters of fact, which are the second objects of human reason, are not ascertained in the same manner; nor is our evidence of their truth, however great, of a like nature with the foregoing. The contrary of every matter of fact is still possible; because it can never imply a contradiction, and is conceived in the mind with the same facility and distinctness, as if ever so comfortable to reality."* [Hume, p 323]

Hume continues to characterize matters of fact;

> *"All reasonings concerning matter of fact seem to be founded on the relation of cause and effect. By means of that relation alone we can go beyond the evidence of our memory and senses.* [Ibid.]

On the next page Hume continues;

> *"I shall venture to affirm, as a general proposition, which admits of no exception, that the knowledge of this relation is not, in any instance, attained by reasonings a priori; but arises entirely from experience, when we find that any particular objects are constantly conjoined with each other.* [Hume, p 324]

This position is consistent with inferential statistics; correlation between variables, that is not stochastic, suggests a relationship between the variables that may or may not be cause and effect. One variable may be the cause and the other the effect; or, it may be the other way around; or both may the effect of some other cause.

> *"Should it be a said that, from a number of uniform experiments, we infer a connection between the sensible qualities and the secret powers;…* [Hume, p 331]

While Hume was influenced by Locke, it should also be noted that he was a friend of Adam Smith. Both he and Smith had been influenced by Francis Hutcheson. Hume was influenced by the mechanical view of the world and wanted to produce a Newtonian psychology. [Depew, p 115] In addition to Hume's contributions to the literature on how knowledge is acquired, he also contributed to economic thought.

Adam Smith [1723-1790]

Adam Smith is primarily know as a "moral philosopher" and economist and made only minor contributions to methodology. Since Smith is widely regarded as the person who systematized and laid out the basic principles of Classical Economics (Some erroneously regard Smith as the "father" or originator of economics.), we will investigate the evidence that he was influenced by such writers as Copernicus, Galileo,

Descartes, and Newton. Most of the evidence of Smith's awareness and debt to these writers is found in his *Essays on Philosophical Subjects*. These are a group of essays written by Smith and published after his death.

For Smith,

> *"Philosophy is the science of the connecting principles of nature. Nature, after the largest experience that common observation can acquire, seems to abound with events which appear solitary and incoherent with all that go before them, which therefore disturb the easy movement of the imagination; which make its ideas succeed each other, if one may say so, by irregular starts an sallies; and which thus tend, in some measure, to introduce those confusions and distraction we formerly mentioned. Philosophy, by representing the invisible chains which bind together all these disjointed objects, endeavors to introduce order into this chaos of jarring discordant appearances, to allay this tumult of the imagination, and to restore it, when it surveys the great revolutions of the universe, to that tone of tranquillity and composure, which is both most agreeable in itself, and most suitable to its nature.* [Smith, *EOPS*, p 45-46]

In "The History of Astronomy," one of essays, Smith demonstrates a firm understanding and admiration of Newton's system. In both the *Theory of Moral Sentiments*, and *Wealth of Nations*, Smith uses analogies of machines when describing systems. In reference to Newton, Smith says,

> *"His system, however, now prevails over all opposition, and has advanced to the acquisition of the most universal empire that was ever established in philosophy. His principles, it must be acknowledged, have a degree of firmness and solidarity that we should in vain look for in any other system.* [Smith, *EOPS*, p 104-105]

Smith, as a "moral philosopher," had and awareness and interest in methodology. He, like his friend Hume, tended to follow an empirical approach to the process of knowing the world about him.

Jeremy Bentham [1748-1832]

Bentham was not a significant contributor to the literature on the process of knowing. He did, however provide self-interest as the rationalization for human choice and behavior, including the pursuit of knowledge. His formalization of the philosophy of Utilitarianism became the foundation for modern economic thought. Utilitarianism is the belief that humankind is governed by pleasure and pain with the primary objective being the maximization of utility (or happiness, satisfaction) of the group of individuals whose interests are of concern. Bentham's Utilitarianism had at least two important repercussions; first is that it establishes a new objective for the human behavior including the acquisition of knowledge; and second, it is a reductionist approach to theory and policy.

Utilitarianism establishes a **consequentialist ethic**: the right and wrong of human choices or actions are to be judged on their consequences, specifically, Does it increase the utility of humans? This is a departure from many the earlier criteria used to measure the justice of an act. **Deontological ethics** (based on duty) was often used by earlier ethicists. Bentham's position establishes self-interest as a just motivation for human choices. Later economists, trying to emulate the mechanics of the Newtonian model, replace gravitational forces with self-interest as the universal force that drives human behavior in a social system.

As a reinforcement of the reductionist approach to science, Bentham held that;

> *"The community is a fictitious body, composed of the individual persons who are considered as constituting as it were its members. The interests of the community is, what? – the sum of the interests of the several members who compose it.* [Bentham, p 18]

Since the utility of society (or the community) can be derived by adding the utilities of each person, it is possible to explain the behavior of the society and measure its welfare by looking only at individual behavior and welfare.

Auguste Comte [1798-1857]

Comte's contributions are more important as a foundation for social science than as philosophy. His work is in the tradition of the French Rationalists, sometimes called French Positivists. Marie Jean Antoine Nicolas de Caritat (better know as Marquis de Condorcet [1743-1794]) and Claude Henri de Rouvroy (better known as Saint-Simon [1760-1825]) are earlier contributors to this tradition. Comte was an assistant of Saint-Simon for about seven years. While he has many original ideas, he synthesizes and develops many of the ideas expressed by his antecedents. The goal or objective of this tradition was the perfection of society through the application of science. To a limited degree, some of Comte's ideas formed the basis of Logical Positivism. However, Scott Gordon points out that there is some affinity for Comte's brand of positivism among the logical positivists, the two are distinct philosophies. [Gordon, p 304]

It is Comte's goal to develop a complete system of natural and social sciences to be used to control society for the good of humankind. He argues that the individual and society progress through three stage so development; "Theological, or fictitious; the Metaphysical, or abstract; and the Scientific, or positive." [Comte, p 2] He believes that in positive science society is controlled by some yet undiscovered "*single general fact:- such as Gravitation.*" Comte's positive philosophy was intended to be objective and provide absolute certainty. The ability to apply positive science to the structure of society requires that prediction was a primary objective.

Comte cites Francis Bacon in his belief that "*there can be no real knowledge but that which is based on observed facts.*" [Comte, p 3] However, he continues;

> *"If it is true that every theory must be based on observed facts, it is equally true that facts cannot be observed without the guidance of some theory. Without such guidance, our facts would be desultory and fruitless; we could not retain them; for the most part we could not even perceive them.* [Ibid. p 4]

Comte developed a theory of a "*Hierarchy of Sciences"* that held mathematics was the most general and was necessary for physics and astronomy. Chemistry and biology where at a higher level (i.e. they were built on mathematics). The highest level of science was the "*crowning science of the hierarchy, the science of man as a social creature, which would disclose the laws by which human history is governed.*" [Gordon. p 291]

John Stuart Mill [1806-1873]

John Stuart Mill contributed to a wide range of social sciences, particularly economics. These will be covered in the chapter on classical economics. Here we are concerned with his contributions to the process of knowing. His major contributions were contained in *A System of Logic: Ratiocinative and Inductive*, [1843]. Mill's intellectual contributions to the process of knowing were, in his own words:

> *"...an attempt, not to supersede, but to embody and systematize, the best ideas which have been either promulgated on its subject by speculative writers or conformed to by accurate thinkers in their scientific inquiries."* [Mill. P 3]

As an economist, the work of Mill was that of synthesizing Classical Economics and integrating it with a revised version of Jeremy Bentham's [1748-1832] Utilitarianism. His synthesis of philosophy of social sciences and the uses of the inductive process include Locke and Comte among others. It was in his selection and ordering of ideas and arguments that Mill extended and added to economic thought and the literature on the process of knowing.

The purpose of Mill's *A System of Logic* is, as its name implies, to outline a system by which scientific reasoning can proceed. It is a system to encourage consistency of reasoning rather than proof of truths. The primary purpose is;

> *"the object of logic,..., is to ascertain how we come by that portion of our knowledge (much the greater portion) which is not intuitive, and by what criterion we can, in matters not self evident, distinguish between things proved and things not proved, between what is worthy and what is unworthy of belief."* [Mill, p 14]

He argues that "Truths are known to us in two ways: some are known directly and of themselves; some through the medium of other truths. " [Mill, p 8] The first are

known directly from senses (consciousness) and intuition. The second is known by inference;

> *"The truths known by intuition are the original premises from which all others are inferred."* [Ibid.]

Mill emphasizes the importance of language and names we attach to things in the process of logic. Book I of A System of Logic is "Of Names and Propositions." It includes an analysis of language and the process of naming things. He includes chapters on the processes of definitions and classification of names of things. Mill emphasizes the importance of language and words to the process of logic.

Mill sets down five canons to be used as criteria to determine causal relationships and judge generalizations made about those relationships:

> ***First Canon**: If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon.* [Mill, p 214]
> ***Second Canon**: If an instance in which the phenomenon under investigation occurs and an instance in which it does not occur have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.* [Mill, p 215-216]
> ***Third Canon**: If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common, save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or and indispensable part of the cause, of the phenomenon.* [Mill, p 221]
> ***Fourth Canon**: Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents.* [Mill p, 223]
> ***Fifth Canon**: Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation*. [Mill, p 227]

Mill borrows the concepts of "social statics" and "social dynamics" from Auguste Comte. While these ideas are not so important for epistemology, they become more important for the structure of economics. Social statics are defined by Mill as a condition of equilibrium or stability and social dynamics as the conditions of movement or the laws of "progress." [Mill, p 347-348] We shall develop these ideas more fully in the section on Mill's economics.

Charles Darwin [1809-1882]

Darwin, a biologist, is included here for two reasons. First, he successfully uses empirical methods of observation, collection and classification of data to form the basis of new interpretations of phenomena. He takes a Newtonian approach to the evolutionary process. [Depew, p 110] Second, his explanation of evolution altered the way we view the world.

Darwin attributed the theory with which he organized the data he had collected while sailing on the "Beagle." [Depew, p 71, 115] He also credits Adam Smith for providing the principle of the division labour as the impetus for his insight about evolutionary diversity. [Depew, p 115] Darwin's theory of evolution, in turn, is a rationalization of a competitive process to allocate scarce resources. Herbert Spencer and others convert (some may say subvert) Darwin's theory of evolution in to a social theory (Social Darwinism) that rationalizes a ***laissez faire*, free market** approach.

Sherlock Holmes [1854-1957] and the Victorians [1840-1900]

Sherlock Holmes was a fictional detective that is perhaps one of the most famous characters of the **Victorian era**. The dates of his birth and death are based on a "biography" written by William S. Baring-Gould. [Baring-Gould] Holmes, neither a professional philosopher nor economist, represents Victorian society's fascination with the application of the "scientific method" (particularly deduction) to human behavior. It is representative of many of the events of the era.

Sir Arthur Conan Doyle [1859-1930] modeled his famous detective after Dr. Joseph Bell, one of Doyle's professors of medicine at Edinburgh University. Holmes' applied the methods used by Bell to draw inferences from observations. Holmes, a keen student of human nature, observed seemingly unrelated, irrelevant "facts" and used reason to explain criminal behavior. The first Holmes story (*A Study in Scarlet)* was published in 1887. Holmes epitomized the science of the era; in the *Five Orange Pips* [1891] he states,

> *"The ideal reasoner would, when he has once been shown a single fact in all its bearings, deduce from it not only all the chain of events which led up to it, but also the results which would follow from it. As Cuvier would correctly describe a whole animal by the contemplation of a single bone, so the observer who has thoroughly understood one link in a series of incidents, should be able to accurately state all the other ones, both before and after. We have not yet grasped the results which the reason alone can attain to.* [Doyle, p 181]

Doyle, through the still popular Holmes, held out the hope of a science of knowing that was capable of certainty. While Holmes popularized the use of science and reason to explain and predict human criminal behavior, explanations of human behavior were

offered by others. Examples of applications of science to human and social behavior during the Victorian era include:

- Alfred Marshall [1842-1924] published *Principles of Economics* [1890] as a study in human economic behavior; Heinrich Gossen [1810-1858], Karl Menger [1840-1921], William Stanley Jevons [1835-1882], , Léon Walras [1834-1910] and a variety of others made significant contributions to the analysis of human behavior with respect to economic choice;
- Augustin Cournot [1801-1877] published his *Researches into the Mathematical Principles of the Theory of Wealth* in 1838, which is a little before the Victorian era, but its title suggests a science of wealth.
- Sigmund Freud analyzed the human psyche in *Studien über Hysterie* [1895];
- Herbert Spencer [1820-1903], later a proponent of "social Darwinism," published *Social Statics* [1850], *The Development Hypothesis* [1852] and *Principles of Psychology* [1855]
- Francis Ysidro Edgeworth [1845-1926] published *Mathematical Psychics* [1881] that offered an application of utilitarian principles to human choices.
- Karl Marx [1818-1883] was producing an explanation of history and the "capitalist" system that was in his view "scientific;"
- Emile Durkheim [1858-1917] was integrating ethics, religion and positivism to describe social behavior in *De la division du travil sociale* [1893];
- "Methodenstriet" or battle of the methods (between Karl Menger who advocated abstract deductive methods and the German Historical school who advocated a historical approach) began in 1854;
- Edward Burnett Tylor [1832-1717] became the first professor of anthropology at Oxford in 1896. [Boorstin, p 646]
- Frederick Winslow Taylor [1856-1915] developed and applied "scientific management" to the control of workers in modern industry during the late 1800's.

Tyler is of some interest because he named his study the science of culture. [Ibid.] Not only is the term "science of culture" revealing about the perspectives of knowing, but it also signals a firm commitment to a "*culture of science*." Human behavior as well as the physical world became a subject for the scientific method. Increasingly only information that could be measured and quantified was considered as important.

With the science of wealth, only knowledge that could be translated into pecuniary values was important. There were voices of opposition to this trend, however they tended to be disenfranchised. While the work of these contributors [Marx, Thorstein Veblen [1857-1929] and others] was not integrated into the mainstream, their criticisms did influence the course of society.

During the Victorian era, social science emerged as a more mature discipline. The scientific, quantitative, mechanistic methods of Descartes, Newton and Comte came into favor as the perspective to guide explanations of human behavior.

Logical Positivism

In 1924, the Vienna Circle was founded by Moritz Schlick (1882-1936) to study and develop a method by which factual knowledge could be discovered and confirmed or verified through an empirical "scientific" method. It was based on a belief in the ability of "science" to discover knowledge ("truth") through empiricism. The development of logical positivism was an extension of the work by William of Ockham (1285-1347 ? 49), Francis Bacon (1561-1626), David Hume (1711-1776), August Comte (1798-1857) and the early work of Ludwig Wittgenstein (1889-1951). The goal of logical positivism was to find a criterion to demarcate "scientific truth" from non-scientific discourse. In short, they hoped to rid philosophy of metaphysics[4] and ultimately convert philosophy into logic.

Linguistics tended to play an important role. Statements could be divided into "true" and "false" and meaningless. Scientific statements were empirically verifiable; metaphysical statements were neither true nor false, rather they were to influence or express an attitude. Some of the basic tenets of logical positivism identified by Moritz Schlick and Rudolf Carnap are:

- "*Whenever there is a meaningful problem one can in theory always give the path that leads to its solution.*" [Schlick, p 56]
- "*The act of verification is the occurrence of a definite fact that is confirmed by observation*" (empiricism) [Ibid.]
- "*There is thus no other testing and corroboration of truths except through observation and empirical science.*" [Ibid.]

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[4] *Metaphysics* is a term that has many meanings. Generally, it refers to beliefs of statements that go beyond empirical "facts" of nature or "scientific" questions. In Aristotle's writing it was the "first principles" on which all knowledge was based.

- "*Every science is a system of cognitions, that is of true experiential statements." "The practical following of this path may of course be hindered by factual circumstances*." [Ibid.]
- "*By means of philosophy statements are explained, by means of science they are verified. The latter is concerned with the truth of statements, the former with they actually mean*." [Ibid.]
- "*Logical analysis reveals the alleged statements of metaphysics to be pseudo-statements*." [Carnap, 1959, p 61]
- "(Meaningful) *statements are divided into the following kinds. First there are statements which are true solely be virtue of their form* ("**tautologies**" according to Wittgenstein; they correspond to Kant's "analytic judgements") *They say nothing about reality.... Secondly, there are the negations of such statements ("contradictions"). They are self-contradictory, hence false by virtue of their form.*" [Carnap, p 76]
- "*With respect to all other statements the decision about truth or falsehood lies in the protocol sentences. They are therefore (true or false) empirical statements and belong in the domain of empirical science. Any statement that one desires to construct which does not fall within these categories becomes automatically meaningless*." [Carnap, p 76]

Because they were unable to find a method to verify "truth," logical positivism was less than successful and was challenged by alternative explanations of the development of knowledge.

Karl Popper [1902-1993]

One of the major critics of the method of logical positivism was Karl Popper (1902-1993). In his *Logic of Scientific Discovery*, Popper advocated that the process of science required the elimination of those hypotheses, which could be "falsified" or proven false. A simplified version of Popper's approach is commonly included as what is referred to as the "scientific method" or "hypothesis testing" in many different disciplines. The testing of hypotheses necessarily results in *Type* or T*ype II* errors. There is always a chance that a null hypothesis has been incorrectly rejected; this is a Type I error. A Type II error is a failure to reject an incorrect hypothesis. A reduction in the probability of an error of one type will increase the probability of an error of the other. Consequently, "truth" is probabilistic.

The problem with Popper's approach is that science, at any given time consists of theories and hypotheses which have not yet been falsified. Popper's method is often

referred to as "falsification." Karl Popper summarizes his approach to the theory of knowledge and its growth very simply,

> *"The way in which knowledge progresses, and especially our scientific knowledge, is by unjustified (and justifiable) anticipations, by guesses, by tentative solutions to our problems, by* conjectures*. These conjectures are controlled by criticism: that is by attempted* refutations*, which include severely critical tests. They may survive these tests; but they can never be positively justified: they can neither be established as certainly true nor even as 'probable' (in the sense of the probability calculus)"* [Popper, 1963, p vii]

Popper argues that neither reason nor observation can be the source of knowledge. [Popper, 1963, p 4] He cautions that a belief in human's ability to use reason and observation as the source of knowledge can be dangerous. The false, "optimistic" epistemology of Bacon and Descartes cannot be true and may lead to fanaticism and/or authoritarianism. [Popper, 1963, p 8]

There are nine theses that Popper uses to explain his approach. A few of the most salient are:

- "*There are no ultimate sources of knowledge. Every source, every suggestion is welcome; and every source every suggestion is open to critical examination*."
- "*Quantitatively and qualitatively by far the most important source of our knowledge-apart from inborn knowledge- is tradition*."
- "*Knowledge cannot start from nothing-from a tabula rasa- nor yet from observation. The advance of knowledge consists, mainly, in the modification of earlier knowledge*."
- "*Pessimistic*[5] *and optimistic*[6] *epistemologies are about equally mistaken. There is no criterion of truth at our disposal, and this fact supports*

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[5] Pessimistic epistemology is the belief that it is not possible for humans to know or recognize truth. (Popper, 1963, p 11)

[6] Optimistic epistemology is the belief that "truth is manifest" and that "there is no need for any man to appeal to authority in matters of truth because each man carried the sources of knowledge in himself; either in his power of sense-perception which he may use for the careful observation of nature, or in his power of intellectual intuition which he may use to distinguish truth from falsehood by refusing to accept any idea which is not clearly and distinctly perceived by the intellect." [Popper, 1963, p 5]

pessimism. But we do possess criteria that, if we are lucky, may allow us to recognize error and falsity. Clarity and distinctness are not criteria of truth, but such things as obscurity or confusion may indicate error. Similarly coherence cannot establish truth, but incoherence and inconsistency do establish falsehood."

- "*Neither observation nor reason are authorities*."
- "*Every solution of a problem raises new unsolved problems; the more so the deeper the original problem.*" [Popper, 1963, pp. 27-28]

Mark Blaug has outlined a set of phrases from Popper's *Logic of Scientific Discovery*, [1935, 1968 translation] that outlines the methodological rules. These include; [Blaug, 1980, p 19]

- "*…adopt such rules as will ensure the testability of scientific statements; which is to say, their falsifiability [1965 p 49]*
- *…only such statements may be introduced in science as are inter-subjectively testable [1965 p 56]*
- *…those theories should be given preference that can be most severely tested"* [1965, p 121]

Blaug continues his commentary on Poppers approach:

> *"…and that theory, as we have seen, consists of the falsifiability principle plus the negative methodological rules strewn throughout his writings. Moreover, the theory of scientific method, even if we loosely describe it as a kind of logic, is not a logic of scientific 'discovery', but rather a logic of justification, because the problem of how one discovers new fruitful scientific hypotheses has been ruled out by Popper from the very beginning as a psychological puzzle."* [Blaug, 1980, p 20]

John Pheby describes Popper's approach:

> *"The process begins with a problem. Popper requires that we provide a clear exposition of the problem and for this we can propose a theory. Here hypotheses will be put forward which, it is hoped, can be tested and therefore have some bearing upon the problem under consideration. The next stage, error elimination, is crucial: this is where falsification is actively sought so that dubious hypotheses can be discarded. Inevitably the process is ongoing as fresh arise - this necessarily follows from Popper's belief that we can never arrive at ultimate truth; we strip off one layer only to continually discover yet another."* [Pheby, p 26]

Proponents of Popper's method generally believe that by identifying those hypotheses that are "false," the body of knowledge that is left is, in some sense, "true." It is "true" in the sense that it has not been shown to be false. It is necessary to remember that just because a hypothesis has not been shown to be false does not mean that it is true in an absolute sense. Rather, Popper's method leads to the discovery of "probable truth." [Fisher, p 10]

Thomas Kuhn [1922-1996]

In 1962 Thomas Kuhn published his now famous *The Structure of Scientific Revolutions* in which the often used (and misused) term "paradigm' was popularized. While there is some confusion as to a precise definition of the word paradigm, it can be thought of as "normal science" which "include law, theory, application and instrumentation together - provide models from which spring particular coherent traditions of scientific research." (Kuhn, 1970, p 10) A paradigm is:

- an "*accepted model or pattern*" [Kuhn, p 23],
- a framework by which a scientific community acquires a "*criterion for choosing problems that, while the paradigm is taken for granted, can be assumed to have solutions,*" [Kuhn, p 37]
- a "disciplinary matrix" composed of "*symbolic generalizations*" which "*look like laws of nature*[7]," "*shared commitments to beliefs*," "*widely shared values,"* and *"exemplars*[8]." [Kuhn, pp. 182-188]

Kuhn's approach is essentially a "truth by consensus" which is contained in the paradigm. This paradigm (and its associated "truth by consensus") is practiced until there are "anomalies" (problems that the existing paradigm cannot explain) or an alternative paradigm with greater explanatory powers replaces it. He argues that a science operates within a paradigm. This paradigm is the "community structure of science' or the "disciplinary matrix" which consists of symbolic generalizations (deployed without question), shared commitments to a set of beliefs and a set of values. [Kuhn, 1970] The members of the science use this paradigm to resolve anomalies. When an **anomaly** of major significance or a large number of anomalies cannot be explained,

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[7] In economics, the "law of demand" is an example.

[8] Exemplars are concrete problems-solutions used from the start of one's education/training process. In economics, the use of supply-demand explanations of price changes is an example.

the paradigm must be questioned and a new paradigm for that science developed. In this manner "science progresses."

It could be argued that the anomaly of the "great depression" forced a change in the paradigm used by economists. The rate of change in technology that is occurring currently may force yet another reexamination of the paradigm used by mainstream, neoclassical microeconomists. Kuhn's approach leads to "truth by consensus." [Fisher, p 6; Lakatos, 1970 p 92]

Imre Lakatos [1922-1974]

Lakatos' method is expressed in his book, *Proofs and Refutations*, [Cambridge University Press: Cambridge, 1976]. Lakatos' approach, while in the tradition of one of his teachers, Karl Popper, is critical of both Popper and Kuhn. He advocated a more sophisticated form of falsification of "groups of theories" and combined it with "scientific research programmes (SRP's)" which were more specific than paradigms. Lakatos' SRP consists of two elements, the "hard core, protective belt" and the "positive heuristic." [Pheby, p 56] The hard core is constructed of "basic axioms and hypotheses" that are accepted without question and is used as a defense mechanism. The positive heuristic is the body of theories and problems that drive the research programmes. [Pheby, p 56]

Imre Lakatos extends Popper and creates a more sophisticated version of "falsification." Rather than test hypotheses, he identifies "research programmes" which are subjected to the process of falsification. Research programmes are series of interconnected theories (or hypotheses).

Paul Feyerabend [1924-1994]

Feyerabend's book, *Against Method* [Verso: London, 1988, originally published by New Left Books, 1975] advocates an approach to science that has been called "theoretical anarchism." Feyerabend argues that the "success of science cannot be used as an argument for treating yet unsolved problems in a standardized way" and scientific achievements can "be judged only after the event." [Feyerabend, p 2] Feyerabend's approach to the methodology of science is radically different because of his objectives. He claims his purpose is "humanitarian not intellectual" in that he wants "to support people not advance knowledge." He is "against ideologies that use the name of science for cultural murder." [Feyerabend, p 4] While he does not disavow the title of "theoretical **anarchist**," he does provide insights into the evolution of science and knowledge. Feyerabend summarizes some of his insights:

- "*Neither science nor rationality are universal measures of excellence. They are particular traditions, unaware of their historical grounding.*" [Feyerabend, p 231]
- "*Yet it is possible to evaluate standards of rationality and to improve them. The principles of improvement are neither above tradition nor beyond change and it is impossible to nail them down.*" [Feyerabend, p 248]
- "*Science is a tradition among many and a provider of truth only for those who have made the appropriate cultural choice.*" [Feyerabend, p 256]
- "*The entities postulated by science are not found, and they do not constitute an 'objective' stage for all cultures and all of history. They are shaped by special groups, cultures, civilizations; and they are shaped from a material which depending on its treatment, provides us with gods, spirits, a nature that is a partner of humans rather than a laboratory for their experiments, or with quarks, fields, molecules, tectonic plate. Social monotony thus implies cosmic monotony - or 'objectivity,' as the latter is called today.*" [Feyerabend, p 260]

The Pragmatists

Charles Sanders Peirce (1839-1914), William James (1842-1910) and John Dewey (1859-1952) were the major contributors to the pragmatists' approach to the study of the sources and nature of knowledge and "truth." Pragmatism is described as a "cluster of ideas" that "made knowledge and truth thoroughly dependent on human needs and interests." [Smith, John. 1978, p 7]

Charles Sanders Peirce identifies the basic maxim of pragmatism:

> *"In order to ascertain the meaning of an intellectual conception one should consider what practical consequences might conceivably result by necessity from the truth of that conception; and the sum of the consequences will constitute the entire meaning of the conception."* [Peirce, Volume V, p 9]

Peirce developed the concept of abduction as part of the process in the creation of knowledge. Some of the basic concepts important to Peirce's approach are:

- Abduction is a creative process
- Knowledge is a self-corrective process [Davis, p 3]
- New knowledge comes from abduction: induction and deduction test abductions. [Davis, p 25]

- Abduction is a creative leap which typically come to us in a flash [Peirce, Volume 5, p 181]
- Knowledge and abduction are "the *new combination of ideas*, or the *relation between them* is what is new in abduction." [Davis, p 48]

William James approaches the problem of epistemology by asking;

> *"Grant that an idea or belief to be true, what concrete difference will it's being true make in anyone's actual life? How will the truth be realized? What experiences will be different from those which would obtain if the belief were false?"* [James, p 97]

His answers are that;

- "*True ideas are those that we can assimilate, validate, corroborate and verify. False ideas are those that we cannot.*" [James p 97]
- "*The truth of an idea is not a stagnant property inherent in it.*"
- "*Truth happens to an idea. It becomes true, is made true by events.*" [James p 97]
- "*We must find a theory that will work; and that means something extremely difficult; for our theory must mediate between all previous truths and certain new experiences. It must derange common sense and previous belief as little as possible; and it must lead to some sensible terminus or other that can be verified exactly.*" [James p 104]
- "*The 'facts' themselves meanwhile are not true. They simply are. Truth is the function of the beliefs that start and terminate among them.*" [James, p 108]

The pragmatism of John Dewey suggests a methodology that recognizes that man has two modes of belief;

1) beliefs about actual "existences" and events and
2) "*beliefs about ends to be striven for, policies to be adopted, goods to be attained and evils to be averted.*" [Dewey, 1929, p 18]

Rather than relying solely on what Dewey calls a "spectator theory of knowledge," he advocates that the process of valuation is a necessary component of any complete theory of knowing. One of the key elements of pragmatism is that there is no dichotomy between "positive" and "normative" knowledge, that "science" is not separate from

"human values and valuation." Dewey uses "Heisenberg's principle of indeterminacy"[9] to argue that certain knowledge cannot be the result of solely empirical nor rationalist methods; human values are a component of any knowledge. The process of evaluation is based on an "instrumental theory of value" not utilitarian value theory based on desires, preferences and wants.

Milton Friedman

Milton Friedman [1912-] is one of the best known economists of the 20th century. His article, "The Methodology of Positive Economics" in *Essays in Positive Economics* [1953] was one of the most important influences on economic thought. In this important piece, Friedman sets the standards for *normative* and *positive* economics as well as influencing several generations of economists. He argues that positive economics is "*independent of any ethical position"* and its task is to provide "a *system of generalizations that can be used to make predictions about the consequences of any change in circumstances;"* it is deals with "*what is."* [Friedman, p 4] Normative economics is dependent on positive economics and deals with "*what ought to be*."

Friedman argues that economics can be a positive science. The structure of this positive science, like all positive sciences, consists of two parts; first, is a language and second, is a "*body of substantive hypothesis designed to abstract essential features of complex reality.*" [Ibid. p 7] According to Friedman, language is a set of tautologies whose primary function is to organize and classify empirical material to facilitate our understanding. This language has no substantive content. This component or element in positive science may be evaluated by formal logic to determine if it is consistent and complete. Empirical or factual evidence and presumably the use of the language will reveal how well the analytical filing system functions. [Ibid.]

The body of "substantive hypotheses" or theory is primarily to yield "*valid and meaningful (i.e. not truistic) predictions about phenomena not yet observed*." [Ibid.] The only test of the validity of the hypotheses or theory is its "*predictive power for the class of phenomena it is intended to 'explain*.'" If there are alternative hypotheses that may be chosen, Friedman suggests two criteria; simplicity and fruitfulness. Simplicity is

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[9] The Heisenberg "Uncertainty Principle" or "Principle of Indeterminacy" developed in quantum physics shows that when measuring two related, observable quantities, such as position and momentum or energy and time, the measurement of one results in uncertainties in the other. This principle is related to the wave particle duality explained by Nails Bohr. The Heisenberg-Bohr or Copenhagen interpretation denies the possibility of deterministic models for both matter and light.

an echo of the work of William Ockham [1285-1347 (49?)] or Ockham's razor. Fruitfulness reflects the precision of predictions as well as their relevance for wider or more generalized applications. A more "fruitful" set of hypotheses would also suggest additional lines of research. The validity of a theory cannot be evaluated on the basis of the reality of the assumptions, rather a

> *"…hypothesis can be tested only by the conformity of its implications or predictions with observable phenomena; but it does render the task of testing hypotheses more difficult and gives greater scope for confusion about he methodological principles involved. More than other scientists, social scientists need to be conscious about their methodology.* [Friedman, p 40]

Deirdre McCloskey

Of all the individuals whose views on methodology have been discussed, Friedman and McCloskey are the only writers who can be identified as "economists." McCloskey's book, *The Rhetoric of Economics*, [University of Wisconsin Press: Madison, 1985] has gained widespread attention among economists. McCloskey argues that the method economists claim to follow is not the method that they follow in practice. Most economists, as well as individuals in most other disciplines, claim to follow the "scientific method" of falsification (i.e. hypothesis testing), usually in the format expressed by some integration of Popper/Lakatos/Kuhn. McCloskey charges that as a result of attempts to create and follow a modern science, "modernism" has become a dominant theme. According to McCloskey, *modernism* is a "word that can be fully defined only in use." [McCloskey, 1985, p 5] She points out that modernism is not limited to economics but is also present in philosophy, architecture, music, and politics. This list can be expanded to include management, accounting and a multitude of other fields. While it may not be possible to give a precise definition of modernism, it is possible to characterize its nature. Some of its characteristics are identified in the following quotes about modernism:

- "*knowledge is to be modeled on the early twentieth century's understanding of certain pieces of nineteenth-century and especially seventeenth-century physics*." [McCloskey, 1985, p 5] (Presumably, Comte, Descartes and Newton are the seventeenth century physicists in the reference.)
- It is the "*notion that we can know only what we cannot doubt and cannot really know what we can merely assent to*." [McCloskey, 1985, p 5]
- It includes the belief that "*only falsifiable hypotheses are meaningful; the evidence is consistent with the hypothesis; of tastes one ought not, of course, to quarrel.*" [McCloskey, 1985, p 6]

- "*Modernism views science as axiomatic and mathematical and takes the realm of science to be separate from the realm of form, value, beauty, goodness, and all unmeasurable quantity.*" [McCloskey, 1985, p 6]
- It is "*functionalist and given to social engineering and utilitarianism, the modernist is antihistorical, uninterested in cultural or intellectual traditions.*" [McCloskey, 1985, p 6]

McCloskey advocates the use of classical rhetoric to advance economic theory through the same methods used in literary criticism. Rhetoric, which includes the use of fact, logic, metaphor and story, provides the criterion and framework that guides the development of science.

Deirdre McCloskey argues that,

> *"(E)conomists do not follow the laws of inquiry their methodologies lay down."* [McCloskey, 1983, p 482]

Rather,

> *"Economists in fact argue on wider grounds and should. Their genuine workaday rhetoric, the way they argue inside their heads or their seminar rooms diverges from the official rhetoric."* [McCloskey, 1983, p 482]

McCloskey proposes that the development of "knowledge" about economic relationships and behavior is pushed forward by "rhetoric." The many dimensions of rhetoric emerge from quotes McCloskey chooses from Wayne Booth. Rhetoric is:

- "*the art of probing what men believe, rather than proving what is true according to abstract methods.*"
- "*the art of discovering good reasons, finding what really warrant assent, because any reasonable person ought to be persuaded.*"
- "*careful weighing of more-or-less good reasons to arrive at more-or less probable or plausible conclusions - none too secure but better than would be arrived at by chance or unthinking impulse*."
- the "*art of discovering warrantable beliefs and improving those beliefs in shared discourse.*"
- not to "*talk someone else into a preconceived view; rather it must be to engage in mutual inquiry.*" [McCloskey, 1983, pp. 482-483]

McCloskey argues that,

> *"Each step in economic reasoning, even the reasoning of the official rhetoric, is metaphor. The world is said to be 'like' a complex model, and its measurements*

are said to be like the easily measured proxy variable to hand." [McCloskey, 1983 p 502]

Even "...mathematical theorizing is metaphorical and literary." [McCloskey, 1983, p 505] In *If You're So Smart*, published in 1990, McCloskey argues that,

> *"Like other arts and sciences, that is, economics uses the whole rhetorical tetrad: fact, logic, metaphor, and story. Pieces of it are not enough. The allegedly scientific half of the tetrad, the fact and logic, falls short of an adequate economic science, or even a science of rocks or stars. The allegedly humanistic half falls short of an adequate art of economics, or even a criticism of form and color."* [McCloskey, 1990, p 1]

To consider the rhetoric and storytelling of economics does not mean that economics is or should be without method. Rhetoric provides a framework and criterion that guides the development of economic theory. It is rhetoric that makes theory more relevant, identifies the ethical content and increases flexibility in the evolution of economic knowledge.

WHICH METHODOLOGY IS "CORRECT?"

Which of the methodological arguments is "correct" and should be followed? There is not a universally accepted answer in any academic discipline nor among those who study the philosophy of science. To understand and contribute to any field of knowledge, it is necessary to be aware of the methodology(ies) that have guided the development of accepted ideas, hypotheses, theories, concepts, tools, values and ideologies that are used within that discipline. Ignorance of methodology dooms an individual to perpetual training and re-training rather than opening the door to education.

Methodological problems apply to all knowledge including Newtonian mechanics, the theory of relativity and quantum mechanics as well as economics. In economics, the methods used and ideological preconceptions of individual economists and schools of thought help to explain many of the differences in explanations of problems and policies advocated.

Modern economic theory has a long tradition of following a "modernist" methodology characterized by a strong faith in empiricism and rationalism. Within modern economics, knowledge is believed to be advanced by inductive or empirical investigations which can verify (or fail to falsify) "positive[10]" concepts, hypothesis,

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[10] Positive economics defined in neo-classical economics as the description and explanation of what is or "reality" or "just the facts, ma'am."

theories or models developed by deductive or rationalist logic. Normative economics (or the study of what "ought to be") is seen as distinctly separate from positive economics.

NORMATIVE ECONOMICS AND STORY TELLING

A healthy dose of skepticism about the methodology of "positive" science and "modernism" allows greater awareness of the role of "normative" science in economics. Normative economics is the study of "What ought to be." It necessarily involves individual and social values, ethical judgement and at the end of the day, a respect for others.

Any judgement about what ought to be is influenced by our values and ideology. Joan Robinson [1903-1983] argues that,

> *"It was the task of the economist to over come these sentiments and justify the ways of Mammon to man. No one likes to have a bad conscience. Pure cynicism is rather rare. Even the Thugs robbed and murdered for their goddess. It is the business of economists, not to tell us what to do, but to show why what we are doing is in accord with proper principles."* [Robinson, p 21]

Robinson places great importance on the role of ideology in economics. She defines an ideological proposition as a logical abstraction that is much like an elephant, "it is something that exists, that we can describe and discuss and dispute about." [Robinson, p 2] In discussing the problem of black swans and white swans, she points out that the argument is about how we set up categories not about the creatures. An ideological proposition is incapable of being tested; we believe it because we believe it. Our ideology is the product of our experiences, values and beliefs. Robinson argues that,

> *"any economic system requires a set of rules, an ideology to justify them and a conscience in the individual which makes him [sic] strive to carry them out."* [Robinson, p 23]

The methodologies characterized by Feyerabend, the pragmatists and McCloskey, and to a lesser extent, Lakatos, show that science (and economics) is not free from ideology. It is necessary to understand the prevailing ideology in a culture, society, group or corporation in order to interpret one's own perspective. Imagine a luxury train, the Orient Express. You find your way to the club car and find a billiard table. You shoot the cue ball down the table (parallel to the tracks) in the direction the train is coming from at the same speed the train is travelling. You perceive that the ball is rolling toward the other end of the table. To some one observing the train pass by, as they peer into the window they perceive that the cue ball is stationary and that the

table, you and the train are moving away from the point where the ball is fixed. Your perspective determines your interpretation of the event.

A culture and its attendant processes are perceived differently by observers inside to those outside the culture. Economic theories are like cue balls, they are constructed and used in a philosophical and historical context. It is necessary that the student become aware of both the ideology and methodology incorporated within the analysis.

The general characteristic of the methodology that guides this text is a mixture of pragmatism, Feyerabend's approach and rhetoric. Abduction is used to formulate hypotheses; empiricism (induction) and logic (deduction) are used to evaluate the hypotheses with respect to social and humanistic values: Does the knowledge promote the wellbeing and long term development of human societies in ways which improve the lives of individuals, families and social groups? Economic theories and schools of economic thought are accepted as stories that must be critically evaluated. Some of the criteria used for evaluation are:

- Are the stories internally consistent?
- Do the stories conform to perceptions of our experiences?
- How do the stories alter our perceptions of "reality" and values?
- Do the stories promote values that contribute to the long-term wellbeing of individual humans within various organizational structures and society?

Beware those individuals and groups who have found the methodology that provides them with truth; they only have to impose that truth on those who fail to perceive the truth correctly. Remember the warning of Popper, false methodology may produce fanaticism or authoritarianism or even worse, both.

Glossary
CHAPTER 2
A PROBLEM OF KNOWING

Alchemy- during the middle ages and renaissance alchemy was the study natural phenomena in hopes of finding (1) a method for the conversion of base metals such as lead into gold; (2) the basis of life; (3) a universal solvent. Their activities involved the use of experimentation and were often regarded as magic. Often they were seen as outside the realm of Christianity and in opposition to the Church.

Anarchy – is a political belief that humans are capable of living without formal organizational structures such as government and laws. An anarchist is one who believes that government is not necessary for the operation of society. Individuals will contract among themselves and resort to custom, tradition, contract or other voluntary associations to resolve differences. The popular use of the term often implies that society is in a state of disorder or chaos. Because of this difference in definitions, the context in which the word is used is important.

Anomaly- is a departure from what is expected or predicted in a specific set of circumstances. It is an event or phenomena that is not consistent with the prevailing or current knowledge about the event.

Consequentialist ethic- is a system of ethics based on the consequences or outcomes of choices. The "rightness" or "wrongness" of an act is judged on the outcomes of the act. Utilitarianism is a consequentialist ethic that is the basis for modern economics and industrial societies.

Copernican Revolution- the transition from the Ptolmeic system of astronomy to the Copernican system. Ptolmey [127-151 AD] believed that the sun and planets rotated about the earth. Copernicus [1473-1543] argued that the earth and planets orbited the sun. Copernicus' system was contained in *De Revolutionibus Orbium Coelestium* published in 1543. While many believed in the arguments of Copernicus, It was Galileo [1564-1642] and Kepler [1571-1642] who provided empirical evidence to support this view.

Cromwell- Oliver Cromwell [1599-1658] was an English Puritan, General in the "New Model Army," and Lord Protector. When the Civil war began in 1642, Cromwell was given control of the New Model Army that represented the interests of Parliament

that was in opposition to Charles I (Stuart). Cromwell's armies won the civil war, executed Charles I in 1649 and put down the rebellions in Ireland and Scotland. He was made Lord Protector of England and instituted a "puritanical" military rule. Charles II was recalled and the monarchy was re-instated in May of 1660.

deontological ethic- is as system of ethics that uses the concept of duty to judge the moral correctness of choices rather than the consequences or outcomes.

Diogenes- Diogenes of Sinope or "Diogenes the Dog" [400-325 BCE] was a Cynic (a Greek school of philosophy). Diogenes is reputed to have lived an a wine cask and went hunting for an honest man with a lighted lamp during daylight.

epistemology - the study of the origin, nature, methods and limits of knowledge. There are several disciplines that study the processes that contribute to knowing; the history of science and the sociology of knowledge are two closely related fields. Methodology is one aspect of epistemology.

explanation- a story which defines the relevant things or events and characterizes the causal relationships among them.

facts- denotes things or events that are "known," usually through direct senses.

"free market"- the concept of a free market is the belief that individuals voluntarily exchanging goods with exclusive property rights will necessarily increase everyone's happiness, satisfaction, welfare or utility.

functional relationship- a function is a mathematical relationship such there is one and only one value of the dependent variable for each value of the independent variable(s). A functional relationship is one in which there is a firm causal relationship between a dependent variable (the effect) and one or more independent variables (the cause(s)).

heliocentric- denotes that the sun (Greek root is *helios*) is at the center.

Indulgences- the Catholic Church allowed the sale of "rights" to commit certain acts that might be sins. These "rights" were called Indulgences and suspended punishment for the sinful acts. The printing press allowed for mass printing of certificates that were sold to raise money. The sale of such Indulgences was one of the events that precipitated the posting of the 95 theses by Luther in October 1517.

industrial revolution- Is the transformation of the society that began in the mid 18th century. All facets (social, economic, technological, religion, political, etc) of society were changed by the events. The term "industrial revolution" may be misleading; it was a continuation of the "scientific revolution," "agrarian

revolution," Protestant reformation and a complex of other forces. The term is used to denote fundamental changes in society.

information- facts, information and knowledge are terms that are often used without great precision (and precision of the terms may not be possible). They are defined here for convenience. Facts are things are events that are known by senses; there is no interpretation required. Information is the next step on a continuum. Information implies that facts have been organized or ordered in some way. Knowledge implies that there is some understanding and interpretation of the information or facts. Wisdom implies a system of values to guide judgement about the meaning and application of knowledge.

Inquisition- refers to a Church court, the procedure and the personnel who had the authority to charge and prosecute heretics at the local and regional levels. The Inquisition was created by Pope Gregory IX in 1231. The Dominicans were entrusted with the Inquisition in 1233. By 1252, torture was used as a tool of enforcement. The Spanish Inquisition began in 1481. Portugal became involved in 1531. In 1542, Pope Paul began the Roman Inquisition. The first Protestants were burned at the stake in 1543 in Spain. Galileo was called before the Inquisition for the first time in 1615. The powers of the Inquisition were suppressed in Portugal in 1751; abolished in France in 1772 and in Italy and Spain in 1808.

knowledge- Knowledge implies that there is some understanding and interpretation of the information or facts. Wisdom implies a system of values to guide judgement about the meaning and application of knowledge.

mechanics- sometimes referred to as the corpuscular philosophy. Generally, a mechanical perspective explains all phenomena as matter and motion of matter. Mechanical explanations have long been used. There are three basic types of mechanics: classical, Cartesian and Newtonian. Classical mechanics differentiates between motion and matter on earth and in the heavens. Motion is the result of actions between connected bits of matter. Cartesian mechanics denies any difference between motion and matter on earth and heavens. Newtonian mechanics depends on experimental science; there need be no connecting matter (gravity): the world is largely space or void and bits of matter.

methodology - generally seen as the system of values, beliefs, principles and rules that guide analysis within a given discipline.

ontology- that part of metaphysics that is a study about the existence of humans.

orthography- a study of the use of symbols to be used in writing and transmission of ideas and concepts.

Oxford Calculators – a group of logicians/scientists/mathematicians at Merton College, Oxford University during the period 1328-1350. Four of the best-known members were Richard Swineshead, John Dumbleton, William Heytesbury and Thomas Bradwardine. The Oxford Calculators were sometimes called the "Merton School." In natural philosophy, their primary interests were in local motion and velocity. They were influenced by Aristotle and worked on logical theory and mathematics.

parameters- in algebraic expressions a parameter is a symbolic constant or a symbolic coefficient that determines the form of an equation. A coefficient is a constant that is joined to a variable. In the equation $Y = a + bX$, both a and b are parameters.

prediction- is a speculation about the probability of occurrence or nonoccurrence of a future event based on currently known information and assumptions about the relationship of the past and the future.

reductionist- reductionism is the process of reducing or decomposing an event or thing into is components and then studying each component to determine the nature of the whole. Economic theory tends to decompose an economic system into individuals; analyze each individual's behavior; and based on the knowledge of each individual's behavior draw conclusions about the system.

Resolution and Composition – sometimes referred to as resolutive and compository or analytic-synthetic or inductive-deductive. "Roger Bacon had proposed a refinement of Aristotle's inductive-deductive scheme of scientific inquiry by insisting upon independent testing of the principles reached by induction and active experimentation to extend the factual basis of science." [Bynum, p 136]

Sophists- a group of itinerant teachers in Greece about 490 BCE-375 BCE who, for a fee taught lessons on how to succeed, rhetoric and logic.

Tableau- was a "table" created by François Quesnay [1694-1774] to demonstrate the flow or, circulation of goods and money in the Physiocratic economic system. *Tableau économique* was published in 1758. The *Tableau* is often credited as the first input-output matrix that was popularized by Wassily Leontief [1906-] between the late 1930's and 1960. It remains a popular tool to describe and analyze the structure of an economy.

tautology- a proposition that is true by nature of its form or construction. In macroeconomics C, I, G, X_n are all defined as expenditures by particular groups (consumers, investors, government, and net expenditures by foreigners) to say that $C + I + G + X_n$ = aggregate expenditures is a tautology.

taxonomy- is the process of naming, identification and organizing or classifying groups of things or events.

teleological- the belief that there is a final purpose or design and that events proceed toward that purpose.