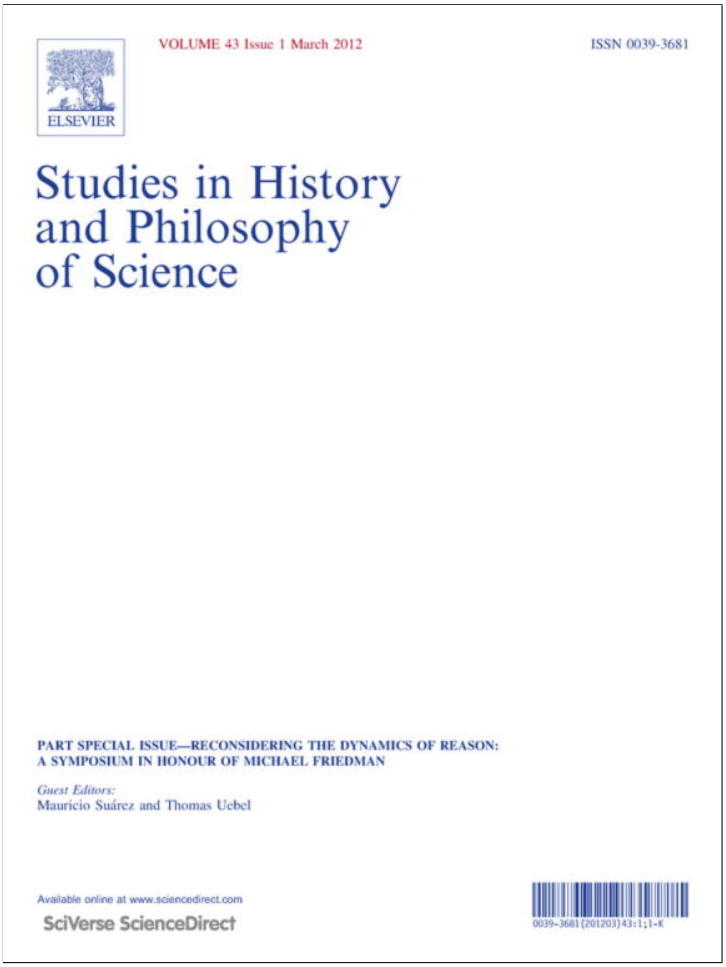

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# From Bacon to Banks: The vision and the realities of pursuing science for the common good

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ABSTRACT

Francis Bacon's call for philosophers to investigate nature and "join in consultation for the common good" is one example of a powerful vision that helped to shape modern science. His ideal clearly linked the experimental method with the production of beneficial effects that could be used both as "pledges of truth" and for "the comforts of life." When Bacon's program was implemented in the following generation, however, the tensions inherent in his vision became all too real. The history of the Royal Society of London, from its founding in 1660 to the 42-year presidency of Joseph Banks (1778–1820), shows how these tensions led to changes in the way in which both the experimental method and the ideal of the common good were understood. A more nuanced understanding of the problems involved in recent philosophical analyses of science in the public interest can be achieved by appreciating the complexity revealed from this historical perspective.





## 1. Introduction

The pursuit of science for the common good is a topic that permeated many early discussions about scientific methodology but it was left out of much 20th century philosophy of science. In the current and welcome resurgence of scholarship on this topic, however, some writers have used Francis Bacon as a convenient foil. This has not only led to historical misunderstanding but also to a lack of appreciation for the full complexity of the issue.

Philip Kitcher, for example, has argued that science should be devoted to the well-ordered pursuit of significant truth—where significance is determined by epistemic as well as "moral and social values" (2001, p. 65; cf. pp. 85–91, 117–135). In the process, though, he has perpetuated a Popperian account of Bacon as one who stressed "the importance of unprejudiced observation," "the patient accumulation of empirical data," and "the detached scientific stance" (2001, pp. 29, 109–110; cf. Popper, 1968). On the other hand, Sheldon Krimsky who has also argued for a "public-interest model" of science, contrasts it with what he finds to be a Baconian model that includes an inordinate quest for "productivity" and "profits" (Krimsky, 2003, pp. 177–178; cf. Duhem, 1905; Farrington, 1979). Following a Duhemian account, Krimsky finds Bacon too interested in the outcomes of science.

In addition to the contradictory nature of these characterizations of Bacon, both interpretations are too simple. In the following I will first look at Bacon's promotion of experimental practices for the production of useful knowledge that could be used to advance the common good. I will then turn to an examination of how Bacon's ideal was put into practice by subsequent generations of British natural philosophers.

## 2. Experimental natural philosophy and useful knowledge

Bacon is a controversial figure in the history of philosophy and science. By most accounts he was a political opportunist and a misogynist who went to great lengths to achieve fame and financial reward (Coquillette, 1992; Farrington, 1979; Jardine & Stewart, 1998). There is a striking disconnect, however, between his life and his written works concerning the pursuit and cultivation of useful knowledge. In his writing, Bacon adhered closely to the Renaissance Humanist ideal of the improvement of the moral and social worlds, and he sought to extend the concerns of morality and the

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promotion of an active life to the sphere of natural philosophy (Sargent, 2002). As Bacon noted in his *New Organon* (Bk. I, aph. 24), he sought to popularize experimental methodology in order to "render the sciences active" (1620, p. 73).

Bacon was not original in his advocacy of experimentation. Indeed, he made clear in many places the extent to which his work was dependent on the work of the many inventors, mechanics, chemists, anatomists, and horticulturists among his contemporaries. He was also clearly not the only one who wrote utopian narratives or who advocated the establishment of cooperative research laboratories and libraries. What did set Bacon apart was the way in which he produced a popular synthesis of the many examples of practical knowledge that flourished in his time and constructed a powerful argument for a transformation of the Aristotelian philosophical framework that dominated the universities.

Bacon maintained that natural philosophy should be reformed in such a way as to yield useful knowledge. The Aristotelians, he claimed, considered philosophy to be a purely contemplative and speculative pursuit and he took the scholastics' inability to use their philosophy for the production of beneficial effects as a sign that they failed to possess reliable knowledge. In contrast to the lack of progress in the philosophy of the schools, Bacon argued that the mechanical arts "grow and get better by the day" (1620, 13).

Although Bacon's ultimate goal was the establishment of a broad conception of knowledge that would be useful for all areas of life, he warned his readers that they would be

> wide of the mark if they thought our aim could be met if the experiments of the arts were gathered together for the sole purpose of bringing each art to a better condition. For although in many cases I do not absolutely despise this particular purpose, yet what I have in mind is plainly that streams of experiments of the mechanical arts should flood on every side into the sea of philosophy (1620, pp. 463–465).

In Book I of the *New Organon* (aph. 99) he explained in more detail how the production of useful knowledge requires "experiments of no use in themselves but which only contribute to the discovery of causes [causarum & Axiomatum], which experiments I have grown used to calling *Light-bearing* [*Lucifer Experimental*] as against *Fruit-bearing* [*Fructiferorum*] ones" (1620, pp. 157–159). It was in support of this point that Bacon wrote his famous, and often misquoted, aphorism (I, 3) concerning knowledge and power. Significantly, he did not write: "knowledge is power." Rather, his complete aphorism reads:

> Human knowledge and human power come to the same thing, for ignorance of the cause puts the effect beyond reach. For nature is not conquered save by obeying it; and that which in thought is equivalent to a cause, is in operation equivalent to a rule (1620, p. 65).

Bacon's conception of 'power' refers to the ability to manipulate nature and 'knowledge' refers to the understanding of causal processes. Simply put, we need accurate causal knowledge in order to produce effects in a reliable manner. Conversely, our ability to produce consistent effects can serve as a sign that our knowledge is accurate. Toward the end of the Book I (aph. 124) Bacon made this point more succinctly: "Thus truth and utility are (in this situation) the very things themselves; and the very works give much more as guarantors of the truth, than providers of material benefits" (1620, p. 187; cf. Perez-Ramos, 1988). Experimental results may serve as tests for the truth of causal theories. They remained fallible tests, however, because neither the human senses nor human reason were capable of achieving certainty. Thus, although Bacon wanted beneficial effects, they were not necessarily tied to commercial or industrial applications, and he clearly understood the prior need for accurate theoretical understanding of natural processes. The above discussion also should make it clear that Bacon was not an advocate of disinterested objectivity. That interpretation apparently has its origins in Bacon's discussions of the "idols of the mind".

Bacon's idols represent prejudgments that humans make based on such things as cultural background, language, and theoretical commitments. Some idols, however, are innate and "rooted in the very nature of the intellect" (1620, p. 35). These present the greatest difficulty because

> just as an uneven mirror bends the rays of things according to its own shape and section, so the mind when it is affected by things by way of the sense faithlessly implants and intermixes its own nature with the nature of things when sorting out and devising its notions (Ibid.).

The mind cannot be "cleansed" of these idols as Popper would have it. Indeed, "all we can do is to point them out, and draw attention to and expose the mind's deceitful power" (Ibid.).

Errors arise not only from the mind, but also because of the "dullness, inadequacy and unreliability of the senses" (1620, p. 87). In order to address both the mental and sensible causes of error, Bacon hoped that by his works he would have

> solemnised a true, lawful and enduring marriage between the empirical and the rational faculties (whose protracted and inauspicious divorce and mutual rejection has caused so much upset in the human family) (1620, p. 21).

He also suggested the need for a brotherhood of scientists whereby the labours of many would be conjoined and an exchange of information would take place among all of the scholars of Europe. Many investigators—observers, experimenters, and theoreticians—were required to guard against the idols and the defective sensations of any particular individual (1605, pp. 56–58; cf. Sargent, 1996).

Recognizing the need for a corrective for the interests of particular individuals and classes, is not the same as demanding disinterested objectivity. In the Baconian blend of theory and practice, extra-scientific interests played a role in both knowledge production and legitimization. Interests were an integral part of a cyclical methodological procedure whereby experimental philosophers would seek to uncover knowledge of causal processes by careful interpretation of empirical data and then subsequently test their causal hypotheses by further experimental trials and the production of works. Because the production of works was intrinsic to his process, Bacon needed to address this goal of his experimental program.

As a statesman, Bacon appreciated the importance of political support for his reform efforts. As he explained in the second book of the *Advancement of Learning*, some arts, such as navigation and printing, had produced an "opennesse of the world" and "disclosed multitudes of experiments, and a Masse of Naturall History" that could serve as the foundation for the new philosophy (1605, p. 181; cf. Houghton, 1941). In the *New Organon*, he continued to discuss how, "by prolonged voyages and journeys (which have become prevalent in our times) many things in nature have been disclosed and found out which could shed new light on philosophy" (1620, p. 133, aph. 84). But, there was still much to be done. As he wrote in his "Preparative to a Natural History" appended to the *New Organon*, "the materials for the intellect are so widely spread out that they ought to be sought out and gathered in (as if by agents and merchants) from all sides" (1620, p. 451). Although worthwhile, the task was somewhat daunting—the "collection of a natural and experimental history of the kind I envisage, and which ought to exist, is a mighty work fit (say) for a king, and one requiring much labour and expense" (1620, p. 171, aph. 111).

To enlist royal support, Bacon first had to overcome political and religious objections concerning the usefulness of natural philosophy. In his *Advancement of Learning*, he addressed those who believed that "learning doth soften mens mindes," and pervert "mens dispositions for matter of gouernement and policie" (1605, p. 9). In response, Bacon noted that philosophy makes "men positiue and reguler" and teaches them "the force of Circumstances, the errours of comparisons, and all the cautions of application" (p. 12).

In opposition to religious critics, Bacon argued that Christians have a duty to study nature. God gave us "two Bookes or volumes to studie." The Scriptures reveal "the will of God" and "the creatures" express "his power." Thus, natural philosophy can be "an effectuall inducement to the exaltation of the glory of God" because contemplation of the world enhances belief by "drawing us into a due meditation of the omnipotencie of God, which is chiefly signed and engrauen upon his workes" (1605, pp. 37–38). The effects produced by experimental investigations could also fulfill a further religious duty. Bacon's concept of usefulness went far beyond the merely expedient to include the Christian conception of charity. Experimenters, he wrote, should "be admonished to think on the true ends of knowledge" and

> seek it not for personal gratification, or for contention, or to look down on others, or for convenience, or reputation, or power, or any such inferior motive, but for the benefit and use of life, and that it be perfected and regulated in charity (1620, p. 23).

One interest remained paramount—all inquirers should join together and in their counsel promote "utility and human greatness [vtilitatis & amplitudinis humanae fundamenta moliri]" (1620, pp. 24–25).

Bacon's political and religious arguments were thus bolstered by ethical concerns for the common good. In his expanded discussion of the reform of learning in *De Augmentis*, he included the reform of moral philosophy. In much the same way as he had criticized Aristotelian natural philosophers, he criticized the "general scholastic knowledge" of moral philosophy as "for the most part empty and unprofitable" (1623, p. 14). In this discussion of moral philosophy he also expanded on what he meant by the common good. He drew a distinction between "Self-good" and the "Good of Communion" where, "the latter is in degree the greater and worthier" (1623, p. 7). To illustrate what he meant, he recounted how Pompey had put the interests of Rome ahead of his own self-interest. Pompey did not allow "the love of life, which is the predominant feeling in the individual," to "outweigh affection and fidelity to the commonwealth" (Ibid.). The "Good of Communion" is "the common duty of every man as a member of a state," and he censured those philosophers "who retired too easily from civil business that they might avoid the indignities" of life (pp. 9–10). The "contemplative life" is fine for "private repose," Bacon wrote, but "not for the good of Society." We have a duty to serve the public good because "in this theatre of man's life it is reserved only for God and Angels to be lookers on" (pp. 8–9).

All of the above aspects of Bacon's program for the reform of learning are represented in the utopian tale of the *New Atlantis* that resembled the many popular narratives documenting voyages made by explorers and merchants. Unlike other voyage narratives, however, the unknown island kingdom depicted here was both Christian and scientifically advanced. After a detailed description of the island's history and social customs, the narration turned to the major philosophical point of the story—an account of the island's scientific research society told by the "Father of Salomon's House" (1627, p. 155).

Not surprisingly, in a statement that reflected the goals of *The New Organon*, the account began with a description of the dual goals of Salomon's House: "The End of our Foundation is the knowledge of Causes, and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible" (1627, p. 156). In a section clearly designed to excite hope and curiosity in his readers, the narrative then turned to a description of some of the society's many scientific achievements. "We have fair and large baths" for the "cure of diseases" as well as "brew houses, bake houses, and kitchens, where are made diverse drinks, breads, and meats, rare and of special effects" (1627, p.160). The society also promoted the mechanical arts. They had instruments of sight such as telescopes and microscopes, as well as some for sound, such as those that "further the hearing greatly" and "some that give back the voice louder than it came." In the island's "engine houses" there were "instruments of war, and engines of all kinds, that provided them with "some degrees of flying in the air", as well as "ships and boats for going under water" (1627, p. 161–163).

The fellows of Salomon's House achieved these innovations through a cooperative research effort, but unlike the rather democratic and open process of cooperation presented in *The New Organon*, here the work was accomplished through a hierarchical division of labor (Sargent, 1996). The stages of inquiry remained the same, however. There were fellows who collected natural and experimental histories, including the "Merchants of Light" who traveled to foreign countries to learn of any new inventions or discoveries; the Depradators who "collect the experiments which are in all books"; the Mystery-men who "collect the experiments of all mechanical arts, and also of liberal sciences"; and the Miners who "try new experiments, such as themselves think good" (1627, p. 164). These were followed by those involved in the early stages of induction, such as the Compilers who "draw the experiments of the former four into titles and tables, to give the better light for the drawing of observations and axioms" and the Benefactors who look "into the experiments of their fellows, and cast about how to draw out of them things of use and practice for man's life, and knowledge as well for works as for plain demonstration of causes." At this point, the fathers of Solomon's House hold "divers meetings and consults of our whole number, to consider of the former labours and collections," which is then followed by the work of the Lamps who "direct new experiments, of a higher light, more penetrating into nature than the former" and the Inoculators who "execute the experiments so directed." Finally, at the top of the hierarchy were the Interpreters of Nature who "raise the former discoveries by experiments into greater observations, axioms, and aphorisms" (1627, p. 165).

Education and communication were also central to the mission of Salomon's House. The fellows had "a great number of servants and attendants, men and women" as well as numerous "novices and apprentices" so that "the succession of the former employed men do not fail" (1627, p. 165). In addition, the fellows would periodically visit the "principal cities of the kingdom" to "publish new profitable inventions" and to warn of impending "diseases, plagues, swarms of hurtful creatures, scarcity, tempests, earthquakes, great inundations, comets, temperature of the year, and divers other things" (1627, p. 166). Unlike the free and open communication that Bacon described in the *New Organon*, however, the fathers of Salomon's House concealed those things that they thought "fit to keep secret" (1627, p. 165). Bacon was acutely aware of the need for tradesmen, artisans, and engineers to protect the secrecy of their processes for themselves and for the country. His civil service in the early Stuart patent system was guided by his desire to foster technological innovation particularly as a patent referee while Solicitor General and Attorney General from 1607 to 1617 (Pastorino, 2011). Despite this tension, however, Bacon's advice bears little resemblance to what has been called the Baconian

ideal. Indeed, Bacon's emphasis on solving major social problems in health and human welfare bears a striking resemblance to Krimsky's call for a "public interest model" for academic pursuits. Similarly, Bacon's presentation of a scientific division of labor for the investigation of truths relevant for the pressing interests of his day mirrors Kitcher's ideas about the well-ordered pursuit of significant truth.

Although Bacon never succeeded in garnering royal, religious, or public support for his project, his advice caught the imagination of the next generation of philosophers, theologians, craftsmen, and merchants, who incorporated his ideas into their tracts on political, educational, economic, and religious reforms.

## 3. The Hartlib circle and the interregnum

One group of reformers, gathered around Samuel Hartlib and John Dury, promoted schemes for the advancement of learning (Webster, 1970, 1975). Their broadly Baconian program for reform included the introduction of such subjects as chemistry, anatomy, and husbandry into the university curriculum in order to produce public-spirited citizens capable of actively serving the needs of the Commonwealth. As Hartlib wrote in his *Englands Thankfulness*, the reform of the schools would thus include the "true advancement of Sciences, which my Lord of Saint *Albanes* [Bacon] hath wished" (1647, p. 94). In *A Motion Tending to the Publick Good of this Age,* Dury wrote that this "perfection of human learning" would be a "publique good" that "works as well for this age, as for posterity" (1642, p. 21). Dury defined the public good as "nothing else but the *universall* private good of everyone," and, like Bacon, he was clear that he meant the common good: "that which serveth the turne of some only, although they may be many, and even the greater part, is not to be counted truly Publique; but that is properly Publique which is common, and reacheth alike unto all" (1642, p. 6).

By the 1650s Hartlib's circle had expanded to include John Milton, the mathematician John Wallis, the natural philosopher Kenelm Digby, Milton's close confidante Katherine, Lady Ranelagh, and younger members such as Katherine's brother Robert Boyle, the minister John Beale, and the physician William Petty. The inherent tensions within the Baconian program began to surface among this diverse group. While the members agreed that all classes should be educated, for example, there were differing ideas over the way in which to achieve that goal. Dury argued that students should pursue various educational paths according to their abilities not their means (1650, p. 6). Petty, who was from a merchant family, agreed that those of any class should be allowed to study according to their ability, whereas Milton wished to maintain the established social order.

Additionally, although the ideal of promoting the common good remained as a guiding principle in some works, such as Robert Boyle's "An Invitation to a free and generous Communication of Secrets and Receits in Physick", Petty emphasized the promotion of commercial applications (Boyle, 2000, Vol. 1, pp. 1–9). In his direct appeal to the middle class, he called "for the advance of all mechanical arts and manufactures," by the establishment of "a college of tradesmen" (1648, p. 5). Petty did retain some concern for the common good, however, in his suggestion for "an office of common address" to be put in place at the college so that the "wants and desires of all may be made known unto all" (1648, p. 2).

## 4. The Royal Society

At the Restoration of Monarchy in 1660, members from Hartlib's group as well as natural philosophers from other London and Oxford groups began meeting at Gresham College in what the gentleman horticulturalist, John Evelyn, referred to as the "Philosophic Club" (1907, Vol. 3, p. 157). After one of these meetings, Boyle, Petty, Christopher Wren, John Wilkins, and Sir Robert Moray (who had been with Charles II in exile), discussed "a design of founding a colledge for the promoting of Physico-Mathematical Experimental learning" (*Record of the Royal Society* 1940, p. 7). They sought royal support because, as Wren wrote, the "administration of Government" is facilitated "by the promoting of useful Arts and Science, which, upon mature Inspection, are Found to be the Basis of Civil Communities and free Governments" (Wren, 1750, pp. 196–197). Shortly thereafter, Moray reported that the King had granted them a charter that constituted them "a corporation under the name of the Royal Society for the improvement of natural knowledge by experiment" (Evelyn, 1907, Vol. 3, p. 190).

The Royal Society was to be the institutional embodiment of Bacon's call for cooperative research whereby individual members would contribute according to their differing abilities as simple observers, fact gatherers, experimenters, or interpreters. According to Joseph Glanvill, Bacon's Salomon's House had provided the "Prophetick Scheam" of the Society (1665; cf. Sprat, 1667). The necessity of an extensive cooperative research effort constituted the internal justification of the Society's methods and was practically implemented in the Society's statutes (Record, 1912, p. 250). In statute 4, for example, an ambitious schedule of three-hour weekly meetings were established for members

> to order, take account, consider, and discourse of philosophical experiments and observations; [as well as] to read, hear, and discourse upon letters, reports, and other papers, containing philosophical matters (Record, p. 289).

In order to expand the exchange of information and ideas to the international community Charles II granted that the Royal Society shall have "full power and authority" to

> enjoy mutual intelligence and knowledge with all and all manner of strangers and foreigners, whether private or collegiate, corporate or politic, without any molestation, interruption, or disturbance whatsoever; provided that this our indulgence…be not extended to further use than…things philosophical, mathematical, or mechanical (Record, p. 235).

Among the offices established by the Society's statutes, a Secretary was assigned to keep a record of communication. Henry Oldenburg, a founding member of the Council, tutor to Boyle's nephews, and son-in-law of John Dury, served as secretary from 1662 until his death in 1677. His position was significantly expanded in 1665 when he became the editor of the newly established *Philosophical Transactions* that was designed to advance the cause of open communication. In his introduction to volume 1, Oldenburg wrote "Whereas there is nothing more necessary for promoting the improvement of Philosophical Matters, than the communicating to such, as apply their Studies and Endeavours that way" it was "therefore thought fit to employ the *Press*" to inform those who engage in studies for "the advancement of Learning and profitable Discoveries" (Oldenburg, 1665, p. 1).

With the official constitution of a society for the advancement of learning, however, the tensions in the Baconian program became all the more apparent. There was disagreement among members about the extent to which knowledge should be freely communicated to the public. Because the society aimed at improving human welfare, Robert Hooke, among others, argued that members had a duty to restrict the dissemination of knowledge that could have a detrimental social or physical effect. In addition, secrecy was often demanded by the chemists, glassblowers, metalworkers and other craftsmen whose resources were necessary for experimental

investigations (Newman & Principe, 2002; Perez-Ramos, 1988; Sargent, 1995). Boyle, the earlier advocate of the "free and generous communication of secrets," notoriously kept some processes secret himself so that he would be able to exchange them for the secrets of the alchemists. He also argued that tradesmen should have the right to profit from their innovations and they would be reluctant to share the secrets of their processes with the fellows of the Royal Society unless they had the assurance that these secrets would not in turn become public knowledge (Boyle, 2000, Vol. 6, pp. 396–398; McMullin, 1985; Sargent, 1996; Sargent, 1999).

Tensions also arose in connection with the constitution of the society. When Thomas Sprat recounted the history of the Royal Society in 1667, he described how the contributions of all social classes were to be employed in an effort to foster philosophical and social tolerance in pursuit of the civil stability and economic advantages so glowingly described by Bacon's *New Atlantis*. The work of the Royal Society was to be done "not onely by the hands of Learned and profess'd Philosophers; but from the Shops of *Mechanics*; from the Voyages of *Merchants*; from the ploughs of *Husbandmen*; from the Sports, the Fish-ponds, the Parks, the Gardens of *Gentlemen*" (1667, p. 72). As Sprat noted, however, the Society itself was mostly composed of gentlemen. In his justification for this continuing social stratification, Sprat argued that merchants and other tradesmen would seek personal profit from experiments too soon, whereas gentlemen would be more interested in increasing our knowledge of nature.

Yet, the leading gentleman of the Royal Society, Robert Boyle, argued strenuously in defense of working with tradesmen. In his *Usefulness of Experimental Natural Philosophy*, Boyle was critical of what he found to be the "haughtiness" of some of his contemporaries who thought that mechanical work or commerce with tradesmen was beneath them.

> It seems to me to be none of the least prejudices, that either the haughtiness and negligence, which most men naturally are prone to, or that wherewith they have been infected by the Superciliousness and Laziness, too frequent in Schools, have done to the Progress on Natural Philosophy and the true Interest of Mankind, that Learned and Ingenious Men have been kept such strangers to the Shops and Practices of Tradesmen (2000, Vol. 6, p. 467).

Such commerce was of crucial methodological importance. It not only increased the quantity of information but it improved its quality because data were gathered from a broad base of observers whose varied perspectives could mitigate the effect of individual prejudices.

To further international cooperation, Boyle compiled a list of "general heads" concerning the "things to be observ'd" by merchants, ship captains and other travelers in order for them to best contribute to natural histories that would be useful for the advancement of learning (Boyle, 1667; Boyle, 2000, Vol. 5, pp. 508–511). He participated directly in trading companies and foreign corporations in order to receive information concerning curiosities not known in England. He became an "adventurer" in the Hudson's Bay Company "for the better gaining of such information" about extreme degrees of cold (Boyle, 2000, Vol. 4, p. 546). He was also a member of the East India Trading Company "whereto", he wrote, "the desire of Knowledge, not Profit, drew me." (Vol. 11, p. 385). Boyle had lengthy correspondence with a number of American colonists, but in this instance, his acquaintances were not fostered by informational concerns alone but also by missionary zeal. In 1662, Charles II had appointed Boyle as governor to the New England Company, which was a Corporation for the Propagating of the Gospel in America. Under these auspices, Boyle paid to have the Bible translated into native American languages, much as he had earlier paid for an Irish translation. Boyle's charitable impulses continued throughout his life. In 1688, he published a volume of *Medicinal Experiments: Receipts Sent to a Friend in America*, to aid those in the new land who had little access to trained medical practitioners. Subsequent volumes were published posthumously in 1692 and 1695 (2000, Vols. 11, 12).

Despite some instances of secrecy, Boyle generally ascribed to the Baconian connection between experimental learning and the common good. He often prefaced his Experimental Histories with a discussion of the charitable and beneficial uses that motivated his work. In his *Spring of the Air*, for example, he wrote how the experiments there would have both theoretical and practical benefits. Because the air is "so necessary for humane life," a

> True Account of any Experiment that is New concerning a thing, wherewith we have such constant and necessary intercourse, may not onely prove of some advantage to humane Life, but gratifie Philosophers, by promoting their Speculations on a Subject which hath so much opportunity to sollicite their Curiosity (2000, Vol. 1, p. 158).

Robert Hooke, Boyle's one-time laboratory assistant and curator of experiments for the Royal Society, also displayed this concern for the promotion of science in the interests of the public good. In 1664 Sir John Cutler endowed a Royal Society lectureship for the "promotion of Mechanick Arts" that provided Hooke with an annual stipend. In his *Micrographia* Hooke wrote that Cutler had observed that "the *Arts* of life have been too long *imprisoned* in the dark shops of Mechanicks themselves, and there *hindered from growth*, either by ignorance or self-interest; and he has bravely *freed* them from these inconveniences" and had thus followed the way of "one of the *wisest* of our *Statesmen*, the *Lord Verulam* (Hooke, 1665, pp. [xxvi–xxvii]; cf. *Record*, p. 140).

## 5. The popularization of experimental science

From its start, the Royal Society and its members were subject to criticism and satirical ridicule. In 1676 Thomas Shadwell presented a performance of his play, *The Virtuoso*, dedicated to William Cavendish, the Duke of Newcastle, that questioned the usefulness of experimental methods. The virtuoso, Nicholas Gimcrack, a parody of both Robert Boyle and Robert Hooke, was described as "a sot that has spent two thousand pounds in microscopes to find out the nature of eels in vinegar" (1966 p. 22). Gimcrack also had no need to travel to "take the air" because he had merchants in the countryside who "bottle up air and weight it" and send it to him hermetically sealed (pp. 103–104). In the next century Jonathan Swift pilloried the members of the Royal Society in much the same manner. His *Gulliver's Travels* had similarities to Bacon's *New Atlantis* but, unlike the enlightened fathers of Salomon's house, the inhabitants of the island of Lagado had allowed their houses to fall into disrepair and their land to go uncultivated as they devoted themselves to "Schemes of putting all Arts, Sciences, Languages, and Mechanicks upon a new Foot" (1726, p. 156). Swift also satirized the idea that scientific methods could be used to promote the common good. In "A Modest Proposal for Preventing the Children of Ireland from Being a Burden to their Parents or Country" Swift wrote that his plan to breed Irish children as food for the gentry had "no other Motive than the Public Good of my Country, by advancing of Trade, providing for Infants, relieving the Poor, and giving some Pleasure to the Rich" (1729, p. 29).

Despite these satirical works, or perhaps because of them, the popularity of experimental practices soared during the eighteenth century, fueled as well by the economic and political interests associated with global exploration and trade (Impey & MacGregor, 1985; Newman, 2004; Newman & Principe, 2002). Coffeehouses

and public houses in London provided space for experimenters to present popular lectures on theoretical and practical discoveries (Golinski, 1992; Sorrensen, 1999; Stewart, 1992). In addition, instrument makers frequently offered public lectures that were both entertaining and informative, in order to broaden their customer base. In 1758, for example, Benjamin Martin, maker of "Philosophical, Optical, and Mathematical Instruments" advertized a lecture to be held at his house in Fleet Street where he would be "shewing the most entertaining and considerable experiments" of magnetism and electricity. The advertisement went on to note that "At his shop may be had a new Electrical Machine, Price eight Guineas" (Morton & Wess, 1993).

The most illustrious instrument makers of the century were the George Adamses, father and son, who were the official instrument makers to George II and III (1760–1820). They produced a number of elaborately embellished instruments for the kings, but they also sold much more practical instruments. The younger Adams (1750–95) also wrote treatises on pneumatics and other scientific topics related to the use of his instruments. In his *Essays on the Microscope*, for example, Adams combined both practical and theoretical concerns when he introduced his readers "to the system of Linnaeus" so that they would learn "how to discriminate one" insect from another (1787, p. vii). Near the end of this work Adams provided a list of prices for the scientific instruments he had for sale (p. 720) and in a separately paginated appendix, he listed another catalog of instruments that included those "for Recreation and Amusement", such as diagonal optical glasses, magic lanterns, and electrical games (p. 13).

Merchants, traders, and instrument makers served as important resources for natural philosophical inquiry. In addition, instrument makers brought the methods and instruments of experimentation to a larger segment of society. In the first century of the Royal Society, natural philosophers continued to pursue science for what they believed to be a genuinely communal good, although their particular interests and values would often lead to different suggestions for how the common good could best be achieved (Sargent, 1999, 2005). During the society's second century rhetorical appeals to the common good continued, yet there were significant changes in the description of the ways in which experimental practices could contribute to it. In part, these changes were the result of popular Enlightenment thinkers who sought to introduce scientific methods into studies of the mind, the economy, politics, and ethics. In the process they changed the conceptual framework through which science was understood. A necessarily brief look at three such thinkers, David Hume, Adam Smith, and Jeremy Bentham, provides illustration for how the Enlightenment concepts were at variance with the earlier Baconian ideal.

In *An Enquiry Concerning Human Understanding* (1748), Hume argued that human knowledge was limited to two areas, quantitative mathematical relations and empirically based matters of fact (1993, p. 114). He reduced morals to natural sentiment and he rejected the logical legitimacy of inductive methods, insisting instead that our belief in the existence of causal processes was simply the result of our experience of the constant conjunction of events. He did not deny the usefulness of such beliefs. But, they only had a practical justification, not a logical one, and, therefore, did not rise to the level of knowledge (pp. 22–25; 35–37). In *The Wealth of Nations*, Smith constructed a theory of Political Economy that was designed for two practical objectives (1) to create a system that would enable individuals to provide revenue for themselves and (2) to supply the state "with revenue sufficient for pubic services" (1937, p. 397). He was concerned with the common good, but thought that it would be more practically achieved through an individualized approach. In opposition to the mercantile system that depended on government regulation, Smith argued for a system of free trade where every individual looks to "his own advantage" and "not that of society" (p. 421). By "pursuing his own interest," an individual "frequently promotes that of the society more effectually than when he really intends to promote it." Indeed, he added, "I have never known much good done by those who affected to trade for the public good" (p. 423).

As economic theory developed in the writings of David Ricardo, Thomas Malthus, and James Mill in the nineteenth century, useful knowledge increasing came to be seen as that which would benefit individuals, reflecting a shift from the common good as an abstract concept to a more practical concept of the good as a sum of the members of a community. This emphasis on individualism can be seen in Bentham's *Introduction to the Principles of Morals and Legislation* (1780). Bentham sought to establish an empirical foundation for both moral and civil laws of conduct that would be based on the likely consequences of actions, not on any intuition about absolute moral goods—a point that he noted Hume had made, but only in a vague manner (1823, pp. 289–290). The determination of whether an action was right or wrong depended on a calculation of the short and long-term pleasures and pains that an action would produce for all of those affected it. Then, if one wanted to determine the common good, that would depend on a calculation of the sum of the pleasures and pains of all individuals in the community.

> The interest of the community is one of the most general expressions that can occur in the phraseology of morals: no wonder that the meaning of it is often lost. When it has a meaning, it is this. The community is a fictitious *body*, composed of the individual persons who are considered as constituting its *members*. The interest of the community then is, what?—the sum of the interests of the several members who compose it (1823, p. 3).

These Enlightenment ideals would come to characterize the work of the Royal Society during Joseph Banks long presidency (1788–1820). Although Banks did not write philosophical works that would reveal his adherence to any set of beliefs, under his leadership the public stance of the Royal Society became closely aligned with the Enlightenment emphasis on strict empiricism, individuality, practicality, and a bottom-line style of thinking in opposition to the earlier Baconian ideal of useful knowledge for the common good.

## 6. Joseph Banks and the transformation of the Royal Society

Through the offices of his patron the Earl of Sandwich, first Lord of the Admiralty, Joseph Banks was assigned as naturalist on board the *Endeavour* during Captain Cook's third exploratory voyage to the Pacific in 1776. Banks returned to England with thousands of plant and animal specimens, including many curiosities from Australia (Chambers, 2000, p. 42). Subsequently he became the de facto director of the Botanical Gardens at Kew, where his work included the development of precise directions for how new plants discovered on naval and merchant voyages should be put up for shipment as well as directions for which plants should be transported to other parts of the British empire to be cultivated for commercial benefit (see Carter (2000), Chambers (2000), Gascoigne (1994) and Lyte (1980)). Banks became a powerful advocate for establishing the usefulness of science for advancing the wealth, power, and prestige of the British Empire. In 1778, the Earl of Sandwich helped Banks secure the presidency of the Royal Society, which brought with it a close association with George III, who clearly appreciated the entertainment value of science given his penchant for elaborate scientific instruments. Once president, Banks retained the position for 42 years until his death in 1820.

While Bacon wrote about the ways in which science could benefit the state as well as the common good, Banks was much more finely focused on the concerns of empire and commerce.

He believed that science should serve the good of all, yet in cases of conflict, national interests were to be put ahead of international interests. Given the loss of the American colonies and the centuries-old power struggles with France, the domination of new lands was necessary (Gascoigne, 1998). Banks championed the English settlement of Australia for this purpose and was instrumental in establishing a national imperative for science that would allow Britain to achieve both political and scientific dominance. His political ambitions were closely intertwined with commercial and practical interests. Although Banks initially took issue with Smith's criticisms of the mercantile system when they were at odds with his personal interests, as a member of the Privy Council on the Board of Trade, Banks argued that free trade would stimulate production and open markets. In letters to the Prime Minister, William Pitt the Younger, Banks outlined numerous ways by which science and government could work together to achieve successes in navigation, timekeeping, and the spice trade (Banks, 2000, pp. 155–160, 163, 185; cf. Chambers, 2000, p. 41). He also pointed out the ways in which agricultural improvements could lead to economic progress and national self-sufficiency that would protect England from the misery and death that Malthus had predicted (Gascoigne, 1998).

Banks's commercial and nationalistic concerns did not lead him to discard all traditions within the Royal Society. He maintained and encouraged a large international correspondence, and, much as Boyle had done before him, he was also an investor in the East India Co. and a founding member of the African Association, which gave him access to merchants, settlers, and missionaries who sent him information for the construction of natural histories (Gascoigne, 1998; Keay, 1991). But, Banks did initiate a shift away from the earlier Baconian methods and goals. As a naturalist, he placed most importance on the Humean empirical collection of facts as opposed to the experimental determination of causal processes. Most importantly, however, the Baconian theme of science for the common good took on troubling overtones when Banks produced a rather crude objective calculation of the costs and benefits of a social experiment. On 29 March 1799, Banks wrote to Charles Jenkinson, first Earl of Liverpool, that he had been "directed by the Commee of the African Association to deposit in your Lordship's" hands a proposal concerning the recent discovery of gold in the Niger River. He advised the Earl that it would first be necessary to "secure coastal African lands to the British throne, either by Conquest or by Treaty." Banks added

> Should the Experiment be made, I have little doubt that in a very few years a trading Company might be established under the immediate controul of Government, who would take upon themselves the whole expense of the measure; would govern the Negroes far more mildly, and make them far more happy than they now are under the Tyranny of their arbitrary Princes; would become popular at home by converting them to the Christian Religion, by inculcating in their rough minds the mild morality which is engrafted on the Tenets of our faith, and by effecting the greatest practicable diminution of the Slavery of mankind upon the Principles of natural Justice and commercial Benefit (2000, pp. 209–210).

In effect, Banks had transformed the ideal of science for the common good into a calculation concerning national economic and political interests. At the same time, the possibility of such calculations contributed to the newly-emerging ideal of "objectivity." Despite all of the extra-scientific interests that motivated Banks, for example, in a 1780 letter to Benjamin Franklin he described himself as both the "President of the Royal Society" and "the Friend of disinterested discovery" (2000, p. 54). The scientific knowledge generated experimentally was now considered to have been objectively discovered; only its practical applications involved commercial and political interests. Banks's commitment to this newly emerging ideal of useful knowledge as applied science also led him to work with Count Rumford on a design for a second scientific society—the Royal Institution

## 7. The Royal Institution

Rumford, the American-born Benjamin Thompson, served briefly as a British spy during the American Revolution, became a fellow of the Royal Society in 1779, and was knighted by George III. Shortly thereafter he entered the service of the Elector of Bavaria who made him a Count as reward for the improvements he made to the efficiency of the Bavarian army. Among these improvements, Rumford designed a new way to manufacture cloth for army uniforms that would have greater insulating properties and thus require less clothing for the soldiers. In order to get the cloth and uniforms made, however, he had to find a labor force. He did so by having the beggars of Munich and Mannheim, including men, women, and children, put into "Houses of Industry for the Poor" (Rumford, 1970, Vol. V, pp. 36–44). These workers were housed, clothed, and fed a diet based on "rigorous economy and scientific principles of nutrition." Rumford found that

> the *cheapest*, most *savoury*, and most *nourishing* food that could be provided was a soup composed of *pearl barley, pease, potatoes, cuttings of fine wheaten bread,* vinegar, salt, and water (Rumford, V, 173; cf. Brown, 1979, pp. 96–97; Gascoigne, 1994, p. 186; Thomas, 1999, p. 14).

He further commented that his system contributed greatly to the public good because it had the added benefit of "putting an end to mendacity, and clearing the country of beggars, thieves, robbers, etc." that he described as "detestable vermin" who "infested all the streets, public walks, and public places" (pp. 18, 14). Such workhouses also came into existence in England as part of the Benthamite reform movement.

After his work in Bavaria, Rumford returned to England and became a member of the Society for Bettering the Condition and Increasing the Comforts of the Poor (V, p. 453). It was to this society that Rumford first presented his

> Proposals for forming by subscription, In the Metropolis of the British Empire, A Public Institution for Diffusing the Knowledge and Facilitating the General Introduction of Useful Mechanical Inventions and Improvements, and for Teaching, by Courses of Philosophical Lectures and Experiments, the Applications of Science to the Common Purposes of Life (V, p. 439).

Banks, also a member of the Society for Bettering the Condition of the Poor, hosted the first formal meeting of the Institution at his home (Thomas, 1999; cf. Caroe, 1985; Crowley, 1990; Gascoigne, 1998; Lyte, 1980).

The Institution, which was granted a Royal charter in 1800, blended well the commercial interests of businessmen with the political aspirations of the British Empire. In 1801 Humphry Davy, who had published a paper in the *Philosophical Transactions* on the anesthetic effects of nitrous oxide the previous year, was appointed lecturer. Davy was particularly adept at giving popular lectures illustrated by spectacular experimental demonstrations. His dynamic style, coupled with his ability to explain abstruse processes in entertaining fashion, turned his evening lectures into social events that drew crowds of both men and women.

Davy believed that science could and should transform society for the better. In 1815 he invented the safety lamp that limited underground explosions thereby saving miners' lives and benefiting the mining industry (Davy, [1812] 1840; cf. Knight, 1992;

Levere, 1980). Banks, himself a mine owner, wrote to Davy on 30 October 1815:

> no one else could discover the means of defending society from a Tremendous Scourge of humanity, and to have by the application of Enlightened Philosophy found the means of Providing a Certain Precautionary measure Effectual to guard mankind for the future against this alarming and increasing Evil (2000, p. 317).

The establishment of the Royal Institution, with its focus on practical application, in opposition to the Royal Society that was increasingly seen as devoted to the more esoteric elements of pure science, created an institutional divide between theory and practice—something that Bacon and his early followers had rejected. Davy's invention of the lamp, however, as well as his discoveries in agriculture and elemental chemistry, had been made possible by theoretical work that he accomplished by developing experimental techniques for the electro-chemical analysis of materials.

Davy understood well the necessity of combining theory and practice, yet his description of scientific practice was not the dynamic process described by Bacon but the newer ideal of an empirical and progressively cumulative collection of facts and laws, which he nonetheless attributed to his predecessor. In an early lecture Davy stated, Lord Bacon was "the first philosopher who laid down plans for extending knowledge of universal application," and "who ventured to assert, that all sciences could be nothing more than expressions or arrangements of facts" ([1804] 1840, Vol. 7, p. 121). In 1820, when Davy succeeded Banks as president of the Royal Society, his inaugural address was titled, "On the Progress and Prospects of Science." He concluded his address with an expression of the type of nationalistic pride that Banks had fostered before him:

> Let it not be said that, at a period when our empire was at its highest pitch of greatness, the sciences began to decline; let us rather hope that posterity will find, in the *Philosophical Transactions* of our days, proofs that we were not unworthy of the times in which we lived (1840, Vol. 7, p. 15).

## 8. Concluding remarks

The pursuit of science for the common good started out as an abstract ideal that became more complex and problematic as it was applied in concrete situations. The historical shift away from the communal and toward the individual also contributed to this growing complexity. To conclude, there are two themes intertwined in the above account that should be briefly addressed. One concerns the history of philosophy of science and the other has to do with science in the public interest.

(1) Philosophers of science, among others, should be aware of distortions in the history of philosophy of science, particularly as they arose from the 19th century natural philosophers' triumphant account of the history of science. Davy for example, described the history of science as one continuous story of progress. His comments in his Presidential address reflect that style. He hoped that "our philosophers will attach no importance to hypotheses, except as leading to the research after facts." In doing so, he said:

> I trust that in all our researches we shall be guided by that spirit of philosophy, awakened by our great masters, Bacon and Newton; that sober and cautious method of inductive reasoning which is the germ of truth and the permanency in all the sciences (1840, Vol. 7, p. 14).

As the century wore on, the rhetoric of a disinterested or detached objectivity also became the norm and it was read back into the works of seventeenth century experimental philosophers. Indeed by the next generation, Auguste Comte, William Stanley Jevons, and John Stuart Mill will all trace positivism back to the works of Bacon (Comte, 1988, pp. 38–45; Jevons, 1875, pp. vi–vii, 134–135; Mill, 1866, pp. 8–9; cf. Campbell, 1986; Haac, 1995).

(2) The pursuit of science in the public interest will always be problematic. Ethically, it is necessary to be clear on what we mean by the common good—is it to be determined by a Utilitarian calculation or is there a workable Baconian conception? Even if we are able to solve that issue, however, implementing science for the common good will always involve the imposition of values derived from economic, political, and religious interests and convictions that can lead to paternalistic, chauvinistic, and imperialistic practices. Science and its applications have always had these tensions, although philosophers of science in the twentieth century mostly failed to acknowledge them. The interests guiding research must be made transparent so that they can be assessed, but transparency is not enough. Banks was certainly transparent in his nationalistic and commercial goals. Further, not all interests can be made transparent. Bacon's idols of the mind, those prejudices and biases that are so ingrained that we have difficulty recognizing their existence or their influence, will always create problems. This situation strengthens current arguments about the need for scientific research to be conducted by all segments of society (Kourany, 2003; Longino, 1990; Longino, 2002). The particular prejudices of individual researchers and research societies are easier to recognize when the scientific community at large is composed of investigators with varied interests derived from their varied backgrounds.

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