KNOWLEDGE AND POWER: COURTLY SCIENCE AND POLITICAL UTILITY IN THE WORK OF ROGER BACON*

CONOCIMIENTO Y PODER: CIENCIA EN LA CORTE Y UTILIDAD POLÍTICA EN LA OBRA DE ROGER BACON

E. R. Truitt

University of Pennsylvania

Abstract

In his major works for the pope, as well as several other works from his maturity, Bacon focused on the utility of natural knowledge, both in terms of human know-how and what that know-how could produce. He looked to the courtly sciences (such as medicine, astral science, optics, and material science), which privilege application and knowledge gained through the sensorium, as sources of natural knowledge and as exemplars for the potential of natural knowledge. This essay argues that Roger Bacon's work ought to be understood within the context of the court. Bacon's emphasis on devices in the pursuit of knowledge and utility demonstrates the extent to which the courtly sciences (such as engineering, navigation, alchemy, and divination) were valued alongside traditional natural philosophical frameworks, and need to be understood in that context. Both the courtly sciences and Bacon's theory of *scientia experimentalis* focus on materials, sensory knowledge, and knowledge of particulars in pursuit of applied ends. Bacon drew inspiration from the courtly sciences in theorizing how natural knowledge could serve ruling power. By examining Bacon's major works on *scientia experimentalis* and analyzing his reliance on examples from the history of Alexander the Great, this essay demonstrates the interrelation of political power and erudite knowledge, and how they intersected through the cultivation and application of *experimentum* and technology. Finally, Bacon's interest in the utility of knowledge suggests that courtly settings in this period are significant locations for the development and applications of natural knowledge.

Keywords

Courtly Sciences; *Scientia experimentalis*; Technology; Alexander the Great; Political Power

Resumen

En sus principales trabajos para el Papa, así como en ciertas obras de madurez, Bacon se centró en la utilidad del conocimiento natural, tanto en términos de saber práctico humano como de lo que

ese saber podía producir. Miró a las ciencias practicadas en la corte (como la medicina, la ciencia astral, la óptica y la ciencia de la materia), que privilegian la aplicación y el conocimiento obtenido a través de los sentidos, como fuentes de conocimiento natural y como ejemplos del potencial del conocimiento de la naturaleza. Este ensayo sostiene que la obra de Roger Bacon debe entenderse en el contexto de la corte. El énfasis de Bacon en los dispositivos para la búsqueda del conocimiento y la utilidad demuestra hasta qué punto las ciencias desarrolladas en la corte (la ingeniería, la navegación, la alquimia y la adivinación) se valoraban junto a distintos ámbitos filosóficos tradicionales sobre la naturaleza, y es en este contexto en el que deben ser entendidos. Tanto las ciencias desarrolladas en la corte como la teoría de Bacon sobre la *scientia experimentalis* se centran en los materiales, el conocimiento sensorial y el conocimiento que persigue fines aplicados de hechos concretos. Bacon se inspiró en las ciencias desarrolladas en la corte para teorizar cómo el conocimiento natural podía servir al poder gobernante. Examinando las principales obras de Bacon sobre la *scientia experimentalis* y analizando cómo recurre a ejemplos de la historia de Alejandro Magno, este ensayo demuestra la interrelación entre el poder político y el conocimiento erudito, y cómo se entrecruzan practicando y aplicando el *experimentum* y la tecnología. Por último, el interés de Bacon por la utilidad del conocimiento sugiere que los escenarios cortesanos de este periodo son lugares significativos para el desarrollo y las aplicaciones del conocimiento natural.

Palabras clave

Ciencias desarrolladas en la corte; *Scientia experimentalis*; Tecnología; Alejandro Magno; Poder político

"The extraordinary advantage in this world from these three sciences, against the enemies of the faithful of the Church, is obvious; her enemies should be completely destroyed by the efforts of enlightened wisdom, rather than engaged with soldiers' weapons".[1]

* E. R. Truitt, History and Sociology of Science Department, University of Pennsylvania. I wish to thank Assef Ashraf, Paola Bertucci, Allison Calhoun, Jonathan Conant, Hal Cook, Henry Cowles, Liam Daley, William Eamon, Ignacio Gallup-Diaz, Shannon Gayk, Sarah Guerin, Carissa Harris, Nicholas Hermann, Patricia Ingham, Fontini Kondyli, Ada Kuskowski, Elaine Leong, Pamela Long, Irene Malfatto, Alex Marr, Timothy McCall, William Newman, Tara Nummedal, Joanna Radin, Ahmed al-Rahim, Eric Ramírez-Weaver, Alisha Rankin, Bill Rankin, Kellie Robertson, Eric Song, Jamie Taylor, John Tresch, Scott Truesdale, Alicia Walker, Ittai Weinryb, Josh White, Michael Witmore, and Nasser Zakariya for their suggestions and feedback.

[1] Roger Bacon, *Opus Maius*, edited by J. H. Bridges, 3 vols. (Oxford: Clarendon Press, 1897-1900), 6.12, II, 221: "Et jam ex istis scientiis tribus patet mirabilis utilitas in hoc mundo pro ecclesia Dei contra inimicos fidei, destruendos magis per opera sapientiae, quam per arma pugnatorum..."

Roger Bacon (ca. 1214-1292) wrote these words in a treatise he sent to Pope Clement IV on the educational reforms necessary to strengthen and protect Christendom. The "efforts of enlightened wisdom" (*opera sapientiae*) resulting from the three sciences are the forms of knowledge, inventions, and capabilities for discernment made possible by mastery of *scientia experimentalis*, which was Bacon's term for a new branch of knowledge that offered a route to greater knowledge of God and temporal domination.[2] In his major philosophical works for the pope, as well as several other works from his maturity, Bacon focused on the utility of natural knowledge, both in terms of human know-how and what that know-how could produce.[3] He looked to the courtly sciences (such as medicine, astral science, optics, and material science), which privilege application and knowledge gained through the sensorium, as sources of natural knowledge and as exemplars for the potential of *scientia experimentalis*. Bacon argued that sense experience was critical to understanding the natural world, and he articulated a theory of knowledge that relied on experience to affirm theoretical or text-based knowledge, and on instruments or devices to help gain greater insight into natural knowledge.[4] Furthermore, he maintained that

[2] *Scientia experimentalis* has often been misleadingly translated as "experimental science", suggesting a false equivalency between Bacon's theory of knowledge acquisition and the later theory of experimental science that developed in the seventeenth century. Therefore, in order to avoid similar confusion, I prefer to retain the original Latin.

[3] Many of Bacon's works do not exist in critical editions, in part due to his habit of writing multiple drafts and re-purposing his work under multiple titles, which makes manuscripts of his work difficult to organize. See A. G. Little, "Roger Bacon's Works with References to the MSS, and Printed Editions", in *Roger Bacon: Essays Contributed by Various Writers on the Occasion of the Commemoration of the Seventh Centenary of his Birth*, edited by A. G. Little (Oxford: Clarendon Press, 1914), 375-425; Jeremiah Hackett, "Roger Bacon: His Life, Career, and Works", in *Roger Bacon and the Sciences: Commemorative Essays*, edited by J. Hackett (Leiden: E J. Brill, 1997), 9-23; Amanda Power, *Roger Bacon and the Defence of Christendom* (Cambridge: Cambridge University Press, 2011), 11-12. The following editions, however imperfect, are in standard use. Bacon, *Opus maius*, ed. Bridges; *Opus minus*, in *Fr. Rogeri Bacon Opera Quaedam Hactenus Inedita*, edited by J. S. Brewer (London: Longman and Green, 1859), 313-389; *Opus tertium*, in *Fr. Rogeri Bacon Opera*, 3-310; *Opus tertium*, in *Part of the Opus tertium of Roger Bacon, including a fragment now printed for the first time*, edited by A. G. Little (Aberdeen: University Press, 1912), and in *Un fragment inédit de l'Opus tertium précédé d'une étude sur ce fragment*, edited by P. Duhem (Quaracchi: Collegii S. Bonaventurae, 1909), and in *Opus tertium*, edited and translated by N. Egel (Hamburg: Felix Meiner, 2020). The standard English translation of *Opus maius*, by R. B. Burke, 3 vols. (Philadelphia: University of Pennsylvania Press, 1928) can be misleading; he offers "science" for *scientia* and "experimental" for *experimentalis*. More recently (and only partially), see *Ruggero Bacone, Filosofia, scienza, teologia dall'Opus maius*, translated by V. Sorge and F. Seller (Rome: Armando, 2010); *Ruggero Bacone, La scienza sperimentale Lettera a Clemente IV—La scienza sperimentali—I segreti dell'arte e della natura*, translated by F. Bottin (Milan: Rusconi, 1990). Bacon's letter to Pope Clement IV is found in *Epistola Fratris Rogeri Baconi,* edited and translated by E. Bettoni, *Lettera a Clemente IV* (Milan: Biblioteca Francescana Provinciale, 1964).

[4] The importance of sensory knowledge to the development of natural knowledge and technology in slightly later periods is well-documented by a number of excellent studies, among them Pamela O. Long, *Openness, Secrecy, and Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2001) and Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2006).

such knowledge was practically useful. The insights into nature gained through mastery of *scientia experimentalis* could allow the pious Christian attain a greater understanding of divine wisdom and, therefore, closer union with God. Not only could *scientia experimentalis* help strengthen Christendom morally (by fostering a deeper connection with God), it could be used to intervene in the natural order to strengthen Christendom politically.

Understood as knowledge gained through the sensorium, *scientia experimentalis* offers a blueprint for how inherent human ingenuity could harness the hidden, untapped potential of nature. *Scientia experimentalis* encompasses three purposes, or prerogatives: first, to test and confirm theoretical knowledge; second, to create instruments or machines to pursue knowledge; and finally, to uncover the secrets of nature and unite all knowledge into a single, comprehensible strand. According Bacon, other than moral philosophy *scientia experimentalis* effectuates the most important step toward *sapientia* (by which he meant both ecstatic communion with God and the state of learned wisdom that could be harnessed to serve Christianity). Furthermore, devices and instruments are equally important to epistemology as to affairs of state. Instruments, devices, and processes are central to *scientia experimentalis*; they are both engine that drives the acquisition of new knowledge and the result of that knowledge. Some, like optical devices, give rise to new information and new knowledge; others, like flying machines or magnetic weapons, enable the pursuit of new knowledge or political utility. Additionally, by fostering a deep and thorough understanding of nature and her capabilities, *scientia experimentalis* could help ratify theoretical knowledge and conclusions reached through logical reasoning (*argumentum*), test received wisdom, explicate Scripture, and banish superstition and error.

Bacon's works on natural philosophy have been the subject of sustained scholarly interest within a number of subfields. Scholarship in the history of science and history of philosophy has established Bacon's capacious interest in natural knowledge, contextualized his ideas in the context of contemporary Latin philosophy, and examined his philosophical methods, including *scientia experimentalis.*[5] As Bacon wrote his most

However, these works are concerned with the development of experimental philosophy in the early modern period, not with experiential knowledge in the medieval period.

[5] The bibliography on this aspect of Bacon's work is vast. For a start, see Hackett, *Roger Bacon and the Sciences*; Jeremiah Hackett, "Roger Bacon's Concept of Experience: A New Beginning in Medieval Philosophy?", *The Modern Schoolman* 86 (2008/09): 123-146; Jeremiah Hackett, "*Ego Expertus Sum*: Roger Bacon's Science and the Origins of Empiricism", in *Expertus sum. L'expèrience par les sens dans la philosophie naturelle médiévale*. Actes du colloque international de Pont-à-Mousson, 5-7 février 2009, edited by T. Bénatouïl and I. Draelants (Florence: SISMEL-Edizioni del Galluzo, 2011), 145-173; *Roger Bacon's Communia Naturalium: A 13th Century Philosopher's Workshop*, edited by P. Bernardini and A. Rodolfi (Florence: SISMEL-Edizioni del Galluzzo, 2014); Yael Kedar, "The Intellect Naturalized: Roger Bacon on the Existence of Corporeal Species within the Intellect", *Early Science and Medicine* 14 (2009): 131-157; *The Philosophy and Science of Roger Bacon: Studies in Honor of Jeremiah Hackett*, edited by N. Polloni and Y. Kedar (London: Routledge, 2021).

important works after he had joined the Franciscan Order, both he and his works have also been appraised within that institutional and intellectual milieu.[6]

Given his intellectual ties to both Oxford and Paris, and later to the Franciscan Order, Bacon has been well established within the contexts of both the classroom and the cloister. I argue here that he ought to be understood also within the context of the court, attentive to matters of rulership and the applications of natural knowledge in the service of Christian leadership. Bacon's emphasis on devices in the pursuit of knowledge and utility demonstrates the extent to which the courtly sciences (such as engineering, navigation, alchemy, and divination) were valued alongside traditional natural philosophical frameworks, and need to be understood in that context. Even though, unlike Alcuin of York or Michael Scot, Bacon was not formally in service of any particular ruler, he was deeply concerned with the educational curriculum and the possibilities that natural knowledge provided. I begin by articulating how *scientia experimentalis* was central to Bacon's agenda of epistemic reform. Both the courtly sciences and *scientia experimentalis* focus on materials, sensory knowledge (*experimentum*), and knowledge of particulars in pursuit of applied ends. I then outline how Bacon drew inspiration from the courtly sciences in his theory of *scientia experimentalis* and also how this theory served ruling power. Bacon's program found expression at the request of Pope Clement IV, who held both spiritual and temporal authority. In his three major works, *Opus maius, Opus minus,* and *Opus tertium* (ca. 1265-68), Bacon outlined the major educational reforms necessary to strengthen Christendom morally and politically. In a shorter work attributed to him from about a decade later, *Letter on the Hidden Powers of Art and Nature, and on the Invalidity of Magic* (*Epistola de secretis operibus*), Bacon elaborated further on the possibilities of creating machines and devices for knowledge-acquisition, defense, and domination that *scientia experimentalis* provides.[7] I then analyze Bacon's reliance on examples from the history of

[6] Zachary Matus, *Franciscans and the Elixir of Life: Religion and Science in the Later Middle Ages* (Philadelphia: University of Pennsylvania Press, 2017); Power, *Roger Bacon*; Amanda Power, "Going among the Infidels: The Medicant Orders and Louis IX's First Mediterranean Campaign", *Mediterranean Historical Review* 25 (2010): 187-202; Amanda Power, "Franciscan Advice to the Papacy in the Middle Ages", *History Compass* 5 (2007): 1550-1575.

[7] Bacon, *Epistola de secretis*, in *Fr. Rogeri Bacon Opera*, ed. Brewer, 523-51; *Frier Bacon: His Discovery of the Miracles of Art, Nature, and Magick. Faithfully translated out of Dr. Dees own Copy, by T. M. and never before in English* (London, 1659). This text has not always been accepted as a genuine work of Bacon's, due largely to the fact that the work, as it exists now, contains material in the later chapters that seem very different from the tenor and style of Bacon's other works. However, more recent scholarship suggests that the first eight chapters of this work, which closely echo some of the material found elsewhere in Bacon's earlier works, are by Roger Bacon, and there is additional compelling evidence to suggest that the final three chapters, the authenticity of which have been called into question, are also by Roger Bacon. See William Newman, "The Philosophers' Egg: Theory and Practice in the Alchemy of Roger Bacon", *Micrologus* 3 (1995): 75-101; Dorothea W. Singer, "Alchemical Writings Attributed to Roger Bacon", *Speculum* 7 (1932): 80-86; Meagan S. Allen, *Roger Bacon's Medical Alchemy: Medieval Pharmacology and the* Prologatio Vitae, Ph.D. dissertation (Indiana University, June 2021), Appendix I.

Alexander the Great to illustrate the potential of learned natural knowledge combined with experience for moral and politically effective leadership. Bacon repeatedly invoked examples from the history of Alexander the Great and his tutor, Aristotle, drawn from the pseudo-Aristotelian *Secret of Secrets* (*Secretum secretorum*) as well as the corpus of Latin and European vernacular literature on Alexander. In doing so, as I demonstrate, he explored the interrelation of political power and erudite knowledge, and how they intersected through the cultivation and application of *experimentum* and technology. Finally, I consider how Bacon's interest in the utility of knowledge suggests that courtly settings in this period are significant locations for the development and applications of natural knowledge. In examining Bacon's work on *scientia experimentalis* it becomes apparent that medieval science was not only, or even mainly, scholastic, and instead encompassed sources of knowledge other than texts and settings beyond the classroom or the cloister, from individuals of different social registers and in settings that privileged use and the exercise of temporal power.

Scientia experimentalis

Bacon articulated *scientia experimentalis* – the branch of learning that involves active participation in the natural world, and the utility of that knowledge – in his major *opera, Opus maius, Opus minus,* and *Opus tertium*. It was in these texts, addressed to Pope Clement IV and written at his request, that Bacon introduced and outlined *scientia experimentalis* in the context of a major educational reform of the university curriculum in the service of buttressing Latin Christianity. Bacon's goal was to convince the pope of the importance of learning foreign languages, natural philosophy, and applied natural knowledge – alongside Christian moral philosophy and ethics – in the service of defending Christendom from external threats, like the Mongols, and internal threats, like heresy.[8]

Scientia experimentalis (knowledge gained from observation or other sensory perception), according to Bacon, could confirm and also correct rationality (reasoning from first principles or knowledge gained from texts) and is necessary to reach a full understanding of natural phenomena. Bacon expressed his frustration that the masters at Paris and Oxford emphasized reasoning from *argumentum* over *experimentum* and argued that this was just one reason that the university curricula needed reform.[9] In the medieval period *experimentum* and *experientia* were often used interchangeably to connote a sense of active participation in knowing the world, one which encompassed proof and trial, but also included experience and knowledge gained through the senses.[10] Medieval

[8] *Epistola Fratris Rogerii Baconi*, ed. Bettoni, 70-72. The Mongol invasions of 1240-42 left many in Latin Christendom shaken and were believed by many, including Bacon, to presage the arrival of the Antichrist; Peter Jackson, *The Mongols and the West, 1221-1410*, 2nd ed. (London: Routledge, 2018), 142-153; Power, *Roger Bacon*, 40-42.

[8] Bacon, *Opus maius* 6.2, ed. Bridges, II, 172.

[10] Although these words were usually used interchangeably, *experientia* was sometimes used to suggest a more limited way of knowing (experience of singular events), while *experimentum* could

writers in many different periods and genres mention the importance of different tests to demonstrate, for example, the purity of a natural substance.[11] As the lynchpin to his proposal of educational reform Bacon argued for a method to natural philosophy that looked to experience equally as to causes and syllogisms, and that would yield useful knowledge. This branch of knowledge could help teach the literal meaning of natural things; next to moral philosophy (the section that concludes *Opus maius* and immediately follows the section on *scientia experimentalis*) it is the most useful for teaching an understanding of theology. It is also a critical step toward *sapientia*, which, within the Franciscan tradition, referred to the prelapsarian state of total communion with God. This state of being could be partially restored through years of careful study and self-mastery and directed in the service of faithful Christians.[12] And, Bacon argued, *scientia experimentals* could be used to forward the goals of Christian nations, as it could both impart useful natural knowledge and enable the creation of engines of war, such as burning mirrors, and engines of statecraft, such as tools for navigation.[13]

The first dignity of *scientia experimentalis* concerns different ways of knowing things. Bacon recognized divine illumination as a source of knowledge, and attributed the wisdom of the first patriarchs and prophets to direct inspiration from God. Echoing pseudo-Ptolemy, Bacon asserted there are two ways of knowing things: experience of philosophy and divine inspiration (the latter is the best and surest way).[14] Leaving aside divine illumination, however, there are two ways of knowing about nature: rationality (*argumentum*) and sense experience (*experimentum*). But relying purely on rationality may still leave room for doubt; *argumentum* does not always provide certainty, nor can it account for particular or irregular phenomena.

> *Argumentum* draws a conclusion and makes us concede the conclusion, but does not make the conclusion certain, nor does it remove doubt so that the mind may rest in the understanding of the truth, unless the mind discovers it by way of experience... For if a man who has never seen fire should prove by a sufficient syllogism that fire burns and

sometimes be used to suggest the grasp of the principle behind particular or singular events. See Hackett, "Roger Bacon's Concept of Experience", 127.

[11] For example, Isidore of Seville on testing balsam for purity, *Etymologiarum*, edited by W. Lindsay, 2 vols. (Oxford: Clarendon Press, 1911), 17.8.14; see also E. R. Truitt, "The Virtues of Balm in Late Medieval Literature", *Early Science and Medicine* 14 (2009): 711-736, esp. 718-724; Michael McVaugh, "Determining a Drug's Properties: Medieval Experimental Protocols", *Bulletin of the History of Medicine* 91 (2017): 183-209.

[12] Bacon, *Opus maius* 6.12, ed. Brewer, II, 219-20. See also Hackett, "Roger Bacon on *Scientia Experimentalis*", 277-316, 310; Power, *Roger Bacon*, 52-56.

[13] Bacon, *Opus maius* 6.12, ed. Bridges, II, 221.

[14] Bacon, *Opus maius* 6.1, ed. Brewer, II, 169-70. This is an echo of the Augustinian doctrine of illumination, as well as al-Kindi's assertion that the search for scientific truth and morality were connected. See Thérèse-Anne Druart, "Al-Kindi's Ethics", *Review of Metaphysics* 47 (1993): 329-57; Hackett, "Roger Bacon on *Scientia Experimentalis*", 285. On Bacon and the concept of *sapientia* and its place within Franciscan attitudes to knowledge and education, see Power, *Roger Bacon*, 55-58; 144-152.

> injures things and destroys them, his mind would not be satisfied, nor would he avoid fire, until he placed his hand or some combustible substance in the fire, so that through experience he might prove that which reasoning taught. But when he has had actual experience of combustion his mind is made certain and rests in the fullness of truth. Therefore, *argumentum* does not suffice, but *experientia* does.[15]

Bacon here offers a critique of purely syllogistic thinking: without both *argumentum* and *experimentum* certainty is impossible. He then clarifies Aristotle on the importance of knowledge through experience:

> Thus, when Aristotle said that proof is a syllogism that makes us know, this is understood as proof accompanied by experience, and not of the bare proof itself. As he said in the first book of the Metaphysics, it is said that those who know through experience both the reason and the cause are wiser than those who know something through experience and know only the bare truth without the cause. But here I speak of he who knows through trial both reasoning and cause. And these men are perfect in their wisdom...[16]

Bacon drew on the Aristotelian distinction between knowledge of a fact (*quia*) and knowledge of the cause of a fact (*propter quid*); the latter, according to Bacon, is knowledge gained with the additional benefit *per experientiam*.[17] He then went on to use the rainbow as an example: Because it is found in multiple guises and settings in nature it must be investigated via experience, rather than through *argumentum* alone.[18]

Bacon was the only of his contemporaries to devote so much thought and time to theorizing and explicating *scientia experimentalis*, but he was one of many to use

[15] Bacon, *Opus maius* 6.1, ed. Bridges, II, 167-168: "Argumentum concludit et facit nos concedere conclusionem, sed non certificat neque removet dubitationem ut quiescat animus in intuit veritatis, nisi eam inveniat via experientiae [...] Si enim aliquis homo qui nunquam vidit ignem probavit per argumenta sufficientia quod ignis comburit et laedit res et destruit, nunquam propter hoc quiesceret animus audientis, nec ignem vitaret antequam poneret manum vel rem combustibilem ad ignem, ut per experientiam probaret quod argumentum edocebat. Sed assumpta experientia combustionis certificatur animus et quiescit in fulgore veritatis. Ergo argumentum non sufficit, sed experientia."

[16] Bacon, *Opus maius* 6.1, ed. Bridges, II, 168: "Quod ergo dicit Aristoteles quod demonstratio syllogismus est faciens scire, intelligendum est si experientia comietur, et non de nuda demonstratione. Quod etiam dicit sapientiores expertis, loquitur de expertis qui solum noscunt nudam veritatem sine causa. Sed hic loquor de expert, qui rationem et causam novit per experientiam. Et hi sunt perfecti in sapientia."

[17] Bacon, *Opus maius*, 6.1, ed. Bridges, II, 167.

[18] Bacon, *Opus maius*, 6.2, ed. Bridges, II, 172-174, although he continues discussing the rainbow over the next ten chapters, as well. Bacon's discussion of the rainbow has invited significant scholarly examination; in particular, see David Lindberg, "Roger Bacon's Theory of the Rainbow: Progress or Regress?", *Isis* 57 (1966): 236-249; David Lindberg, "Lines of Influence in Thirteenth-Century Optics: Bacon, Witelo, and Pecham", *Speculum* 46 (1971): 66-83.

experimentum/experientia and to argue for its importance.[19] Bacon cited ancient antecedents as well as medieval Latin and Arabic adherents.[20] Furthermore, he was part of a robust community of scholars concentrated around Paris and Oxford that explored the role of marvelous particulars and accumulated experience (*empireia*) in Latin natural philosophy. Bacon found the work of Robert Grosseteste (ca. 1168-1253), generative for his own thinking, particularly the latter's emphasis on *experimentum* in understanding natural phenomena, such as comets and the rainbow.[21] Grosseteste's work circulated in Paris in the 1230s and 1240s while Bacon was living there, and Bacon also drew heavily on Grosseteste's commentary on Aristotle's *Posterior Analytics* when he lectured on the subject as part of the arts curriculum at the university in Paris in the 1240s.[22] Others with ties to Oxford and Paris shared Bacon's interest in *experientia.* William of Auvergne (ca. 1180-1249) was bishop of Paris (and therefore head of the university) while Bacon was there. William, a master of theology before becoming bishop, wrote extensively on natural philosophy and natural particulars, and stressed the importance of *experimentum* in understanding preternatural and non-manifest natural phenomena.[23]

Bacon also read Latin translations of Arabic texts on instruments and experience, and this engagement shaped his thinking about the role of *scientia experimentalis*. In addition to his engagement with al-Kindi's (ca. 800-870 AD/ 185-256 AH, Alkindus in Latin) work on mathematics, optics, and astral science,[24] Bacon was one of the first natural

[19] Much of the scholarship on *scientia experimentalis* within the history of science has focused on how Bacon's ideas relate to the development of experimental philosophy in the seventeenth and eighteenth centuries. See, for example, Alastair C. Crombie, *Robert Grosseteste and the Origins of Experimental Science, 1100-1700* (Oxford: Oxford University Press, 1953). For a clear sense of how Bacon's ideas were very much characteristic of interest in *experimentum* in the Latin Christian West in the second half of the thirteenth, see Lynn Thorndike, Jr., "Roger Bacon and the Experimental Method in the Middle Ages", *Philosophical Review* 23 (1914): 271-298.

[20] Bacon, *Opus maius*, 4.4.16, ed. Bridges, II, 253 (Ptolemy); 5.1.1, II, 419 (Aristotle); 6.1, II, 585 (Pliny); see also Hackett, "*Ego Expertus Sum*"; Steven J. Williams, "Roger Bacon in Context: Empiricism in the High Middle Ages", in *Expertus sum*, 123-144, 131.

[21] Robert Grosseteste, *De cometis*, edited by L. Baur, *Die philosophischen Werke des Robert Grosseteste, Bischofs von Lincoln* (Munster: Aschendorf, 1912); Grosseteste, *Commentarius in Posteriorum Analyticorum Libro*, edited by P. Rossi (Florence: Olschki, 1981); Bacon on Grosseteste, *CSP*, in *Fr. Rogeri Bacon Opera*, ed. Brewer, 394-519, 469; Crombie, *Robert Grosseteste*, 62-74; Hackett, "Roger Bacon and *Scientia Experimentalis*", 287; Williams, "Roger Bacon in Context", 127-128.

[22] Jeremiah Hackett, "*Scientia experimentalis*: from Robert Grosseteste to Roger Bacon", in *Robert Grosseteste: New Perspectives on His Thought and Scholarship*, edited by J. McEvoy (Turnhout: Brepols, 1995), 89-119, 107-109; Cecilia Panti, "The Theological Use of Science in Robert Grosseteste and Adam Marsh According to Roger Bacon: The Case Study of the Rainbow", in *Robert Grosseteste and the Pursuit of Religious and Scientific Learning in the Middle Ages*, edited by J. Cunningham and M. Hocknull (Stuttgart: Springer, 2016), 143-163, esp. 145-151.

[23] William of Auvergne, *De universo*, 2.3.23, edited by P. Aubouin, *Opera omnia*, 2 vols. (Paris, 1674), I, 1065, col. 1. See also Antonella Sannino, "Guillaume d'Auvergne e i *libri experimentorum*", in *Expertus sum*, 67-88.

[24] Two of these works, *De aspectibus* and *De radiis*, are extant only in their Latin versions. Al-Kindi, *De radiis*, edited by M.-T. d'Alverny and F. Hudry (Paris: J. Vrin, 1975); see also Faye Getz, "Roger Bacon

philosophers of the thirteenth century to take up Ibn al-Haytham's (Alhacen) work on optics, *Kitab al-Manaḍir* (ca. 1030 AD/421 AH).[25] In this work, translated into Latin in the first half of the thirteenth century as *De aspectibus*, Ibn al-Haytham posited a theory of visual perception that would stand on mathematical, physical, and physiological grounds. Rather than the long-held theory of extromission (that we perceive objects because of the rays our eyes emit), he advanced a theory of intromission (that we perceive objects because they emit rays to the eye). His theory reconciled existing knowledge of the behavior of rays and angles (geometry) with the physiology of the eye and the perception of visual phenomena. His method proceeded from induction, mathematics, and demonstration, with the latter two methods necessary to confirm conclusions when induction or observation yielded insufficient grounds for certainty.[26] Therefore, he introduced a new concept that diverged from Aristotle's notion of *empeiria* (accumulated experience). *I'tibaar* (in Arabic, in Latin *experimentatio*) is a test to investigate physical properties directly with an apparatus designed for that purpose, in order to arrive at certainty or exactitude by subjecting an observation to artificially variable conditions.[27] For Ibn al-Haytham, *i'tibaar* is a process for confirming or disproving knowledge. Bacon grappled with Ibn al-Haytham's theory of intromission first in a brief work on visual perception and the emanation of force, *The Multiplication of Species* (*De multiplicatione specierum*, ca. 1266), and shortly after on a section of *Opus maius* on optics, which later

and Medicine", in *Roger Bacon and the Sciences: Commemorative Essays*, edited by J. Hackett (Leiden: E. J. Brill, 1997), 337-364, 353; David Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago: University of Chicago Press, 1976), 18-57.

[25] *De aspectibus* was, according to Bacon, taught only at Oxford before 1270, and only twice. Bacon, *Opus tertium*, ed. Brewer, 37: "Haec autem scientia non est adhuc lecta Parisius, nec apud Latinos, nisi bis Oxoniae in Anglia..." On the dating of *De aspectibus* to the 1240s, see A. Mark Smith, "Alhacen's Theory of Visual Perception: A Critical Edition, with English Translation and Commentary, of the First Three Books of Alhacen's 'De aspectibus', the Medieval Latin Version of Ibn al-Haytham's 'Kitāb al-Manāẓir': Volume One", *Transactions of the American Philosophical Society* 91/4 (2001): i-337. On Ibn al-Haytham's influence on the development of medieval Latin optics, see David Lindberg, "The Western Reception of Arabic Optics", in *The Encyclopedia of the History of Arabic Science*, edited by R. Rashed, 3 vols. (London: Routledge, 1996), II, 716-29; Lindberg, *Theories of Vision*, 58-86.

[26] Abdelhamid I. Sabra, "Ibn al-Haytham's Revolutionary Project in Optics: The Achievement and the Obstacle", in *The Enterprise of Science in Islam: New Perspectives*, edited by J. P. Hogendijk and A. I. Sabra (Cambridge, MA: Harvard University Press, 2003), 85-118; Smith, *Alhacen's Theory of Visual Perception*, xxviii-xxxii; Eilhard Wiedemann, "Zu Ibn al Haitams Optik", *Archiv für Geschichte der Naturwissenschaften und der Tecknik* 3 (1910/11): 1-53; Eilhard Wiedemann, "Arabische Studien über den Regenbogen", *Archiv für Geschichte der Naturwissenschaften und der Tecknik* 4 (1912/13): 453-460.

[27] Abdelhamid I. Sabra, *The Optics of Ibn al-Haytham: Books I-III On Direct Vision*, 2 vols. (London: The Warburg Institute, 1989) II, 18-19; Smith, *Alhacen's Theory of Visual Perception*, for example, I, 215. See also Hackett, "Roger Bacon on *Scientia Experimentalis*", 289-90; Graziella Federici Vescovini, "La Fortune de l'Optique d'Ibn Al-Haitham: Le livre *De aspectibus* (*Kitab al-manazir*) dans le moyen âge Latin", *Archives internationales d'histoire des sciences* 40 (1990): 220-238. On the earlier history of "experiment" in Arabic optics, see Elaheh Kheirandish, "Footprints of 'Experiment' in Early Arabic Optics", *Early Science and Medicine* 14 (2009): 79-104.

circulated as a stand-alone work (*Perspectiva*).[28] Bacon echoed Ibn al-Haytham's concept of *experimentatio* both in the idea of using *scientia experimentalis* as a way to confirm theories and the importance of specific instruments to do so. He also built on this concept, suggesting that *experimentatio* could be employed to discover new knowledge, as well.

Scientia experimentalis could also put received wisdom to the test. Bacon mentions several commonly held ideas about the natural world and disproves each, through experience. Diamonds can only be broken by goats' blood? No, "without that blood one can easily break a diamond. For I have seen this with my own eyes, and this is necessary, because gems cannot be carved except with fragments of this stone".[29] The beaver, when hunted for its musk glands, castrates itself in order to save its life? No, "the beaver has these glands under its breast, and both the male and female produce these glands".[30] Hot water in a container freeze more quickly than cold water in a container? No, even though "it is argued that contrary is excited by contrary, just as when enemies face off against each other. But it is certain that cold water freezes more quickly for anyone who makes the experiment".[31] *Scientia experimentalis* does not replace theoretical knowledge or knowledge drawn from first principles; however, it ratifies the knowledge found in authoritative texts and conveyed through syllogism and attests to the veracity of received wisdom.

Bacon wrote of his direct experience in testing commonly held beliefs and of the importance of using specific tests and instruments, but when direct observation and experience were not possible, he recognized the necessity of relying on the testimony of trustworthy and careful eyewitnesses. Aristotle could attest to more than Ptolemy regarding the regions of the world, because "Aristotle, on the authority of Alexander, sent two thousand men throughout different parts of the world to prove through experience

[28] Bacon's theory of *species* basically states that a force emanates from all objects; this emanation of force is what allows for visual perception of those objects. However, Bacon also allowed for extramission, believing that sensory perception is not passive. See David Lindberg, "Roger Bacon on Light, Vision and the Universal Emanation of Force", in *Roger Bacon and the Sciences*, 243-275, esp. 245-250; David Lindberg, *Roger Bacon and the Origins of Perspectiva in the Middle Ages: A Critical Edition and English Translation of Bacon's Perspectiva, with an Introduction and Notes*, edited and translated by D. Lindberg (Chicago: University of Chicago Press, 2006), lxxxiii-lxxxvi.

[29] Bacon, *Opus maius*, 6.1, ed. Bridges, II, 168: "Sed nondum certificatum est de fractione per hujusmodi sanguinem, quanquam elaboratum est ad hoc; est sine illo sanguine potest frangi de facili. Hoc enim vidi oculis meis, et necesse est hoc, quia gemmae non possunt sculpi nisi per fragmenta hujus lapidis."

[30] Bacon, *Opus maius*, 6.1, ed. Bridges, II, 168: "Sed non est ita, quia castor habet ea sub pectore, et tam mas quam femina hujusmodi testes producit."

[31] Bacon, *Opus maius*, 6.1, ed. Bridges, II, 169: "Deinde vulgatum est, quod aqua calida citius congelatur qam frigida in vasis, et arguitur ad hoc quod contrarium excitatur per contrarium, sicut inimici sibi obviantes. Sed certum est quod aquia frigida citius congelatur experienti."

all things that are on the surface of the earth, as Pliny says in his *Natural History*".[32] Because of the need to rely on others' observations and experiences, the character of the experimenter was of paramount importance. But not all testimony is equally valid, because not all eyewitnesses are moral, educated, observant, or trustworthy. In the case of Aristotle, his great wisdom and discernment extended to his ability to choose trustworthy, accurate men to send on this expedition.

The second prerogative of *scientia experimentalis* covers the useful and incredible results from the combination of human ability and natural knowledge. These results include processes to refine metals, such as alchemy, recipes for longevity and rejuvenation, and the creation of new devices.[33] All these are emblematic of the transformative possibilities of *scientia experimentalis*. Bacon's interest in all manner of devices and their potential utility, in both political and philosophical realms, appears in his works from the mid-1260s forward. Although instruments and devices are central to *scientia experimentalis*, Bacon discusses their importance to the enterprise of gaining natural knowledge throughout *Opus maius*. For example, understanding the science of the stars – the positions of planets, the altitudes of heavenly bodies, the appearance of unusual phenomena, like comets – requires the use of special instruments. This knowledge is crucial to being able to form accurate judgements or predictions about all manner of things (weather, the harvest, travel, medicine, horoscopes).[34]

The third prerogative of *scientia experimentalis* enabled understanding the secrets of nature, by which Bacon mainly meant marvelous particular phenomena, and the uses to which this knowledge could be turned. Utility was critically important to Bacon: Natural knowledge for its own sake was less important than how that knowledge could be used to defend Christian kingdoms or be mobilized to attain *sapientia*.[35] *Scientia experimentalis* realized and facilitated knowledge – of particulars, like non-manifest qualities, or of natural forces and phenomena that allowed the construction of devices and instruments – that could be authenticated and used. For example, "when properly prepared, yellow petroleum, which comes forth from rock, burns whatever it meets ... and water will not

[32] Bacon, *Opus maius*, 6.1, ed. Bridges, II, 169: "Aristoteles auctoritate Alexandri misit duo millia hominum per diversa loca mundi ut experientur omnia quae sunt in superficie terrae, sicut Plinius testator in Naturalibus."

[33] See Meagan S. Allen, "Roger Bacon's Medical Alchemy and the Multiplication of Species", in *The Philosophy and Science of Roger Bacon*, 159-74; William Newman, "An Overview of Roger Bacon's Alchemy", in *Roger Bacon and the Sciences*, 317-336; on medicine, see Faye Getz, "Roger Bacon and Medicine: The Paradox of the Forbidden Fruit and the Secrets of Long Life", in same, 337-364; and Agostino Paravincini Bagliani, "Ruggero Bacone, Boniface VIII, e la theoria della *prolongatio vitae*", in *Medicina e scienza della natura, alla corte dei papi nel Ducento*, edited by A. Paravincini Bagliani (Spoleto: Centro Italiano di studi sull'alto medioevo, 1991), 281-326.

[34] Bacon, *Opus maius*, 4.2.1, ed. Bridges, I, 109-10; 4.4.16, ed. Bridges, I, 230-31.

[35] Power, *Roger Bacon*, 164-207.

extinguish it".[36] Explosive compounds of different minerals can produce deafening alarms, so that "neither army nor city can withstand them".[37] Here, and elsewhere, as we shall see later, Bacon argues for the possibility of inventions (and their applications) in the future because of their existence in the past. This line of reasoning subtly echoes another of the fruits of the third prerogative of *scientia experimentalis*: to enable concurrent knowledge of the past and future, in the present.

> [The third dignity of this science] consists in two things; namely, in the knowledge of the future, the past, and the present, and in wonderful works by which it excels in the power of making predictions the ordinary astronomy dealing with predictions... [This] branch of knowledge has discovered the terms and method by which it can easily answer every question, and... it can show us the forms of the celestial forces, and the influences of the heavenly bodies on this world without the difficulty of the ordinary astronomy.[38]

Bacon's comments on this purpose of *scientia experimentalis* are somewhat obscure, but it is similar in outcome to judicial astronomy, but without the need for complex astronomical tables and expensive instruments that astral prediction usually required.

Courtly Science

Astral predictions and new military devices are just two examples Bacon gave of the ways that *scientia experimentalis* could serve political utility and Christendom. He articulated throughout his mature work manifold astonishing possibilities for devices and processes with practical value, and consistently focused on the applied nature of natural knowledge to achieve temporal, material ends alongside *sapientia.* Furthermore, several of the works in which he promoted the potential for *scientia experimentalis* were written specifically for courtly readership, such as the papal curia. Yet Bacon also drew inspiration from the courtly milieu, from people, branches of knowledge, and processes to develop and test his own natural knowledge and theory of knowledge acquisition.

The courtly sciences refer to those branches of natural knowledge and know-how in which the purpose is to intervene in the natural order, either to improve the human condition or to consolidate power (or both). I use the term "courtly" to differentiate this type of knowledge from the learned, text-based, or doctrinally focused knowledge characteristic of the cloister and the classroom. Courtly, or applied, knowledge

[36] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 217-218: "Oleum citrunum petroleum, id est, oriens ex petra, comburit quicquid occurrit, si rite praeparetur [...] eam aqua no extinguit."
[37] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 218: "Nec posset civitas nec exercitus sustinere."
[38] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 215-216: "Et hoc in duobus consistit; scilicet in cognitions futurorum praeteritorum et praesentium, et in operibus admirandis quibus excedit astronomiam judiciariam vulgatam in potestate judicandi [...] Haec autem scientia definitiones et vias adinvenit, per quas expedite ad omnem quaestionem respondeat [...] et per quas ostendat nobis figurationes coelestium virtutum; et impressions coelestium in hoc mundo, sine difficultate astronomiae vulgatae." See also Hackett, "*Ego Expertus Sum*", 309-310.

encompasses the branches of knowledge that were particular to elite concerns and pastimes, such as the mantic arts (chiromancy, geomancy, augury, astral prediction, and other divinatory practices) or knowledge of animal breeding and behavior linked to hunting, as well as non-elite but vital areas of knowledge, such as mining and irrigation. Some types of knowledge, such as astral prediction, might also require text-based, theoretical knowledge. Some, such as animal husbandry, did not. Still others, like medicine, were valued when practiced both with and without engaging *argumentum.* What all have in common is a focus on acquiring natural knowledge through sensory experience, albeit through the kind of repeated experience characteristic of empiricism, rather than the specific test or *experimentum* that Bacon argued was necessary to confer certainty.

Bacon wrote his major works at the request of the pope, who was specifically interested in his ideas about how epistemic reform could be yoked to political and spiritual authority. In 1264, shortly before his elevation to the papacy, Guy of Foulques acted as papal legate to England during the civil war between Henry III and the barons. However, due to the conflict Foulques was unable to reach England and stayed in Paris, where it seems likely that he encountered Bacon.[39] While in Paris in 1265 Foulques was named pope and returned to Rome, but the two men remained in contact.[40] As Clement IV he concerned himself with internal threats, such as heresy (ever more common in the thirteenth century, according the Church), but also external threats, like the Mongols, who had recently established control over southern Russia and the Balkans. Intrigued by what he knew of Bacon and his ideas, he wrote to Bacon in 1266, requesting copies of his work be produced and sent to him in secret. Over a period of months Bacon wrote *Opus maius, Opus minus*, and *Opus tertium* and sent these, in batches, along with his earlier treatises on the emanation of force and burning mirrors, a treatise on celestial divination and judicial astrology, and four separate treatises on alchemy.[41] Clement IV died in

[39] Although not a Franciscan, Foulques was an admirer of St. Francis and a supporter of the friars, and likely that he sought out the Franciscan foundation while in Paris. Power, *Roger Bacon and the Defence of Christendom*, 63-64. It is also possible that the two men met earlier, in 1257; see Norbert Kamp, *Enciclopedia dei Papi*, 3 vols. (Rome: Instituto della Encyclopedia Italiana, 2000), II, 401-411, at 9.

[40] From a letter Clement wrote to Bacon in 1266 we know Bacon had written to him previously, and that he had used William Bonecor, the English royal legate dispatched by Henry III to the pope, to convey his missive. *Fr. Rogeri Bacon Opera*, ed. Brewer, 1. See also Power, *Roger Bacon*, 67-68.

[41] Bacon, *Opus minus*, 322; *Opus tertium*, ed. Little, 61; *Opus tertium*, ed. Brewer, 270. The alchemical treatises were sent separately, and intended only to make sense when read alongside one another. Two were incorporated into the *Opus minus*, one was included with the *Opus tertium*, and one is no longer extant longer extant; see Little. Likewise, the treatise on judicial astrology is no longer extant. The chronology of Bacon's works has been a matter of sustained discussion; see Lindberg, *Roger Bacon's Philosophy,* xxiv-xxv; Franco Alessio, *Mito e scienza in Ruggero Bacone* (Milan: Ceschina, 1957), 295-315. As Power makes perfectly clear, despite the difficulty of producing such an output and the financial constraints on Bacon as a Franciscan, it seems most likely that he had the support of his superiors in the Order. Power, *Roger Bacon*, 72-73.

November 1268, and there is no evidence that he read the works he had requested. However, Bacon's treatises sparked interest within the papal curia.[42]

Bacon tantalized and assured his intended reader – Pope Clement IV and his advisers – of the potential of *scientia experimentalis* to fortify Christendom against the forces of the Antichrist. Bacon urged the pope, "in order to spare Christian blood, the Church ought to consider the use of these inventions against unbelievers and rebels, and it should do so *especially* because of the coming perils in the times of the Antichrist, which (with the grace of God), if prelates and princes fostered inquiry and investigated the secrets of art and nature, it would be easy to face".[43] Demonstrations of the kinds of technological marvels made possible by *scientia experimentalis* could be used to convert non-Christians, by making them believe in what they might not understand.[44] According to Bacon, *scientia experimentalis* made possible devices that could demonstrate and bestow natural knowledge as well as *sapientia.* One such theoretical example is an armillary sphere combined with a magnet. Without knowing through experience that a magnet attracts iron, one could not envision how to put it to use or understand that the attractive and repulsive forces of the magnet might be related to the ebbing and flowing of tides, or other examples of action at a distance. Devices such as this one could in turn yield new information about nature: "This instrument would be worth a king's ransom, and would render useless all other astronomical instruments and clocks, and would be a most beautiful instrument of *sapientia*".[45] And in addition to providing useful devices, *scientia experimentalis*, as a method for knowledge-acquisition, made possible a more complete understanding of the Bible than offered by reasoning (the practice of exegesis), and was "the most useful apart from that of morals".[46]

Slightly later, during the 1270s, Bacon seems to have completed a short text on the potential of *scientia experimentalis* and the natural and technological marvels it could enable, *Letter on the Hidden Powers of Art and Nature, and on the Invalidity of Magic* (*Epistola de secretis*). We know little about the circumstances of its composition or its intended

[42] Power, *Roger Bacon*, 74.

[43] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 222: "Et hoc deberet ecclesia considerare contra infidels et rebelles, ut parcatur sanguine Christiano, et maxime propter future pericula in temporibus Antichristi, quibus cum Dei gratia facile esset obviare, si praelati et principes stadium promoverent et secreta naturae et artis indagarent." Emphasis mine. On the relationship between Bacon's scientific ideas and belief in the Apocalypse, see Zachary Matus, "Reconsidering Roger Bacon's Apocalypticism in Light of His Alchemical and Scientific Thought", *Harvard Theological Review* 105 (2012): 189-222.

[44] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 221.

[45] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 203: "Et tunc thesarum unius regis valeret hoc instrumentum et cessarent instrumenta astronomiae, et horolgia, et esset pulcherrimum spectaculum sapientiae."

[46] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 221: "Quod utilissima est haec scientia post morale."

audience.[47] Judging from its tone, focus, and level of detail, the text seems to be directed to a ruler or courtier, rather than to a natural philosopher. However, it was completed during a period of doctrinal upheaval within the Franciscan Order, and it is also possible that Bacon wrote *Hidden Powers* to clarify the difference between *scientia experimentalis* and magic, which he considered fraudulent and pointless. As Bacon laid out in *Hidden Powers*, not only could *scientia experimentalis* help discern the deceptions practiced by magicians and charlatans, but when yoked to human know-how it also made possible incredible inventions and processes, which could in turn be used to strengthen a Christian realm or Christendom as a whole. The combination of learned and experiential knowledge in the service of the ruling elite – courtly science – is the entire point of *Hidden Powers.*

As is common with Bacon's work, *Hidden Powers* repeats several of the points made elsewhere, especially in the fifth and sixth books of *Opus maius*, on optics and *scientia experimentalis*, respectively. The fifth chapter of *Hidden Powers*, on optical illusions and lenses, is titled "Artificial Optical Experiments" (*De experientiis perspectivis artificialibus*), recalling Ibn al-Haytham's articulation of the importance of using lenses and other visual instruments to measure and investigate optical phenomena. Lenses and other practical knowledge of optics could also be used in the service of further textual education, measurement, and espionage.[48] The following chapter, "On Marvelous Experiments" (*De experimentis mirabilibus*), covers natural marvels like the magnet and Greek fire, making evident the conceptual association between *experimentum* and natural particulars.[49]

Hidden Powers also expands on the possibilities *scientia experimentalis* could afford to explore new terrain and to consolidate political authority. These possibilities fall under the second prerogative of *scientia experimentalis*: to make instruments or machines using natural laws and powers. The effects they produced or the things they could do were not due to demons or to trickery, but purely to natural forces, combined with human ability to understand nature and to make things.

> First, those things achieved through the design and reckoning of skill alone: Now an instrument for sailing without oarsmen can be made such that the largest ships, both riverboats and seagoing vessels, can be moved under the direction of a single man at a greater speed than if they were filled with men. And a chariot can be made that moves at an unimaginable speed without animals; such we think to have been the scythe-bearing chariots with which men fought in ancient times.[50]

[47] In its current form seems to be a hybrid, with the first eight chapters conforming to Bacon's earlier works, and the last three diverging sharply in terms of tone and content. My concern here is with the earlier chapters, which follow his earlier *opera* closely.

[48] Bacon, *Epistola de secretis*, ed. Steele, 534.

[49] Bacon, *Epistola de secretis*, ed. Steele, 536-538.

[50] Bacon, *Epistola de secretis*, ed. Steele, 533: "Et primo per figuram et rationem solius artis. Nam instrumenta navigandi possunt fieri sine hominibus remigantibus, ut naves maxime, fluviales et marinae, ferantur unico homine regente, majori velocitate quam si plenae essent hominibus. Item currus possunt fieri ut sine animali moveantur cum impetus inaestimabili; ut aestimamus currus

Other inventions could be used for civil engineering and civil defense, to lift heavy weights or evade capture.[51] Devices could be made that would render entire armies or civilian populations powerless: "[An] instrument could easily be made by which one man could drag a thousand men against their will toward himself, and attract other things in the same way".[52] Furthermore, the use of lenses and knowledge of perspective could burn an enemy army or town to cinders, or confuse it with illusions. Knowledge of lenses and mirrors – *perspectiva* – could be used in the service of espionage: they could be shaped and placed "so that hidden things appear evident".[53] Elsewhere, Bacon reflected on the past application of knowledge of optics and mathematics: understanding the properties of rays and the phenomenon of reflection, Alexander the Great was able to use a mirror to turn the venomous gaze of a basilisk from his own army, where it was trained, back onto itself, "so that it was killed by its own venom".[54] In fact, "all things of such marvelous utility to the state belong chiefly to [*scientia experimentalis*]".[55] This emphasis on military use echoes Bacon's earlier assertions in his works for Clement IV that *scientia experimentalis* could help defend Christendom from her enemies.

Bacon focused on the applications of *scientia experimentalis* relative to the courtly sciences, and directly addressed issues of political, social, and military domination. He also drew from the courtly sciences and stressed the importance of viewing unlettered experts, such as farmers, as important sources of natural knowledge, especially *experimentum*. Bacon looked outside of the university setting to pursue his interest in *experimentum* beyond what was readily available in the curricula of Oxford and Paris; between roughly 1247 and 1257 he pursued a self-funded career as an independent scholar. He spent some of this time in Oxford and some in Paris, and came into contact with the vibrant circle of experimenters, as well as Latin translations of Arabic texts on instruments and experience. He reflected on this time in his third treatise (*Opus tertium*) for Pope Clement IV (1268),

falcati fuisse, quibus antiquitus pugnabatur." On Bacon and the mechanical arts, see Elspeth Whitney, "The Artes Mechanicae, craftsmanship and moral value of technology", in *Design and Production in Medieval and Early Modern Europe*, edited by N. van Deusen (Ottawa: The Institute of Mediaeval Music, 1998), 75-87.

[51] Bacon, *Epistola de secretis*, ed. Steele, 533.

[52] Bacon, *Epistola de secretis*, ed. Steele, 533: "Posset etiam de facili fieri instrumentum quo unus homo traheret ad se mille homines per violentiam, mala eorum voluntate; et sic de rebus aliis attrahendis."

[53] Bacon, *Epistola de secretis*, ed. Steele, 534-535: "Et occulta videantur manifesta."

[54] Bacon, *Opus maius*, 4.4.7, ed. Bridges, I, 143: "Sicut Alexander docrina Aristotelis ut historiae narrant, basilisci speciem venenosam positi super murum civitatis ad interficiendum exercitum per corpora magna polita retorsit in eandem civitatem, ut per proprium destrueretur venenum."

[55] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 221: "Est tamen considerandum, qod licet aliae scientiae multa mirabilia faciant, ut geometria practica facit specula comburentia omne contumax [...] tamen omnia hujusmodi utilitatis mirificae in republica pertinent princialiter ad hanc scientiam [experimentalis]."

> I have for twenty years labored especially in the pursuit of wisdom, abandoning the opinions of the masses, I have spent more than two thousand pounds on these studies, for books of secrets, various experiments, languages, instruments, tables, and other things; and to seek the friendship of learned people, as well as seeking their close counsel on languages, diagrams, numbers, tables, instruments, and many other things.[56]

In this passage Bacon clearly states his efforts in pursuit of natural knowledge and wisdom: learning foreign languages; studying books, diagrams, and tables (likely astronomical tables); buying and using instruments, carrying out or witnessing experiments; and talking to experts. Knowledge gained first-hand, through sensory experience, and in conjunction with wisdom in books, was so important to Bacon that he spent the fortune of a lifetime in pursuit.

As demonstrated earlier, Bacon's interest in *experimentum* was of a piece with learned culture, especially at Oxford and Paris in the thirteenth century. Yet Bacon found one peer in particular exemplary of the potential for his new educational program, particularly *scientia experimentalis*. Peter of Maricourt, who likely studied at the University of Paris in the middle of the thirteenth century, wrote a treatise on magnetism, *Treatise on the Magnet* (*Epistola de magnete*, 1269), that emphasized the utility of scientific knowledge and the importance of experience.[57] He also, in this work and in others, applied his knowledge in the creation of new instruments and devices, such as a new kind of compass needle, a universal astrolabe, and a perpetual motion-machine.[58] Bacon worked with Peter in Paris, and considered him a source of inspiration.[59] In the *Opus Tertium,*

[56] Bacon, *Opus tertium* 17, ed. Brewer, 59: "Nam per viginti annos quibus specialiter laboravi in studio sapientiae, neglecto sensu vulgi, plus quam duo millia librarum ego posui in his, propter libros secretos, et experientias varias, et linguas, et instrumenta, et tabulas, et alia; tum ad quaerendum amicitias sapientum, tum propter instruendos adjutores in linguis, in figuris, in numeris, in tabulis, et instrumentis, et multis aliis." Presumably, in this statement Bacon is referring to the period before he entered the Franciscan Order, as he would have had to take a strict vow of poverty upon joining.

[57] Peter Peregrinus of Maricourt, *Epistola de magnete*, edited by L. Sturlese and R. Thomson, *Petrus Peregrinus de Maricourt, Opera* (Pisa: Scuola Normale Superiore, 1995); in English, *The Letter of Petrus Peregrinus on the Magnet, c. 1269*, translated by Fr. Arnold (New York: McGraw, 1904). Little is known about his life; he may have been a pilgrim (hence "Peregrinus") and he was at the siege of Lucera, in the Kingdom of Sicily, in 1268-69, likely as an engineer.

[58] J. Luis Rivera, "Pierre de Maricourt", in *A Companion to Philosophy in the Middle Ages*, edited by J. E. Garcia and T. B. Noone (Oxford: Oxford University Press, 2003), 538-539; Amelia Carolina Sparavigna, "Peter Peregrinus of Maricourt and the Medieval Magnetism", *Mechanics, Materials Science, and Engineering* 12 (2016): 1-8; Andreas Kleinert, "Le moteur magnéto-mécanique de Pierre de Maricourt. Comptes-rendus du séminaire: Origine des idées scientifiques, ruptures et continuités", *Centre Commun d'Histoire des Sciences et d'Epistémologie de Lille* 1 (2005): 22-34; Robert J. Halleux, "Entre philosophie naturelle et savoir d'ingénieur: *L'Epistola de magnete* de Pierre de Maricourt", *Archives internationals d'histoire des sciences* 50 (2006): 3-17; Silvia Nagel, "Pietro Peregrino: il sapiens-simplex eccelente di Ruggero Bacone", in *Francescani e le scienze* (Spoleto: Centro Italiano Di Studi Sull'Alto Medioevo, 2012), 19-47.

[59] Williams, "Roger Bacon in Context", 129-132.

written perhaps a year before *Treatise on the Magnet,* Bacon lauded Peter's erudition, his natural knowledge gained from both texts and practice, and his dedication to the pursuit of wisdom:

> I know of only one person who deserves praise for his work in [*scientia experimentalis*], for he does not care for discourses and aggressive debates, but diligently pursues the works of *sapientia*; in these he is at peace. Therefore, what others blindly struggle to see, as bats in the twilight, this man apprehends in the full light of day because he is a master of *experimentum*. He knows about nature through experience [*per experientiam*], and medicine or alchemy, and all things terrestrial and celestial. Indeed, he would be ashamed if some layman, or a little old lady, or a soldier, or a rube from the countryside would know something of which he himself was ignorant. He has carefully investigated the smelting of metal ore and how to work gold, and silver and other metals and minerals; he has mastered all sorts of arms used in military service and in hunting, besides which he has carefully investigated all matters relating agriculture and surveying and all matters pertaining to the countryside; and he has even closely examined the experiments [*experimenta*], incantations, and devices of old women and sorcerers; and likewise [examined] all the illusions and devices of conjurers so that nothing that is to be known might escape his notice, and he knows more than enough to condemn magic and all deceitful things.[60]

Bacon's praise of Peter reveals his own views about what investigating the natural world using *scientia experimentalis* required: mastery of traditional university subjects, like astral science, alongside subjects that combine text and practice, like alchemy and medicine; direct experience in metallurgy and mining, important subjects not covered in an arts education, as well as the military arts of ballistics and other weaponry; willingness to test received wisdom; and the use of one's erudition and discernment to identify and repudiate magic and deception.

Bacon also expressed the view that people from different registers, with kinds of experience, could be a source of knowledge for the natural philosopher. Soldiers could offer insight into weaponry, ballistics, and mining; folk remedies and "old wives' tales"

[60] Bacon, *Opus tertium* 13, ed. Brewer, 46-47: "Non enim cognosco nisi unum, qui laudem potest habere in operibus hujus scientiae; nam ipse non curat de sermonibus et pugnis verborum, sed persequitur opera sapientiae, et in illis quiescit. Ed ideo quod alii caecutientes nituntur videre, ut vespertilio lucem solis in crepusculo, ipse in pleno fulgore contemplator, propter hoc quod est dominus experimentorum; et ideo scit naturalia per experientiam, et medicinalia, et alkimistica, et omnia tam coelestia quam inferior; immo verecundatur si aliquis laicus, vel vetula, vel miles, vel rusticus de rure sciat quae ipse ignorant. Unde omnia opera fundentium metalla, et quae operantur auro, et argento, et ceteris metallis, et omnibus mineralibus, ipse rimatus est; et omnia quae ad militiam, et ad arma, et ad venationes ipse novit; omnia quae ad agriculturam, et ad mensuras terrarium et opera rusticorum, examinavit; etiam experimenta vetularum et sortilegia, et carmina earum et omnium magicorum consideravit; et similiter omnium joculatorum illusions et ingenia; ut nihil quod sciri debeat lateat ipsum, et quatenus omnia falsa et magica sciat reprobare." Peter is mentioned twice in marginal glosses of different manuscripts, and Bacon mentions Peter by name elsewhere.

[*vetula, vetularum*] might provide information into medicine or botany; and the rustic who toiled in the fields had experiential knowledge of meteorology, astral observation, and agronomy. When practical experience and empirical knowledge are valued and even weighed on par with book knowledge, the ranks of who can be considered authoritative and knowledgeable expand, requiring scholars to engage with a wider range of "knowledge holders" than if considering only textual authorities. Yet Bacon is not promoting an egalitarian view of knowledge; his use of "ashamed" (*verecundus*) in this passage is as revealing as it is condescending. He makes it clear that full investigation into nature should draw from people in different registers and walks of life, but still marks this endeavor as one invested in authority and hierarchy. Authoritative texts may be mistaken, due to ignorance of particulars, lack of attention to *experimentum*, or poor translation, but Bacon strongly believes in the divide between the ignorant masses (*vulgus*) and the wise few (*sapientes*).[61] His condescension rests on the belief that he (and Peter of Maricourt) are distinct from the rustics and old women, more learned and, ultimately, more capable of making natural knowledge.

Alexander the Great: Experience and Invention

Natural knowledge appeared in texts that circulated outside of the university curriculum, in genres that emphasized useful knowledge alongside exploration, and in the literature of entertainment. These texts were intended for elite lay audiences, although they might include knowledge gained from non-elite sources. One such example is the avian hunting treatise by king and Holy Roman Emperor Frederick II (1194-1250), *The Art of Hunting with Birds* (*De arte venandi cum avibus*), which draws on both the Aristotelian textual tradition and empirical knowledge of raptor behavior and care.[62]

Frederick's court was also an avenue of transmission of the complete Latin translation of the ruling handbook *The Secret of Secrets* (*Secretum Secretorum*), which captivated Bacon.[63] He spent decades studying it and produced his own edition of it, with copious marginal glosses, in the 1270s. This text, a translation of the Arabic *Kitab sirr al-asrar*, circulated as a letter that Aristotle, at the end of his life, sent to his pupil, Alexander the Great.[64] In it, he confided to Alexander those secrets of nature he had withheld from

[61] Bacon, *Opus maius*, 1.4, ed. Bridges, I, 9-10.
[62] Frederick II, *De arte venandi avibus*, Prologue: https://www.hsaugsburg.de/~harsch/Chronologia/Lspost13/FridericusII/fri_arsp.html [accessed February 2, 2018]; Thomas T. Allsen, *The Royal Hunt in Eurasian History* (Philadelphia: University of Pennsylvania Press, 2006).
[63] Steven J. Williams, "The Early Circulation of the Pseudo-Aristotelian *Secret of Secrets* in the West: The Papal and Imperial Courts", *Micrologus* 2 (1994): 127-144; Steven J. Williams, "Roger Bacon and His Edition of the Pseudo-Aristotelian *Secretum secretorum*", *Speculum* 69 (1994): 57-73; Steven J. Williams, "Roger Bacon and the *Secret of Secrets*", in *Roger Bacon and the Sciences*, 365-394.
[64] On the emergence of the text through accretion, see Mahmoud Manzaloui, "The Pseudo-Aristotelian *Kitab Sirr al-asrar*: Facts and Problems", *Oriens* 23-24 (1974): 147-257; Mario Grignaschi, "L'origine et les metamorphoses du *Sirr al-'asrar*", *Archives d'histoire doctrinale et littéraire du moyen âge*

his earlier works out of care not to squander knowledge on a populace that was not prepared to receive it, but that Alexander – the great conqueror and empire builder – would need in order to be a powerful, canny, and just ruler. Translated in full for the first time around 1230, it promotes the utility of natural knowledge in the service of worldly power. *The Secret of Secrets* shares with the historical literature on Alexander the Great a focus on rulership, natural knowledge, and exploration for knowledge-acquisition.[65] The prologue of *The Secret of Secrets* puts the work into the context of an existing and robust epistolary relationship between Alexander and Aristotle, and in many instances *The Secret of Secrets* appears bound together with Latin works on Alexander or vernacular texts on the Alexander tradition.[66] Furthermore, episodes and examples drawn from the life of Alexander and *The Secret of Secrets* appear in *Hidden Powers*.

Although there are many variations on the legends of Alexander, in virtually all of them his interest in first-hand experience going beyond ordinary human knowledge and his ingenuity are his defining characteristics. *Ingenium* and *engin*, in Latin and Old French respectively, are the terms that refer to this kind of innate, inventive spirit. But these terms and their cognates also encompass other meanings, such as intellectual wit, invention, chicanery, deception, stratagem, and extraordinary technical knowledge.[67] In the Anglo-Norman *Roman de Toute Chevalerie* (ca. 1180), written at the sophisticated court of Henry II Plantagenet and based in part on the *Letter from Alexander the Great to Aristotle* (*Epistola Alexandri Magni ad Aristotelem*), the narrator ends his introduction to Alexander with this summation: "He was brave and victorious, wise and ingenious".[68] In the

43 (1976): 9-112; Mario Grignaschi, "Remarques sur la formation et l'interprétation du *Sirr al-'asrar*", in *Pseudo-Aristotle, The Secret of Secrets: Sources and Influences*, edited by W. F. Ryan and C. B. Schmitt (London: Warburg Institute, 1982), 3-33.

[65] Steven J. Williams, "Two Independent Textual Traditions? The Pseudo-Aristotelian *Secret of Secrets* and the Alexander Legend", in *Trajectoires européenes du* Secretum secretorum *du Pseudo-Aristote (XIIIe-XVIe siècle)*, edited by C. Gaullier-Bougassas, M. Bridges, and J.-Y. Tilliette (Turnhout: Brepols, 2015), 27-54.

[66] A late antique text that purported to be a copy of a letter that Alexander had sent to Aristotle, describing the marvels he had seen and the novel experiences he had had, circulated widely from the fourth century onward. See *Epistola Alexandri Macedonis ad Aristotelem magistrum suum de itinere suo et de situ Indiae*, edited by W. Walther Boer, Beiträge zur Klassischen Philologie (Meisenheim am Glan: Hain, 1980); this work has been edited and translated into English by Lloyd L. Gunderson (Meisenheim am Glan: Hain, 1980); Williams, "Two Independent Textual Traditions?", 29, 33-49.

[67] *Dictionnaire historique de la langue française*, s.v.v. "ingénieur", "engin"; *Glossarum mediae et infimae latinitatis*, edited by C. DuCange, 10 vols. (Paris: Librarie des Sciences et des Arts, 1937-38), s.v. "ingenium"; *Dictionnaire de l'ancienne langue française*, edited by Godefroy, s.v. "engignart", "engigne", "engigneor". See *OED*, s.v.v. "engine", "ingenious".

[68] "Hardiz estoit e conqueranz, sages e enginus." Thomas of Kent, *The Anglo-Norman Alexander* (*Le Roman de Toute Chevalerie*), edited by B. Foster with I. Short, 2 vols. (London: Anglo-Norman Text Society, 1976), I, 7,30. This text is available with a modern French facing page translation, *Le Roman d'Alexandre ou Le Roman de Toute Chevalerie*, translated by C. Gaullier-Bougassas and L. Harf-Lancner (Paris: H. Champion, 2003). On the intellectual culture of the Plantagenet court, see Francine Mora-Lebrun, '*Mettre en romanz*': *Les romans d'antiquité du XIIème siècle et leur postérité (XIIIème-XIVème siècles)*

contemporary *Roman d'Alexandre* (ca. 1185) by Alexander of Paris, Alexander the Great's extensive knowledge of the natural world and his technological ingenuity are two of his essential qualities.[69] Alexander's conquest of new territory extends to new geographical realms and new frontiers of knowledge, from the farthest reaches of India, to the deep sea, to the dizzying heights. In multiple versions of his biography, he devises a flying machine, powered by griffins, and a glass diving bell to explore rivers and oceans. Both inventions enable Alexander to gain new knowledge through experience and to explore nature's secrets beyond what was at that time known. Perched on his flying machine he could experience the world as no human before him, able to view the terrain as a synoptic whole as it unfurled beneath him. From the safety of his diving bell, he could observe the creatures at the bottom of the ocean that were otherwise invisible to humans. Moreover, in several of the Alexander-texts from this period his endeavors are discussed in terms (either by the narrator or Alexander himself) of experience and proof: "*experimentum*" and "*esprover*".[70] And he employs his know-how for conquest, as well as exploration: In *Roman d'Alexandre*, Alexander's successful campaigns against several cities hinge on the inventions he devises, such as the floating siege towers that he designed and built, which allowed him to capture the city of Tyre.[71]

Alexander embodies the ruler enlightened by traditional education, first-hand experience, *and* technical knowledge. His education from Aristotle, his tutor and interlocutor, included philosophy, astral science, geography, as well as the secrets of nature. In the *Historia de preliis*, the tenth-century Latin prose re-telling of the late antique Greek version by pseudo-Callisthenes, Alexander recounts how he designed a flying contraption that used winged animals to see the earth in a new way. "I planned with my friends that I should build a device [*ingenium*], so that I might ascend into the sky and see what may be seen from the sky. I designed and built the device [*ingenium*], where I would sit, and caught gryphons and bound them with chains and I put a pole in front of them at whose end was food for them, and they began to take off into the sky".[72] In *Roman*

(Paris: H. Champion, 2008), 53-86; *La fascination pour Alexandre le Grand dans les littératures européenes (Xème-XVIème siècle)*, edited by C. Gaullier-Bougassas, 4 vols. (Turnhout: Brepols, 2004), II, 794-798 and III, 1334-1345.

[69] Alexander of Paris, *The Medieval French Roman d'Alexandre*, vol. 2: *Alexandre de Paris*, edited by E. C. Armstrong, D. L. Buffum, B. Edwards, and L. F. H. Lowe (Princeton: Princeton University Press, 1937), 3,400. Available with facing page translation into Modern French, although lacking part of the second *branche*, Alexandre de Paris, *Le Roman d'Alexandre*, translated by L. Harf-Lancner (Paris: H. Champion, 1994). See also Catherine Gaullier-Bougassas, "Savoir scientifique et 'roman historique:' l'Alexandre anglo-normand de Thomas de Kent", in *Savoirs et fiction au Moyen Âge et à la Renaissance*, edited by D. Boutet and J. Ducos (Paris: H. Champion, 2015), 143-159.

[70] *Roman d'Alexandre*, 3,396-398.

[71] *Roman d'Alexandre*, 1,2189-2378, 2895-2901; 2,1904-2006.

[72] Leo, *Historia de preliis* 3.27, edited by F. Pfister (Heidelberg: Sammlung Mittellateinischer Texte, 1913), 126: "Cogitavi cum amicis meis, ut instruerem tale ingeium, quatenus ascenderem caelum et viderem, si est hot caelum, quod videmus. Preparavi ingenium, ubi sederem, et apprehendi grifas et

d'Alexandre Alexander's adventure explicitly links experiential knowledge to the confirmation of text-based learning, via measurement. "Alexander forged the path up to the sky when his golden chair, attached to four gryphons, was carried up; and his thought [having been] was enlightened by astral science such that he knew the compass of all the stars".[73] Speculative, imaginary, or legendary machines and devices appear frequently in literary texts in romance in the twelfth and thirteenth centuries, and literary texts were conceived of as spaces to stage thought experiments, and to engage with different kinds of experience.[74]

Bacon was clearly familiar with these legends, as he cited a few of them in *Hidden Powers*. He insisted that "an instrument for flying can be made, such that a man sits in the middle of it, turning some sort of engine [*ingenium*] by which artificially constructed wings beat the air in the way a flying bird does".[75] Alexander's diving bell also appears in *Hidden Powers*. "And instruments can be made for walking in seas and rivers, right down to the bottom, without bodily danger... For Alexander the Great used these to see the secrets of the sea, according to what Ethicus the astronomer says".[76] *Hidden Powers*, *The Secret of Secrets*, and multiple versions of the medieval Alexander-legend all present Alexander's reign as a dynamic blend of invention and expansion.

For Bacon, Alexander's association with Aristotle was crucial to his political and military success. Alexander received from his tutor not only a traditional education, but also an education in nature's secrets and how to use them, and it was from this education that he was able to conquer his empire. Bacon emphasized the importance of Aristotle, the learned counselor, to Alexander's success in his works to the pope. "Aristotle stands out as the primary [teacher], and it is perfectly clear from what has been said how by the paths of *sapientiae* Aristotle was able to deliver the world to Alexander".[77] In both his works for the pope and in his edition of *The Secret of Secrets* (likely intended for a secular

liquid eas cum catenas, et psui vectes ante eos et in summitate eorum cibaria illorum et ceperunt ascendere celum."

[73] *Roman d'Alexandre*, 1,71-77: "Et la voie du ciel refu par lui tentee/ Quant la chaiere d'or en fu lassu portee/ Par les quatre grifons, a qui fu acouplee;/ Et fu d'astronomie sa pensee enluminee,/ Que de toutes estoiles connut la compassee."

[74] Patricia Clare Ingham, *The Medieval New* (Philadelphia: University of Pennsylvania Press, 2015), 50-55; E. R. Truitt, "'Trei poëte, sages dotors, qui mout sorent di nigromance': Knowledge and Automata in Twelfth-Century French Literature", *Configurations* 12 (2005): 167-193; Brian Stock, "The Self and Literary Experience in Late Antiquity and the Middle Ages", *New Literary History* 25 (1994): 839-852.

[75] Bacon, *Epistola de secretis*, ed. Steele, 533: "Item possunt fieri instrumenta volandi, ut homo sedeat in medio instruenti revolvens aliquod ingenium, per quod alae artificialiter compositae aerem verberent, ad modum avis volantis."

[76] Bacon, *Epistola de secretis*, ed. Steele, 533: "Possunt etiam instrumenta fiere ambulandi in mari, vel fluminibus, usque ad fundum absque periculo corporali. Nam Alexander magnus his usus est, ut secreta maris videret, secundum quod Ethicus narrat astronomus."

[77] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 222: "Sed Aristoteles extitit principalis; et facile patet per praedicta quomodo per vias sapientiae potuit Aristoteles mundum tradere Alexandro."

ruler), Bacon presented Alexander's reign as the outcome of a thorough education in both *argumentum* and *experimentum*.[78]

Conclusion

Bacon looked to the past, in part, to conjure the future. By relying on Alexander as an exemplar for the possibilities of *scientia experimentalis*, Bacon grounded his epistemological reform in ancient precedent and suggested that the possibilities of *scientia experimentalis* are credible *because* of that precedent. As he wrote in *Hidden Powers*, "And a chariot can be made that moves at an unimaginable speed without animals; such we think to have been the scythe-bearing chariots with which men fought *in ancient times*".[79] Elsewhere, in the same text, he cited another ancient example of military and political subjugation made possible by the fruits of *scientia experimentalis*. "Thus, it is thought Julius Caesar, using huge mirrors on the shores of Gaul, apprehended the dispositions and locations of the forts and cities of Great Britain".[80] These inventions and instruments used to exist, but do not any longer. Yet the knowledge that they *have existed* is what allows Bacon to make claims about how they could be made and used in the future. The accounts of past devices prove that their presence in the future is not theoretical or speculative. The third prerogative of *scientia experimentalis* includes the unification of past, present, and future knowledge. In this case, Bacon argues here that his new science can recover past knowledge for future use. Additionally, these objects highlight Bacon's point about the need for experience to work in tandem with textual knowledge. Bacon and his contemporaries only know of the flying machine, submarine, optical devices, and other instruments through texts, which is why Bacon cannot describe how to make them.

Bacon drew on multiple sources for his concept of *scientia experimentalis* and the kinds of devices and processes that it facilitated and warranted. He read newly translated Latin versions of Arabic texts in optics, secrets, and astral science alongside contemporary treatises on natural particulars and *experimentum*, and ancient history to articulate the possibilities of *scientia experimentalis*. He drew from the academic register of natural philosophy to literary expressions of the possibilities of human art, and review of his influences demonstrates the widespread interest in knowledge through sense experience. Bacon combined his influences with his own ideas about the purpose of technology to enable new knowledge, improve the human condition, and be used in the exercise of power, especially through the creation of devices or inventions. Additionally, it is clear that Bacon viewed experimental knowledge as vital to political success. He

[78] Bacon, *Opus maius*, 6.12, ed. Bridges, II, 217. On the likely intended audience for Bacon's edition of *The Secret of Secrets*, see Williams, "Roger Bacon and the *Secret of Secrets*", 378-80.
[79] See note 48. Emphasis mine.
[80] Bacon, *Epistola de secretis*, ed. Steele, 534: "Sic enim aestimatur Julius Caesar super littus maris in Galliis, deprehendisse per ingentia specula dispositionem et situm castrorum et civitatum Britanniae majoris."

viewed the knowledge that *scientia experimentalis* provided as important personally – it could help convert people to Christianity, develop their intellect in accordance with Christian morality, and protect people from falling prey to the deceptions of magicians and other charlatans – and politically – it could be used to protect and fortify Christian kingdoms and to conquer.

In Roger Bacon's work we find a more complicated picture of medieval science than the partial but persistent narrative of medieval science that privileges natural philosophy and university disciplines.[81] Bacon participated in the intellectual communities of thirteenth-century Paris and Oxford, in which interest in *experimentum* was prevalent, but he went beyond his contemporaries to carry out and to champion *experimenta*, and he asserted the importance of gathering knowledge from multiple social registers. Bacon's emphasis on the importance of sensory knowledge, as well as natural knowledge gained from unlettered experts (albeit within a hierarchical structure) suggests a crossover between natural philosophy and the workshop or the home long before the fifteenth century.[82] Additionally, his insistence on subjecting theories to confirmation by *experimentum* – careful observation and contrived tests – and his interest in experience as an epistemic method has implications for understanding the role of experience in the narrative of the development of "Western science".[83] Finally, Bacon's assertion of the courtly sciences as intellectually and practically vital and his focus on the utility of natural knowledge to pursue political ends attest to the fluid distinctions between the spheres of classroom, cloister, and court in thirteenth century Latin Christendom.

E. R. Truitt
etruitt@sas.upenn.edu

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[81] See David Lindberg's textbook, *The Beginnings of Western Science*, 2nd ed. (Chicago: University of Chicago Press, 2008), which still dominates the field.

[82] In the historiography of science, cooperation and collaboration between artisans and natural philosophers in the late fifteenth and sixteenth centuries is considered to be one of the conditions that fostered the experimental science of the seventeenth century. See, for example, William Newman, *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004); Deborah Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2008); Pamela O. Long, *Artisan-Practitioners and the Rise of the New Sciences, 1400-1600* (Corvallis, Ore.: Oregon State University Press, 2011).

[83] See Hackett, "Roger Bacon on *Scientia experimentalis*", 314-315, on this point.