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Bacon, Francis

Born: 22 January 1561 Strand, London, UK

Died: 9 April 1626 Highgate, UK

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Abstract

The general aim of Francis Bacon's philosophy was the reformation of human knowledge, with the intent to put it into practice and use it for the benefit of humankind. He criticized Aristotelian-Scholastic philosophy on the grounds that its method was unable to bring about progress. Bacon's method of induction was the antidote to the idleness of previous philosophies, and it had a twofold function. First, it was supposed to eradicate the errors and idols from human mind, so that this could become like a polished mirror in which the nature could reflect itself, leading to the cultivation of virtues and elimination of vices. Second, it was supposed to discover the inner structure of matter and its activity. This was done by gradual abstraction and, most important, with the help of experiments. Bacon's emphasis on experience and the use of experiments as the right tools to be employed in the study of nature was an idea that influenced future generations of philosophers, and it is considered a building stone in the establishment of the societies of knowledge founded in the second half of the seventeenth century. Bacon contended that his method of induction should be employed beyond the study of nature into other disciplines, such as ethics. This enterprise, he believed, would bring about not only knowledge, but also welfare and happiness.

Alternate Name

Francis Bacon Lord Verulam; Viscount St. Albans

Biography

Francis Bacon was born in London, on January 22, 1561. His father, Nicholas Bacon, was the Lord Keeper of the Great Seal of England during the reign of Elizabeth I. His mother was Anne (Cooke) Bacon, the daughter of Sir Anthony Cooke, the tutor of Henry the VIII's son, Prince Edward. All the Cooke sisters, including Anne, were successfully matched with powerful men, providing the Bacon family with important political connections. Moreover, Francis and his older brother Anthony received a very good humanistic education from their mother, which is prominent in Bacon's later writings.

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When he was 12 years old, Francis went with his brother Anthony to study in Cambridge. There, at Trinity College, they continued receiving a humanistic education. In 1576, at age 15, Francis travelled to Paris with the British ambassador. He remained there for almost 3 years, only returning to England in January 1579 upon hearing of his father's unexpected death. Though Sir Nicholas arranged profitable marriages and set a good inheritance for all his older children (two with Anne and six with his first wife), he died before making any arrangement for the youngest, Francis. This fact affected Bacon for the rest of his life, who struggled to pay his monthly expenses, was arrested for debt; and even in his wealthy years, he was in debt due to his flamboyant and expensive lifestyle. The financial problems would be a recurrent theme throughout his life.

After his return to England, Bacon went to Grey's Inn, one of the four inns of the court, professional associations for barristers and judges in London. In 1581, he joined Parliament, and in 1584 he became part of the committee dealing with the redress of disorders in common informers. In the same period, he also tried to receive advancement at the Inn, but unsuccessfully. Moreover, his attempts to expedite an early promotion to full bench status before he was fully eligible created problems at Grey's Inn. However, with the help of his uncle, Lord Burghley, Bacon was promoted in the spring of 1586 and even attended the pensions, the governing council of the inn. In 1588, he was elected Reader, possibly with the direct intervention of Queen Elizabeth.

However, the queen's attitude toward Bacon grew less favorable after he argued for granting her fewer subsidies in 1593. This affected Bacon's career, making his promotion impossible, a fact that led Bacon to considering dedicating his life to study. However, this did not happen. Bacon continued to be a member of the Parliament, even though without a crown office, and he was employed by the queen in several legal capacities. The Earl of Essex, Bacon's patron and friend, tried to intervene and bring him back on the political stage, but the auspicious situation changed for Essex himself. Judged guilty in 1600 for his decisions during his campaign in Ireland, Essex was dismissed from all political offices. Bacon also spoke against the Earl of Essex and it has been considered that he might have influenced queen's attitude against Essex. Essex was eventually executed for treason in 1601, and it was Bacon who wrote the official account.

Bacon's situation improved after the coronation of James I in 1603, whom Bacon supported and whose favor he gained by appealing to his pretence of being erudite. The same year, he was dubbed Sir Francis Bacon, a promise made by Elizabeth but never fulfilled. Later, in 1607, after continuing to serve in the Parliament with a somewhat anomalous status, Bacon finally received a crown office – that of Solicitor-General, which provided him with a good annual income. However, only 1 year later, in 1608, he became Clerk of the Star Chamber, and then in 1613, Attorney-General. This time period coincides with the beginning of Bacon's prolific writing of natural philosophical texts. In 1605, he published *The Advancement of Learning*, dedicated to the king, followed by *De sapientia veterum* in 1609. Several other works circulated in form of manuscript over the next few years. Also, in 1606, Francis Bacon married Alice Burnham, the daughter of the deceased Sherriff of London, whose stepfather had arranged a high dowry for her. Later on, Bacon tried to make use of his relation to her family: he settled the marriage of one of Alice's sisters and tried to instrument another one for his own financial benefit (Jardine and Stewart 1998).

As Attorney-General, Bacon's ascension continued, given that he played key roles in several political matters and off-stage affairs, through which he secured his position. In 1617, Bacon became the Lord Keeper, an office once held by his father. Bacon's fortune became even more favorable when, as a result of his activity and connections (in this case with the Duke of Buckingham, George Villiers), was made Lord Chancellor in January 1618 and in July of the same year, Baron Verulam of Verulam.

In the next couple of years, though Bacon's political activity was intense, his image started to become undermined: his ostentatious entrances were criticized and his rhetorical style mocked.

This setback, combined with the cumulative effect of a series of minor challenges, led to Bacon's fall from political office in 1621 (Jardine and Stewart, p. 433). Though in January 1621, again with the help of Buckingham, Bacon is made Viscount Saint Alban, he was charged with accepting bribes 2 months later. From the initial two cases, the final charge numbered twenty-eight counts. Bacon gave up his original intention to defend himself for each particular case and gave a generalized submission for all the charges. It is believed that this happened because the king wanted to protect Buckingham by sacrificing Bacon (Jardine and Stewart 1998). This would also explain why neither the king nor Buckingham intervened for Bacon. After Bacon sent the submission for each charge, he was punished with a £40,000 fine, imprisoned in the Tower of London, and dismissed from the parliament and all public offices. His title, however, was not suspended. After only a few nights of imprisonment in the Tower of London, he was released. Bacon hoped to regain his status but was asked to retire to Gorhambury, his residence.

Bacon spent the last 5 years of his life working on his philosophical writings and performing experiments, though he never lost hope of returning to politics, and even served on the Privy Council in the last years of James' reign. It was during this time when he completed or rewrote several writings that had started in the early years and published most of his parts of the *Great Instauration*. During a trip, Bacon fell ill and died at the Earl of Arundel's house in Highgate, near London. In one of his last letters, Bacon claimed that he would die as Pliny the Elder, "by trying an experiment." The story that he got a cold as a result of preserving chickens in snow is probably nothing more than an anecdote, but it is very likely that he was indeed studying the processes of preservation and induration of bodies. It might also be, given the descriptions of the symptoms, that he was trying to cure his illnesses with soporiferous substances (Jardine and Stewart 1998). Though Bacon wanted to be buried in St. Alban, it was later discovered he was not buried there, a fact that gave birth to several conspiracy theories. Moreover, the financial issues that had bothered Bacon during his lifetime continued, with his will and possessions creating several difficulties for his servants, wife, and creditors. His manuscripts were published in the following years by William Rawley, Bacon's last secretary and amanuensis, and by Isaac Gruter, who had inherited the papers from William Boswell, Bacon's brother-in-law.

Heritage and Rupture with the Tradition

Throughout the history, Bacon was considered to be the first promoter of experimental philosophy and of the inductive method. Bacon criticized the Aristotelian-Scholastic philosophy, which was a prevalent view of the universities in the beginning of the seventeenth century. In doing so, he emphasized the importance of studying nature through experimentation, and not through mere observation or analysis of ancient philosophical texts. Moreover, Bacon was equally critical of his contemporaries for not finding the right method able to advance human knowledge. Despite his openly critical attitude, Bacon's relation with the past philosophies is in fact a highly complex one: he admits that there are seeds of knowledge in the ancient and modern authors which should be both valued and used, something he does himself. However, his sources are difficult to capture given Bacon's eclecticism and the lack of references to these sources.

Bacon's attitude toward received philosophies seems to have changed over the course of his life, from very critical to more moderate. In Bacon's early works, such as the unpublished *Cogitata et visa* (*Thoughts and Conclusions*) and *Redargutio philosophiarum* (*Refutation of Philosophies)* (written in 1607 and 1608, respectively), what is at stake is the criticism and rejection of past philosophies. This rejection is crucial, according to Bacon, in order to make the advancement of science possible; otherwise, these philosophies will keep obstructing the acquisition of knowledge. In the *Cogitata et visa*, Bacon affirms that all previous theories, opinions, and notions should be brushed away, so that the mind can be brought in contact with facts without any bias.

Several of the ideas exposed in these early texts are to be found in later published works, particularly the first book of the *Novum organum* (1620) where Bacon discusses the current state of natural philosophy before presenting his own method. However, in his later writings, Bacon is more charitable toward tradition, affirming that he would spend time on received ideas, with the aim of perfecting them and of gaining access to new ones through them.

Another important aspect of his relationship with tradition is the fact that Bacon challenged the status of authoritative figures and texts. According to him, if philosophers worship ancient authority they are merely teachers exposing the ideas of those authors, but not inventors and thus there can be no progress. The only authority one should accept is nature itself. That is why received opinions and theories have to be tested and confronted with facts prior to being accepted in the body of knowledge or rejected from it. As expected, his criticism aims at both the Aristotelian-Scholastic philosophy and that of his contemporaries. His solution for the lack of progress is a method that follows the order of nature in acquiring theoretical knowledge, while protecting the mind as much as possible from error. This is Bacon's method of induction, which in fact should be applied to all areas of knowledge.

The Criticism of the Previous Philosophies

When it comes to refuting previous philosophers and criticizing the deplorable state of philosophy, Aristotle's name is the one repeatedly reoccurring in Bacon's writings, starting with the early ones. He gives two main criticisms toward Aristotle: first, that his philosophy was infested by logic and, second, that his philosophy corrupted almost the entirety of philosophy produced after him. Starting with the second concern, according to Bacon, Aristotle was guilty for having reduced many splendid intellects to mental slavery, being responsible for the "deplorable state" of Scholastic philosophy, and in consequence, for the lack of advancement of knowledge for hundreds of years. As for the first issue, the infestation of philosophy with logic, Bacon contented that, instead of engaging in studying nature, Aristotle busied himself with comparing, contrasting, and analyzing notions about nature. His use of the syllogism was not adequate to capture the subtlety and obscurity of nature. Against Aristotle's deductive method, Bacon proposed his induction as the only suitable way to investigate nature. Moreover, even if in the biological writings Aristotle mentioned experience, Bacon concluded that in fact Aristotle first established some theories and then he provided some empirical evidences that were in agreement with his theories. Thus, he is more blameworthy than his Scholastic followers, who completely ignored experience.

Plato was, for Bacon, a man with a deeper understanding than Aristotle because he engaged with the knowledge of forms and he employed induction. However, Bacon suggests that Plato actually failed in both – because his forms were abstract and his induction was based on superficial and vulgar materials. Bacon's conclusion is that Plato's writings on natural philosophy have thus no foundation in facts. In a similar way in which Aristotle mixed philosophy with logic, Plato corrupted it by mixing it with theology.

According to Bacon, pre-Socratic philosophers such as Anaxagoras, Leucippus, Democritus, Parmenides, Empedocles, and Heraclitus all advanced ideas closer to truth than those of Aristotle or Plato, because they all conceived, in different ways, primary matter as having the source of activity in itself. The only exception is Pythagoras, who Bacon insists founded a religious order, and not a school of philosophy. Among the pre-Socratics, Democritus was the one to whom Bacon paid most tribute in his writings. He admired Democritus for having dissected nature instead of abstracting it like Plato and Aristotle. This is why he was the only one to arrive at "minima," the smallest particles of matter out of which all things are composed. Democritus, and other atomists, comprehended that the activity of nature is caused by some imperceptible entities within matter itself. Even if Bacon did not agree with all the premises of the atomist philosophy, such as the void, he still considered this theory

to be closer to the truth than any other ancient theory.

Turning now to modern authors, in both the *Cogitata et visa* and *Redargutio philosophiarum*, Bacon mentioned the new generation of philosophers (Bernardino Telesio, Girolamo Fracastoro, Girolamo Cardano, and William Gilbert), but only in order to criticize them. They should just be put together with the ancients, Bacon stated, because they either did not engage in a proper study of nature, or, if they did it was only with some specific experiments, which did not grasp the variety of nature. However, all of them influenced Bacon in various ways, either in his speculative or his experimental philosophy. Telesio was probably the one to whom Bacon attributed more importance. In 1612, he wrote a treatise, not published during his life, *De principiis atque originibus* (*On Principles and Origins*), in which he discussed the philosophy of Telesio, Parmenides, and Democritus. The book is an analysis of the fable of Cupid, which for Bacon is the symbol of atom, and it explains how nature was created from the first atom. Bacon argued against Parmenides and Telesio, both who claimed that there are two principles of things: fire and earth for Parmenides, and heat and cold for Telesio. Bacon considered that none of these can be principles because they are changing entities, and not immutable as principles should be.

Influence of Magic and Alchemy

Regarding the operative disciplines such as alchemy, magic, and mechanics, Bacon's attitude was critical but at the same time he admitted that the work of some members of these crafts is preferable to that of Scholastic natural philosophers. The reason for this preference is the fact that the former work with nature, while the latter take their ideas about nature from books, without making any use of experience. Alchemy, for example, reduced the study of nature to few experiments on distillation, separations, and liberation, and its speculative philosophy was full of errors and based on phantasy. While trying to produce gold, the alchemists made several discoveries from which human life benefitted. Magic, on the other hand, is based on fancies and superstitions and, instead of producing genuine effects, it only excites wonder. Moreover, their very few discoveries are trivial and akin to imposture. Finally, for mechanics Bacon had more admiration than for the other practical arts. The mechanical arts are, according to Bacon, founded on nature and the light of experience and for this reason they flourish and always progress. Despite these criticisms, magic (and also alchemy to a lower extent) shaped the Baconian program: on the one hand, magic was using the natural powers of bodies to bring about practical ends; on the other hand, the only way to discover those powers was through trials and experiments. Both these ideas stay at the basis of the Baconian method (Henry 2002).

Bacon's Sources

There is still much work to be done in identifying Bacon's sources and in analyzing his originality in dealing with them. His philosophy has often been characterized as "eclectic." However, the variety of sources does not mean Bacon's system is not original and coherent at the same time. It is his fierce criticism toward most of the representative philosophers of both antiquity and modernity that makes following the influence these philosophers exercised upon Bacon's thought difficult. His humanist education can be easily seen from his works *The Advancement of Learning* or the *De augmentis scientiarum*. Ancient authors, especially the Stoics and Epicureans, influenced his ideas on matter. Bacon's natural and experimental histories are filled with experiments borrowed from natural magic (especially from Giambattista della Porta's *Magia naturalis*, second edition, 1589), alchemy, books of secrets and recipes, agriculture, etc. Another source for his more practical writings are the travel books, especially those about the New World, like Jose de Acosta's or Nicolas Monardes', and also those about other parts of the world, such as George Sandys' treatise. However, two of the most

important sources of his natural histories remain Pliny the Elder's *Historia naturalis* and Pseudo-Aristotle's *Problemata*.

Innovative and Original Aspects

The Great Instauration

Bacon's solution to the errors generated by the previous philosophies (both ancient and modern) was his inductive method. The idea of induction appeared in his early unpublished works and was developed in the *Instauratio magna*, Bacon's project for the reformation of knowledge. Bacon considers that induction is the method that gradually gathers information about nature and brings it to the understanding, which creates axioms, first middle axioms, and then general ones. Put it differently, induction starts from the variety of particulars and arrives at the universals, or what Bacon considers "forms." First, facts are collected, then ordered into tables, and lastly generalizations can be made, on the basis of the information from the tables. Theoretical knowledge or axioms, even less general ones, which do not arrive at universals, are accepted as long as no contradictory instance can be found.

This method was supposed to eliminate the four main problems of the current natural philosophy: (1) that the information provided by the senses is not accurate; (2) that notions are poorly abstracted from the impressions of the senses; (3) that induction based on enumeration, without exclusions and separations, is useless; and (4) that establishing first general principles and then establishing middle axioms from these general ones is the "mother of all errors" (Bacon 1996-, vol. XI). This last point is connected to Bacon's distinction between anticipation and interpretation of nature. According to him, there are two ways to investigate nature. One goes from the senses and particulars to very general axioms, and it is from these general axioms that middle ones are inferred. This is the anticipation of nature, and it does not provide knowledge, because it is very easy for the mind to make mistakes in the passage from facts to general axioms. The other way is by drawing axioms from senses and particulars by degrees until it reaches the highest generality at the end of the process. This is the interpretation of nature, or induction. Bacon's induction should not be applied to natural philosophy only. He considered that other disciplines, such as logic, ethics, and politics, could benefit from his method. All these disciplines can start from the compilation of tables, and apply induction according to the nature of things.

In 1620, Bacon started publishing his project on the reformation of knowledge, the *Instauratio magna* (*The Great Instauration*). As the title of the project suggests, its aim was to provide a method that will help humankind regain its central role as the king of creation, which includes the knowledge Adam had before the fall of man. In turn, this knowledge will improve human life, providing new discoveries and resources. Human life can be improved if one discovers medicines, makes bigger crops, and produces objects that alleviate men's work. The *Instauratio magna* was planned to be composed of six parts:

1. *The Partitions of the Sciences*
2. *Novum organum,* or *Directions concerning the Interpretation of Nature*
3. *The Phenomena of the Universe,* or *Natural and Experimental History for the Building up of Philosophy*
4. *The Ladder of the Intellect*
5. *Precursors,* or *Anticipations of the Philosophy to Come*
6. *Precursors, or Anticipations of the Philosophy*

From the six, only the first part was finished, published under the title *De dignitate et augmentis scientiarum* (*On the Dignity and Advancement of Learning*, 1623, a development of the 1605 *The Advancement of Learning*). The second, the *Novum organum* (*The New Organon*) was planned to have six parts, but only two of them were published in 1620, together with the introduction to *Instauratio magna*, and the short treatise, *Parasceve at historiam naturalem et experimentalem* (*A Preparative to a Natural and Experimental History*), and a *Catalogue of particular histories*. Bacon planned six natural histories to form part of *The Phenomena of the Universe*,

only two of which were published during Bacon's lifetime, *Historia ventorum* (History of the Winds) in 1622 and *Historia vitae et mortis* (History of Life and Death) in 1623. A third one, *Historia densi et rari* (*History of Dense and Rare*), appeared in 1658 and a fourth might have been written, *Historia gravis et levis* (*History of Heavy and Light*), but if so it is lost. From this last one and from other two, *Historia sympatiae et antipathiae rerum* (*History of the Sympathy and Antipathy of Things*) and *Historia sulphuris, mercurij et salis* (*History of Sulphur, Mercury, and Salt*), only the introductions arrived to us, published with the *Historia ventorum* in 1622. (It is probable that only the introductions were ever written.) The last three parts of the *Instauratio magna* were never published, and only a fragment discovered later, the *Abecedarium novum naturae*, was probably prepared to compose the fourth part. This unfinished and fragmentary character of Bacon's works explains why Bacon's philosophy is not systematic, but it also represents a characteristic of Bacon's philosophy as collective and of his vision of his own philosophy as model and incentive to further investigation.

The Idols of the Human Mind

Bacon saw the relation between the mind and the human knowledge as a mirroring one: the human mind is a mirror in which nature should reflect itself. However, after the fall of man, the mirror stopped reflecting nature in an accurate way. Minds are now full of "idols," errors, and false notions. By idols, Bacon means natural tendencies and defects of the mind, which hinder the acquisition of knowledge. In the first book of the *Novum organum*, Bacon described four classes of idols. Some are innate, others are extrinsic: the innate are rooted in the nature of the intellect, which have a tendency to make errors, even more than the senses; the extrinsic idols enter the human mind either from dogmas and sects of philosophers, or from misguided laws of demonstration. The extrinsic idols can be eliminated, but the innate cannot. One can draw attention to the possibility of error, and the best weapon against them is to use induction, which has means of discovering a mismatch between nature and theories. Let's now discuss the four types of idols separately.

The "Idols of the Tribe" are rooted in the human nature. They originate from the evenness of the substance of the human spirit, its preconceptions, its narrowness, its restlessness, from contamination by the affections, or the inadequacy of the senses. It is because of these idols that men do not look further than what is visible; and when they do, they abstract from nature rather than search what is in nature, such as spiritual matter, schematisms, and laws of motion.

The "Idols of the Cave" belong to the particular individual, and they arise eitherfrom someone's own nature, education, the books that person read, or from the impressions these all make on the soul; put it differently, they come from the tendency to excessive composition and division, from love of studying certain periods, or from contemplating large- or small-scale objects. Examples of this type are Aristotle, who made his philosophy a slave of logic, or William Gilbert, who created a philosophy explaining the entire natural world based on very few observations about magnets.

The "Idols of the Market" are derived from the mutual agreement and association of human race; they entered the mind because of alliances between words and names. They are either names of things that do not exist (such as "first mover," "the element fire") or names of things that are ill-defined and roughly abstracted from the things (such as "radical moisture").

The "Idols of the Theatre" (or "Theories") entered men's mind from the dogmas of the philosophers and misguided laws of demonstration. The cause of error resides in three kinds of false philosophy: Sophistical, Empirical, and Superstitious. The most illustrative example of the first class is Aristotle, who corrupted natural philosophy with dialectic; the second class invented theories based only on a few experiments, like the sect of the alchemists or William Gilbert; while the third mixed natural philosophy with theology, like Pythagoras and Plato.

The Disciplines of Knowledge

The first book of the *Instauratio Magna*, *De dignitate et augmentis scientiarum* (1623) contained the tree of knowledge, a scheme

of all the disciplines pertaining to human knowledge. The *De augmentis* is an enlargement of the earlier treatise *The advancement of learning* (1605). The first book of both writings constitutes a eulogy of knowledge and a defence of it from all the possible attacks and criticisms raised by theologians and men of estate. Bacon argues that knowledge can only lead to the improvement of human nature, by making men more devotional and eradicating heresy, by making them better citizens, by cultivating virtues and eliminating vices.

In the following books (one in the first short edition, expanded into eight in the *De augmentis*), Bacon exposes his structure of human knowledge, offering detailed definitions, descriptions, and illustration of all the disciplines of human knowledge. His own tree of knowledge is picking influences from Aristotle, medieval Christian authors, and humanists. The three main disciplines correspond to the three faculties of the mind: history corresponds to memory, poetry to imagination, and philosophy to reason. History can be natural or civil (the last can be further divided into ecclesiastical, literary, and civil); poetry can be narrative, dramatic, and parabolic; while philosophy can be of deity, of nature, and of man. These three branches meet in one trunk, which is "*Philosophia prima*," defined by Bacon as a receptacle for those axioms which are common to more than one science, even if not to all of them. The *Philosophia prima* also comprises the "Adventitious Conditions of Essence," such as Much and Little, Like and Unlike, or Possible and Impossible. Bacon compares his classification of sciences to the branches of a tree: in the same way in which the branches meet and are intertwined, in the same way one subject can be studied by more than one discipline, while information must be communicated from one discipline to another, leading to a better and quicker advancement of each of those disciplines.

Natural and Experimental History

For Bacon, knowledge of nature starts with the accumulation of natural histories. Before offering the readers his own histories, Bacon first criticizes the histories written by his contemporaries, and then he devotes himself to defining and illustrating how a proper natural and experimental history should be written and what it should contain in order to constitute the material for natural philosophy. At the end of the *Novum organum*, and before the *Historia naturalis et experimentalis*, Bacon includes a short treatise *Parasceve ad historiam naturalem* (*Preparative for Natural History*). The main criticism toward the existing natural histories is that they only contain descriptions of nature and not reports of experimental practices. In order to be complete and to be used as material for induction, natural histories should contain three subdivisions: histories of generation (nature free); histories of monsters or preter-generations (nature erring); and histories of arts or experiments (nature bound). The last one is, according to Bacon, the most important.

The first two types of histories contain observations, so they are based on experience; the last is composed of experiments. The difference between experience and experiment is that experiments are "theorized experience" or "thought-after experience" (Fattori 2012). The compilation of natural and experimental histories is performed according to "learned experience," the art of proceeding from one experiment to another. The literate experience is seen by Bacon's commentators as either a method to order the material from natural histories into tables out of which axioms will be drawn (Jardine 1974), or as a help for the mind to generate natural histories and to keep under control the experimental variation of parameters (Jalobeanu 2015). There are several functions that experiments have in Bacon's natural histories, including but not limited to verification, illustration, and demonstration to concept-formation, exploration, classification, and modelling. Bacon himself divided experiments into two kinds: experiments of light (*experimenta lucifera*) and experiments of fruit (*experimenta fructifera*). The first are called of light because they are used to provide knowledge, while the second are called of fruit because they are oriented toward production. The natural and experimental histories compiled by Bacon have attracted scholarly attention due to the fact that they do not entirely

follow Bacon's own guidelines. Instead of being collections of observations and experiments, they contain a great quantity of philosophy, which was supposed to be the next discipline in the hierarchy of knowledge. These histories contain not only observations and experimental reports, but also theories, explanations, advice to further experimentation, etc.

Philosophy of Nature

Bacon starts his analysis of natural philosophy by distinguishing it into speculative (also called natural science or theory) and operative (or natural prudence). Speculative natural philosophy seeks causes, while operative natural philosophy consists in the use of speculative knowledge for the production of effects: once we know the cause of a process, we can produce it artificially. Bacon followed Aristotle in considering that true knowledge is knowledge by causes; he also agreed on the existence of four causes: material, efficient, formal, and final. However, final causes are problematic for Bacon. In the *Novum organum*, Bacon says that they only relate to the actions of humans, and thus pursuing them only corrupts the progress of science. In the *De augmentis*, Bacon's attitude is slightly changed: final causes should be part of metaphysics, and not physics, because they constitute intentions and they presuppose a mind in nature.

Regarding speculative philosophy, Bacon first discriminates his approach from Aristotle's: if for Aristotle, the study of nature should start with individual bodies, for Bacon individuals are bundles of qualities, and the investigation should start with these qualities. They are pairs such as heat and cold, dense and rare, heavy and light, etc. These qualities, called by Bacon "schematisms" or "simple natures," can be known from the point of view of the three causes (material, efficient, and formal) and the type of cause is what further distinguishes between the disciplines of natural philosophy. The study of material and efficient cause pertains to physics. These causes are first variable, second dependent on matter, and third different for each individual that has the given quality. For example, fire is the cause of induration in clay, but the cause of melting in wax. The study of the formal cause is part of metaphysics. This cause, simply called "form" or "law," is common for all bodies that have this quality. The knowledge specific to metaphysics is thus more general and universal than the one of physics. For Bacon, natural knowledge is like a pyramid: natural and experimental histories constitute the basis of the pyramid, physics the middle because it investigates those causes that are variable and dependent on matter, and metaphysics is the apex since it studies the universal and abstract causes.

Each of the two disciplines of speculative natural philosophy has an operative correspondent: mechanics uses the knowledge of physics in order to create effects, and natural magic applies that of metaphysics. Mechanics only imitates natural processes and translates the knowledge of physics to similar matter, that is, in cases that are very similar to those that lead to the discovery of the material and efficient causes. Because the knowledge of metaphysics is more general and goes deeper into the constitution of bodies, natural magic has greater power over nature, and it is capable of both fundamentally transforming existing natural bodies and creating new bodies that never existed before, in the sense of new species. In other words, once the form of several simple natures is known, it becomes possible to create new combinations of simple natures that never appeared in the course of nature: metals, animals, and plants different than the existing ones. Because of the unpopularity of magic and its connection to witchcraft and demonology (reflected also in Bacon's own criticisms, as we have seen), Bacon was at pains to distinguish his own conception of natural magic from the common use. For him, magic is the supreme knowledge of nature, which is used in transforming natural bodies. It does not include superstitions, witchcraft, or supernatural powers, but only a thorough knowledge of the laws of bodies (the forms) and the relations between them.

Mathematics has an auxiliary role for both speculative and operative natural philosophy. Bacon defines its subject as "quantity when applied to matter" and considers mathematics as one of the Essential Forms of things. Because at

the same time it is the form most abstracted and separable from matter, its investigation should properly belong to Metaphysics, though all parts of natural philosophy could benefit from mathematical knowledge. Mathematics is pure and mixed. Pure mathematics, Geometry and Arithmetic, handles quantity "entirely severed from matter and from axioms of natural philosophy." Mixed mathematics, on the other hand, considers quantity to such extent that it assists to explain, demonstrate, and actuate some axioms and parts of natural philosophy. Disciplines such as perspective, music, astronomy, cosmography, architecture, and machinery cannot have any inventions or demonstrations without the help of mathematics.

Inductive Method

The passage from natural history to metaphysics, that is, from sensible things to the forms of simple natures, is done with the Baconian method of induction. If *experientia literata* helps passing from one experiment to another, induction moves from experiments to axioms and back to experiments. Bacon offered two examples of how induction should work, one in the early unpublished *Valerius terminus* (1603), where he analyzes the form of white, and another in the *Novum organum*, where he analyzes the form of heat. Bacon's method starts by correcting the information provided by the senses, and then it orders experiences and experiments into tables of presence and absence. The table of presence gathers all the instances in which a simple nature is present and searches for another nature, which is always present with the first one. In contrast, the table of absence includes those instances where the nature under study is expected to be found, but it is not. The third and last table, the table of comparison, catalogs the variation of the degrees of presence and absence of the two natures, the one under study and the one discovered to be related to it – its form. This discovery of the relation between the simple nature and its form is an eliminative process and it is within it that we can find the only legitimate use of formal inference in the interpretation of nature (Jardine 1974). In the accumulation of instances of both presence and absence of the simple nature under study, and in ordering and comparing them, Bacon gives primary importance to what he calls "prerogative instances." They are designed to help during the process of induction in various ways: they either give practical help in devising experiments by extending the power of senses, or suggesting technological benefit, or solve problems of procedure in the course of organizing the information.

Cosmology and Matter Theory

In parallel with his experimental programme, Bacon also developed a system of speculative philosophy, which can be found in both his early, unpublished works and the *Great Instauration*. Speculative philosophy was meant to remain provisory until verified through the process of induction, aspect which is also seen in the fact that some details are changed, which shows Bacon's willingness to adjust his ideas in accordance with the experimental results.

For Bacon, the way in which the bodies are situated in the universe, as well as the interaction between them, is based on the distinction between tangible and pneumatic matter. The tangible matter, dense, heavy, and inactive, is placed in the center of the earth, which coincides with the center of the universe; while the second, rare, light, and highly active occupies the rest of the universe, the sky of the fixed stars. There is a zone where the two interact, and this is placed on the surface of the Earth, more precisely, a few miles below the surface and a few miles up in the skies. The matter of the skies is of the same nature as the pneumatics from the zone of interactions, but purer than the sublunary one. Moreover, fire becomes stronger with distance from earth, while the air becomes weaker, so while in the sublunary world fire needs air as nourishment in order to survive, in the skies of fixed stars the fire is dominant and shines without the need of nourishment (see *Thema coelis*). The tangible matter from this zone of interaction cannot exist without pneumatics in it (even if those are air, the densest type of pneumatics), while pneumatics can be both free and attached to tangibles. However, pneumatic matter does not "want" to be imprisoned in the tangible one and thus tries to

escape and unite with similar matter existing in the skies, causing thus the variety of processes we can observe. What Bacon considers to be the main natural processes (desiccation, liquefaction, maturation or concoction, putrefaction, and vivification), to which all the others can be reduced, result from this attempt of the pneumatics to escape the union with tangible matter.

Both tangible and pneumatic matters are separated into two "families" or "quaternia" of things: sulfurous and mercurial. Sulfurous family is crude, watery, and noninflammable, while mercurial is concocted, oily, and inflammable. While the Paracelsian influence is obvious, Bacon transforms the Paracelsian theory in two significant points. First, Bacon changes the status of sulfur and mercury. If for Paracelsus they were spiritual principles out of which the material world was formed, for Bacon they are families of things. In other words, they distinguish all the things between inflammable (sulfurous) and noninflammable (mercurial). Second, Bacon rejects salt from this distinction and for him salt is the union of sulfur and mercury, namely, any body, pneumatic or tangible, which is composed of both substances (Rees 1975).

Bacon's cosmos, thus, is classified in accordance with the two aforementioned distinctions: between tangible and pneumatic and between sulfur and mercury. Taking into consideration their intermediaries, there are four types of matter. Tangible matter has two levels: at the subterranean level, it is distinguished into sulfur and mercury (the metals), and in the interaction zone, into oily and concocted substances on the one hand and crude and watery on the other. Pneumatic matter also has two levels: at the interaction, we find terrestrial fire and air, and in the skies of the fixed stars, sidereal fire and ether. These are the eight simple substances. As mentioned, for Bacon, salt is a composite of the two families, and these are, for the two sets of levels, just mentioned: subterranean salts, juices of plants and animals, attached animate and inanimate spirits, and the heaven of fixed stars. The twelve types of matter then can be schematized in Table 1 below.

Individual bodies, as we can observe them, are composed of subterranean salts and spirits or juices of plants and animals and spirits. Spirits are a special kind of pneumatic matter, namely, a composite of fire and air, that is, of sulfur and mercury. However, there is further distinction between individuals, depending on the type of spirits they contain and the way in which they are distributed throughout the tangible parts. As it results from the *Historia vitae et mortis* and the *Sylva sylvarum*, metals and stones, which are inanimate beings, have "cut-off spirits," this is spirits scattered in between their tangible parts. Plants and animals have two types of spirits: one is common with the inanimate beings (the cut-off spirits), but they also have a branched spirit, which is responsible for certain faculties, such as nourishment, growth, and generation. What is specific for animals is that this animate spirit has a main "cell" or "seat' in the body, the brain, that makes other faculties possible, such as the will, imagination, memory, and possible reason.

The activity of bodies, the interactions between and within bodies, is based on the interaction between tangible and pneumatic matter, but each of these types of matter has appetites that they want to satisfy. Appetites are desires impregnated in matter since its creation. The sympathy and antipathy things have between one another is the cause of appetites. There are three appetites of tangible matter: rest; motion toward what is alike; and the avoidance of void, of a contrary body, and of torture. The appetites of pneumatic matter are of four types: of self-preservation, of bettering their condition, of propagation of their nature, and of enjoyment of their nature. These are more powerful than the appetites of tangible matter, producing more effects which are also more complex. In *Abecedarium novum naturae*, Bacon describes all these appetites and adds four simple motions for each of these appetites. The simple motions are actions through which the appetites work to gain supremacy against the other appetites, in this way satisfying themselves. Resistance, a simple motion of the appetite of self-preservation, is always invincible. Further, when in certain combinations, sequences, and quantities, these simple motions form the composed

Bacon, Francis, Table 1 Structure of matter theory in Rees 1977

	Sulfur quaternion	Intermediates	Mercury quaternion
Tangible bodies (with attached spirits)	Sulfur (subterranean)	Salts (subterranean and inorganic beings)	Mercury (subterranean)
	Oil and oily inflammable substances (terrestrial)	Juices of animals and plants	Water and crude noninflammable substances (terrestrial)
Pneumatic substances	Terrestrial fire (sublunar)	"Attached" animate and inanimate spirits (in tangible bodies)	Air (sublunar)
	Sidereal fire (planetary matter)	Heaven of the fixed stars	Ether (planetary medium)

motions, or the visible processes we observe in nature, such as generation, growth, assimilation, or desiccation.

Individual bodies can also be analyzed as clusters of qualities; Bacon calls them schematisms or simple natures. These are always pairs of contraries, such as dense and rare, hot and cold, or heavy and light. The classification of schematisms is made according to five characteristics of either the tangible or the pneumatic matter which comprises individual bodies: the quantity of matter, the fluid and determinate parts, the proportion of spirits within a body, the inequality of its inanimate parts, the types of spirits, and the most profound schematisms (sulfur and mercury).

Bacon's matter theory and his general idea of a productive science was based on a consideration of matter as indefinite and as absolute potency. At this level of explanation, Bacon was influenced by the atomist theory, both in its ancient and modern versions. For Bacon, the atom is the material principle of all things. Primary matter has a form: its resistance to annihilation, which is at the same time its corporality, an appetite, and a motion. The world is the result of the emanation of the atom: the atom has a diffusive power, which creates the multiplicity of the world (Manzo 2006).

Philosophy of Man

Another branch of philosophy is the study of man. This can in turn be divided into philosophy of humanity (which considers men as species) and civil philosophy (which considers men as members of society). The first, philosophy of humanity, studies the body and the soul of man. Logic and ethics are branches of the "Use and Objects of the Faculty of the Soul"; logic is concerned with the functioning of understanding, and ethics with the working of will, appetites, and affections. Ethics is further divided into Exemplar, or the Platform of Good, and Georgics, or Culture of the Mind. Bacon considers the latter deficient, because philosophers before him were not concerned with the practical improvement of conduct. Contrarily, for him, the main virtue of philosophers should be encountered in the active life. The public implication of philosophy is one of the main characteristics of philosophers. Science is a form of practicing the "common good" and it is superior to individual good, and active good is always greater than passive good. This leads Bacon to the conclusion, developed especially in the *Essays*, that what can be seen as immoral can actually be useful for the public use, and the other way around: what seems to be virtuous can be dangerous for the public good. For Bacon, rhetoric plays an important role in moral philosophy. It is fundamentally ethical, and it has a strong effect on human affairs. Rhetoric helps reason to apply to imagination and move the will in order to perform the good actions. Rhetoric and persuasion are needed because both reason and will are weak. This is why imagination plays a crucial role for Bacon – it censors the images of vices, selecting those of virtues and transforming them in vivid representations (Vickers 1968).

Philosophy of Divine

Bacon argued for a duality of truth: some truth can only be subject to divine revelation, while others can be acquired through philosophical

investigation. They also correspond to the two books: the Bible and the nature. The first is the work of God's hands and the second is written by God's finger. Bacon discussed theology in *De augmentis scientiarum*, and he also wrote several theological treatises: *Meditationes Sacrae* (1597), *Prayers* (1603), *Translations of Certain Psalms into English* (1624), and *A Confession of Faith* (published posthumously in 1641). But in a way Bacon's scientific project is based on theology: the aim of natural philosophy is to recover the state lost by the man after the Fall. Bacon was an orthodox Anglican and throughout his life he prosecuted both radical Protestants and Catholics.

Theology follows, according to Bacon, the same divisions as philosophy, according to the faculties of the human mind: Sacred history (including prophecy) corresponds to memory, Parables (which are a kind of divine poesy) correspond to imagination, and Doctrines and Precepts correspond to reason. Ecclesiastical history is part of civil history and is divided into History of the Church, History according to the prophecies, and History of divine judgements or providence. The last of these is supposed to observe the correspondence between God's revealed and secret will, in other words, between what serves to console the faithful and what serves to convince the wicked. Natural Theology or Divine Philosophy is a rudiment of "knowledge" about God, which is obtained by the light of nature and the contemplation of the creatures. This light is enough, according to Bacon, to refute atheism and provide information about the laws of nature, but not to establish religion. In order to convert idolaters and the superstitious, miracles are needed; but natural theology suffices to know that God exists, that he governs the world, that he is supremely powerful, wise and prescient, good, a rewarder, an avenger, and an object of adoration. Natural theology also makes it possible to attain knowledge about the nature of angels and spirits starting from corporeal things.

Legal Philosophy

Among his philosophical works, Bacon also composed a large amount of juridical treatises. Most of his life he was a practitioner who served in many legal roles: as advocate hired for certain trials, King's advocate, judge, and acted as vice-regent when the king was absent. Bacon is considered to have been the first analytical and critical jurist in the Anglo-American tradition and the first to apply an empirical and inductive analysis to law-making (Coquillette 1992). Bacon emphasized the importance of the process, that is, the application of the substantive legal doctrines in practice, and the process through which the legal doctrines developed. Moreover, he developed a method that can be applied to jurisprudence. Instead of having a corpus of substantive doctrine, he established "methods of compiling, reforming, interpreting and using law" (Coquillette 1992). Because of the abundance of reported cases, Bacon argued for a systematic and critical digest of case reports. He was against torture, but also against fictions and legal distinctions. Similar to the way in which he considered that natural philosophy should be digested into maxims, he thought that the legal information should be preserved and diffused in the same form.

Impact and Legacy

In the seventeenth century, Francis Bacon was seen as the apologist for science and the authority of experimental science. In the second half of the century, Bacon became the emblematic figure of the new scientific societies across Europe, such as Accademia della Scienza (Florence), Académie des Sciences (Paris), and the Royal Society. However, it is still a matter of debate how much his own speculative ideas and the proper method of investigating nature influenced the following generations of natural philosophers.

Bacon's influence in France was immediate. Since the early 1620s, Bacon was famous for his reformation of knowledge within the intellectual circle formed around the brothers Dupuy. Moreover, Descartes characterizes Bacon's method as the legitimate complement of his own approach. Marin Mersenne stresses Bacon's criticism of scholastic philosophy as important, even though he does not give much importance to Bacon's inductive method or to his experimental practices. Nicolas Malebranche holds a similar attitude, while Pierre Gassendi is more critical, arguing

that the method of induction is unable to prove anything. In the Netherlands, Bacon's works were read and discussed by Constantijn Huygens and Isaac Beeckman, while other important figures in diffusing Bacon's works were the brothers Gruter: Isaac Gruter published a few manuscripts inherited from William Boswell (Bacon's brother-in-law) and Jacob Gruter translated *Sylva sylvarum* in Latin.

The situation was different in England. Baconian philosophy became popular during the Interregnum. Bacon's idea of improving human nature and human life with the help of natural philosophy was very widespread among the members of the Hartlib Circle, and it coincided with their protestant views on salvation. Bacon's advice for gathering natural histories was seen by most circle members as an egalitarian approach, something mirrored in Jan Amos Comenius' educational reform. The natural historical approach was followed in practice by Ralph Austen, John Evelyn, and William Petty. While it is difficult to find what is common for all Bacon's followers, some characteristics seem to identify them as Baconians: being in favor of *negotium* instead of *otium*; having an experimental, natural-historical, and inductive approach to natural science; institutionalization of natural philosophy and means to communicate knowledge; cooperative research; as well as a utilitarian and technological approach to social issues. Their identity as Baconians was also evident in the things they were opposed to: useless erudition, metaphysical speculation, superstition, theological controvert, improper reliance on unaided reason, as well as Aristotelianism and scholasticism (Rees 2002).

With the restoration of the monarchy in 1660 and the establishment of the Royal Society, the Baconian scientific project becomes the preeminent vision of British natural philosophy. The Royal Society is the materialization of Solomon's House in *the New Atlantis*. But more than this, the aims of the society coincided with those of Bacon's *Instauratio Magna*: scientific progress attained through experimentation and examination of particulars, collaboration, and technological control over nature. The influence of Bacon's induction over the most representative exponents of the Royal Society, such as Robert Hooke, Robert Boyle, and Isaac Newton, is still a matter of debate. Hooke was invested into collecting particulars; Boyle made use of the crucial experiment, a transformation of the crucial instance (*instantia crucis*) from the *Novum organum*; and Newton, though not mentioning Bacon even once, adopted the collection of particulars, the induction, and the crucial experiment as parts of his science. It is however disputable to what extent Bacon's speculative ideas were adopted by his followers. One can argue for example that Boyle's concept of "texture" holds a close resemblance to Bacon's idea of the "form of a simple nature." However, it could be that the oblivion of Baconian speculative ideas is the result, on the one hand, of its resembles, at the language level, with the Aristotelian substantial form, so much rejected by early modern natural philosophers, and, on the other, of his vitalist and Paracelsian conception of nature, rejected by most of the corpuscularian mechanist philosophers.

During the Enlightenment, Bacon is again seen as the revolutionary figure of philosophy. It is the humanitarian value of his technological exploitable science used to satisfy the need of the society that made Bacon significant for authors such as Jean le Rond D'Alembert, Denis Diderot, Nicolas de Condorcet, or Jean Jacques Rousseau (Pérez-Ramos 1996). Yet another interpretation of his contribution to science is given by the nineteenth-century Victorian philosophers, such as John Herschel, William Whewell, and John Stuart Mill. For these philosophers, the accent of induction is on the process of mapping out the process taking place in the mind of the practitioner while performing the scientific research. It is nevertheless debatable how much their concept of induction coincided with the Baconian idea exposed in the *Novum organum*. Bacon's fame started to fade toward the end of the nineteenth century, with the fierce criticisms of authors like David Brewster, Justus von Liebig, or G.H. Lewes. For Thomas Kuhn, the Baconian approach was a pre-paradigmatic one, to be developed only in the late seventeenth century and Bacon was the proponent of an experimentation style design to investigate how nature behaves

under previously nonexistent circumstances. Kuhn's commentators did not focus on Bacon, since their emphasis was on the paradigmatic figures, but this started to change in the last decades of the twentieth and early twenty-first centuries.

Cross-References

- ▶ Appetite
- ▶ Aristotelianism
- ▶ Baconism
- ▶ Cardano, Gerolamo
- ▶ Della Porta, Giambattista
- ▶ Experiment in Renaissance Science
- ▶ Induction
- ▶ Matter in Renaissance Science
- ▶ Method and Order, Renaissance Concept of
- ▶ Natural History in Renaissance Science
- ▶ Natural Magic
- ▶ Observation in Renaissance Science
- ▶ Ontology
- ▶ Paracelsus and Paracelsianism
- ▶ Practical Knowledge
- ▶ Scientific Method in Renaissance
- ▶ Spirit in Renaissance Medicine
- ▶ Telesio, Bernardino

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