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RESEARCH ARTICLE

Johann Christoph Sturm's eclectic scientific method and his indebtedness to Francis Bacon

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Abstract

In this paper, I argue that Johann Christoph Sturm's eclectic scientific method reveals an unexpected indebtedness to Francis Bacon's thought. Sturm's reception of Bacon is particularly surprising given that the German academic context in the second half of the seventeenth century was still largely Aristotelian. Sturm is indebted to Bacon in the following respects: (1) the critique of the current state of knowledge, (2) eclecticism, (3) a fluid transition from natural history to natural philosophy, (4) the conception of science as hypothetical and dynamic and (5) experimental philosophy and the use of instruments. Given that Sturm mentions Francis Bacon in important places in his work, these respects should not easily be dismissed as commonplace. Bacon is one of Sturm's salient sources and they are both deeply concerned with a thoroughgoing reform of existing scientific practices.

Francis Bacon (1561–1626) is often acknowledged as one the masterminds of modern (in particular, experimental) science. He was seen as having laid the foundation of the scientific agenda of the Royal Society, founded in 1660 – less than fifty years after his death.[1] He is perhaps unrivalled in his call for a radical new start in the study of nature grounded in a fundamentally new method. However, the diffusion of Bacon's thoughts on method on the European mainland and their adoption in the academic environment of early modern universities have not been extensively studied.[2] While there is a growing amount of research in the French intellectual context on Bacon's influence on figures such as Descartes, Gassendi and Mersenne, as well as within the probably even more liberal Dutch context, cases of a possible adoption of Bacon's scientific method in other continental European countries

[1] Antonio Perez-Ramos, *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition*, Oxford: Clarendon Press, 1988, p. 14; Dana Jalobeanu, *The Art of Experimental Natural History: Francis Bacon in Context*, Bucharest: Zeta Books, 2015, p. 200; Rose-Mary Sargant, 'Bacon as an advocate for cooperative scientific research', in Markku Peltonen (ed.), *The Cambridge Companion to Bacon*, Cambridge: Cambridge University Press, 1996, pp. 146–71, 166; Stephen Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*, Cambridge: Cambridge University Press, 2001, p. 2; William T. Lynch, *Solomon's Child: Method in the Early Royal Society of London*, Stanford, CA: Stanford University Press, 2001, pp. 1–33, 233–49; Peter Harrison, *The Fall of Man and the Foundations of Science*, Cambridge: Cambridge University Press, 2007, pp. 184, 198–9.

[2] Jalobeanu, op. cit. (1) p. 41, also notes, 'Much more needs to be done, at the level of sources, ways of transmissions and ways of interpretation at work in various forms of Baconianism.'

remains largely unclear.[3] One of the few attempts to clarify the adoption of Bacon's method, here, for the purpose of educational reform of the university curriculum in Germany, is Heßbrüggen-Walter.[4] He analyses the philosophical discussion between Gerard De Neufville (1590–1648) and Johann Clauberg (1622–65). His conclusion, however, remains rather negative, arguing that De Neufville regards the adoption of Bacon's method, particularly his educational project, as dangerous and devastating to the institutional framework of universities. Clauberg, in turn, favours a Cartesian rather than a Baconian reform.[5]

In this paper, I will argue that with respect to Johann Christoph Sturm's eclectic scientific method, we are confronted with an unexpected indebtedness to and positive reception of Bacon's thought. Sturm's reception is particularly surprising given that the German academic intellectual context in the second half of the seventeenth century, unlike the British, French or Dutch context, was still largely (what we might call for the sake of simplicity) Aristotelian-scholastic.

Sturm (1635–1703) was a professor of mathematics and physics at the University of Altdorf from 1669 until his death. More than just another scholastic university lecturer, he actively strove for an improved natural philosophy taking into consideration recent developments in the field, both theoretical and practical. Sturm, for instance, adopted the Cartesian conception of matter as purely extended and passive, reconceived scholastic forms as purely passive modifications of matter, and advocated an occasionalist explanation of causal interaction while at the same time retaining the traditional notion of finality in nature.[6] While this is a telling indication of Sturm's eclectic intuitions, he also sought to abide by the practical experimental standards of his day, such as making use of the new instruments available like the telescope, microscope, air pump and diver's bell. Sturm's scientific method remains under-studied, perhaps because scholars identified him as 'yet another Aristotelian scholastic'.[7] To the best of my knowledge, this article is indeed the

[3] Perez-Ramos, op. cit. (1), pp. 8–12; Claudio Buccolini, 'Mersenne translator of Bacon?', *Journal of Early Modern Studies* (2013) 2, pp. 33–59; Elodie Cassan, *Bacon et Descartes: Genèses de la modernité philosophique*, Lyon: ENS éditions, 2014; Andrea Strazzoni, 'The Dutch fates of Bacon's philosophy: "libertas philosophandi", Cartesian logic and Newtonianism', *Annali della Scuola Normale Superiore di Pisa: Classe di Lettere e Filosofia* (2012) 4, pp. 251–81; Benedino Gemelli, 'Bacon in Holland: some evidence from Isaac Beeckman's Journal', *Journal of Early Modern Studies* (2014) 3, pp. 107–30.

[4] Stefan Heßbrüggen-Walter, 'Institutioni scholasticae minime accomodata: de Neufville and Clauberg on not teaching Bacon', in Andrea Sangiacomo (ed.), *History of Universities*, vol. 33: *Reshaping Natural Philosophy: Tradition and Innovation in the Early Modern Academic Milieu*, Oxford: Oxford University Press, 2020, pp. 36–56.

[5] Jürgen Klein, 'The reception of Francis Bacon in 17th-century German philosophy', *Intellectual News* (2004) 14, pp. 75–93; Daniel P. Colette and Doina-Cristina Rusu, 'Comenius, Bacon and the Royal Society', in Dana Jalobeanu and Charles T. Wolfe (eds.), *Encyclopedia of Early Modern Philosophy and the Science*, Dordrecht: Springer, 2022; Jalobeanu, op. cit. (1), pp. 187–92; Guido Giglioni. 'How Bacon became Baconian', in Daniel Garber and Sophie Roux (eds.), *The Mechanization of Natural Philosophy*, Dordrecht: Springer, 2013, pp. 27–54, 47–9.

[6] Christian Henkel, 'Mechanism, occasionalism, and final causes in Johann Christoph Sturm's Physics', *Early Science and Medicine* (2021) 26, pp. 314–40; Henkel, *Occasionalism and the Debate about Causation in Early Modern Germany*, London and New York: Routledge, 2024, pp. 48–85; Andrea Sangiacomo, 'Johann Christoph Sturm's natural philosophy: passive forms, occasionalism and scientific explanations', *Journal of the History of Philosophy* (2020) 58, pp. 493–520.

[7] Michael Albrecht, *Eklektik: Eine Begriffsgeschichte mit Hinweisen auf die Philosophie- und Wissenschaftsgeschichte*, Stuttgart–Bad Cannstatt: Friedrich Frommann Verlag (Günther Holzboog), 1994, pp. 309–57; Albrecht, 'Johann Christoph Sturm', in Helmut Holzhey and Wilhelm Schmidt-Biggemann (eds.), *Grundriss der Geschichte der Philosophie: Die Philosophie des 17. Jahrhunderts. Das Heilige Römische Reich Deutscher Nation, Nord- und Ostmitteleuropa*, Basel: Schwabe, 2001, vol. 4/2, pp. 942–47; Thomas Ahnert, '"Nullius in verba": Autorität und Experiment in der Frühen Neuzeit. Das Beispiel Johann Christoph Sturms (1635–1703)', *Zeitsprünge* (2003) 7, pp. 604–18; Constance W.T. Blackwell, 'The case of Honoré Fabri and the historiography of sixteenth- and seventeenth- century Jesuit Aristotelianism in Protestant history of philosophy: Sturm, Morhof and Brucker', *Nouvelles de la République des*

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first one in English to investigate Sturm's scientific method, and it shows his indebtedness to Bacon.

I will show that Bacon is not only one of Sturm's salient sources for the development of his scientific method, but that their approaches bear strong similarities. These consist of (at least) five elements, all of which are also found in Bacon. These elements are as follows.

1. The critique of the current state of knowledge, in particular, the dogmatism or sectarianism of (what they considered) Aristotelian scholasticism, and the call for a new method to further the advancement and progress of the sciences.
2. Eclecticism, which is at the heart of the implementation of this method. Eclecticism goes hand in hand with the belief in science as a collective endeavour motivated by the feebleness resulting from the conception of the postlapsarian state of the human mind – Bacon and Sturm share this Protestant intuition. Importantly, Sturm identifies Bacon as a fellow eclectic philosopher and hence as a combatant in a fight for an overhaul of the sciences.
3. A fluid transition from a natural history, a documentation of phenomena, to a natural philosophy, that is, the causal explanation of phenomena.
4. The idea of science as hypothetical and dynamic.
5. The necessity of an experimental philosophy and the use of instruments.

Critique of the current state of the sciences and a call for a new method

Sturm introduces his philosophical main work, the *Physica electiva* (1697/1722) with a quotation from Bacon's *De augmentis scientiarum* (1623):

> Another Errour of a diuerse nature from all the former, is the ouerearly and preemptorie reduction of knowledge into Arts and Methodes: from which time, commonly Sciences receiue small or no augmentation. But as young men, when they knit and shape perfectly, doe seldome grow to a further stature: so knowledge, while it is in Aphorismes and obseruations, it is in growth; but when it once is comprehended in exact Methodes; it may perchance be further pollished and illustrate, and accomodated for vse and practise, but it encreaseth no more in bulke and substance.[8]

lettres (1995) 1, pp. 49–78; Blackwell, 'Sturm, Morhof and Brucker vs. Aristotle: three eclectic natural philosophers view the Aristotelian method', in Daniel A. Di Liscia, Eckhard Kessler and Charlotte Methuen (eds.), *Method and Order in Renaissance Philosophy of Nature: The Aristotle Commentary Tradition*, Aldershot: Ashgate Publishing Limited, 1997, pp. 381–407; Josef Bohatec, *Die cartesianische Scholastik in der Philosophie und reformierten Dogmatik des 17. Jahrhunderts. I. Teil: Entstehung, Eigenart, Geschichte und philosophische Ausprägung der cartesianischen Scholastik*, Leipzig: A. Deichert'sche Verlagsbuchhandlung, 1912; Myriam Dennehy, 'Leibniz et Sturm, lecteurs de Boyle', in Myriam Dennehy and Charles Raimond (eds.), *La philosophie naturelle de Robert Boyle*, Paris: Vrin, 2009, pp. 331–59; Stefan Kratochwil, 'Johann Christoph Sturm und Gottfried Wilhelm Leibniz', in Hans Gaab, Pierre Leich and Günter Löffladt (eds.), *Johann Christoph Sturm (1635–1703)*, Frankfurt am Main: Harri Deutsch, 2004, pp. 104–18; Heribert M. Nobis, 'Die Bedeutung der Leibnizschrift "De ipsa natura" im Lichte ihrer begriffgeschichtlichen Voraussetzungen', *Zeitschrift für philosophische Forschung* (1966) 20, pp. 525–38; Ulrich Leinsle, 'Universalmathematik und Metaphysik bei Johann Christoph Sturm', in Gaab, Leich and Löffladt, op. cit., pp. 153–83; Henkel, opera cit. (6); Sangiacomo, op. cit. (6); Andrea Sangiacomo, 'The normalization of natural philosophy: occasional causality and coarse-grained reality', in Sangiacomo, op. cit. (4), pp. 202–36; Michael Albrecht, 'Hypothesen und Phänomene: Zu Johann Christoph Sturms Theorie der wissenschaftlichen Methode', in Gaab, Leich and Löffladt, op. cit., pp. 119–35.

[8] Francis Bacon, *The Oxford Francis Bacon* (ed. Graham Rees *et al.*), Oxford: Oxford University Press, 2001– (hereafter *OFB*), vol. 4, pp. 29–30. I am using the English translation from the *Advancement of Learning*, Book 1, pp. 29–30. When citing Bacon, I leave the emphases unchanged unless otherwise indicated. When citing from the *Advancement of Learning*, I follow Bacon's old English orthography.

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This passage appears in the context of Bacon's critique of errors, which he claims have impeded progress in the sciences and in learning. What Bacon takes issue with here is that in some cases knowledge is codified too rashly. Instead of allowing it to grow in a less determined preliminary form (aphorisms or observations), it is put down in such a way that nothing can be done about it but put it into practice. While Bacon favours knowledge that is useful in contrast to knowledge that is purely speculative, abstract and fantastical (as he finds exemplified by the scholastics), it should still be open to further improvement. Finally, the quest for knowledge does not end with one fixed application but is open-ended.

According to Sturm, the whole of philosophers bracketing sceptics and doubters (*sceptios ac dubitatores*) can be subsumed in two classes: sectarians and eclectics.[9] While sectarianism impedes learning, eclecticism furthers the advancement of the sciences. Hence it is precisely as part of Sturm's characterization of sectarian philosophy that we find his critical engagement with the current state of the sciences, and his dissatisfaction with some of his university colleagues in the field of natural philosophy. Since Sturm himself was a university professor of physics and mathematics, he is constrained by the academic guidelines of teaching as well as by rules of engaging with his colleagues. Hence we should expect his critique to be balanced and moderate, though no less compelling.

For Sturm, sectarian thinkers are being led by an authority on whom they slavishly depend. They do not follow their own reasoning, but spend their time absorbing, reproducing and fiercely defending what they have learned *ex cathedra*.[10] Most of the sectarians follow one leader (*unum Ducem sequentium*), and that is why Sturm defines sectarian philosophy as follows:

> Therefore, in this treatise [the *De philosophia sectaria et electiva*], we call sectarian philosophy that which draws [*hausit*] nearly all its doctrines [*dogmata*] not seldom even the very order of what is to be taught, from the mouth or the writings of one master or teacher [*doctoris*] so that it seems to the followers [of sectarian philosophy] themselves that other things which are truer or more correct can nowhere be found.[11]

The most notable sects in Sturm's days are (according to him) the Aristotelians (*secta Aristotelica*), with their two main branches, the Greek interpreters and the scholastic commentators; the Cartesians (*secta Cartesiana*); the Gassendists (*secta Gassendica*), reviving

[9] Johann Christoph Sturm, *De philosophia sectaria & electiva habita 1679: Respondente Joh. Christophoro Sauter Norimbergensi*, in Sturm, *Joh. Christoph. Sturmii P.P. Philosophia eclectica, h.e. exercitationes academicae*, Frankfurt and Leipzig: Jobst Wilhelm Kohles, 1698, vol. 1 (hereafter *PSE*), p. 3. Bohatec, op. cit. (7), p. 14, points out that Sturm follows Gerardus Vossius's (1577–1649) characterization of philosophy as presented in the latter's *De philosophia et philosophorum sectis*.

[10] Sectarians are those 'who preferred to be led [rather] than walk [by themselves] and who followed [the path] previously tread by [their] master due to a feminine affection in such a way that they spent all their effort on correctly apprehending [*percipiendis*] and interpreting doctrines and hypotheses familiar to them, on fiercely defending [them] against the ones thinking differently [*contrasentientes*], and on vigorously fighting against the contrary opinions of these [i.e. those thinking otherwise] and refuting [them]'. Sturm, *PSE*, op. cit. (9), p. 3: 'qui duci quam ire malebant & praeeuntem magistrum affectu foemineo ita sequebantur, ut omne suum studium in dogmatibus ac hypothesibus sibi familiaribus recte percipiendis ac interpretandis, adversus contrasentientes mordicus defendendis, horumque contrariis opinionibus acriter impugnandis ac refutandis, collocarent.' All translations from the Latin original are my own. I leave the orthography and italics unchanged unless stated otherwise. To facilitate reading, I will occasionally change the punctuation.

[11] The formulation 'unum Ducem sequentem' appears at Sturm, *PSE*, op. cit. (9), p. 4. The indented quote reads in Latin: '*Sectariam* itaque *Philosophiam* hoc nostro tractatu eam appellamus, quae dogmata sua, imo haut raro docendorum etiam ordinem ex unius Magistri aut Doctoris vel ore vel scriptis ita hausit pleraque omnia ut alia verius rectiusque dicta nuspiam repertum iri videatur ipsius asseclis'. Sturm, *PSE*, op. cit. (9), pp. 11–12.

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Epicurean and Democritean thought; and the Neoplatonists (*secta Neo-Platonica*).[12] In his *Physica electiva*, Sturm also mentions the alchemical school (the *Spagyric* school or that of the chemists (*Chemicorum*)) as the fourth main one, omitting Neoplatonism.[13]

Bacon influenced Sturm's critique of the state of learning and his call for reform. However, since Bacon was free from the constraints of university statutes (he did not hold a university position during his life) and since the Aristotelian-scholastic framework was still firmly in place in his period, Bacon's critique of the state of the sciences is more outspoken than Sturm's. Bacon laments that the predominant Aristotelian-scholastic philosophy is authority-ridden, based on empty words, unworldly and essentially useless as far as the improvement of the human condition is concerned: 'For once men have surrendered their judgements and … concurred in supporting one man's opinion they do not enlarge the actual sciences but discharge the servile function of furnishing a guard of honour for certain authors.'[14]

What Bacon criticizes here is that men have stopped using their own reason, evaluating things for themselves, and have instead chosen to blindly and slavishly follow one man's standpoint. While this 'one man' might stand for authority more generally, given the context of Bacon's writing, it stands for Aristotle in particular. According to Bacon, this one-sidedness has led to a stalemate in the enquiry into nature. Bacon's critique also extends to the way the sciences are being taught and 'research' is conducted:

> Now the condition of the knowledge handed down and received is pretty much this: it is barren in works, and bloated with questions, its rate of growth is slow and sluggish, it simulates perfection in the whole but is poorly developed in its parts, it is popular in its distinctions and distrusted by its own authors, and therefore it is fortified and tricked out with all sorts of cunning devices.[15]

Bacon's objection is directed against scholasticism and its transmission of knowledge. He takes issue with its disputation-based, dialectic character. Instead of studying the things themselves, the schoolmen dedicate themselves to a highly intellectualist, but ultimately pointless, enterprise: they fabricate questions, and use an excessively complicated and complex technical vocabulary to answer them. Yet this serves more to safeguard their purely self-centred system than to further knowledge. In addition, Bacon also insinuates that scholastic philosophy might crumble if it were in open competition with other philosophies. Its abstract technicalities are its survival strategy. Indeed,

> we find that everything in the customs and organisation of schools, academies, and similar foundations meant as seats for learned men and the cultivation of knowledge militates against the advancement of learning. For the lectures and exercises are so arranged that it would hardly occur to anyone even to consider thinking anything unusual.[16]

Novelty does not emerge, and where it does, it is systematically suppressed.

[12] Sturm, *PSE*, op. cit. (9), p. 13.

[13] Johann Christoph Sturm, *Physica electiva sive hypothetica: tomus primus*, in J. Ecole, H.W. Arndt, R. Theis, W. Schneiders and S. Carboncini-Gavanelli (eds.), *Christian Wolff: Gesammelte Werke, Materialien und Dokumente*, Hildesheim: Georg Olms Verlag, 2006, vol. 97.1.1. (hereafter *PE* I), preface, art. 3.5.

[14] Bacon, *Great Instauration Preliminaries*, *OFB*, op. cit. (8), vol. 11, p. 13.

[15] Bacon, *Great Instauration Preliminaries*, *OFB*, op. cit. (8), vol. 11, p. 15.

[16] Bacon, *Novum Organum I: aphor. 90*, *OFB*, op. cit. (8), vol. 11, p. 147.

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Bacon also criticized other 'sects' of the past and the near present: the philosophical systems of the pre-Socratics, and Renaissance natural philosophers such as Patrizi, Telesio, Bruno and Campanella, as well as Severinus and Gilbert.[17] For him, they are all guilty of creating 'fictions' of nature rather than natural philosophies that have enquired into the things themselves.[18] Similarly, Bacon criticizes the philosophy of the 'chemists' (i.e. the alchemists) for having 'founded a fantastic philosophy on a few furnace experiments'.[19] Furthermore, sectarianism entails that 'authority is taken for truth, not truth for authority.'[20] Bacon's overall anti-sectarian stance is perhaps most clear in his critique of the '*Idols of the Theatre, or Theories*'. Bacon here subsumes some of the aforementioned philosophers under three kinds of sects or 'three kinds of *false Philosophy*: the *Sophistical, Empirical*, and *Superstitious*'.[21] While the sophist or rational philosophy *à la* Aristotle and the scholastics is most concerned with squeezing nature into a narrow set of preconceived categories and with dialectics, the empirical philosophy *à la* Gilbert and the alchemists forms the most general theories from only a handful of experiments.[22] In modern terms one might think of the results (theories, propositions and so on) of empirical philosophy as lacking (statistical) significance. Superstitious philosophy *à la* Pythagoras, Plato and modern mosaic philosophers of Bacon's own days finally mixes philosophy and theology – which for Bacon should be kept separate – and arrives at results more fantastical than empirical philosophy does. Furthermore, this kind of philosophy corrupts philosophy and theology alike.[23]

For both Sturm and Bacon, the diagnosis of the deplorable state of the sciences motivates a call for a methodological and educational reform, or, as Bacon himself puts it, 'the only course left was to try to do everything again with better assistance, and undertake a wholesale *Instauration* of the sciences, arts and all human learning, raised on proper foundations'.[24] This new method is grounded in the use of both reason and experience, non-dogmatic philosophizing and ridding oneself of preconceived notions.[25] Furthermore, Bacon endorses eclecticism, causal explanations in natural philosophy, the idea of science as a collective enterprise and experimentation. I will discuss each of these elements in turn starting with eclecticism.

Eclecticism and science as a collective endeavour

While sectarian philosophy has led to a stalemate in learning, according to Sturm, eclecticism will advance the sciences in the future. The eclectic method consists in nothing else than 'to select and adopt [*sibi sumere*] from all sects of Philosophers that which is true, having left behind what is false and erroneous'.[26] According to Sturm, any free future philosopher should be an eclectic.[27]

[17] Bacon, *Historia Naturalis et Experimentalis*, *OFB*, op. cit. (8), vol. 12, p. 9. Silvia Manzo, 'Reading scepticism historically: scepticism, acatalepsia, and the fall of Adam in Francis Bacon', in Plínio Junqueira Smith and Sébastien Charles (eds.), *Academic Scepticism in the Development of Early Modern Philosophy*, Cham: Springer, 2017, pp. 81–102.

[18] Bacon, *Historia Naturalis et Experimentalis*, *OFB*, op. cit. (8), vol. 12, p. 7.

[19] Bacon, *Novum Organum I: aphor. 54*, *OFB*, op. cit. (8), vol. 11, p. 89.

[20] Bacon, *Historia Naturalis et Experimentalis*, *OFB*, op. cit. (8), vol. 12, p. 9.

[21] Bacon, *Novum Organum I: aphor. 62*, *OFB*, op. cit. (8), vol. 11, pp. 96–9, 99, emphasis in original.

[22] Bacon, *Novum Organum I: aphor. 63*, *OFB*, op. cit. (8), vol. 11, pp. 98–101.

[23] Bacon, *Novum Organum I: aphor. 65*, *OFB*, op. cit. (8), vol. 11, pp. 101–3.

[24] Bacon, *Great Instauration Preliminaries*, *OFB*, op. cit. (8), vol. 11, p. 3.

[25] Bacon, *Great Instauration Preliminaries*, *OFB*, op. cit. (8), vol. 1, pp. 21, 25 153, 155, 175. Bacon explicitly says that he is not 'laying foundations of sect or dogma, but of utility and human greatness. Bacon, *Great Instauration Preliminaries*, *OFB*, op. cit. (8), vol. 11, p. 25.

[26] Sturm, *PE* I, op. cit. (13), preface, art. 2.1: 'ex omnibus Philosophorum sectis id quod verum est seligere & sibi sumere, relictis falsis & erroneis'. See also Sturm, *PSE*, op. cit. (9), p. 6.

[27] Sturm *PE* I, op. cit. (13), preface, art. 2,1: 'Eclecticum esse debere, qui futurus liber Philosophus est'.

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The case for eclecticism is made *ex negativo* by challenging sectarianism and, positively, by bringing to light the strengths of the eclectic method. Concerning the former, the adoption of sectarian philosophy is first of all not a necessity (*Sectariae quippe Philosophiae* primo *nulla est necessitas*, emphasis in original). It is not the only option.[28] Second, following one authority is even dangerous and damaging to the advancement and augmentation of the sciences.[29] In contrast to this, eclectic philosophers are defined as

> those who did not want to hang on to every word of someone, nor swear by the words of one master; they knew and collected for their storehouse everything that is true and good from the words and writings of whatever teachers [*Doctorum*], not convinced by the authority of the person teaching but by the weight of the arguments and the force of the demonstrations; even more they added from themselves as much as they could; they make it their business [*sustineant*] to see with their own rather than with someone else's eyes.[30]

The anti-authoritarian approach of eclecticism, following one's own reasoning rather than the dogmas of a certain teacher, is what allows one to appreciate truth in (almost) every philosopher's works. Furthermore, in a dissertation *On the Authority of the Interpreters of Nature* (*De authoritate interpretum naturae*), Sturm cautions against endorsing extreme positions in philosophy. More concretely, he cautions against falling from one extreme position into another by replacing Aristotelian with Cartesian natural philosophy.[31] This is an aspect of Sturm's eclectic approach that might well have been taken from Bacon. In part, avoiding extreme positions might have struck Sturm as wise given that humans are prone to error, and extreme, immoderate positions are perhaps more likely to be false. The eclectic method indeed acknowledges the feebleness of the human mind, its proclivity to err.[32]

As Bacon before, Sturm takes this cue from the Protestant position of the corruption of the human mind after the Fall. Since humans on their own tend to misjudge things or make mistakes, they depend on one another as correctives. If past or present scientific theories show signs of error in that they do not meet the objective criteria that good hypotheses, on which they are based, must meet (section IV), they can be improved. The scientific study of nature, if it is to succeed, hence becomes a collective endeavour:

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[28] See Sturm *PSE*, op. cit. (9), pp. 28–9.

[29] Sturm, *PSE*, op. cit. (9), p. 29: 'That way of philosophizing [i.e. the way of the sectarians], which trusts but the authority of one leader, is not only not necessary, but not even useful, nay even dangerous and damaging to the advancement of the sciences.' 'Neque vero *non necessarius* tantum, sed ne utilis quidem, imo perniciosus noxiusque scientiarum augmentis est ille philosophandi modus [i.e. the way of the sectarians], quo ducis unius authoritati fidere nimium'.

[30] Sturm, *PSE*, op. cit. (9), pp. 3–4: 'qui ab unius ore pendere, aut in verba unius Magistri jurare nolentes, ex ore scriptisve Doctorum quorumcunque, quicquid veri bonique, non docentis authoritate, sed Argumentorum pondere ac demonstrationum αναγκη convicti, cognovissent, in horrea sua colligebant, adeoque, de suo subinde, quantum poterant addentes, oculis suis potius, quam alienis videre sustineant'. See also Sturm, *PSE*, op. cit. (9), pp. 6, 28.

[31] Johann Christoph Sturm, *De authoritate interpretum naturae et speciatim Aristotelis habita 1672: Respondente M. Augusto Huss. Norimb*, in Sturm, *Joh. Christoph. Sturmii P.P. Philosophia eclectica*, op. cit. (9), vol. 1, 155–6: 'But I would be altogether foolish, if, willing to shake off the yoke of the Aristotelian Monarchy I were to subject [my] bowed head to the Cartesian rule or that of another name, or if I proposed to others that they subject themselves … *having fallen from one extreme into another*'. 'Ineptus autem omnino essem, si jugum Aristotelicæ Monarchiæ excussurus imperio Cartesiano aliivè cujuscunque nominis demissam cervicem subjicerem, aliisve ut se subjicerent, suaderem … *uno extremo ad alterum delapsi*.' My emphasis.

[32] Sturm, *PSE*, op. cit. (9), p. 23.

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> By the name of the eclectic philosophers we understand in this whole treatise no others than those, who do not reject without a difference all the things that are found [*inventa*] and left [*tradita*] by the heads of different sects, and who are not so moved by the authority of one leader that they do accept all of his utterances and *bons mots* [*dicteria*], but who acknowledge the feebleness [*imbecillitatem*] of the human mind [*humani ingenii*], which makes it apparent that all depths of nature and reason cannot be exhausted by one or a few men; they persuade themselves that the truth can only be viewed in part, and that the sciences are to be advanced and stabilized by means of united powers [*junctis viribus*] and communicated advice [*communicato consilio*].[33]

Drawing upon Vossius's *De philosophorum sectis* (1657/8), Sturm points out, 'Therefore, if no one is free from error, it has to be considered [*videndum*] not so much who says something, as what someone says'.[34] Science is also a collective endeavour, because the number of things to be studied is endless.[35] The 'multitude of works and artifices of the divine Intellect and Omnipotence in this vastness of Nature is so great and [their] subtlety so abstruse' that no scientist on her own, not even the most ingenious, could exhaustively investigate it. Some scientists specialize in one discipline, others in another, while at the same time results are shared and put together.[36]

It should be stressed that although eclecticism means collecting what is good in other authors, it does not just aim at a mere collection of true or probable hypotheses (the selection criteria of which will be discussed below), but instead at the formulation of a coherent system of natural philosophy based on what is found in other authors.[37] Eclecticism in Sturm's eyes explicitly invites the correction, emendation and augmentation of existing theories.[38]

When considering Sturm in relation to Bacon, the first thing that needs to be noted is that Bacon's discontent with the scientific practices of his contemporaries refers to the two extreme unmediated approaches by means of which they conduct their studies. On the one end is the extreme 'empiricism' of philosophers such as William Gilbert (1544–1603) and the alchemical tradition more generally, on the other end is the extreme 'rationalism' of the scholastics. Bacon seeks a middle way, and this also leads him to spell out his eclectic intuitions:

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[33] Sturm, *PSE*, op. cit. (9), pp. 7–8: 'Eclecticorum Philosophorum nomine per totam hanc tractationem non alios non intelligere, quam eos, qui non rejiciunt promiscue quaecunque ab aliis sectis earumque capitibus inventa sunt aut tradita, nec unius Ducis authoritate ita commeventur, ut ejus effata & dicteria promiscue probent & propugnent omnia; sed humani ingenii imbecillitatem agnoscentes, quae ab uno aut paucis quibusdam hominibus omnes Naturae & Rationis abyssos exhauriri nunquam patiatur […]; verum ex parte perviderí posse, junctisq; viribus & communicato consilio scientias augendas & stabiliendas esse, sibi persuadent'. See also Sturm, *PSE*, op. cit. (9), p. 23; Sturm, *PE* I, op. cit. (13), preface, art. 3.3; for the feebleness of the human mind as motivating eclecticism see Ahnert, op. cit. (7), p. 605; Albrecht, *Eklektik*, op. cit. (7), p. 322, 329, 354; Albrecht, 'Johann Christoph Sturm', op. cit. (7), p. 945.

[34] Sturm, *PSE*, op. cit. (9), p. 59: 'Quod si nemo erroris expers, non tam videndum quis aliquid dicat, quam quid aliquis dicat'. Vossius himself takes this from Seneca. Albrecht, *Eklektik*, op. cit. (7), p. 252. For the eclecticism of Vossius see Albrecht, *Eklektik*, op. cit. (7), §23.

[35] Sturm, *PSE*, op. cit. (9), p. 16; *PE* I, op. cit. (13), preface, arts. 1.6, 2.3; Albrecht, *Eklektik*, op. cit. (7), p. 318; Albrecht, 'Johann Christoph Sturm', op. cit. (7), p. 945; Blackwell, 'Sturm, Morhof and Brucker', op. cit. (7), p. 56, also points out that Sturm's eclectic approach is motivated by the idea that truth 'was collective and not in the possession of any one man'.

[36] Sturm, *PE* I, op. cit. (13), preface, art. 2.3: 'operum ac artificiorum divinae Sapientiae & Omnipotentiae in hac Naturae vastitate tanta sit multitudo, & subtilitas tam abstrusa'.

[37] Sturm, *PE* I, op. cit. (13), preface, art. 3.2; Albrecht, *Eklektik*, op. cit. (7), p. 323.

[38] Sturm, *PSE*, op. cit. (9), pp. 48, 69.

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> Those who have dealt with the sciences have either been empirics [*Empirici*] or dogmatists [*Dogmatici*]. The empirics, in the manner of the ant, only store up and use things; the rationalists, in the manner of the spiders, spin webs from their own entrails; but the bee takes the middle path: it collects its material from the flowers and garden, but its special gift is to convert and digest it.[39]

Remarkably, Bacon avails himself of the metaphor of the bee, which from the time of Seneca onwards has become the heraldic animal of eclecticism.[40] Rather than following the teachings of one author, philosophers seeking to advance in the sciences should draw on a multiplicity of sources and select what is valuable: 'So the end ought to bee from both Philosophies [of earth and heaven], to separate and reiect vaine speculations, and whatsoeuer is emptie and voide, and to preserue and augment whatsoever is solide and fruitfull.'[41]

Although Bacon seems at times relatively critical or even dismissive of his predecessors and contemporaries, academic research has shown Bacon's indebtedness to a multiplicity of sources – in particular, Renaissance natural philosophy, the early modern alchemical tradition, books of secrets, early modern books of recipes, and authors such as Desiderius Erasmus (1466–1536), Paracelsus (1493–1541), Girolamo Cardano (1501–76), Bernadino Telesio (1509–88), Giambiattista della Porta (1535–1615), Julius Caesar Scaliger (1540–1609), Hugh Plat (1552–1608), Oswald Croll (1563–1609), and George Sandys (1577–1644). What is more, Bacon is probably one of the most outspoken defenders of science as a collective endeavour. In the *Novum Organum*, he propagates

> the labours of many working together … following a path which is (unlike that of the rationalists) open not only to single travellers but one in which men's work and labour (especially for the gathering in of experience) can best be shared out and then brought together. For only then will men begin to know their own strength, when instead of countless men doing the same thing, some will be responsible for some things, others for other things.[42]

According to Bacon, science is not a practice for idle disconnected armchair philosophers ('the rationalists'), but a collective effort of the many, particularly useful in data collection ('gathering in of experience'). Due to the vastness and subtlety of nature, a division of labour in the sciences is of vital importance. Eclecticism, unlike dogmatism or sectarianism, endorses and encourages the work of the many.

Bacon's *New Atlantis*, his scientific utopia of an ideal scientific society, published posthumously in 1626 together with his *Sylva sylvarum*, lends further support to Bacon's eclectic inclusivist conception of science. On the fictitious island kingdom of Bensalem, the scientific society of 'Solomon's House' is organized into different 'offices', three of which explicitly engage in collecting scientific works and experimental procedures as well as findings from other countries. Others conduct new experiments. Others compile and summarize the experiments. Still others reflect on the practical value (bettering the human condition) as well as the theoretical value (causal explanations of the hidden processes of nature) of the scientific findings. Finally, after plenum discussions of all members have

[39] Bacon, *Novum Organum I: aphor. 95*, *OFB*, op. cit. (8), vol. 11, p. 153.

[40] See Lucius Annaeus Seneca, *Epistles. Volume II: Epistles 66–92* (tr. Richard M. Gummere), Cambridge, MA: Harvard University Press, 1920, epistle 84.

[41] Bacon, *Advancement of Learning* I, in *OFB*, op. cit. (8), vol. 4, p. 32.

[42] Bacon, *Novum Organum I: aphor. 113*, *OFB*, op. cit. (8), vol. 11, p. 171.

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been held, new experiments are conducted and higher-order 'observations, axioms and aphorisms' are conceived.[43]

In a word, Bacon and Sturm both share eclectic intuitions, and they share the conviction that a multiplicity of sources diligently subjected to rational and experimental scrutiny can help overcome the stalemate in the sciences. They agree that the latter is due to an excessive respect for authority, to a point of servility. Since human nature after the Fall has become corrupt, no single author is likely to have seen the whole truth. Bacon and Sturm share this 'Protestant intuition' which leads them to a critical investigation of a multiplicity of sources, as well as to the idea that human beings qua scientists must serve as correctives for one another. Science, for both Sturm and Bacon, is a collective endeavour, not a one-man show.

I should also note, however, the following two differences between Bacon's and Sturm's eclecticism: (1) Bacon does not explicitly call himself an eclectic. Sturm, in contrast, splits the history of philosophy into two dominant camps, sectarians and eclectics, and makes clear his adherence to the latter. (2) Unlike Bacon, Sturm is very outspoken about all his sources. Sturm meticulously cites authors' works, and sometimes he even provides page numbers. However, as to (1), not flagging one's conviction of eclecticism does not essentially make one less of an eclectic than doing so. Furthermore, Sturm – unlike Bacon – might have found himself in an intellectual context in which it was common practice to show one's intellectual commitments (being an Aristotelian, a Cartesian, an eclectic and so on). As to (2), Sturm's profession as university professor, as well as the traditions, expectations and practices that follow from working in academia, sufficiently explain his way of revealing his sources. Bacon's scepticism about explicitly mentioning an author's name is explained by his conviction that doing so could lead to a relapse into the practices of proving more by authority than by matters of fact.[44]

From natural history to natural philosophy

Throughout the *PE*, Sturm follows a three-step process in natural philosophy. The first step consists in collecting phenomena, either reported by other natural philosophers or encountered by means of observation or experimentation.[45] They need to be reported faithfully (*fideliter*), accurately presenting the circumstances under which the phenomena obtained.[46] However, Sturm does not contend himself with putting forth a natural history (in the Renaissance tradition), but aims at a natural philosophy that gives deeper causal explanations for why the phenomena are such as they are, and why they occur.

The second step, hence, consists in collecting and presenting with the same faithfulness old and new hypotheses that have been suggested to account for the phenomena. Sturm meticulously presents hypotheses old – inter alia pre-Socratic and Aristotelian ones – and new: the physics of Gassendi, of Descartes and of the latest Aristotelian-scholastic philosophers. His knowledge of more and even less prominent authors is impressive and precise.[47]

[43] Francis Bacon, *The Works of Francis Bacon, Baron of Verulam, Viscount of St. Alban and Lord High Chancellor of England* (eds. James Spedding, Robert Leslie Ellis and Douglas Denon Heath), 14 vols., London: Longman & Co, 1857–1874, *New Atlantis*, vol. 3, pp. 164–5.

[44] See Bacon, *Parasceve, aphor. 3*, *OFB*, op. cit. (8), vol. 11, p. 457.

[45] Albrecht, *Eklektik*, op. cit. (7), 347; Albrecht, 'Hypothesen und Phänomene', op. cit. (7), p. 132.

[46] Sturm, *PE* I, op. cit. (13), preface, art. 3.4.

[47] Andrea Sangiacomo and Christian Henkel, 'Johann Sturm', in Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy*, 2024, at https://plato.stanford.edu/entries/johann-sturm/ (accessed 13 November 2024), sect. 1.2.

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The third step – linking into his eclectic method – aims at selection and reconciliation. Sturm selects what he deems good and reasonable while ridding himself of (what he considers) mere pseudo-explanations, prejudices and preconceived notions. I will come back to Sturm's criteria of what qualifies as a good scientific hypothesis in the following section. Overall, in this three-step process, the presentation of phenomena establishes the *explanandum*; the hypotheses cover some ground towards approximating a solution. But since the different hypotheses either contradict or run parallel to one another, a true explanation must select from existing theories what is true, reject what is false, and add what needs to be added. Sturm proceeds from a natural history to a natural philosophy, from facts and phenomena via hypotheses to causal explanations. In this, he is inspired by Bacon. However, Bacon's distinction between natural history and natural philosophy is less clear-cut than Sturm's.

The relationship between natural history and natural philosophy for Bacon is very complex. So much so that spelling out the details of this intimate interplay exceeds the scope of this paper.[48] However, there is a sense for Bacon (as there is for Sturm) in which natural history provides the experiential and experimental data from which natural philosophy derives the causes explaining the occurrence of these data. Natural philosophy furnishes a theory of the hidden processes underlying the manifest phenomena of nature. In this sense, the transition from natural history to natural philosophy is a transition from the manifest to the latent. Natural history can be seen as a foundation or starting point of natural philosophy:

> For the *raison d'être* [*ratio*] of a natural history drawn up for its own sake is one thing, but one compiled systematically to inform the intellect for the building up of philosophy is quite another … [W]e should have good hopes of natural philosophy once natural history (which is its basis and foundation) has been better organized, but none at all before.[49]

One might also think of this transition as one from the senses to reason, from experience to thought. However, as Rusu points out, this distinction might exist more *idealiter* than *realiter*.

Indeed, a natural history produced 'systematically' might already suggest this. Theory and practice go hand in hand for Bacon – experiments, according to him, serve both as 'instruments of light' (gaining knowledge of causes) and as 'instruments of fruit' (producing effects and improving the *conditio humana*).[50] They 'cannot be separated in the process of a scientific investigation'.[51] However, natural history and natural philosophy might still be said to have different objectives; that is, presenting the phenomena and delivering causal explanations respectively. Bacon criticizes his predecessors for their satisfaction with a mere portrayal of phenomena as curiosities to impress.[52] The scientific study of nature, however, has to penetrate the subject matter in greater depth, seeking a theoretical foundation (or so he thinks).

[48] Doina-Cristina Rusu, 'From natural history to natural magic: Francis Bacon's Sylva sylvarum', PhD dissertation, University of Bucharest and University of Nijmegen, 2013; Guido Giglioni, Dana Jalobeanu and Sorana Corneanu, *Early Science and Medicine* (2012) 17, *Special Issue on Natural Histories in Francis Bacon*.

[49] Bacon, *Novum Organum I: aphor. 98*, *OFB*, op. cit. (8), vol. 11, p. 157. See also Jalobeanu, op. cit. (1), p. 207.

[50] Rusu, op. cit. (48), pp. 73–4, 97.

[51] Doina-Cristina Rusu, 'Abolishing the borders between natural history and natural magic: Francis Bacon's *Sylva Sylvarum* and the *Historia vitae et mortis*', *Society and Politics* (2014) 8, pp. 23–42, 26.

[52] Jalobeanu, op. cit. (1), pp. 201–3.

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Although Sturm opts for a stricter separation of phenomena and their explanation, still Bacon and Sturm would agree that phenomena only constitute one aspect of a natural philosophy, one which is by no means self-standing but needs to be complemented by theory. They also both avail themselves of theories already available. However, they do not take any theory to be proven beyond doubt. Rather, they take theories to be subject to improvement to do justice to the phenomena.

The status of science: hypothetical and dynamic

Eclecticism, according to Sturm, explicitly engages in scrutinizing and selecting among existing hypotheses. Blackwell also notes that 'the eclective method had of necessity to use reasoning by hypotheses, rather than certitude since human beings could not know enough to establish scientific certainty'.[53] Hence the feebleness of the human mind alluded to earlier to some extent grounds both the eclectic method and the use of hypotheses.

Hypotheses – at least in Sturm's last physics textbook, the *Compendium physicae modernae sanioris* – have a place in between observations by the senses and, *pace* his earlier writings, certainties revealed by the demonstrative method. He points out that some things – bodies themselves (*corpora ipsa*) (that is, as common objects, their variations, effects, passions (what they undergo) and phenomena) – are in themselves obvious, in that they are observed by the senses and by means of experiments, or in that they can be known through the use of the newly invented instruments.[54] Some things – the particular natures and 'forms' of natural bodies, which are by and large hidden from the senses – are merely conjectured rather than infallibly demonstrated (*supponuntur verius & conjiciuntur, quam infallibiliter demonstrantur*).[55] Some things, finally – such as the proximate causes of observed effects and their way of operating – can be made certain when phenomena and hypotheses align; that is, they are

> deduced [*deducuntur*] from phenomena and hypotheses in such a way by means of the demonstrative method that due to the ubiquitous harmonizing correspondence itself of the phenomena with the hypotheses, by means of a certain demonstrative regress, the things that had been assumed in a way seemingly true [*verosimiliter*], ascend to [*evadant*] truth and certainty.[56]

According to Sturm, hypotheses play a central role in all theory building. Causes cannot be observed, but only what we might call 'approximated' by hypothetical reasoning.[57] Hypotheses are developed and built into a coherent and consistent system. But how do we choose hypotheses? What criteria are we to apply?

At the beginning of his preface to the *PE* I, Sturm – possibly inspired by Boyle or Mariotte – extensively investigates criteria that good hypotheses have to meet. (1) They

[53] Blackwell, 'Sturm, Morhof and Brucker versus Aristotle', op. cit. (7), p. 384.

[54] Johann Christoph Sturm, *Physicae modernae saniori compendium erotematicum in tironibus gratiam*, Nuremberg: (the widow of) B. Joh. Hoffmann and Engelbert Streck, 1704 (hereafter *CPMS*), pp. 2–3.

[55] Sturm, *CPMS*, op. cit. (54), p. 3.

[56] Sturm, *CPMS*, op. cit. (54), pp. 3–4: 'ex phaenomenis & hypothesibus demonstrativa methodo sic deducuntur, ut ex ipsa phaenomenorum cum hypothesibus, & harum cum istis, consonante ubique correspondentia, per regressum quendam demonstrativum, ea quae antea verosimiliter erant supposita, in veritatem ac certitudinem ipsam … evadant'.

[57] Sturm, *PE* I, op. cit. (13), preface, art 3.1.

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have to have a reasonable degree of possibility and agree with the phenomena.[58] (2) They have to take into account the prevailing circumstances.[59] (3) A hypothesis is better in case it can accommodate more phenomena and the circumstances under which the most notable ones obtain.[60] (4) Simpler hypotheses are to be preferred[61] – the reasoning behind this for Sturm is that simple hypotheses mirror the simple ways of God.[62] (5) Good hypotheses should conflict neither with phenomena, nor with other established hypotheses, nor with evident principles.[63] (6) Hypotheses have to satisfy not only the intellect but also the imagination and the senses.[64] Sturm's reasoning here seems to be that all natural phenomena pertain to the world of extension and its modifications like shape and motion. The senses and the imagination are first and foremost concerned with the realm of extended beings. Therefore, to assess the correctness of hypotheses about natural phenomena, one needs to consult both faculties.

Sturm regards natural philosophy not only as hypothetical but also as dynamic.[65] These are different aspects of natural philosophy. The former shows that hypotheses are explicitly encouraged in doing natural philosophy. The latter stresses that natural philosophy is in a state of constant transformation, and this includes both the discovery of new phenomena that require explanation and new hypotheses invented or existing ones being refined to account for the phenomena. For Sturm, the study of nature is a never-ending project. It can only approximate truth, getting closer and closer.

Bacon's perspective on science influenced that of Sturm in that it is precisely both hypothetical and dynamic or open-ended. Although the epistemological status of science for Bacon has been contested in academic scholarship, I believe that holding that Bacon endorses hypotheses and probable knowledge squares better with his conviction of the postlapsarian feebleness of the human mind, his critique of authority and dogmatism, his eclectic intuitions and belief in science as a collective endeavour, and his belief in the open-endedness of scientific practices.[66] The strongest, though indirect, evidence for his endorsement of hypotheses or hypothetical knowledge – I take them to be synonymous – seems to be Bacon's introduction of an intermediary epistemological category besides 'reliable' and 'downright unreliable'; that is, 'of doubtful reliability'. According to Bacon, when compiling a natural history, merely probable or doubtful knowledge needs to be indicated to future readers by using 'a phrase like *they say*, or *they report*, or *I have it on good authority*, and the like'.[67]

[58] Sturm, *PE* I, op. cit. (13), preface, art. 3.1: 'aliquam saltem possibilitatem sanae rationi conspicuam, & cum phaenomenis connexionem ostentent'; Albrecht, *Eklektik*, op. cit. (7), pp. 342–3; Albrecht, 'Johann Christoph Sturm', op. cit. (7), p. 946; Albrecht, 'Hypothesen und Phänomene', op. cit. (7), pp. 125–6 n. 1).

[59] Sturm, *PE* I, op. cit. (13), preface, art. 3.1: 'circumstantiis utcunque satisfacere'.

[60] Sturm, *PE* I, op. cit. (13), preface, art. 3.1: 'Tanto meliorem esse hypothesin, quanto pluribus phaenomenis & primarii circumstantiis satisfecerit (caeteris interim paribus existentibus)'.

[61] Sturm, *PE* I, op. cit. (13), preface, art. 3.1: 'una vero caeteris sit simplicior ac minus quaesita, suppositisque, paucioribus constans, haec utique caeteris praeferenda erit'.

[62] Sturm, *PE* I, op. cit. (13), preface, art. 3.1: 'Opificem naturae Sapientissimum nunquam per ambages & operoso apparatu facturum fuisse, quod simpliciore modo nulloq negotio fieri potuit'.

[63] Sturm, *PE* I, op. cit. (13), preface, art. 3.2: 'sui generis phaenomenis tantum accurate respondere debet bona hypothesis, sed nec ab ullo alterius generis, quod compertum quidem sit & exploratae certitudinis, nec ab ullo sanae rationis evidenti principio dissentire'.

[64] Sturm, *PE* I, op. cit. (13), preface, art. 3.3: 'non intellectui solum, sed imaginationi quoque, si non etiam sensui satisfaciant'.

[65] Albrecht, *Eklektik*, op. cit. (7), p. 329.

[66] Silvia Manzo, 'Bacon's natural histories: a double attitude towards skepticism', in José R. Maia Neto, Gianni Paganini and John Christian Laursen (eds.), *Skepticism in the Modern Age*, Boston, MA: Brill, 2009, pp. 123–37, 136–7; Manzo, op. cit. (17), p. 96; Harrison, op. cit. (1), pp. 4, 48, 172.

[67] Bacon, *Parasceve, aphor. 8*, *OFB*, op. cit. (8), vol. 11, p. 467.

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Furthermore, when criticizing sectarianism and dogmatism, Bacon laments that 'these fickle and wrongheaded … philosophies have put theses before hypotheses'.[68] In other words, past philosophers have posited as given (the basic meaning of the Greek *thesis*) things that are in reality just assumed or conjectured (the basic meaning of the Greek *hypothesis*). Instead of confronting what is only conjectured with experience and experimental findings and instead of changing their conjectures as the phenomena demanded, these past philosophers tinkered with the phenomena. The order of reasoning, however, starts from a hypothesis and may only later acquire the necessary confirmation. In a similar vein, Bacon accuses experimental philosophers of rushing from 'a handful of experiments' to 'generalities and principles of things' in a way unfounded in the things themselves.[69] The adoption of hypotheses ties in well with Bacon's humbler and dynamic perspective on science. Bacon conceives of the sciences not only as a collective endeavour of the many but also as one that is open-ended. He realizes that the 'completion [of his scientific project] is not confined entirely to a single age but to a succession of them.'[70] The open-endedness of learning results from the impossibility of eradicating the idols of one's own mind, and the subtlety of nature.

Comparing Sturm and Bacon on the matter of hypotheses shows that despite the fact that Sturm's theoretical considerations on hypotheses are more refined than Bacon's, they share the same sentiment: science as starting from, and as a means to compensate for, the feebleness of the postlapsarian human mind can only provide knowledge that is probable or hypothetically true, though ideally striving for certain knowledge.[71] They both regard science as dynamic: it is a collective endeavour which takes into consideration experimentation and new developments in instrument making.

Experimental philosophy

Sturm endorses experimentation and the use of ever better instruments to enquire into nature. But not only that. He was among the first university professors in Germany to introduce an experimental physics at an academic level.[72] Inspired by the experimental method advanced by Boyle and way before by Bacon, Sturm offered regular, yet private, experimental *collegia*.[73]

Looking at his *Collegium experimentale sive curiosum* (1676/85) reveals that Sturm was familiar with the state of the art of experimental science, putting to good use the new instruments available at the time – the telescope, microscope, air pump, diver's bell and so on.[74] He discusses the experimental practices of other natural philosophers, such as Caspar Schott (1608–66), Robert Boyle and Otto von Guerikke (1602–86).[75] Most importantly for our

[68] Bacon, *Historia naturalis et experimentalis*, *OFB*, op. cit. (8), vol. 12, p. 11.

[69] Bacon, *Novum Organum I: aphor. 64*, *OFB*, op. cit. (8), vol. 11, p. 101.

[70] Bacon, *Great Instauration preliminaries*, *OFB*, op. cit. (8), vol. 11, p. 25.

[71] Manzo, op. cit. (66), p. 137, original emphasis, notes that 'Bacon's project suggests *in theory* that the obtaining of absolute certain knowledge is possible but *in fact* such knowledge is revealed to be impossible … *Malgrè lui*, Bacon shows himself developing *in fact* a kind of probabilistic science.'

[72] Gunter Lind, *Physik im Lehrbuch 1700–1850: Zur Geschichte der Physik und ihrer Didaktik in Deutschland*, Berlin: Springer, 1992, p. 92; Fritz Krafft, 'Der Weg von den Physiken zur Physik an den deutschen Universitäten', *Berichte zur Wissenschaftsgeschichte* (1978) 1, pp. 123–62, 136; Hans Schimank, 'Die Wandlung des Begriffs "Physik" während der ersten Hälfte des 18. Jahrhunderts', in Karl-Heinz Manegold (ed.), *Wissenschaft, Wirtschaft und Technik: Studien zur Geschichte*, Part VI, Munich: F. Bruckmann, 1969, pp. 454–68, 456.

[73] Blackwell, 'Sturm, Morhof and Brucker versus Aristotle', op. cit. (7), pp. 383, 407; Albrecht, *Eklektik*, op. cit. (7), p. 312.

[74] Albrecht, *Eklektik*, op. cit. (7), p. 314.

[75] Gerhard Wiesenfeldt, 'Das *Collegium experimentale sive curiosum* und die Anfänge experimenteller Naturlehre in Deutschland', in Gaab, Leich and Löffladt, op. cit. (7), pp. 184–202, 195.

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purposes, he is familiar with the *Sylva sylvarum* – Bacon's showpiece of his own experimental philosophy. In his *Physica electiva*, Sturm discusses the findings of Bacon's experiments in three different passages dedicated to three different topics of natural philosophy:

1. The effects, properties, and general nature of water, in particular, the resistance of water to compression.[76] Here, Sturm builds on an experiment of Bacon's *Novum Organum II*; that is, aphorism XLV.[77]
2. Putrefaction.[78] Here, Sturm avails himself of experiments 343 and 919 of Bacon's *Sylva sylvarum*.
3. The diverse effects of the Moon on the Earth, or earthly bodies.[79] Here, Sturm uses experiments 890, 892–4 and 896 of Bacon's *Sylva sylvarum*.

More generally, Sturm cites Bacon not only when discussing phenomena, but also when contemplating the various explanations of the phenomena.

The use of experimentation for Sturm is not only to amplify the senses and to obtain a more thorough understanding of nature. It also serves to correct and refute hypotheses. These are assessed in terms of whether they agree with the (newly discovered) phenomena and the results of experiments. If hypotheses conflict with new experimental findings, they lose credibility and might ultimately need to be rejected.

When assessing Bacon's impact on Sturm, the importance Bacon assigns to the role of experimentation in the study of nature is striking and can in itself hardly be overstated. It is precisely in the absence of an experimental confrontation with nature that the shortcomings of the armchair philosophy of the scholastics lie – or so he thinks. Bacon is a particularly vocal propagator of an experimental philosophy. Indeed, 'all truer interpretation of nature is accompanied by means of instances, and apt and appropriate experiments, where the sense judges only the experiment while the experiment judges nature and the thing itself'.[80] According to Bacon, experiments help the philosopher study nature in its infinite subtlety and aid both the mind and the senses, which Bacon thinks are corrupted since the Fall of Man. Experiments have a vital function, both as correctives for the senses which are prone to be deceived and to test other authors' hypotheses about the workings of nature. If hypotheses go against established experimental results, they must be abandoned. Inversely, insofar as experiments and hypotheses agree, the latter gain credibility.[81] Furthermore, experiments can help bring to light the hidden processes of nature that would otherwise – that is, without the intervention of the natural philosopher – remain unnoticed. Experiments are controlled, thought-through, closely monitored and repeatable interventions into nature, which distinguishes them from vulgar experience.[82] Bacon's ideal scientific island kingdom Bensalem (see above) is indeed itself a large-scale experimental laboratory buzzing with experiments and interventions in all areas of natural philosophy: experiments on hot and cold; manipulations of plants and animals; and experiments with light, sound and smell, as well as mechanics proper.

The subtlety of nature and the postlapsarian state of humankind motivate not only Bacon's experimental philosophy, but also his endorsement of the use of instruments: 'In

[76] Johann Christoph Sturm, *Physica electiva sive hypothetica, Tomus secundus*, in Ecole *et al.*, op. cit. (13), vol. 97.2.1. (hereafter Sturm, *PE* II.1), pp. 194–5.

[77] Bacon, *OFB*, op. cit. (8), vol. 11, p. 375.

[78] Sturm, *PE* II.1, op. cit. (76), pp. 360–1.

[79] Johann Christoph Sturm, *Physica electiva sive hypothetica. Tomus secundus*, in Ecole *et al.*, op. cit. (13), vol. 97.2.2. (Sturm, *PE* II.2), pp. 931–2, 935–6.

[80] Bacon, *Novum Organum I: aphor. 50*, *OFB*, op. cit. (8), vol. 11, p. 87.

[81] Rusu, op. cit. (48), 63, 71, 109; Jalobeanu, op. cit. (1), pp. 263, 276, 280; Lynch, op. cit. (1), p. 23.

[82] Rusu, op. cit. (48), p. 79, 89–90.

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fact it is perfectly obvious in every great work undertaken by human hand that individual powers cannot be strengthened nor the powers of all be combined without instruments and machines.'[83] The use of microscopes, telescopes and other visual aids, such as surveying instruments and astrolabes, either amplifies vision or straightens it.[84] It assists in obtaining an idea of reality that is more correct. Bacon might also have in mind more concrete mechanical means to compensate for the lack of human strength in a very literal sense. Pulleys and levers, for instance, allow one to lift heavy weights. Furthermore, the realization of Bacon's experimental philosophy is by and large based on the use of instruments. However, Bacon's conception of instruments is too far-reaching and innovative to be confined to the use of visual aids only. He took the microscope and telescope to be rather coarse-grained instruments in the enquiry of nature. More fine-grained instruments, such as plants, are needed to bring to light the hidden motions of spirits grounded in their appetites with which Bacon is mainly concerned.[85]

However, it should be remembered that (1) Bacon's experimental philosophy is always informed by and intimately linked to theory. It immediately aims at the establishment of humbler so-called 'middle axioms' and not at grand unified theories. (2) Bacon's conception of instruments does – unlike Sturm's – also contain instruments for thinking properly. They are not merely the physical tools we use to explore nature, but also more abstract ones to straighten out our mind, which is full of preconceived notions and illusory thoughts accepted on the basis of authority. Furthermore, Bacon's instruments are part of his project of providing a *medicina mentis* for the idols of the mind.

Bacon and Sturm share the conviction of the importance of experimental philosophy and the use of instruments. Sturm's conception of experimental philosophy and instruments is certainly less broad and innovative than Bacon's. Sturm cites Bacon's *Sylva sylvarum* – Bacon's main work in experimental philosophy – several times in his *Physica electiva sive hypothetica*. He stresses – as does Bacon – the role of experiments as both lending support to hypotheses and serving as correctives. Experimental philosophy and the use of instruments help to make up for human beings' fallen nature and help explore the subtle processes of the world invisible to the naked eye.

Conclusion

Sturm's scientific eclectic method is strongly indebted to Bacon. They both take issue with the current state of learning and use it as a point of departure for providing an antidote: eclecticism. They thought that the collective endeavour of the many, free from the constraints of authority, selecting from previous philosophers what seems good and true while adding what needs to be added will advance the sciences. They both believe that, due to the feebleness of the postlapsarian human mind, its proclivity to suffer from preconceived notions or idols and the subtlety of nature, science can only be hypothetical. One needs to collect natural phenomena, and slowly advance towards ever safer and more promising causal explanations, availing oneself of instruments and experiments. Experimentation and the collective intellectual strength of the scientific community serve as correctives to proposed accounts of nature.

Bacon is not the only, but certainly a salient, source of Sturm's scientific method in that Sturm mentions him in prominent places, such as the beginning of the *Physica electiva*, his main work. His reliance on Bacon consists in the fact that Sturm found in him

[83] Bacon, *Novum Organum I*: preface, *OFB*, op. cit. (8), vol. 11, p. 55.

[84] Bacon, *Novum Organum II: aphor. 39*, *OFB*, op. cit. (8), vol. 11, pp. 343–4.

[85] Doina-Cristina Rusu, 'Using instruments in the study of animate beings: Della Porta's and Bacon's experiments with plants', *Centaurus* (2020) 63, pp. 393–405.

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a well-respected and convincing fellow eclectic thinker whose case would help establish a new kind of science. In contrast to some of his academic colleagues, Sturm might have seen in Bacon a more independent thinker with no clear allegiances to any specific school. When Sturm deviates from Bacon's scientific method, this is mostly because Sturm was constrained by university guidelines or academic practices, or perhaps humbler in the presentation of his ideas. None of this changes anything regarding Sturm's indebtedness to Bacon.

Sturm is by no means the only German philosopher inspired by Bacon. Among others, Christian Wolff (1679–1754), Georg Friedrich Meier (1718–77) and even Immanuel Kant (1724–1804), who prominently introduces the second edition of his *Critique of Pure Reason* with a quote from the *Great Instauration*, could be shown to be more or less indebted to Bacon. Alas, this topic must be left to be explored in future research.

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