Roger Bacon : essays contributed by various writers on the occasion of the commemoration of the seventh centenary of his birth / collected and edited by A.G. Little.

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ROGER BACON

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ROGER BACON

ESSAYS

CONTRIBUTED BY VARIOUS WRITERS
ON THE OCCASION OF THE COMMEMORATION
OF THE SEVENTH CENTENARY OF HIS BIRTH

COLLECTED AND EDITED
BY
A. G. LITTLE

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BACON, Roger [1214?-94]

PREFACE

THE Commemoration of the Seventh Centenary of Roger Bacon's birth was undertaken by an Executive Committee, consisting of Sir Archibald Geikie, O.M., K.C.B., then President of the Royal Society (Chairman), Cloudesley Brereton, Sir William Crookes, O.M., now President of the Royal Society, F. A. Dixey, J. P. Gilson, Sir George Greenhill, A. G. Little, F. Madan, Sir William Osler, Professor Poulton, Lieutenant-Colonel Hime (Secretary), Sir Alfred B. Kempe (Treasurer). A General Committee, consisting of subscribers and collaborators, was formed under the presidency of the Right Honourable the Earl Curzon of Kedleston, Chancellor of the University of Oxford.

The proposals of the Committee were (1) to erect a statue of Roger Bacon (by Mr. Hope Pinker) in the University Museum ; (2) to issue the present memorial volume of essays ; (3) to raise a fund for the publication of Roger Bacon's works.

As regards the last object, the hopes of the Committee have been only partially realized. Arrangements have been made for editing the pseudo-Aristotelian *Secretum Secretorum* with Bacon's introduction and commentary (by Robert Steele), Bacon's medical treatises (by E. Withington and A. G. Little), and probably the *Communia Mathematicae* (by Robert Steele and Professor D. E. Smith). Anything beyond these will have to be carried out by private enter-

prise, or through the formation of a Roger Bacon Society.

The volume of Commemoration Essays now issued corresponds with the plan already announced except in two particulars. Sir William Osler being unfortunately compelled to postpone his promised article to a future occasion, Mr. E. Withington most generously contributed at very short notice the article on Roger Bacon and Medicine, which is based on his introduction to the forthcoming edition of Bacon's medical treatises. The second alteration is the addition of the Appendix containing a list of Roger Bacon's works and those attributed to him, which it is hoped may encourage further researches.

On behalf of the Executive Committee I desire to thank the writers of the following articles for their gifts. Each writer is responsible for his own article and for that alone. The work of the editor has been confined mainly to ensuring some uniformity in the spelling of proper names, to correcting the final proofs (with the invaluable assistance of the staff of the Press), and to cutting out from some essays statements which occurred elsewhere. A certain amount of repetition is inevitable in a volume of this kind, nor is it a disadvantage to have the same facts represented in different connexions. Differences of opinion are equally inevitable ; no attempt has been made to reconcile them, and it is surprising that so many estimates of Roger Bacon's manifold activities do not present greater divergences.

A. G. L.

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I

INTRODUCTION

ON ROGER BACON'S LIFE AND WORKS

By A. G. LITTLE

WRITING in 1267 Roger Bacon says: 'I have laboured much at sciences and languages, and it is now forty years since I first learnt the alphabet: I have always been studious, and except for two of those forty years I have always been *in studio*.'[1] The last phrase probably means 'at a university'. Boys generally went to Oxford at the age of twelve or thirteen. It may, then, be inferred that Roger Bacon was born about 1214.

The tradition that he was born near Ilchester is preserved by John Rous,[2] the Warwick antiquary, who was a student at Oxford about 1440, was interested in the history and legends of his university, and had some knowledge of Roger

[1] *Op. Tert.* (Brewer), p. 65; cf. Gasquet's Fragment in *Engl. Hist. Rev.* xii. 507 'Exceptis duobus annis quibus recreationem et solatium quietis sumpsi, ut melius postea laborarem'.

[2] *Hist. Regum Angliae* (ed. Herne, 1716), pp. 29, 82. According to Atkyns, *Ancient and Present State of Gloucestershire*, p. 147, Friar Bacon was born at Todgmore bottom, in the parish of Bisley. 'He was educated at St. Mary's Chapel, now St. Bury Mill on Stroud river in the parish of Hampton, wherein is a room at this day called Frier Bacon's study.' It may be noted that the nuns of Holy Trinity at Caen held Hampton or Minchin-Hampton. Gilbert Baco appears as witness in one of their charters, while William Bacon and Roger his son were concerned in a benefaction to the Abbey of St. Stephen, Caen, in the twelfth century. Round, *Cal. of Doc. France*, nos. 447, 453; cf. no. 551. John Dee's statement that Bacon 'was named, as some think, David Dee of Radik' appears, as Bridges justly says, 'to rest on no authority but that of John Dee's very erratic imagination': *Opus Majus*, i. xxxiv.

Bacon's works. In one place he calls him 'friar Roger Bacon of the English nation and the county of Dorset'; in another, 'that famous clerk friar Robert (*sic*) Bacon of the minorite order, by birth an Englishman, of noble family of the inhabitants of the county of Dorset near Ilchester.' Ilchester is in the county of Somerset, but only some five miles from the boundary of Dorset. And in support of the tradition it may be noted that in 1166 one Roger Bacon held two parts of a knight's fee in Dorsetshire, given to him by his father-in-law, William son of John of Harptree.[1] The name Roger is also found in the twelfth and thirteenth centuries among the Bacons of the Bessin in Normandy,[2] the Bacons of Norfolk,[3] and the Bacons of Essex,[4] and there is little doubt that these were branches of the same family.

Roger Bacon tells us little about his family. His mother was still alive in 1267: his elder brother ('my rich brother') had succeeded to the estates, but having supported the king's cause during the Barons' War had been driven out with his relatives and reduced to poverty.[5] Another brother Bacon describes as a 'scholar'.[6]

It is generally supposed that Roger was related to Robert Bacon, the famous Dominican doctor, who died in 1245. Matthew Paris tells how Friar Robert Bacon of the Order of Preachers, in a speech before the king at Oxford, June 24, 1233, denounced the royal favourites, the Bishop of Win-

[1] *Red Book of the Exchequer*, i. 219. I am indebted to Professor Powicke for this reference.

[2] Round, *Cal. of Doc. France*, p. 160. Delisle, *Excheq. Roll of Normandy* (1184), p. 31. *Red Book of the Exchequer*, ii. 645 (1172). Stapleton, *Observations*, ii. lxxix. Palgrave, *Rot. Cur. Reg.*, ii. 191–2, 374.

[3] *Rot. de Finibus*, p. 443 (1208); *Rot. Litt. Claus.*, i. 254, 333, 534, 535.

[4] Roberts, *Cal. Genealog.*, pp. 424, 634; Close Rolls, 18 Ed. I, m. 17 d.: 34 Ed. I, m. 3 d. schd.

[5] *Op. Tert.* (Brewer), p. 16; cf. *E. H. R.*, xii. 502.

[6] *Op. Tert.* (Brewer), p. 13.

chester (Pierre des Roches) and Pierre de Rievaulx : whereupon seeing the king inclining to reason, a witty clerk of the court (*clericus de curia*), namely Roger Bacun, said : ' My Lord King, what is most injurious and dangerous to sailors crossing a strait ? ' The king replied : ' They know that do business in great waters.' The clerk said : ' I will tell you, my lord : *Petrae et Rupes.*' [1] Was this clerk the famous Roger ? In his writings he does not appear as *iocundus in sermone*, and though he had some knowledge of the inner working of a chancery,[2] there is no evidence that he was ever a clerk in the royal court. That he was already a student at Oxford some years before this may be inferred from his statement that ' Edmund Archbishop of Canterbury first lectured on the book of Elenchs at Oxford in my time '.[3] Edmund Rich was consecrated archbishop April 2, 1234, and had ceased to lecture at Oxford some years earlier. Grosseteste, who exercised the most permanent influence on his intellectual development, was lecturing in the schools of the Franciscans at Oxford from about 1230 to 1235, when he became Bishop of Lincoln.[4]

Bacon took the degree of M.A. at an unknown date, and acquired fame by his lectures at Oxford and Paris. He wrote many elementary treatises for students.[5] ' Men used to wonder before I became a friar (*in alio statu*) that I lived owing to my excessive labours.' [6] To this period probably belong his commentaries on the Physics [7] and

[1] *Chron. Majora*, iii. 244–5.

[2] *E. H. R.*, xii. 501 ' Videmus enim in curiis prelatorum et principum quod una littera transit per multas manus antequam examinata scriptura bullam recipit aut sigillum ' ; cf. *Op. Tert.* (Brewer), p. 57.

[3] *Comp. Stud. Theol.* (Rashdall), p. 34.

[4] *Lanercost Chron.*, p. 45 ; *Eccleston* (ed. Little), p. 61.

[5] *E. H. R.*, xii. 500.

[6] *Op. Tert.* (Brewer), p. 65.

[7] A reference to the Seine (MS. Amiens 406, f. 47, col. a) shows that the second series of *quaestiones* on the Physics was composed in Paris.

Metaphysics, preserved in the Amiens MS. No. 406: they are in the prevalent dialectic style, and perhaps might be put into the class of works which Bacon afterwards ridiculed as 'horse-loads'. His lectures on the pseudo-Aristotelian treatise *De plantis* (preserved in part in the same MS.) were delivered at Paris, where his Spanish students laughed at him for bungling over a word which he thought was Arabic and they told him afterwards was Spanish.[1]

There is some evidence that he went to Paris before 1236. For he says that he began his *Epistola de accidentibus senectutis* at the suggestion of two wise men, namely John of Châtillon (?) and Philip Chancellor of Paris.[2] There were two chancellors of the name of Philip in the thirteenth century: Philip de Grève, who died in 1236 (and was buried in the Franciscan Church at Paris),[3] and Philip de Thoiry, Chancellor 1280–4. Since Bacon refers to the *Epistola* as already published in 1267,[4] it is clear that the Philip referred to must be Philip de Grève. Further, the earliest extant MS., which contains an early version of the work, states that the letter was sent to Pope Innocent IV (1243–54).[5] It bears internal evidence of having been an early work; for it was written at a time when the author did not know Greek. Incidentally Bacon mentions in it that he had been *in partibus Romanis*.

Bacon was certainly in Paris before 1245: for he says

[1] *Op. Maj.* (Bridges), iii. 82; *Op. Tert.* (Brewer), p. 91; *Comp. Studii Phil.* (Brewer), pp. 467–8.

[2] MS. Bibl. Nat. Paris, 6978, f. 27ᵛ: the MS., which is anonymous, has recently been identified by Mr. Steele. 'Et hanc incepi ad suasionem duorum sapientum, scil. Johannis Castellomati (*or* Castelloniaci) et Philippi Cancellarii Parisiensis.' John of Châtillon, O.F.M., was in Paris 1273 (Lecoy de la Marche, *La Chaire franç.*, p. 515): John of Châtillon, Count of Blois, received privileges from Innocent IV (Baluze, *Miscell.*, i. 215).

[3] Brit. Mus. MS. Add. 33956, f. 71.

[4] *Op. Maj.* (Bridges), ii. 209.

[5] MS. Bibl. Nat., 6978.

that he had seen with his own eyes Alexander of Hales,[1] who died in that year. He twice heard William of Auvergne (who died in 1248) dispute on the *Intellectus Agens* before the whole university.[2] He also heard Master John de Garlandia († 1252) denounce ignorant etymologists.[3] And he was in France in 1251, when he saw the leader of the Pastoureaux.[4] We do not know when or where he entered the Franciscan Order, nor the reasons which moved him to take this step. Possibly he felt the need of the protection of a powerful organization. He was clearly of mature years, and it is natural to suppose that he was influenced by his admired friend and master, Friar Adam Marsh.

A tradition preserved in the Register of the Grey Friars of London is perhaps worth mentioning, namely that John of Parma 'wrote to Friar Roger Bakon the treatise beginning *Innominato Magistro*'.[5] This is a well-known letter[6] written by Bonaventura while he was lecturing at Paris and when John of Parma was general minister, i. e. between 1248 and 1257. The 'unnamed master' appears to have had some thoughts of joining the Order, but to have been shaken by a Dominican who attacked the Franciscans for not observing the Rule. The Dominican was rebuked by the English provincial minister, from which it may be inferred that he was an Englishman. Though at least one of Bonaventura's arguments, that namely in favour of studying philosophy in general ('for without practical knowledge of other sciences the Holy Scriptures cannot be understood'), would have appealed to Bacon, and though there is no chronological difficulty, there is no evidence to support the identification of the 'unnamed master' with Roger Bacon.

[1] *Op. Min.* (Brewer), p. 325.
[2] *Op. Maj.* (Bridges), iii. 47; *Op. Tert.* (Brewer), p. 74.
[3] *Comp. Studii Phil.* (Brewer), p. 453.
[4] *Op. Maj.* (Bridges), i. 401.
[5] *Mon. Franc.*, i. 533.
[6] *Bonaventurae Opera Omnia*, viii. 331–6 (ed. Quaracchi).

It may be mentioned that Roger Bacon never became a doctor of divinity (in spite of early statements to the contrary),[1] and it is doubtful whether he was ever in holy orders.

Before he joined the Franciscans he had already cut himself adrift from the traditional methods and objects of study (*neglecto sensu vulgi*) and struck out a line for himself. He had already become convinced of the inadequacy of logic and of the need for the acquisition of positive knowledge. 'During the twenty years (he says in 1267)[2] in which I have laboured specially in the study of wisdom, after abandoning the usual methods, I have spent more than 2000*l.* on secret books and various experiments, and languages and instruments and mathematical tables, &c.' Though a *libra Parisiensium* was only equivalent to a third of a pound sterling,[3] it is difficult to believe that a Mendicant Friar, even so hardy a beggar as Bacon evidently was when the interests of science were concerned, can have obtained so large a sum: it must have included his private means *in alio statu*.

[1] He is called 'magister' in Amiens MS. 406—evidently Master of Arts. No thirteenth-century document, so far as I know, refers to him as Doctor or Master of Theology. The *Chron. XXIV Generalium*, written *c.* 1370, but containing earlier matter, calls him S. Theol. Mag. (p. 360). On the other hand, Bartholomew of Pisa, who is very careful to distinguish between friars who were masters of theology and friars who were not, always refers to him as *frater*, never as *magister*: *Conform.*, i. 338 (ed. Quaracchi) '*Frater* Rogerius Bachon, in omni facultate doctissimus, in eisdem scribendo mirabilis apparet scientiarum diversitate imbutus' (the first appearance of his traditional epithet 'mirabilis'): cf. pp. 341, 547, 'fratrem Robertum (*sic*) Bachon.'

[2] *Op. Tert.* (Brewer), p. 59.

[3] This is Bacon's estimate in the interesting passage quoted by Charles, *Roger Bacon*, p. 305, from MS. Royal 7, F. VIII, f. 4: 'Primum enim speculum consistit 60 libris parisiensium quae valent circiter 20 libras sterlingorum: et postea feci fieri melius pro 10 libris parisiensium, scil. pro quinque marcis sterlingorum [£3 6*s.* 8*d.*]; et postea diligentius expertus in his percepi quod meliora possent fieri pro duobus marcis, vel 20 solidis, et adhuc pro minore.'

His health broke down, and for ten years (*c.* 1256–66) he had, ' owing to many infirmities,' to withdraw from taking any public part in university affairs.[1] He was not, as is often alleged, imprisoned or banished at this time.[2] We have a glimpse of him in Paris during this period listening to a tale of magic.[3] He seems to have been in the habit of supplying new masters of arts at their inception or inaugural disputation with problems in geometry which none of their hearers could solve.[4] He was mainly occupied in investigations and experiments in physics, especially optics, in making lenses, in constructing astronomical tables, and elaborating his theory of the propagation of force.[5] He devoted his leisure to instructing boys in mathematics, sciences, and languages : [6] one of them, John, who came to him poor and eager to learn, about 1260, at the age of fifteen, he supported through alms begged from friends and instructed gratis for the love of God, and afterwards employed as his messenger to the pope.[7] He kept himself thoroughly informed on what was going on in the world, and uses contemporary political and social events to illustrate his points. The Children's Crusade and the Revolt of the Pastoureaux afford him instances of ' fascination '.[8] The quarrels between Henry III and the barons in England, the relations of the English and French kings, the struggle between Empire and Papacy and

[1] *E. H. R.*, xii. 500.

[2] The error arose from a misunderstanding of the words, ' a decem annis exulantem quantum ad famam studii quam retroactis temporibus obtinui.' *Op. Tert.* (Brewer), p. 7.

[3] *Liber Exemplorum*, ed. Little (Brit. Soc. of Franciscan Studies, i), p. 22.

[4] *Op. Tert.* (Brewer), p. 139.

[5] Ibid., pp. 36, 38 ; Charles, p. 305.

[6] *Op. Tert.* (Brewer), p. 159.

[7] *Op. Tert.* (Brewer), pp. 61–3, 89, 111, 135, 139, 221, 270 ; *E. H. R.*, xii. 506 ; *Op. Tert.* (Little), pp. 61, 82 ; *Op. Min.*, p. 320 ; *Op. Maj.*, ii. 171, iii. 23.

[8] *Opus Maj.* (Bridges), i. 401.

final overthrow of the Hohenstaufen by Charles of Anjou, the Crusades of St. Louis, the agitation of William of St. Amour in the University of Paris, are among the subjects he alludes to.[1] He draws attention to the cruelties of the Teutonic knights and points out how fatal these were to the efforts of the friars to convert the heathen Slavs to Christianity.[2] He knew of the great German friar Berthold of Regensburg : ' The magnificent work he is doing in preaching is of more value than that of almost all the other friars together.' [3] He was profoundly interested in the discoveries of the great travellers of the time, especially William de Rubruck : ' I have perused his book diligently and conferred with the author, and with many others who have investigated the geography of the East and South.' [4] In speaking of mechanical discoveries : ' I have not seen a flying machine,' he says in one place, ' and I do not know any one who has seen one ; but I know a wise man who has thought out the principle of the thing.' [5]

Among the learned he made many friends,[6] such as the mysterious Peter de Maricourt,[7] and the unnamed *homo sapientissimus*, who has been identified on doubtful grounds with the Franciscan William de Mara.[8] The enemies he made by his bitter tongue were more important people, chief among them being Albert the Great,[9] who probably

[1] Cf. *Comp. Studii Phil.* (Brewer), pp. 399, 429 ; *Op. Tert.* (Little), p. 19 ; *Op. Maj.* (Bridges), pp. 321, 386.

[2] *Op. Maj.* (Bridges), iii. 121–2.

[3] *Op. Tert.* (Brewer), p. 310.

[4] *Op. Maj.* (Bridges), i. 303, 305, 356–74, 400.

[5] *De Secretis Operibus Artis et Naturae* (Brewer), p. 533.

[6] Cf. *Op. Tert.* (Brewer), p. 58.

[7] e.g. *Op. Tert.* (Brewer), pp. 35, 43, 46–7. See Picavet, *Essais*, &c. (Paris, 1913), cap. xii.

[8] *Op. Tert.* (Brewer) ; *Op. Min.*, pp. 32, 317 ; S. Berger, *Quam notitiam Linguae Hebraicae habuerint Christiani*, &c., p. 35.

[9] *Op. Tert.* (Brewer), pp. 30, 37–42 ; *Op. Min.*, pp. 327–8 : these passages probably refer to Albert rather than to Aquinas. Bacon

was thinking of Bacon when he denounced those critics who were too idle to publish works of their own and only read the works of others to find fault with them.[1] Bacon himself admits that he wrote nothing or next to nothing of importance—confining himself to letters to friends who asked his opinion on special points.[2] This is, however, an exaggeration. Though he received no command to write from his superiors,[3] who were naturally nervous of encouraging independent talent at a time when the publication of the 'Introduction to the Eternal Gospel' had shaken the Order to its foundations,[4] the list of his writings which may be assigned to this period is not inconsiderable. It probably includes the *De Speculis* and the *De Mirabili Potestate Artis et Naturae*, certainly the long astronomical work *De Computo Naturali* (A.D. 1263–4) and the *Metaphysica*[5] (a treatise which in its present fragmentary form gives a very poor impression of Bacon's capacity to deal with questions of pure philosophy), and probably a version

was indignant that he should be quoted as an 'authority' in the schools, and regarded his influence as pernicious mainly because of his ignorance and neglect of languages and mathematics, and the sciences based on mathematics: he reiterates that he is not moved by personal feeling—indeed, he praises him as 'studiosissimus' (Brewer, p. 327)—but attacks him only 'propter amorem veritatis et propter utilitatem communem' (ib. p. 30). That his hostility was not a Franciscan's jealousy of a Dominican is proved by the fact that he simultaneously denounces Alexander of Hales. (On pp. 326–7 of Brewer, for 'Nam quum intravit', &c., read: 'Immo quoniam intravit ordinem fratrum minorum, fuit de eo maximus rumor non solum . . . sed propter hoc quod novus fuit Ordo Minorum.')

[1] Mandonnet, *Siger de Brabant*, i. 246; *Alberti Magni Opera Omnia*, ed. Borgnet, viii. 803–4 (Politics).

[2] *Op. Tert.* (Brewer), p. 13.

[3] Ibid.

[4] Cf. Seppelt, *Der Kampf der Bettelorden*, &c., Breslau, 1907; and the decree against publishing unauthorized writings in the General Constitutions of the Franciscan Order, 1260: *Archiv f. Lit. u. Kirchengesch.*, vi. 110.

[5] Cf. *Op. Tert.* (Little), p. 56.

of the important physical treatise *De Multiplicatione Specierum*, or On the propagation of force. The last two seem, however, to have been written after Bacon had come into communication with Guy de Foulques, the future Clement IV.

Bacon's great opportunity came in 1266. Guy de Foulques, Archbishop of Narbonne (1259) and Cardinal-Bishop of St. Sabina (1261), heard of Bacon's writings from Raymond de Laon, a clerk in the cardinal's service, and commissioned Raymond to obtain them, probably at the end of 1264.[1] Guy was elected Pope under the title of Clement IV on February 5, 1265. In March 1266, Sir William Bonecor or Boncquor, who had been employed in negotiations with the Holy See and with Spain, and who (as Matthew Paris notes) was well versed in the manners and customs of the Spaniards, was sent by Henry III as special envoy to Clement IV,[2] and to his hands Bacon entrusted a letter for the pope, which has not been preserved.[3] The pope, having noted the *viva voce* explanations which the learned knight supplied, wrote to Bacon from Viterbo on June 22, 1266, bidding him send a fair copy of the works which Raymond de Laon had previously mentioned, secretly and without delay, notwithstanding any constitution of the Franciscan Order to the contrary.[4]

Bacon's gratitude was boundless. 'The Head of the Church has sought out me, the unworthy sole of its foot . . . I feel myself elevated above my ordinary strength ; I conceive a new fervour of spirit. I ought to be more than grate-

[1] It is often said that Guy de Foulques heard of Bacon when he was legate in England (1264) ; he failed, however, to gain admittance to England and got no further than Boulogne.

[2] Matt. Paris, *Chron. Maj.*, v. 555, 576. Pat. Rolls, 50 Hen. III, m. 24. Sir W. Bonecor is frequently mentioned in the public records.

[3] Can it have been the *Metaphysica de viciis contractis in studio theologie* ?

[4] The letter is printed in Brewer, *Op. Ined.*, p. 1.

ful since your Beatitude has asked me for that which I have most ardently desired to communicate, which I have worked at with immense toil and brought into light after manifold expenses.'[1] He explains to the pope in some detail the various difficulties which he had had to face: weak health, want of money, lack of assistants, the obstacles thrown in his way by his superiors, the impossibility of finding competent and trustworthy copyists, and his own methods of composition. 'Anything difficult I have to write four or five times before I get what I want.'[2] The pope was wrong in thinking that the work was already written: nothing worthy of his Holiness was written, and the whole had to be composed from the beginning. His first project was an elaborate one, including a systematic and scientific treatment of the various branches of knowledge; he worked at this, writing parts of the *Communia Naturalium*[3] and *Communia Mathematicae*, for some months ('till after Epiphany', i. e. January 6, 1267), but found it impossible. He then started again on a more modest scale and wrote in the next twelve months the preliminary treatise known as the *Opus Majus*,[4] which was supplemented by the *Opus Minus*, and, subsequently, by the *Opus Tertium*.[5]

The *Opus Minus* and the *Opus Tertium* were both of them introductions to and summaries of the *Opus Majus* with some additions (chiefly on the dangerous subjects of alchemy and astrology) and further elucidation of special points. The *Opus Majus* Bacon sometimes calls *Tractatus praeambulus* in contradistinction to the great systematic work on all the sciences

[1] *Op. Tert.* (Brewer), pp. 7–8; Brewer's Introduction, p. xxv.

[2] *Op. Tert.* (Brewer), pp. 13–17; *E. H. R.*, xii. 501.

[3] Mr. Steele has pointed out that part of this was written before the *Opus Majus*: *Com. Nat.*, p. 13.

[4] *E. H. R.*, xii. 501–3.

[5] I hope to discuss on another occasion Father Mandonnet's ingenious and paradoxical theory on 'La composition des trois Opus': *Revue néo-scolastique de philosophie*, 1913.

which he hoped to write,[1] more often *Persuasio*.[2] It was a treatise written with the definite object of persuading the practical man of the practical usefulness of 'wisdom', of scientific knowledge and method. The parts into which it is divided are entitled 'On the Usefulness of the Study of Languages', 'On the Usefulness of Mathematics', and so forth, and at the end of each section the author points out practical applications which were likely to appeal to the ruler of the Church; thus a knowledge of Hebrew and Greek is necessary for understanding the meaning and establishing the correct text of the Bible, a knowledge of Arabic is useful to convict the infidel, a knowledge of geography would save missionaries from much waste labour and many dangers, a knowledge of optics would lead to the construction of instruments which would increase the power of vision, and would enable a leader to make and use burning-glasses and destroy the cities and armies of the enemy.

An admirable sketch of the course of thought in the *Opus Majus* was given by the late Professor Robert Adamson in an address delivered at the Owens College, Manchester, in 1876,[3] and is here reproduced. 'You will find it consist', says Professor Adamson, 'mainly in three things: 1st, A criticism of the spirit in which scientific studies were then pursued; 2nd, an attempt at a classification of the sciences; 3rd, an exposition of a new scientific method. . . . As it

[1] e.g. *Op. Tert.* (Brewer), p. 19, 'In tractatu praeambulo et separato a singulis tractatibus particularibus.' Cf. 21, 22, 23, &c.

[2] e.g. *E. H. R.*, p. 507: 'Persuasio igitur quam mitto habet septem partes,' &c. *Op. Maj.*, iii. 36; i. 305 'praesens persuasio' distinguished from 'scriptura perfecta quam requiritis'; p. 325, 'in hac persuasione' distinguished from 'principaliori tractatu'. See also the titles in the Digby MS.

[3] *Roger Bacon: the Philosophy of Science in the Middle Ages* (Manchester, Cornish, 1876). It is out of print. The following pages are reprinted with the kind permission of Mrs. Adamson.

stands at present the work consists of [six] parts,[1] of which the contents are as follows :

'*Part* I is an exposition of the causes which have hindered the progress of true philosophy among the Latins. These *Offendicula*, as Bacon calls them, are four in number : (1) Dependence on authority (*fragilis et indignae auctoritatis exemplum*) ; (2) Yielding to established custom (*consuetudinis diuturnitas*) ; (3) Allowing weight to popular opinion (*vulgi sensus imperiti*) ; (4) Concealment of real ignorance with pretence of knowledge (*propriae ignorantiae occultatio cum ostentatione sapientiae apparentis*). As Bacon bitterly says, the prevailing mode of argument in his time was : " this is affirmed by our superiors ; this is the customary opinion ; this is the popular view ; therefore it must be admitted." It may seem but a small thing for a writer to reject authority, but one must reflect on what that meant in Bacon's time. It meant absolute revolt against the whole spirit of scholasticism ; it was the assertion of freedom of thought, of the claim of science to push forward to its conclusions, regardless of fancied consequences, with implicit trust in the grand law that all truth is ultimately harmonious. Over and over again Bacon dwells upon the baneful influence of authority, and speaks of it in terms that remind one strongly of his namesake. He points out that the Fathers, after all, were men, and used the same faculty of reason that men now possess. He implores his contemporaries to consider that their authorities not only fall into error, but spend great part of their labour in refuting one another, which would not be the case if they were infallible. And finally generalizing his argument, he makes the weighty observation, that authority may compel belief, but cannot enlighten the understanding (*credimus auctoritati, sed non propter eam intelligimus*). He is willing that all honour should be paid to the ancients ; but, as he says, those who are younger in order of time, enjoy the labours of those who have gone before them ; *Quanto juniores, tanto perspicaciores*, a maxim which, it seems to me, may rank with Francis Bacon's famous apophthegm, *antiquitas seculi, juventus mundi*.

'This strong opposition to Authority extends itself to all that rests on custom or popular opinion. Bacon, indeed,

[1] Part VII, on Moral Philosophy, was first edited by Bridges in 1897.

has a true *savant's* contempt for the *profanum vulgus*. "Whatever", he stoutly declares, "seems true to the many, must necessarily be false." The common people, however, are not guilty of the fourth fault, concealment of ignorance and assumption of knowledge; that is the peculiar property of the learned professors. . . .

'On the whole, then, in this first part we can see Bacon deliberately rejecting the whole spirit and method of scholasticism. He has said himself off from contemporary philosophy, and now proceeds to evolve the system of knowledge which ought to be substituted for it.

'Before beginning his task he has to come to terms with the great scholastic study, Theology; this he does in the Second Part of his work. It is not very easy for us to realize Bacon's position with regard to the question of the relation between Philosophy and Theology. He does not seem to have entered with much earnestness on the matter, and sometimes he is a little inconsistent. He takes up the usual position that all knowledge is revealed in the Scriptures, but is there only implicitly, and thus philosophy has a place alongside of theology as its exponent. "The end of all true philosophy", says he, "is to arrive at a knowledge of the Creator through knowledge of the created world." A better definition has seldom been given. Theology, further, has need of philosophy to prove its principles, otherwise infidels, who do not accept the Scriptures, could never be convinced of the truth of the Christian faith. There is much in this proposition that requires more careful handling than Bacon has given. Evidently, however, the problem is not one of the highest interest for him.

'*Part* III. The third part of the *Opus* lays the first stone of the new building. In order to obtain real knowledge we must study what Bacon calls Grammar, what we should call Philology, for Bacon has a wide idea of Grammar. In particular the Greek, Hebrew, Chaldaic, and Arabic languages must be mastered, for the Scriptures and the best philosophical works are written in these tongues. There were translations no doubt; the Bible has been translated, Aristotle had been translated. But Bacon never wearied in pointing out how miserably defective these translations were.[1] Of Aristotle, in especial, he declared that if he had the power he would burn every book, so miserable had been

[1] [Bacon certainly exaggerated the badness of the later translations: cf. Mandonnet, *Siger de Brabant* (2nd ed.), i. 40. A. G. L.]

the execution. There is no doubt that Bacon was right in this criticism, and the history of some of the Latin translations is sufficient to make their worthlessness intelligible. In many cases they were translated from the Arabic by wretched Arabic scholars; while the Arabic versions were not generally from the original Greek. Most frequently they were from Syriac translations, through which a knowledge of Aristotle first penetrated to the Arabs. Thus the steps would be: Original Greek, Syriac version, Arabic translation of the Syriac, Latin version of the Arabic. It is not wonderful that in too many cases Aristotle was indeed "translated", and that there should be found in his harder works what Bacon calls "horrible difficulties".

'Bacon himself knew Greek well. Among his unprinted works[1] is a fragment of a Greek grammar; and so easy did he think the language that he professed himself able to teach any one to read the ordinary authors within three days. For this boast he has been much blamed; Prantl, the historian of Logic, with all the German capacity for hurling hard names, calls him "a swindler and a charlatan like his celebrated namesake". I think it probable that the particular passage in the *Opus Tertium* has been somewhat misunderstood, and that we must not interpret the language very strictly.

'The Fourth part of the *Opus* is in some respects the most remarkable. In it Bacon handles mathematics, their utility for science and for theology. It is for what he says here that one would claim highest credit for him. Mathematics he calls the gate and key of the natural sciences, the alphabet of philosophy. In it alone do we have perfect and complete demonstration. While therefore mathematics is necessary for all science whatsoever, it is particularly needful and useful for natural philosophy. "Physicists", says Bacon, "ought to know that their science is powerless unless they call in the aid of mathematics." (Naturales mundi sciant quod languebunt in rebus naturalibus, nisi mathematicae noverunt potestatem.—*De Coelestibus* MS.)[2] This opinion is not taken up loosely, not thrown out by chance; it is grounded on a broad and comprehensive theory of natural action. For, according to Bacon, all natural phenomena, all generation, change, transformation, must

[1] [Printed in 1902, ed. Nolan and Hirsch.]

[2] [Charles, *Roger Bacon*, 137, note: Steele, *Opera hactenus inedita*, Fasc. IV, p. 342.]

be regarded as the result, the effect, of the exercise of force by material agents. Matter and Force, in short, are his fundamental physical ideas. Now Force, according to him, is invariably subject to mathematical law. It is propagated, or, as he calls it, multiplied, uniformly and regularly in space and time, and can consequently be expressed by lines and figures. Geometry is therefore absolutely necessary in order to explain the action of natural agents; all natural philosophy is ultimately mathematical.[1]

'This is a wonderful step in advance of any preceding

[1] 'The following passages may be cited in support of what is here said:

'(1) "Omnis res naturalis producitur in esse per efficiens et materiam, in quam operatur, nam haec duo concurrunt primo. Agens enim per suam virtutem movet et transmutat materiam, ut fiat res. Sed virtus efficientis et materiae sciri non potest sine magna mathematicae potestate, sicut nec ipsi effectus producti. . . . Et sic potest ostendi, quod nihil in rebus sciri potest sine geometriae potestate. . . . Omne enim efficiens agit per suam virtutem, quam facit in materiam subjectam . . . et haec virtus vocatur similitudo, et imago, et species, et multis nominibus . . . et haec species facit omnem operationem hujus mundi; nam operatur in sensum, in intellectum, et in totam mundi materiam per rerum generationem, quia unum et idem fit ab agente naturali in quodcunque operetur, quia non habet deliberationem, et ideo quicquid ei occurrat facit idem."—*Op. Maj.*, p. 66 [ed. Bridges, i. 110]. The same at greater length in the *De Multiplicatione Specierum*.

'(2) "Circa vero geometricalia, respectu rerum et scientiarum sciendarum, consideravi quod res omnis, quae fit in hoc mundo, exit in esse per efficiens et materiale principium, ex quo producitur per virtutem efficientis, et ideo tota originalis rerum cognitio dependet ex parte efficientis et materiae."—*Opus Tert.* (*Op. Ined.* [Brewer]), pp. 107–8.

'(3) "Nec mirum si omnia sciantur per mathematicam, et omnia per hanc, quia omnes scientiae sunt annexae, licet quaelibet simul cum hac habet suam proprietatem. Unde quaelibet habet potestatem in aliam, nec potest una sciri sine alia. . . . Et necesse est omnia sciri per hanc scientiam, quia omnes actiones rerum fiunt secundum specierum et virtutum multiplicationem ab agentibus hujus mundi in materias patientes; et leges hujusmodi multiplicationum non sciuntur nisi a perspectiva, nec alibi sunt traditae adhuc; cum tamen non solum sint communes actioni in visum, sed in omnem sensum, et in totam mundi machinam, et in coelestibus et in inferioribus."—*Op. Ined.* [Brewer], p. 37.'

thinker. The mere enunciation of such a thought is sufficient to secure for Bacon a high place among those who have written on scientific method. It by no means detracts from his merit to say, as Prantl says, that Grossetête was an able mathematician; for Grossetête, so far as we know, made no such application of his mathematical knowledge. However imperfectly Bacon realized his great conception, and it must be remembered how weak the instrument then was, and how little was prepared for its application, he at all events threw out a fruitful thought, of which modern physical science is but the exemplification.

'So highly does Bacon estimate mathematics that he makes logic entirely subordinate to it. This attempt to show that logic deals essentially with quantities, and is therefore mathematical in character, is both bold and subtle.[1] He will not allow that logical is synonymous with demonstrative. Mathematics alone can give absolute certainty (*in sola mathematica est certitudo sine dubitatione*); demonstration is in essence mathematical. To logic, indeed, Bacon is rather unjust. He advances against it arguments similar to those afterwards employed by Locke. Logic, he says in effect, is innate; we reason perfectly well without it.

'The Fifth part of the *Opus Majus* treats at great length of Perspective or optics. One can readily understand how this should be for Bacon the very type of physical science. It was exactly conformed to mathematical law; in fact, one may say that his grand idea of all physical science as mathematical in nature was simply an inference from what was so palpable in optics. It is not necessary to enter into the details of the treatise, which begins with the psychology of perception, then takes up the anatomy and physiology of the eye, and finally discusses at great length vision in a right line, the laws of reflection and refraction, the construction and properties of mirrors, lenses, and burning-glasses. There is not much advance beyond Alhazen.[2]

'Part VI. Of all the parts of the *Opus Majus*, the sixth is the most important. It treats of experimental science, *domina omnium scientiarum et finis totius speculationis*. Without experience, as Bacon constantly repeats, nothing can be known with certainty. Even the conclusions of

[1] '*Op. Majus*, 60' [ed. Bridges, i. 102].

[2] [On this cf. the remarks of Bridges, Introduction, pp. lxxii–lxxiii, and the articles of Wiedemann, Vogl, and Würschmidt in this volume.]

mathematical physics, reached by argument from certain principles, must be verified before the mind can rest satisfied. To this great science all the others are subsidiary; they are to it *ancillae* or handmaids, an expression that curiously reminds one of Francis Bacon. The reasoning in favour of experience is well worth quoting at length. "There are two modes in which we acquire knowledge, argument and experiment. Argument shuts up the question, and makes us shut it up too; but it gives no proof, nor does it remove doubt, and cause the mind to rest in the conscious possession of truth, unless the truth is discovered by way of experience, e.g. if any man who had never seen fire were to prove by satisfactory argument that fire burns and destroys things, the hearer's mind would not rest satisfied, nor would he avoid fire; until by putting his hand or some combustible thing into it, he proved by actual experiment what the argument laid down; but after the experiment had been made, his mind receives certainty and rests in the possession of truth, which could not be given by argument but only by experience. And this is the case even in mathematics, where there is the strongest demonstration. For let any one have the clearest demonstration about an equilateral triangle without experience of it, his mind will never lay hold of the problem until he has actually before him the intersecting circles and the lines drawn from the point of section to the extremities of a straight line. He will then accept the conclusion with all satisfaction." (*Op. Maj.*, p. 445 [ed. Bridges, ii. 167].)

'This important passage, it seems to me, marks a distinct advance in the philosophy of science. The science of that time proceeded wholly *per argumentum*; verification was unknown. Not only, however, does Bacon recognize the necessity for experiment, for observation at first-hand, but he has a clear appreciation of the true nature of scientific verification. He has already expounded his ideal of physical science, the application of mathematics to determine the laws of force and to deduce conclusions from these laws; but he is perfectly aware that these general conclusions must be tested by comparison with things, must be verified. The function of experimental science is, in a word, Verification. "This Science", says Bacon, "has three great prerogatives in respect to all the other sciences. The first is—that it investigates their conclusions by experience. For the principles of the other sciences may be known by experience, but the conclusions are drawn from these

principles by way of argument. If they require particular and complete knowledge of those conclusions, the aid of this science must be called in. It is true that mathematics possesses useful experience with regard to its own problems of figure and number, which apply to all the sciences and to experience itself, for no science can be known without mathematics. But if we wish to have complete and thoroughly verified knowledge, we must proceed by the methods of experimental science." (*Op. Maj.*, p. 448.[1]) As an example of his method Bacon analyses the phenomena of the rainbow in a thoroughly scientific manner.

'The second and third prerogatives (though not of such importance) may also be mentioned. The second is—that Experimental Science attains to a knowledge of truth which could not be reached by the special sciences; the third—that Experimental Science, using and combining the results of the other sciences, is able to investigate the secret operations of Nature, to predict what the course of events will be, and to invent instruments or machines of wonderful power.

'From the whole spirit of this great work, of which what has been given is but an inadequate summary, we may gather a fairly accurate idea of what Bacon attempted to perform. We see in it strong opposition to the current modes of thought, a well-grounded rejection of authority and of the syllogistic method as then conceived, an attempt at a classification of the sciences, a clear perception of the necessity for studying nature at first-hand, a comprehensive idea of natural philosophy, and the foreshadowings of a new method of research; in all points, in short, an almost exact parallel to what was presented four centuries later in the *De Augmentis* and *Novum Organum*.'

Part VII on Moral Philosophy was unknown to Professor Adamson. It bears obvious marks of haste (Bacon was unable to revise the later sections before sending the work to the pope);[2] it consists largely of quotations from the dialogues of Seneca, which Bacon had just discovered after a search of more than twenty years,[3] and it incorporates many pages of Bacon's Metaphysics,[4] and is perhaps the least

[1] Ed. Bridges, ii. 172–3. [2] *Op. Tert.* (Little), p. 61.

[3] *Op. Tert.* (Brewer), p. 56.

[4] For portions of Metaphysics included see Steele's edition of *Metaphysica* (Introduction), and Little, *Op. Tert.*, p. xxix.

satisfactory portion of the work. Yet in the few pages devoted expressly to political philosophy we find the curiously modern idea that the aged poor should be maintained by the State.[1]

The *Opus Majus* and *Opus Minus*, together with two versions[2] of the *De Multiplicatione Specierum* and a separate treatise on Alchemy,[3] were sent to the pope by the hand of Bacon's young pupil John, apparently early in 1268.[4] It is doubtful whether the *Opus Tertium* was ever sent. Clement IV died November 29, 1268.

About this time Bacon seems to have returned to Oxford, where he wrote (perhaps now, perhaps earlier) his Introduction and Notes to pseudo-Aristotelian *Secretum Secretorum*.[5] To this period also belong the Greek and Hebrew Grammars,[6] and a fragment generally known as *Compendium Studii Philosophiae*. The latter was written when the Papal See had been vacant many years, but during the pontificate of Gregory X, i. e. about 1272;[7] it professes to deal with four

[1] *Op. Maj.* (Bridges), ii. 251.

[2] *Op. Tert.* (Brewer), p. 38; *Op. Tert.* (Little), pp. 34–5; *Op. Tert.* (Brewer), p. 99 'Tractatum de speciebus . . . quem dupliciter misi vobis, et tertio modo incepi sed non potui consummare'.

[3] *Op. Tert.* (Little), p. 82; *Com. Nat.* (Steele), p. 298.

[4] Father Mandonnet in *Roger Bacon et la composition des trois 'Opus'*, pp. 14–16 (Extrait de la *Revue néo-scolastique de philosophie*, fév. et mai 1913), points out that the references to the capture of Bagdad in *Op. Maj.*, Parts IV and VII (Bridges, i. 266; ii. 389–90), imply that Bacon was writing Part IV in 1267, and Part VII in 1268. Bacon refers to the sending of the *Compendium* to the pope in *Comp. Studii Phil.* (Brewer, p. 424).

[5] *Sec. Secretorum* (ed. Steele), p. 10. 'In illo anno (1264) et sequentibus fuerunt maxime turbationes mundi,' &c.: cf. ibid., p. 39.

[6] Edited by Nolan and Hirsch, Cambridge, 1902. These were not written at the time of the composition of the *Op. Tert.* (ed. Brewer), pp. 65, 88. The Greek Grammar is connected with the *Comp. Studii Phil.* (ed. Brewer, p. 495).

[7] Brewer, pp. 399, 414. Clement IV died November 29, 1268: Gregory X was elected September 1, 1271, and consecrated March 27, 1272; died January 10, 1276.

points: (1) the value of knowledge in speculation and practice; (2) the question what parts of knowledge are essential; (3) the methods of acquiring knowledge; (4) the impediments to knowledge and how to avoid or remedy them. It includes violent attacks on all estates of the world —the papal court, all religious orders without exception, the clergy and universities, kings and princes, and lawyers:[1] then follows a dissertation on the study of languages, in the midst of which the treatise breaks off. It is doubtful whether this treatise was intended to form part of the encyclopaedic work on all the sciences, which, to judge from the fragments of it that remain, was written *more scholastico*, in a much more impersonal way. These fragments were composed partly before and partly after the *Opus Majus*: they incorporate whole sections of the works sent to the pope, and probably a number of dissertations which Bacon wrote originally for the pope, but excluded from the final drafts of the *Opus Majus*, *Opus Minus*, and *Opus Tertium*. A sketch of contents which Bacon drew up for the encyclopaedic work may be given,[2] with the warning that Bacon himself rarely adhered to his own plans.

The work was to consist of four volumes, dealing with the principal branches of knowledge; the first or introductory book of each volume dealt with the general principles of the branch of knowledge under discussion; the remaining books being devoted to the special sciences forming the branch; thus:

Vol. I, Grammar and Logic.
(No further details given in Bacon's sketch.)

Vol. II, Mathematics: Book i, General Principles, or *Communia Mathematicae*: Books ii–vi, Special Mathematical Sciences.

[1] His quarrel with the lawyers went very deep: he held that they were destroying the Church, which had become a great legal institution and lost its spirituality: see, e.g., *Op. Tert.* (Brewer), pp. 84–8; *Comp. Studii Phil.* (Brewer), pp. 418–25.

[2] *Com. Nat.* (ed. Steele), pp. 1, 3.

Vol. III, Physics and Natural Philosophy: Book i, *Communia Naturalium*: Book ii, On Heavenly Bodies: Book iii, On the Elements and Inanimate Compounds: Book iv, On Vegetables and Animals. Or (a slightly different scheme):[1] Books ii, iii, and iv are to treat of the seven natural sciences, (1) Optics, (2) Judicial and Practical Astronomy, (3) Barology, (4) Alchemy, (5) Agricultural Chemistry, (6) Medicine, (7) Experimental Science.

Vol. IV, Metaphysics and Morals.
(No further details given.)

It is impossible to say how much of this great work was written: it is not easy to say how much exists. The difficulty is increased by Bacon's incorrigible habit of beginning according to one scheme, and then, when he grew dissatisfied or lost interest, beginning afresh on another scheme, using the same material (slightly altered) but in a different connexion. However, we may say with certainty that a fragment of the *Communia Mathematicae*[2] exists, perhaps in two recensions; the greater part of the *Communia Naturalium* and of the *De Coelestibus*.[3] The substance of some of the other parts will be found in various works of Bacon: e.g. barology is one of the subjects of the *Tractatus trium verborum*.[4] Medicine is dealt with in a number of short treatises,[5] and alchemy is expounded in the (fragmentary) *Opus Minus*,[6] in the *Opus Tertium*,[7] and elsewhere.

[1] *Com. Nat.*, p. 1, n., pp. 5–9.

[2] An edition is being prepared by Mr. Steele and Professor D. E. Smith.

[3] Edited by Steele, *Opera hactenus inedita*, fasc. ii, iii, iv.

[4] Printed Frankfurt, 1603: a new edition is being prepared by Monsieur J. A. Col.

[5] In the *De Erroribus Medicorum* occurs the phrase 'Hoc est principaliter intentum quantum ad peccata philosophie que redundant in theologicam', which suggests that the treatise may be connected with the group of treatises written for Clement IV.

[6] Ed. Brewer, pp. 313–15, 359–89. [7] Ed. Little, pp. 80–9.

In 1277 occurred the great catastrophe of Bacon's life. The University of Paris had for years been distracted by philosophical and theological quarrels, and by struggles between the secular masters and the mendicant orders in the faculty of theology. On January 18, 1277, Pope Gregory X ordered the Bishop of Paris to inquire into and report on the ' errors ' which disturbed the pure streams of wisdom in the university.[1] Stephen Tempier before he became bishop had been Chancellor of the Church and University, in which capacity he had been noted for his arbitrary and tyrannical measures. He now in conjunction with certain masters of theology seized the opportunity of attacking progressive and independent thought in all directions in a decree issued March 7, 1277.[2] This begins by declaring that students in arts exceeding the limits of their proper faculty presumed to discuss in the schools certain execrable errors enumerated below: for they say that these things are true according to philosophy, but not according to the Catholic faith, ' as though there are two truths and as though there may be truth in the sayings of damned gentiles contrary to the truth of holy scripture.' All maintaining these errors or attending lectures in which they are taught are excommunicated unless within seven days they confess to the bishop or the chancellor, in which case they will be punished according to their faults. Various books of magic are then condemned, and a like sentence passed on all who teach or attend lectures on such subjects. Then follows a list of 219 condemned errors. Enumerated in the wildest confusion, these include doctrines not only of the Averroist artists but of the Dominican theologians—not only of Siger de Brabant but of Thomas Aquinas.

[1] *Chart. Univ. Paris.*, i, no. 471. On the whole subject, see Mandonnet, *Siger de Brabant*, i, chap. ix (2nd ed., Louvain, 1911).

[2] *Chart. Univ. Paris.*, i, no. 473; Mandonnet, *Siger de Brabant*, ii. 175–91.

Some of them may have been directed against Bacon: e. g. Error 150 is, 'That a man ought not to be content with authority in order to have certainty on any question.' Error 151 is, 'In order that a man may have certainty of any conclusion, he ought to be based on principles known by himself.' Several of them are directed against the belief in astrology: e. g. 143, 'Different signs in the heaven signify different conditions in men both of spiritual gifts and of temporal things;' No. 206, 'That health, sickness, life, and death are attributed to the position of the stars and the aspect of fortune;' No. 154, 'That our will is subject to the power of heavenly bodies;' No. 167, 'That from signs (in the heavens) future events of various kinds can be predicted.'

Bacon, like his contemporaries, was a thorough believer in astrology: indeed, when the earth was regarded as the centre of a spherical and limited universe, it was impossible not to believe that the motions of the heavenly were followed by corresponding changes in terrestrial bodies. But Bacon is always insisting that though those influences work unhindered in the inanimate world, they are in the case of man limited by the freedom of the will: they affect only temperament; they may incline a man to a particular course of action, they cannot compel him, because the will is free.[1] Bacon differs from most of his contemporaries in the thoroughness with which he investigated the subject: he frequently rebukes those who argued (very wisely) that the complexity of the subject was too great to permit of any certain results;[2] he read and compared the authorities,

[1] e. g. *Op. Maj.* (Bridges), i. 240; *Op. Tert.* (Little), p. 4; *Comp. Studii Phil.* (Brewer), p. 422.

[2] Cf. *Op. Maj.* (Bridges), i. 394. Also *De Erroribus Medicorum* (MS.). The following passage from Pecham's *Canticum Pauperis pro Dilecto* (ed. Quaracchi, p. 136) is interesting as containing a clear allusion to Bacon: 'Audita proinde laude mathematicae . . . eius gymnasia introivi . . . illiciebar tamen paululum illa mathematicae

compiled astronomical tables, and studied history to establish the effects of constellations and comets; and he did not shrink from applying the science to the elucidation of the foundations of religions.[1]

His attitude to magic is more individual. While showing up unmercifully charlatans and swindlers, he points out that many things are considered magical which are merely the result of some unknown power of art or nature: thus the magnet must appear magical to people who know no better. What power again, if any, have incantations and charms? What is the explanation of the wonderful power of words? 'All the miracles since the world began, almost, have been wrought by words.' It was unreasonable to prohibit the study of these things on the ground that a knowledge of them would, in the hands of bad men, produce evil results. Antichrist would certainly know all about them, and we must be prepared to meet him. The whole question of the 'magical sciences' should be investigated by competent men specially licensed by the pope.[2]

A criticism of the decree of the Bishop of Paris was soon issued under the name of *Speculum Astronomiae*, which has been generally ascribed to Albertus Magnus and printed among his works;[3] it embodies, however, the views of Bacon on astrology and magic, and was probably written either by him or under his inspiration.[4] As to the books of necro-

parte, quae ex motu siderum colligit praesagia futurorum. Considerans vero illam non demonstrationibus deduci, sed experimentis frivolis inniti, sciens etiam ex illius negotii peritissimis, efficaciam siderum super habentes liberum arbitrium esse inter possibile et necessarium, posseque sapientem sideribus dominari, vidi a signis coeli non esse metuendum . . . vanaque reputavi opera et risu digna', &c.

[1] *Op. Maj.*, i. 253–69, 289; *Op. Tert.* (ed. Little), p. 14.

[2] *Op. Tert.* (Brewer), pp. 96–9; *Op. Tert.* (Little), pp. 15–18; *De Potestate Artis et Naturae* (Brewer), pp. 523 et seq.

[3] *Alberti Magni Opera Omnia*, ed. Borgnet, x. 629 et seq.

[4] See Mandonnet, 'Roger Bacon et le Speculum Astronomiae' (*Revue néo-scolastique*, août 1910).

mancy, says the writer, it would be better to keep them than to destroy them. Many of the books condemned contain nothing against the Catholic faith; 'nor is it perhaps just that people who have never touched them should presume to judge them.' It was an open repudiation of ecclesiastical authority.

Towards the end of 1277 John of Vercelli, Master-General of the Friars Preachers, and Jerome of Ascoli, Minister-General of the Friars Minor, met in Paris to devise measures for allaying the scandalous quarrels between the Dominican and Franciscan Orders. They decreed among other things that the friars of both Orders should abstain from mutual detractions; 'and any friar who was found by word or deed to have offended a friar of the other Order should receive from his Provincial such punishment as ought to satisfy the offended brother.'[1] Roger Bacon had certainly offended the leading Dominicans, and if he had also attacked members of his own Order with almost equal vehemence, this would not make the latter less willing to give him up as a sacrifice to their rivals.

'This Minister General brother Jerome (in the words of the Franciscan *Chronicle of the XXIV Generals*[2]) by the advice of many friars condemned and reprobated the teaching of Friar Roger Bacon of England, master of sacred theology, as containing some suspected novelties, on account of which the same Roger was condemned to prison,—commanding all the friars that none of them should maintain this teaching but should avoid it as reprobated by the Order. On this matter he wrote also to Pope Nicholas (III) in order that by his authority that dangerous teaching might be completely suppressed.'

The teaching and the novelties are not defined by the chronicler, but we may infer that the causes of Bacon's imprisonment were his contempt for authority, his attacks

[1] 'Chron. XXIV Gen.' in *Anal. Franc.*, iii. 365.
[2] *Anal. Franc.*, iii. 360.

on the Dominicans and on his own Order, his defence and practice of the ' magical sciences ', in magic being included the unknown powers of art and nature.

It is generally supposed that Bacon remained in prison from the end of 1277 till 1292. Raymond Gaufredi, a supporter of the spiritual friars, was elected General Minister by the anti-Italian party at Rieti at Whitsuntide in 1289: he visited a number of provinces and released some friars unjustly imprisoned in the March of Ancona in 1290. It is possible that Roger Bacon was set free at this time, or at the General Chapter at Paris, May 25, 1292. Jerome of Ascoli, Roger Bacon's enemy, who had ascended the papal throne as Nicholas IV, died on April 4, 1292; on the other hand, Raymond Gaufredi was accused of heresy, and had difficulty in maintaining his position at the Chapter of 1292.[1] The tradition that Roger owed his deliverance to Raymond Gaufredi is supported by a note appended to the summary made by Raymond of an alchemical work of Bacon's: ' And Roger on account of this work by command of the said Raymond was seized by the friars of the Order and imprisoned; but Raymond released Roger from prison because he taught him this work.' [2] This would become intelligible if we might substitute ' Jerome ' for the first ' Raymond '. It is certain that Roger's last dated work was written in 1292. This is a fragment called *Compendium Studii Theologiae*,[3] of which perhaps only the beginning was written. Once more he deals with the causes of error, first

[1] On the general situation see K. Balthasar, *Geschichte des Armutsstreites* (Münster i. W., 1911), pp. 174–84.

[2] ' De Leone Viridi,' printed in *Sanioris Medicinae*, &c. Frankfurt, 1603, pp. 264–85. Cf. MS. Bibl. de l'Arsenal (Paris, 2872, f. 401).

[3] Ed. by Dr. H. Rashdall, Brit. Soc. Franc. Studies, vol. iii. Bacon refers to other parts of the work which do not seem to be extant: pp. 36, 51. Perhaps the version of the *De Multiplicatione Specierum* in Brit. Mus. MS., Royal 7, F. VIII, ff. 2–12, and MS. Angelica 1017 in Rome belonged to this *Compendium*.

among which is undue reliance on authority, and then proceeds to the establishment of truths : this part is occupied with a discussion of the misunderstandings and the real meanings of the terms used ; before this discussion is finished the work breaks off. It may be noticed that Roger at the end of his life goes back to his early reminiscences—the teaching of that ' utter fool ' (*stultissimus*) Friar Richard of Cornwall in 1250, and the lectures of St. Edmund of Canterbury in his early days at Oxford.[1]

' The noble doctor Roger Bacon ', says John Rous,[2] ' was buried at the Grey Friars in Oxford, A. D. 1292, on the feast of St. Barnabas the Apostle ' (June 11). There seems to be no authority for placing his death in 1294.

Though Roger Bacon was in opposition to the general tendencies of his age, it is a mistake to suppose either that he stood alone in his own lifetime or that his influence was negligible after his death. Professor Baur of Tübingen has recently edited among the Philosophical Works of Grosseteste[3] a *Summa Philosophiae*, falsely ascribed to Grosseteste, really written by an unknown Englishman soon after 1265—that is, at the very time that Roger Bacon was engaged on the *Opus Majus*. This work, if not by Bacon himself—which seems impossible—was composed by some one in the very closest sympathy with him ; the whole drift of thought and often even the very expressions are reminiscent of Bacon. Dr. Rashdall has pointed out that the germs of the two rival schools of the later Middle Ages, the Realism of Duns Scotus and the Nominalism of Ocham, are to be found in Bacon.[4] The influence of his physics is obvious in Pecham

[1] *Comp. Studii Theol.*, pp. 34, 52.

[2] *Hist. Regum Angliae*, p. 82. Cf. Royal MS. 13, C. I, f. 151 : 'Anno Christi 1292 obiit Rogerus Bacon professor theologie et quasi eruditus ut magister in octo scienciis ubi alii clerici non potuerunt preter vii scire' (MS. 'scie').

[3] In *Beiträge zur Geschichte der Philosophie des Mittelalters*, Band IX, Münster i. W., 1912.

[4] *Comp. Studii Theol.*, pp. 22–3.

(a not very grateful pupil), and hardly less marked in Giles of Rome and John Dumbleton.[1] It would be interesting to examine how far it can be traced in Raymond Lull, Arnold de Villeneuve, Walter Burley, Thomas Bradwardine, and even Duns Scotus.[2] Again, many others besides Bacon were advocating the study of Greek and Oriental languages. The English Franciscan William de Mara was evidently an admirable Hebrew scholar.[3] Both the Dominican and Franciscan Orders had colleges for the study of Oriental languages before the end of the century,[4] and in 1312 Clement V in the Council of Vienne endeavoured to provide for the establishment and endowment of chairs of Hebrew, Greek, Chaldaic, and Arabic in the Roman Curia and the Universities of Paris, Oxford, Bologna, and Salamanca.[5] This effort was not very successful in the universities, but among the English Franciscans it is possible to trace a thin but continuous line of Greek and Hebrew learning during the fourteenth century. Henry de Costesy, lector to the Franciscans at Cambridge, *c.* 1330, is perhaps the most eminent of these scholars.[6]

Direct allusions to Bacon are few until the period of the Renaissance. William Herbert, lector to the Franciscans at Oxford, obtained some of his manuscripts (two are still extant) for the friary at Hereford.[7] Pierre Dubois at the beginning of the fourteenth century had assimilated his

[1] See Professor Duhem's article in this volume.

[2] Cf. R. Seeberg, *Die Theologie des Joh. Duns Scotus*, Leipzig, 1900, pp, 12, 605.

[3] The Toulouse MS. 402 ought to be edited.

[4] Golubovich, *Bibl. Bio-Bibliog.*, i. 365; Mortier, *Hist. des Maîtres Généraux*, i. 518 seq.

[5] *Chart. Univ. Paris.*, ii, no. 695. Cf. also bull of Honorius IV, Jan. 23, 1286: ibid., i, no. 527.

[6] M. R. James in *Camb. Modern Hist.*, vol. i, and Catalogue of MSS. at Christ's College, Cambridge, no. 11.

[7] M. R. James, 'Library of the Grey Friars of Hereford' (Brit. Soc. Franc. Studies, vol. v).

teaching on ' experience ', and recommends the study of his mathematical works.[1] The early alchemical treatise *De Lapide Philosophorum*, popularly attributed to Thomas Aquinas, quotes ' Rogerius in libro De Influentiis ' (i. e. the *De Multiplicatione Specierum*).[2] William Woodford at Oxford, towards the end of the century, refers to his curious book on Old Age.[3] About the same time Franciscan chroniclers placed him among the famous natural philosophers of the Order and praised his universal learning.[4] In the fifteenth century disputants quoted him in the schools at Oxford,[5] and an official letter of the University mentioned him among the ' modern Oxonians ' who had kept untarnished the brightness of Oxford's fame.[6] Cardinal Pierre d'Ailly incorporated a passage from Bacon's work on geography (*Opus Majus*, iv) in the *Imago Mundi*, a passage which so impressed Columbus that he annotated it fully and quoted it in a letter to Ferdinand and Isabella:[7] thus the *Opus Majus* at second-hand became one of the authorities which inspired him to undertake his great voyage of discovery. And it would appear that through the medium of Paul of Middelburg, Bacon influenced Copernicus.[8]

The extant manuscripts of Bacon's works show that the

[1] *De Recuperatione Terrae Sanctae*, ed. Langlois.

[2] Zetzner, *Theatrum Chem.* (1659), iii. 267. Alchemists in the later Middle Ages often quote Bacon or the numerous spurious works attributed to him: e. g. George Ripley in *The Marrow of Alchymie*; ed. W. Salmon, 1707, p. 646.

[3] Brown, *Fasc. Rer. Expet.*, i. p. 197.

[4] Bart. Pisan. *De Conform.*, i. 338 (ed. Quaracchi): Bodl. MS. Can. Misc., 525, ff. 202^{v}, 203^{r}: *Opuscules de critique historique*, i. 287.

[5] Lambeth MS. 221, ff. 281, 306^{v}.

[6] Ibid., f. 308^{v}.

[7] *Opus Majus* (Bridges), i. pp. xxxiii, 292: Thacher, *Christopher Columbus*, iii. 480: *Select Letters of Columbus* (Haklúyt Soc.), pp. xliii, 140.

[8] *Opus Majus* (Bridges), i. pp. xxxiv, 285: John Dee's *Playne discourse and humble advice* on the reform of the Calendar, MS. Corp. Chr. Coll., Oxford, 254, ff. 141–54.

'Doctor mirabilis' never wanted admirers. Thus of his treatise on Optics (*Opus Majus*, v) (to give one instance) I have found some twenty-seven manuscripts, ranging from the thirteenth to the seventeenth century. The treatises on Optics and Mathematics were probably the most popular in the Middle Ages, and here Bacon, though he made fresh applications of the sciences, was rather the interpreter of the Arabian scientists to the western world than an original investigator. For the most original sides of his work, for his experimental science and his principles of textual criticism, the Middle Ages had little understanding. Bacon has the merit of having pointed out the lines of intellectual advance which the world was to follow two centuries after his death.

II

DER EINFLUSS DES ROBERT GROSSETESTE AUF DIE WISSENSCHAFTLICHE RICHTUNG DES ROGER BACON

VON LUDWIG BAUR

I

WENN man den Begriff 'Lehrer' im strengen Sinn des Wortes nimmt und nur diejenigen Männer unter die 'Lehrer' des Roger Bacon rechnet, welche durch persönlichen mündlichen Unterricht ihm in der Philosophie und Theologie die wissenschaftliche Richtung gaben, so ist es schwer, ja unmöglich, die Lehrer des Roger Bacon erschöpfend und sicher zu bestimmen. Der Begriff des Lehrers ist zudem im Mittelalter in mehrfacher Hinsicht etwas dehnbar. Er verlangt auch nicht notwendig einen erheblichen Altersunterschied zwischen dem Lehrer und seinem Schüler: auch zwischen Freunden gleichen Alters kann ein Lehrer- bzw. Schülerverhältnis bestehen. Und nicht immer war es ein in seiner Dauer oder in der Auswahl der Fächer genau umgrenztes Verhältnis.

Da Roger Bacon in keiner seiner zahlreichen Schriften direkt und bestimmt die Lehrer nennt, deren mündlichem Unterricht und unmittelbarer Leitung er seine Kenntnisse in den verschiedenen Zweigen menschlichen Wissens und seine wissenschaftliche Richtung überhaupt verdankt, so können die Namen derselben nur indirekt aus seinen Andeutungen, aus seinem Studiengang, aus dem Charakter seiner Schriften, der Eigenart seiner wissenschaftlichen Problemstellungen und Lösungsversuche erschlossen werden.

Gerade bei Roger Bacon gilt, dass oft diejenigen, die seine persönlichen Freunde waren, zugleich auch seine bedeutenden und einflussreichen Lehrer wurden. Wenigstens sagt er selbst: 'Quaesivi amicitiam omnium sapientum inter Latinos et feci iuvenes instrui in linguis et figuris et numeris et tabulis et instrumentis et in multis necessariis.' [1]

Es erscheint als glaubwürdig, wenn man annimmt, oder wenigstens vermutet, dass Roger Bacon während seiner Studienzeit in Oxford Richard Fitzacre, Edmund Rich (den hl. Edmund v. Canterbury), den Dominikaner Robert Bacon (seinen Onkel ?) zu Lehrern gehabt habe. Lehrer und zugleich Freunde (trotz des erheblichen Altersunterschiedes) wurden ihm dort Robert Grosseteste und Adam de Marisco. Als er — vor 1245 — nach Paris übersiedelte, da sah er, wie er selbst erzählt (*op. ined.*, ed. Brewer, 325), noch den Alexander v. Hales († 1245) mit eigenen Augen. Er hörte Wilhelm von Auvergne († 1248) noch über den *intellectus agens* vor der ganzen Universität disputieren. Indes ob, oder wie weit ihn mit den beiden Genannten noch ein eigentliches Schülerverhältnis verband, ist nicht mehr zu sagen. Auch mit dem hl. Bonaventura scheint er zu Paris in persönliche Berührung gekommen zu sein, wenn anders die Annahme richtig ist, dass sich der Brief Bonaventuras 'ad magistrum innominatum' an Roger Bacon gerichtet habe.[2] Jedenfalls aber bestand dieses 'Schülerverhältnis', wenn sich je ein solches zwischen Bonaventura und Roger Bacon herausbildete, ausschliesslich für das Gebiet der Theologie und Aszetik. — Aus Bacons Schriften selbst wird man entnehmen dürfen, dass er zu Paris (bzw. Oxford) zu seinen Lehrern sowohl als Freunden zählen dürfte: Campanus von Novara; den Astronomen, Mathe-

[1] *Opus Tertium* (Brewer), p. 58.

[2] Vgl. G. Delorme in *Dictionnaire de Théologie catholique*, ii, s. v. 'Bacon, Roger.'

matiker und Computisten, Johannes von London; den grossen Mathematiker aus der Picardie, Petrus von Maricourt, der ihm zugleich wertvolle optische Kenntnisse vermittelte. Für seine Ausbildung in den Sprachen wurde ihm die Freundschaft mit Magister Nicolaus (Graecus ?), Hermannus Alamannus und Robert Grosseteste wertvoll. Amalrich von Montfort und Adam de Marisco gesellten sich dazu.[1] Wie weit nun der wissenschaftliche Einfluss dieser Männer auf Roger Bacon bestimmend wurde, lässt sich solange nicht in wissenschaftlich einwandfreier Weise feststellen, als wir nicht in den Stand gesetzt sind, durch Vergleichung ihrer Schriften diesen Einfluss exakt zu bestimmen. Vorerst könnte man nur die vagen Vermutungen wiederholen, welche Roger Bacons Biographen durchweg über seine Lehrer und deren Einfluss ausstellten.

Anders verhält sich das mit seinem berühmtesten Lehrer Robert Grosseteste, dessen philosophische Werke durch den Verfasser dieser Arbeit zum erstenmal vollständig und in einer kritischen Ausgabe der wissenschaftlichen Bearbeitung zugänglich gemacht wurden.[2] Sie ermöglichen eine genaue Feststellung des wissenschaftlichen Einflusses, den Robert Grosseteste auf seinen Schüler Roger Bacon ausgeübt hat. Derselbe ist grösser, als man bisher ahnte, und manch ein Lorbeerblatt, das man bisher in den wissenschaftlichen Ruhmeskranz des Roger Bacon eingeflochten hatte, muss nicht ihm, sondern seinem Lehrer Robert Grosseteste zuerkannt werden. Es bestätigt sich auch hier das Urteil P. Mandonnets, dass ein vergleichendes Studium der Wissenschaft des Roger Bacon mit der seiner Zeitgenossen die allzu

[1] Roger Bacon macht die Genannten namhaft im *Opus Tert.* (ed. Brewer), ii. 13, 17.

[2] Lud. Baur, *Die philosophischen Werke des Robert Grosseteste, Bischofs von Lincoln*, Münster (Aschendorff), 1912 (Beiträge zur Geschichte der Philosophie des Mittelalters, hgb. v. Cl. Baeumker u.s.w., IX. Bd.). Demnächst erscheint in derselben Sammlung: L. Baur, *Die Philosophie des Robert Grosseteste, Bischofs v. Lincoln.*

optimistischen Werturteile über ihn bedeutend herabsetzen und den Wert seiner Ideen und Theorien auf ein gerechtes Mass zurückführen werde.[1]

II

Robert Grosseteste übernahm nach seiner Rückkehr von Paris ca. 1224–6 (?) auf Bitten der eben damals in Oxford angekommenen Minderbrüder, speziell des Frater Agnellus v. Pisa, die Aufgabe, den Franziskanernovizen Unterricht in den Wissenschaften, so weit dieser notwendig erschien, zu geben.[2] Es kann kaum zweifelhaft sein, dass auch andere Schüler diesen Unterricht besucht haben werden. Jedenfalls ist eine ganze Anzahl späterer Franziskanerlehrer zu Oxford aus Grossetestes Schule hervorgegangen.[3]

Sicher war dies der Fall bei Roger Bacon, der von Grosseteste in mannigfacher Hinsicht seine wissenschaftliche Richtung empfing. Wir können nicht sagen, wie weit die wissenschaftlichen Anschauungen Bacons auf *mündliche* Anregungen durch Grosseteste zurückgehen. Aber wir können auf Grund der *Schriften* Grossetestes und Bacons diejenigen Lehrpunkte bezeichnen, welche die wissenschaftliche Art des Roger Bacon in zweifelloser Abhängigkeit von seinem Lehrer zeigen.

Grammatik und Sprachenstudium

Man rühmt dem Roger Bacon allgemein nach, dass er die Wichtigkeit, ja Unerlässlichkeit des philologischen Studiums und der Sprachenkenntnis für die verschiedenen Wissenszweige, besonders aber für das Theologiestudium, als erster erkannt und in höchst temperamentvoller Weise

[1] P. Mandonnet, *Siger de Brabant et l'averrhoïsme latin au XIII^e siècle*, Fribourg, 1899, p. 260.

[2] Thomas v. Eccleston (ed. Little, 1909), p. 60.

[3] Vgl. das höchst verdienstliche Buch von A. G. Little, *The Grey Friars in Oxford*, Oxford, 1892, pp. 139 ff.; H. Felder, *Geschichte der wissenschaftlichen Studien im Franziskanerorden bis um die Mitte des 13. Jahrhunderts*, Freiburg i. Br., 1904.

literarisch vertreten habe. In der Tat braucht man nur die einschlägigen Seiten seines *Opus Majus*, des *Opus Minus*, des *Opus Tertium*,[1] des *Compendium Studii*, oder seiner griechischen Grammatik (ed. Nolan and Hirsch, 1902) zu lesen, um zu erkennen, wie sehr dieses Lob berechtigt ist. Roger Bacon betrachtet es als ein unumstössliches Axiom für das akademische Studium, 'Notitia linguarum est prima porta sapientiae' (*Op. Tert.*, cp. 28, ed. Brewer, 102). Grammatik und Sprachenkunde müssen demnach die Grundlage aller wissenschaftlichen Ausbildung sein.[2] Roger Bacon rühmt deshalb auch von sich selbst: 'Iam a iuventute laboravi *in scientiis et linguis*.'[3]

Dieses Interesse Bacons an den philologischen Studien gibt sich in verschiedener Weise in seinen Schriften kund: Er überschüttet jene Männer mit Lob, welche die Sprachen — Latein, Griechisch, Hebräisch, Chaldäisch, Arabisch — beherrschen, oder ihr Interesse am Sprachenstudium irgendwie dokumentierten: Boëthius,[4] Beda,[5] Robert Grosseteste, Adam Marsh, Thomas Wallensis[6] werden als die weisesten Männer, als 'maiores clerici de mundo et

[1] Die Einwendungen K. Werners gegen die Echtheit des von Brewer publizierten *Opus Tertium* halte ich mit H. Höver für nicht stichhaltig. Vgl. Höver im *Jahrb. f. Philos. u. spekul. Theol.*, xxv. (1911), 215 ff.

[2] *The Greek Grammar of Roger Bacon*, ed. Nolan, xxviii; daselbst weitere Belegstellen. [3] *Op. Tert.*, cp. 20, ed. Brewer, 65.

[4] *Op. Tert.*, cp. 10, ed. Brewer, 33; *Op. Maj.*, iii, ed. Bridges, i. 67; *The Greek Grammar . . .*, ed. Nolan, 29.

[5] *Op. Min.*, ed. Brewer, 332; *Greek Grammar*, 41.

[6] *Op. Maj.*, iii, ed. Bridges, i. 67–73; *Op. Tert.*, cp. 10, ed. Brewer, 33; cp. 25, ibid., 91; *Greek Grammar*, 118. Roger Bacon sagt selbst: 'Doctores autem non desunt . . . Graecum vero maxime concordat cum Latino et sunt multi in Anglia et Francia, qui hic satis instructi sunt.' Und: 'Multi inveniuntur, qui sciunt loqui Graecum et Arabicum et Hebraeum inter Latinos,' *Op. Tert.* (Brewer), cp. 33–4. Unter seinen Landsleuten, die im 13. Jahrh. sich mit der griechischen Sprache vertraut machten, sind zu nennen: Daniel Morlai, Michaël Scotus, Robert Grosseteste, John Basingstoke, Adam de Marisco, Wilhelm de Mara. V. Nolan, a. a. O., xliii; Bacon, *Comp. Studii*, vi. 434.

perfecti in scientia divina et humana' gepriesen um ihrer sprachlichen und grammatischen Kenntnisse willen. Andererseits werden diejenigen schwer getadelt, welche keine Sprachenkenntnisse besitzen, oder sich um ein philologisches Wissen nicht kümmern.

Roger Bacon wird nicht müde, immer wieder auf die grosse Bedeutung hinzuweisen, welche die grammatischen, linguistischen und philologischen Kenntnisse als Grundbedingung der Vermittlung der Gedanken fremder Völker und ihrer Literaturen für den Theologen, Philosophen, Exegeten besitzen. Er verlangt deshalb vom Theologen eine eindringende Kenntnis der lateinischen, griechischen, hebräischen, chaldäischen und womöglich auch der arabischen Sprache. Dabei unterscheidet er drei Stufen der zu fordernden Höhe sprachlicher Kenntnisse.[1]

Einen Hauptgrund für den von ihm so oft beklagten Mangel an einer gründlichen Sprachenkenntnis seiner Zeit erkannte Roger Bacon darin, dass die richtige wissenschaftliche Unterrichtsmethode und Lernmethode fehlte; und diese fehlte, weil man keine richtigen Grammatiken hatte, während das praktisch und unmethodisch erlernte Sprechen der lateinischen, griechischen und arabischen Sprache mehr verbreitet war.[2] Daher schrieb Bacon selbst eine griechische Grammatik, in welcher er eine ausgebreitete Kenntnis der alten Grammatiker verrät. Auch eine hebräische Grammatik hat ihn, wie Hirsch mit guten Gründen dargelegt hat, zu ihrem Verfasser.[3]

Vor allem aber suchte Bacon eine philologische Methode

[1] Nolan, a. a. O., xlv; Bacon, *Comp. Studii Phil.*, vi. 433 f.

[2] Mit der ihm eigenen Übertreibungssucht sagt Roger Bacon hierüber: 'Paucissimi sunt, qui sciunt rationem grammaticae ipsius, nec sciunt docere eam; nam non sunt quattuor Latini, qui sciant grammaticam Hebraeorum et Graecorum et Arabum.' Er fügt hinzu: 'bene enim cognosco eos, quia et citra mare et ultra feci inquiri et multum in his laboravi.' *Op. Tert.*, a. a. O., Nolan, xliv.

[3] *The Greek Grammar of Roger Bacon and a fragment of his Hebrew Grammar*, ed. by Nolan and Hirsch, Cambridge, 1902, S. 197 ff.

auszubilden, in welcher die philologischen Regeln der Übersetzungskunst, der Handschriftenkunde, Textkritik und philologischen Hermeneutik zu ihrem Rechte kommen sollten. Bei der grossen Fehlerhaftigkeit der bestehenden Übersetzungen biblischer und profaner Schriften verlangt er Feststellung des handschriftlich fundierten Vulgatatextes, neue direkt aus der Ursprache der betr. Schrift hergestellte Übersetzungen, oder Korrektur der bestehenden Übersetzungen und Ausgleich strittiger Übersetzungen durch Zurückgehen auf den Urtext. In Anlehnung an Augustinus und Hieronymus versucht er Regeln einer philologischen Textkritik aufzustellen ; ein nach solchen Regeln systematisch angelegtes *Bibelkorrektorium* schwebt ihm stets als Ideal vor.[1] Als Grundregeln stellt er auf : Feststellung und Erklärung der Texte nach dem Urtext, einerseits, nach den ältesten auffindbaren Handschriften andererseits. — Die *Übersetzer* müssen die betreffenden Sprachen nicht nur oberflächlich und rein praktisch können, sondern Grammatik und Sprach*idiom* durch und durch beherrschen, um auch die sprachlichen Nuancierungen des fremden Idioms in der Uebersetzung zum Ausdruck bringen zu können. Noch mehr ! Sie müssen auch geistig dem Inhalt der betr. Schriften gewachsen sein. Davon hängt die Richtigkeit, Zuverlässigkeit, der wissenschaftliche Wert der Lexika, Korrektorien, Übersetzungen und Kommentare ab.

Auf die positiven Einzelvorschläge, die Roger Bacon zur

[1] Über die *Bibelkorrektorien* des 13. Jahrh. s. Trochon, *Essai sur l'histoire de la Bible dans la France chrétienne au moyen âge*, Paris, 1878 ; F. P. Martin, *La Vulgate latine au XIII^e siècle d'après Roger Bacon*, Paris, 1888 ; Denifle im *Archiv für Literatur u. Kirchengesch. des Mittelalters*, iv. (1888), 270 ff. ; S. Berger, *De l'histoire de la Vulgate en France*, Paris, 1887 ; Derselbe in *Revue de Théologie et de Philosophie*, 1883 ; vgl. auch *Muséon*, viii. (1889), 444 ff. ; ix. (1890), 301 ff. ; Magenot im *Dictionnaire de la Bible*, art. ' Correctoires ' ; Gasquet, ' English Biblical Criticism in the Thirteenth Century,' in *Dublin Review*, January, 1898, p. 7 ; G. Delorme in *Dictionnaire de Théologie catholique*, ii, s.v. ' Bacon, Roger.'

Verbesserung des arg verschlechterten Pariser Vulgata-Textes machte, brauchen wir nicht einzugehen. Auch seine Versuche, die früheren Bibelkorrektorien der Franziskaner und Dominikaner durch ein nach seinen philologischen Grundsätzen gearbeitetes Korrektorium zu ersetzen, können in diesem Zusammenhang übergangen werden. Nur ein ihm eigentümlicher Gedanke sei noch erwähnt: sein sprachgeschichtlicher Gedanke, alle Sprachen auf eine Ursprache zurückzuführen, wie etwa die Dialekte einer Sprache auf einer gemeinsamen Sprache beruhen.

Von diesen Grundsätzen und philologischen Kenntnissen des Roger Bacon wird man ein gut Teil zurückführen müssen auf die Anregungen, die ihm das Studium der exegetischen Schriften des hl. Augustinus und Hieronymus, sowie der früheren Bibelkorrektorien geboten hatte.[1] Aber es kann doch auch nicht zweifelhaft sein, dass das Interesse des Roger Bacon an Grammatik, Sprachenstudium und philologischer Kritik von der Schule des Robert Grosseteste angeregt und grossgezogen worden ist, und dass es von der ganzen Gruppe der sprachenkundigen Männer gefördert wurde, die Robertus Lincolniensis umgaben: Nicolaus Graecus, John Basingstoke, Adam Marsh, Wilhelm de Mara u. a. Wer sein unmittelbarer Lehrer im Griechischen, Hebräischen, Chaldäischen und Arabischen gewesen ist, wissen wir nicht. Und wie weit Bacon's *grammatische* Kenntnisse des Griechischen etwa auf direkte Unterweisung durch Robert Grosseteste zurückgehen mögen, lässt sich nicht sagen. Er selbst behauptet von Grosseteste, dass dieser nicht so viel Griechisch gewusst habe, als für Anfertigung selbständiger Übersetzungen nötig gewesen wäre.[2] Nur die unterste (dritte) Stufe der von Bacon

[1] Vgl. Denifle, 'Die Handschriften der Bibelkorrektorien im 13. Jahrhundert,' *Arch. f. Literatur u. Kirchengesch.*, iv. (1888), 270 ff.; 292 ff.

[2] *Comp. Studii Phil.*, viii. 472; Nolan, lvii; F. G. Stevenson, *The Life of Robert Grosseteste*, London, 1899, S. 224.

unterschiedenen Sprachenkenntnisse will er seinem Lehrer im Griechischen zugestehen. Ich habe an einer anderen Stelle[1] nachzuweisen versucht, dass dies zwar für die frühere, aber wohl kaum mehr für die spätere Lebenszeit des Robert Grosseteste zutraf.

Sicher ist, dass Roger Bacon die Anregung für seine *Wertung der Sprachenkenntnisse*, und vor allem seine *Übersetzungsgrundsätze*, von Robert Grosseteste erhalten hatte. Dass dieser wenigstens indirekt auch auf seine *grammatischen* Kenntnisse anregend einwirkte, scheint die Bemerkung des Roger Bacon nahezulegen, der es nicht unterlässt, hervorzuheben: Grosseteste '. . . fecit libros grammaticae Graecae de Graecia et aliis congregari.'[2]

Dass seine Vorliebe für die Sprachen und seine philologischen Übersetzungsgrundsätze auf Grosseteste zurückgehen, kann um so weniger einem Zweifel unterliegen, als Bacon (*Greek Grammar*, ed. Nolan 118) selbst gelegentlich auf die Kommentare des Lincolniensis zu Dionysius Pseudoareopagita hinweist.[3] In der Tat entsprechen die grammatischen, philologischen, textkritischen, lexikalischen Bemerkungen, die Grosseteste in den Einleitungen und Kommentaren zu den genannten Schriften niedergelegt hat, ganz dem später von Roger Bacon entwickelten Gedankengang. Beachtenswert ist jedenfalls schon die Betonung des *exegetischen* Studiums im theologischen Lehrplan und seine deutliche

[1] L. Baur, *Die philosophischen Werke des Robert Grosseteste*, Münster (Aschendorff), 1912, S. 42* f.

[2] *Op. Tert.* (Brewer), p. 91. Nolan, a. a. O., lx. Natürlich kommt für Roger Bacon noch mehr der Donatus graecus des John Basingstoke in Betracht, der seinerzeit die byzantinische, in Athen übliche Grammatikmethode befolgte.

[3] So sagt er: ' Et est " arete " virtus gratuita, " dynamis " vero virtus naturalis, qua diversitate ignorata a multis latinis accipitur una pro alia in scripturis autenticis, sicut Dominus Robertus sanctae memoriae quondam episcopus Lincolniensis, doctor famosissimus exposuit in suis Commentariis super libros Dionysii et corrigit ceteros translatores.' Nolan, a. a. O., 118.

Bevorzugung vor dem systematischen der Sentenzen in einem Briefe des Grosseteste (ca. 1246).[1]

In seinen Kommentaren zu der Areopagitica (speziell zu *De divinis nominibus*) gibt Grosseteste eine Art grammatischer Einleitung in die griechische Sprache. Er behandelt hier die Lautlehre, Vokale, Konsonanten, Diphthonge, Aussprache der griechischen Buchstaben, ferner die Genusregeln, Konstruktionseigentümlichkeiten, Composita, signifikante Wortverbindungen, verschiedene Bedeutungen desselben Ausdrucks (Synonymik), Idiomunterschiede zwischen der lateinischen und griechischen Sprache. Namentlich betont er, wie sehr es notwendig sei, von den lateinischen Übersetzungen zum Urtext vorzudringen: einerseits, um eine gute Übersetzung zu erlangen, andererseits, um eine richtige Erklärung der Texte geben zu können. Wer sich nur an die lateinische Übersetzung halte, der werde niemals oder nur mangelhaft den wahren Sinn eines Autors erkennen, während dieser denjenigen nicht verborgen bleibe, die wenigstens einigermassen (mediocriter vel etiam tenuiter) die griechische Sprache verstehen. Diese allein seien auch imstande, die feineren Nuancierungen der Gedanken, die in dem Idiom der fremden Sprache verborgen liegen, aufzufinden und in der anderen Sprache wiederzugeben. Auch können sie bei zweifelhaften und mehrdeutigen Ausdrücken, oder Übersetzungen, ihre Konjekturen machen.

Die Übersetzung selbst hat vor allem einen einwandfreien, gesicherten Text und ein richtiges Verständnis des Textes seitens des Übersetzers zur Voraussetzung. Um einen guten Text zu haben, verwendet Grosseteste immer eine grössere Anzahl griechischer Handschriften. Ob er dabei auch schon die von Roger Bacon gegebenen Regeln der Textkritik anwandte lässt sich aus diesen Ausführungen nicht feststellen. Doch ist es durchaus wahrscheinlich. Bei seinen Übersetzungen verfuhr Grosseteste so, dass er zunächst

[1] *Roberti Grosseteste Epistolae*, ed. Luard, pp. 346–7.

mehrere lateinische Übersetzungen, so weit solche bestanden, vergleichsweise nebeneinander — und diese zugleich in verschiedenen Handschriften — benützte. Diese verglich er dann mit dem griechischen Text und brachte entsprechende Korrekturen an. Wo sich Verschiedenheiten in den Übersetzungen herausstellten, da suchte er diese Verschiedenheiten zu erklären teils palaeographisch, teils durch Zurückgehen auf den griechischen Text.

Endlich gibt er auch gewisse grundsätzliche *Anweisungen und Regeln für das Übersetzen*, insbesondere für solche Fälle, wo das lateinische Idiom sich mit dem Griechischen nicht ohne weiteres deckt, wie z. B. bei den zusammengesetzten Wörtern. Er sagt darüber (*De divin. nomin.*, p. 1) :

‘ Oportet autem huiusmodi dictiones Graecas compositas, cum non habent correspondentes compositiones in Latino nec aequipollentes eis dictiones simplices, transferre in dictiones simplices idem significantes cum dictionibus Graecis, ex quibus fiunt Graecae compositiones. Cum vero inveniuntur in Latino Graecis correspondentes et aequipollentes, convenientissime transferuntur in huiusmodi compositas. Quando vero possunt fingi compositiones non multum absonae Latinitati, convenienter etiam in huiusmodi fit translatio, ut si dicantur compositae ‘ bonidecenter, sacridecenter, boniformiter, omnisciens, omnibonus ’ et huiusmodi. Mens enim auctoris et venustas sui sermonis per huiusmodi compositiones, ut existimo, magis est dilucida. Existimo etiam, quod diligenter consideranti, quae dictiones in Latino diversimode positae habent sibi correspondentes in Graeco compositas et fingenti, ut patet, ex simplicibus Latinis correspondentes compositiones licet Latinitati absonas, sicut nos fecimus in principio expositionis angelicae hierarchiae, patebit dilucidius et mens auctoris et venustas sermonis. Ideo non incongruum nobis videtur, si breviter tangamus quae diversimode positae dictiones in Latino habent in Graeco aequipollentes sibi quoad sensum dictiones compositas.’ [1]

Höchst beachtenswert sind auch *die lexikalischen Notizen*, welche sich in diesen Kommentaren Grossetestes überaus

[1] Zum Ganzen vergl. L. Baur, *Die philosophischen Werke des Robert Grosseteste*, Münster, 1912, S. 37* ff.

zahlreich vorfinden. Es liesse sich daraus unschwer das griechisch-lateinische Lexikon rekonstruieren — wenigstens zum Teil, — das diesem Oxford-Lincolner philologisch interessierten gelehrten Kreise zu Gebote stand. Das würde sicher eine bedeutende und ergebnisreiche Ergänzung sein zu der hoch interessanten Studie ' Über ein griechisch-lateinisches Lexikon des 13. Jahrhunderts ' (MS. London, College of Arms, Arundel, ix), das vor einigen Jahren M. R. James (in den *Mélanges offerts à M. Émile Chatelain par ses élèves et ses amis*, Paris, 1910, S. 396–411) veröffentlichte. Mit guten Gründen weist James jenes Lexikon dem Kreise Grossetestes zu. Der Zusammenhang der *grammatisch-lexikalischen Kenntnisse* des Roger Bacon mit diesem Kreise ist durch die oben angeführte Stelle aus seiner griechischen Grammatik zur Evidenz erwiesen.

III

Noch viel deutlicher, als auf dem Gebiete der Grammatik, Linguistik, Philologie und Textkritik zeigt sich der starke, bestimmende Einfluss des Robertus Lincolniensis auf die wissenschaftliche Richtung seines Schülers auf dem Gebiete der Naturerkenntnis und Naturphilosophie. Manch ein Gedanke und origineller Erklärungsversuch, den man Roger Bacon zum Verdienste anrechnet, geht tatsächlich auf Robert Grosseteste zurück. Es ist hier nicht der Raum zur Verfügung, um das in ausführlichem Beweisgang darzulegen. Ich werde den Beweis in meinem bald erscheinenden Buch, *Die Philosophie des Robert Grosseteste*, erbringen. In diesem Artikel möge es genügen, kurz die Punkte namhaft zu machen, an welchen eine solche richtunggebende Einflussnahme des Lehrers gegenüber dem Schüler tatsächlich stattgefunden hat. Natürlich will damit der fruchtbare Einfluss der arabischen Literatur auf Bacons Naturphilosophie in keiner Weise verkleinert werden.

1. Es ist bekannt, dass Roger Bacon an den verschieden-

sten Stellen seiner Schriften auf die Frage der *Kalenderreform* zu sprechen kommt[1] und dieselbe als dringend notwendig bezeichnet: so z. B. in seinem (nicht edierten) Computus, im *Opus Majus*, ed. Bridges, i. 276; *Opus Tert.*, cp. 70, ed. Brewer, 281 ff., 287 ff. Die Art, wie er die Forderung einer Kalenderreform begründet, der Sinn, in welchem er diese Forderung erhoben wissen will, stimmen vollkommen, oft sogar wörtlich überein mit dem, was Robert Grosseteste in seinem gleichfalls noch unedierten Computus[2] in derselben Hinsicht forderte und begründete. Vor allem machen beide den ganz identischen Vorschlag: (*a*) Um zu einer besseren Kalenderrechnung zu kommen, muss man vor allem die Grösse des Sonnenjahrs richtig bestimmen und die in der bisherigen Kalenderrechnung gemachten Fehler vermeiden. Man muss die wahre astronomische Grösse des Sonnenjahrs der Rechnung zu Grunde legen. (*b*) Auch ohne Verifizierung der astronomischen Grösse des Sonnenjahrs soll der Tag des Frühlingsaequinoctiums nicht nach dem alten Osterkanon und nach veralteten astronomischen Tafeln, sondern einfach durch das Beobachtungsinstrument, oder auf Grund verifizierter, neuer Tafeln bestimmt werden. (*c*) Auf Grund von dem, was Grosseteste bzw. Bacon über die Berechnung der Primationen ausführte, soll der richtige Tag des ersten Vollmondes nach dem Frühlingsaequinoctium wahrheitsgetreu festgestellt werden und dieser Tag soll dann als Osterterminus für die Bestimmung des Osterfestes dienen.

2. Während Grosseteste seine ganze Naturphilosophie in seiner *Lichttheorie* zusammenfasst, hat diese 'Lichtmetaphysik' auf Roger Bacon nicht einen so ausschlaggebenden Einfluss ausgeübt. Nur gelegentlich finden sich verwandte Gedanken bei ihm. Dagegen hat sich Roger Bacon einen

[1] Vgl. Kaltenbrunner, 'Die Vorgeschichte der gregorianischen Kalenderreform,' *Sitz.-Ber. der K. K. Akademie d. Wiss., philol.-hist. Kl.*, Bd. lxxxii, Wien, 1876, S. 289–414.

[2] Über diesen Computus vgl. L. Baur, *Die philosoph. Werke des Robert Grosseteste*, Münster, 1912, S. 65* ff.

wichtigen Grundgedanken der Naturerklärung des Grosseteste zu eigen gemacht, welcher bei diesem mit seiner Lichtmetaphysik aufs engste verknüpft erscheint : nämlich die *grundsätzliche methodische Auffassung der Naturwissenschaft, und die Erklärung des Wirkens und Werdens in der Natur*. Roger Bacon vertritt in seinen verschiedenen Schriften immer wieder die Ansicht, dass der Naturforscher die Natur durch Mathematik und Experiment erklären müsse. Wenn er die Naturwissenschaft auf fruchtbare Weise und in wissenschaftlicher Art betreiben soll, so muss dies mit der richtigen Methode geschehen. Diese ist die mathematische. Speziell die Geometrie ist für die Naturerkenntnis von der allergrössten Wichtigkeit.[1] Die Bedeutung der Mathematik erstreckt sich übrigens auf sämtliche Wissenschaften. Roger beweist dies daraus, dass die mathematischen Kenntnisse uns angeboren seien (vgl. Plato !), ja geradezu die apriorischen Voraussetzungen des wissenschaftlichen Denkens überhaupt bilden (*Op. Mai.*, ed. Bridges, i. 103). Sie sei unter allen Wissenschaften geschichtlich am frühesten erfunden worden (ebd., i. 104). Sie sei die leichteste Wissenschaft (ebd.). Daher sei es auch methodisch allein richtig, vom Bekannten zum Unbekannten (vom Leichteren zum Schwereren) voranzuschreiten, d. h. also im Studiengang mit der Mathematik zu beginnen (natürlich nach der Grammatik). Endlich erhalten die übrigen Wissenschaften durch die Mathematik, bzw. genauer durch die Geometrie, eine Gewissheit ohne Zweifel und eine Wahrheit ohne Irrtum (ebd., i. 106).

Ohne Mathematik, sagt Bacon, ist es unmöglich, zu einer richtigen Erkenntnis über die Dinge dieser Welt zu kommen. Denn jedes Naturding wirkt durch die ihm innewohnenden Kräfte. Diese aber wirken nach Linien, Winkeln und Figuren.[2]

[1] *Op. Tert.*, cp. 58, ed. Brewer, 227 ; *Op. Min.*, ed. Brewer, 321.

[2] Dieser Satz kommt bei Bacon wiederholt vor, so namentlich

Die Proklamierung des Grundsatzes, die Naturwissenschaft (bzw. Naturphilosophie) *more geometrico* zu treiben, wird allgemein für die Zeit des Mittelalters dem Roger Bacon als Verdienst angerechnet. Allein sämtliche von ihm über diese Frage vorgetragenen Gedanken finden sich der Sache nach, nicht selten auch dem Wortlaut nach, schon bei Robert Grosseteste vor. Bacon zitiert ihn zwar nicht im einzelnen Fall, wo er ihm folgt, mit Namen, aber er rühmt doch wenigstens im allgemeinen von ihm (ebenso von Adam de Marisco), dass er es verstanden habe, durch Mathematik die Ursache der Dinge zu finden und ihr Wesen zu bestimmen.[1] Die Abhängigkeit des Roger Bacon von der Naturphilosophie des Robert Grosseteste in vielen grundsätzlichen Fragen lässt sich im einzelnen vergleichsweise dartun. Wir fassen uns dabei so kurz als möglich.

Wenn Bacon (*Commun. Nat.*, i. 5, ed. Steele, 36) sagt: '*agens multiplicat se* aequaliter in omni parte [in omnem partem ?] et secundum omnes diametros et omnes differentias positionis, quae sunt sursum, deorsum, ante, retro, dextrorsum, sinistrorsum. Ergo undique exeunt lineae in omni parte ab agente tanquam a centro. Sed lineae undique exeuntes ab uno loco non possunt terminari nisi ad superficiem concavam sphaerae,' so ist das genau dasselbe, was Grosseteste über die 'sui multiplicatio' des Lichtes bzw. der Kraft in seinem Kommentar zu den zweiten Analytiken (ed. Venet., 1504, fol. 33^{v}) und in der Schrift *De Luce* (s. L. Bauer, a. a. O., 51 ff.) ausgeführt hat.

Da das Licht nach Grosseteste das Wesen der Naturdinge ausmacht, so erfolgt — konsequent nach seiner Ansicht, — gerade so wie in Bacons Naturphilosophie, auch das Wirken und Werden der Dinge nach den Gesetzen des Lichtes, d. h.

Op. Maj., iv, dict. 2, cp. 1, ed. Bridges, i. 110. Der Zusammenhang desselben mit der Schrift des Grosseteste, 'De lineis, angulis et figuris' (s. Baur, *Die philos. Werke des Robert Grosseteste*, S. 59 ff.), ist ganz unverkennbar. Vgl. ebd., S. 78* ff.

[1] *Op. Maj.*, p. iv, dict. 1, cp. 3, ed. Bridges, i. 108.

nach Linien, Winkeln und Figuren. Somit muss die optische Geometrie (Perspectiva) die Grundlage für die gesamte Naturerklärung abgeben. Die geometrischen Linien, Winkel und Figuren beherrschen das ganze Kraftwirken im Universum, in seinen einzelnen Teilen, in den Beziehungen der Dinge und ihren Wechselwirkungen.

Bei Roger Bacon konzentriert sich der Begriff des Naturwirkens genau wie bei Robert Grosseteste in dem Begriff der ' multiplicatio specierum ', die sich nach den Gesetzen der Perspektive vollzieht.

Auch die ' Perspektive ' selbst, von Roger Bacon sehr ausführlich, von Robert Grosseteste nur ganz flüchtig und skizzenhaft behandelt (eben nur insoweit, als sie zum Verständnis des Kraftwirkens oder der Kraftlinien dient), bietet eine Anzahl paralleler Gedanken, vereinzelt sogar fast wörtlich gleicher Stellen.

Die Unterscheidung der Virtus accidentalis im Naturwirken von der Virtus principalis, die Einteilung des Naturwirkens in ein Wirken super lineis, super angulis (und zwar per fractionem, per duplicem fractionem, per reflexionem) und endlich super figuris (nämlich nach sphärischen und pyramidalen Figuren) bei Roger Bacon hat wiederum ihren Vorgang bei Robert Grosseteste.

Die Lehrpunkte über die Naturwirksamkeit in geraden Linien, über die Stärke der senkrecht einfallenden Kraftlinien und ihre Uniformitas, über den Einfall der Kraftlinien im Winkel bei zwei Medien von verschiedener Dichtigkeit, über die Stärke der reflektierten Kraft bei polierten und rauhen, ebenen und konkaven Körpern, über die einfache und doppelte Strahlenbrechung, über das Stärkeverhältnis der gebrochenen gegenüber der reflektierten Kraft, der nach rechtshin gebrochenen gegenüber der nach links gebrochenen, endlich über das Wirken der Naturkräfte nach Figuren, in Kugelform oder Pyramidenform und die jeweiligen Stärkeverhältnisse — all das wird von Roger Bacon in

durchaus übereinstimmender Weise mit den Ausführungen des Robert Grosseteste behandelt. Ich habe in meinem demnächst erscheinenden Buch, *Die Philosophie des Robert Grosseteste*, Münster (Aschendorff), 1914, den Nachweis einer nicht selten ganz wörtlichen Übereinstimmung erbracht und darf auf dasselbe verweisen.

Man hat es ferner als Verdienst des Roger Bacon bezeichnet,[1] dass er als erster unter den Lateinern des Mittelalters die *Lehre von den Brennkugeln* und der ihnen eigentümlichen Strahlenbrechung in Angriff genommen habe. Aber auch hier ist es wieder der anregende Einfluss des Robert Grosseteste gewesen, der unverkennbar auf Roger Bacon stattgefunden hat. Was Roger Bacon (*Op. Maj.*, ed. Bridges, i. 113; *De multiplicatione specierum*, ed. Bridges, ii. 3, 471; *Commun. nat.*, i. 5, ed. Steele, 30 ff.) darüber schreibt, ist, wenn auch nicht so ausführlich, so doch der Sache nach, oft mit denselben Redewendungen schon bei Robert Grosseteste zu lesen.[2]

Auch in ihren Ausführungen über die *optischen Täuschungen* stimmen beide überein. Materiell beruht ja das, was sie darüber zu sagen haben, durchaus auf älteren Vorlagen: auf Euklid, Ptolemäus, Heron, Alkindi, Alhazen. Aber der Umstand, dass auch formell weitgehende Übereinstimmung besteht, lässt den Schluss als berechtigt erscheinen, dass die Abhängigkeit Bacons von Grosseteste auch für diese Fragen als möglich bezeichnet werden darf.

Auf die nur teilweise, allerdings wieder vielfach wörtliche Übereinstimmung in der *Meteorologie* soll kein allzu grosses Gewicht gelegt werden, weil sie, wie es scheint, auf die gemeinsame Quelle, aus welcher beide offenbar schöpften, zurückzuführen ist.

[1] S. Vogl, *Die Physik Roger Bacons*, Diss., Erlangen, 1906, S. 79 f.

[2] Besonders bezeichnend für die unmittelbare Abhängigkeit des Roger Bacon von Grosseteste erscheint es, dass beide [aus der Schrift *De proprietatibus rerum* ?] dasselbe Beispiel wählen und dabei den Ausdruck ‘ urinale ’ zur Bezeichnung des kugelförmigen Glases verwenden.

Aber auf drei andere Roger Bacon und Robert Grosseteste gemeinsame Lehrpunkte möge noch kurz verwiesen werden.

Hier ist zunächst einmal an die *Lehre von den Klimaten*, ihren Unterschieden und den Ursachen dieser Unterschiede zu erinnern. Wohl behandelt Roger Bacon auch diesen Lehrpunkt — wie fast alle übrigen — viel ausführlicher, eingehender, oft auch genauer, als Grosseteste. Aber was er *Op. Majus*, ed. Bridges, i. 132 ff., darüber vorträgt, das hat — wiederum teilweise wörtliche — Anklänge bei Robert Grosseteste in seiner Schrift *De natura locorum*.[1]

Weitgehende und zwar ganz charakteristische Übereinstimmung lässt die Lehre der beiden Männer über *Ebbe und Flut* erkennen. Nicht nur behandeln beide den *Mond* als Ursache der Gezeiten, was ja an sich nichts Auffallendes wäre; nicht nur denken beide die Art dieser Einwirkung und ihre Folgen für die Anschwellung des Wassers[2] bei der Flut ganz gleich, sondern auch in der physikalischen Erklärung der betreffenden Vorgänge besteht zwischen Robert Grosseteste (*De natura locorum*) und Roger Bacon (*Op. Maj.*, ed. Bridges, i. 139 ff.) wieder eine auffallende Übereinstimmung. Beide ziehen nämlich die schon oben erwähnte Art des Naturwirkens (super lineis, angulis et figuris) zur Erklärung heran: Die über dem Meere an einem bestimmten Ort aufgehenden Strahlen des Mondes haben längere Linien und Pyramiden, sind weniger senkrecht, mehr schief, fallen weniger in rechten Winkeln auf, werden weniger direkt zurückgestrahlt, stärker gebrochen. Deshalb ist auch ihre Kraft schwächer. Anders ist es, wenn der Mond mitten am Himmel steht: dann haben seine Strahlen kürzere Linien und steilere Pyramiden: sie fallen mehr senkrecht, werden mehr direkt reflektiert, weniger gebrochen

[1] Vgl. L. Baur, *Die philosophischen Werke des Robert Grosseteste*, Münster (Aschendorff), 1912, S. 65–72.

[2] Grosseteste gebraucht dafür den Ausdruck 'augmentatio' und 'tumor', Roger Bacon dagegen 'ebullitio' (ed. Bridges, i. 139 ff.)

und sind deshalb stärker. Ist der Mond erst daran, allmählig emporzusteigen, so sind seine Kräfte noch schwach; sie lassen die Dämpfe vom Meeresgrunde inmitten des Meereswassers aufsteigen, sind aber noch nicht stark genug, um sie völlig an die Luft herauszuziehen, oder sie aufzusaugen (*consumere*). Daher verdrängen diese Dämpfe die Meereswasser von ihrer Stelle, weil sie ja körperlich sind und nicht mehrere Körper an einem Ort des Raumes sein können. Sie bringen Blasen (*ampullae*) und Anschwellungen (*tumores*) oder Aufwallungen (*ebullitio*, sagt Roger) hervor. Daher steigt das Meer. Wenn der Mond zur Mitte des Himmels emporgestiegen ist, so ist auch seine Kraft grösser, so dass er die Dämpfe aufzuzehren (*consumere*) imstande ist. Auf seinem Höhepunkt angekommen löst er sie auch vollständig auf. Da mit dem Aufhören der Ursache auch die Wirkung aufhört, so fliesst das Meereswasser wieder an seinen Ort zurück, damit kein Vacuum entsteht.

Auch *die* Schwierigkeit wird von beiden aufgeworfen und übereinstimmend behandelt: wie diese Einwirkung des Mondes auf den entgegengesetzten Vierteln der Erde zugleich erfolgen könne. Beide weisen den Erklärungsversuch des Albumazar (oder Alpetragius?) zurück, der diese Erscheinung aus der gleichen (chemischen) Zusammensetzung der entgegengesetzten Erdviertel ableiten wollte. Beide suchen die Erklärung mittels der Theorie der Strahlenreflexion zu finden. Grosseteste stellt sich das in etwas dunkler Wendung des bei Bacon (ed. Bridges, i. 141) deutlicher ausgedrückten Gedankens *so* vor, dass die Mondstrahlen gegen den Sternhimmel, der als dichter Körper aufgefasst wird, ausgestrahlt, und von diesem wie von einem Spiegel auf das entgegengesetzte Erdviertel reflektiert werden. Roger Bacon fügt (a. a. O.) hinzu, dass diese reflektierten Strahlen allerdings schwächer wirken, als die direkten, und dass sie deshalb auch eine schwächere Flut bewirken.

Die auffallendste weil ganz charakteristische Beeinflussung Bacons durch Robert Grosseteste lässt sich feststellen hinsichtlich ihrer *Wärmetheorie*. Bei beiden beruht dieselbe auf einer Art Atomistik, auf der Bewegung, Zerstreuung, Strahlung und Strahlensammlung, als ihren wichtigsten Erklärungsfaktoren.

Besonders auffallend ist ihre gleichlautende Erklärung der Wärmeerzeugung durch die natürliche und gewaltsame Bewegung, die beide in Anlehnung an Aristoteles unterscheiden. In allen Fällen ergibt sich — so führt Grosseteste aus [1] — eine Zerstreuung der molekularen Teilchen infolge der Bewegung. In dem *gewaltsam* Bewegten ist eine doppelte Bewegungskraft wirksam : eine natürliche und eine gewaltsame. Beide suchen die einzelnen Teile eines körperlichen Gegenstandes nach verschiedenen Seiten hin zu bewegen. Die Folge dieser verschiedenen Richtungstendenz ist eine Zerstreuungstendenz (*disgregatio materiae*) in den Molekularteilen dieses Körpers. Daraus entwickelt sich Wärme. Bei der Aufwärtsbewegung sind die Richtungstendenzen der natürlichen und gewaltsamen Bewegung einander direkt entgegen, weshalb daraus die denkbar grösste Zerstreuungstendenz und darum auch die denkbar grösste Wärme sich ergibt. Bei schiefer oder seitwärtiger Bewegung ist diese dagegen geringer.

Ganz dasselbe gilt nun aber auch für die *natürliche* Bewegung. Auch sie entwickelt Wärme aus denselben Ursachen. Diese entsteht daraus, dass die natürliche Bewegung nach der Erdmitte zu erfolgt. Nun aber tritt auch hier neben die natürliche Richtungstendenz noch eine gewaltsame, ihr entgegengesetzte, hinzu. Dass eine natürliche Richtungstendenz dem Erdmittelpunkt entgegen vorhanden sei, wird als zugegeben betrachtet. Eine gewaltsame Bewegung und divergierende Richtungstendenz aber

[1] Robert Grosseteste in der Schrift *De calore solis* bei L. Baur, *Die philos. Werke des Robert Grosseteste*, S. 80 f.

entsteht dadurch, dass der schwere Körper als *Ganzes* sich dem Erdmittelpunkt zu bewegt. Seine kleinsten materiellen Teile behalten innerhalb des Gesamtkörpers beim Fallen gleichen Abstand von einander, fallen also in genau parallelen Linien nach unten. Selbst ins Unendliche fortgeführt treffen sich diese niemals in *einem* Punkte — also auch nicht im Erdmittelpunkt. Während also die Molekularteile des Körpers natürlicherweise dem Erdmittelpunkt zu streben, werden sie tatsächlich nicht dem Erdzentrum zu — also gegenseitig in einem spitzen Winkel — sondern parallel bewegt. So entsteht auch hier wieder eine doppelte Richtungstendenz und daraus die Wärme. Doch ist in diesem Fall die Gegensatzspannung nicht so stark wie im ersten Fall der gewaltsamen Bewegung. Deshalb bringt die natürliche Bewegung unter allen Bewegungsformen die geringste natürliche Wärme im Bewegten hervor.

Diese Gedanken finden bei Roger Bacon (*Op. Maj.*, ed. Bridges, i. 168) ihre nahezu wörtliche Wiederholung, ebenso wie die Lehre des Robert Grosseteste, dass als weitere Ursache der Wärme die Strahlensammlung, *collectio radiorum*, wie beim Brennglas, oder bei der Wärme in Tälern, in Erwägung zu ziehen sei, genau so wieder von Roger Bacon (*Op. Maj.*, ed. Bridges, i. 113 f.) vertreten wird.

Aus dem Gesagten darf mit voller Sicherheit der Schluss gezogen werden, dass die wissenschaftliche Richtung des Roger Bacon, die so deutlich, ja so exklusiv auf Philologie und Naturwissenschaft eingestellt ist, dass Bacon nicht mehr zum Verständnis und zu einer gerechten Wertung der spekulativen Wissenschaft zu kommen vermag, in ganz hervorragender Weise auf seinen Lehrer Robert Grosseteste zurückgeht. Von ihm und Adam de Marisco hat er auch die Geistesrichtung empfangen, die alles Wissen in Unterordnung unter die Theologie betrieben wissen wollte und innerhalb der Theologie eine starke Bevorzugung des

Schriftstudiums, der Exegese, erkennen lässt und einen stark aszetischen, mystischen, fast möchte man sagen intuitionistischen und traditionalistischen Zug verrät. Es ist durchaus richtig, wenn P. Hugo Höver schreibt: 'Der hohe Wert, den Robert Grosseteste dem Sprachstudium und den experimentellen Wissenschaften beilegte, die Unterordnung alles Wissens unter die Theologie und das Studium der hl. Schrift, spiegeln sich in den Werken Bacons getreu wieder.' [1]

[1] P. Hugo Höver, Ord. Cist., 'Roger Bacons Hylomorphismus als Grundlage seiner philosoph. Anschauungen,' in *Jahrb. f. Philosophie und spekul. Theologie*, hgb. v. E. Commer, xxv. (1911), 207 (auch separat erschienen). Vgl. noch G. M. Mauser, Ord. Praed., 'Roger Bacon und seine Gewährsmänner,' in *Zeitschr. f. Philos. und spekul. Theol.*, xxvii. (1913), 1 ff.

III

LA PLACE DE ROGER BACON PARMI LES PHILOSOPHES DU XIII[e] SIÈCLE[1]

PAR FRANÇOIS PICAVET

LE neuvième, le dixième, le onzième et le douzième siècle nous présentent des penseurs remarquables, surtout chez les Byzantins, les Arabes et les Juifs.[2] Au XIII[e], une civilisation nouvelle apparaît dans l'Occident chrétien. Elle absorbe les acquisitions antérieures de l'humanité et elle y joint son apport propre. Elle a de grands savants, des philosophes marquants, des théologiens originaux. Aussi le XIII[e] siècle est-il une période importante dans l'histoire de l'humanité et dans celle du christianisme,

[1] M. Little a donné, dans le volume III des publications de la British Society of Franciscan Studies de 1911, un *De Operibus Rogeri Bacon*. J'ai, dans les *Essais sur l'histoire générale et comparée des théologies et des philosophies médiévales*, 1913, Paris, Alcan, réuni une partie des recherches que j'ai faites ou dirigées sur Roger Bacon : ch. i et ii, Enseignement et recherches à l'École des Hautes Études et à la Faculté des Lettres ; ch. x, Éditions faites et à faire de Roger Bacon (pp. 209–32) ; ch. xi, Le maître des expériences, Pierre de Maricourt, L'exégète et le théologien vantés par Roger Bacon (pp. 233–54) ; ch. xii, Jean disciple de Roger Bacon (pp. 255–64) ; ch. xiii, Quelques-uns de ceux que combat Roger Bacon, Alexandre de Halès, Albert le Grand, S. Thomas (pp. 265–78) ; ch. xiv, Deux directions de la théologie et de l'exégèse catholiques au XIII[e] siècle, S. Thomas d'Aquin et Roger Bacon (pp. 279–94). La *Revue des Deux Mondes* doit publier le 1[er] juin un article sur la formation intellectuelle de Roger Bacon. Une bibliographie complète a été donnée dans ces diverses publications, auxquelles il faut joindre l'*Esquisse d'une histoire générale et comparée des philosophies médiévales*, 2[e] éd., Paris, Alcan.

[2] *Esquisse d'une histoire générale et comparée des philosophies médiévales*, 2[e] éd., Paris, Alcan, ch. vii, pp. 141–77.

dans l'histoire des arts, des sciences, des lettres, comme dans celle des religions et des philosophies.[1]

Il est grand pour l'histoire du christianisme, car le catholicisme y atteint son plein développement en théologie et en philosophie. C'est à lui que reviennent les Pères du Concile de Trente pour lutter au XVI^e^ siècle contre la Réforme ; c'est de lui que se réclame Léon XIII au XIX^e^ pour combattre la philosophie moderne, en empruntant au préalable à la science tout ce qui peut entrer dans les conceptions orthodoxes.[2]

Que le XIII^e^ siècle doive figurer, dans l'histoire de l'humanité, à côté des siècles de Périclès, d'Auguste, de Léon X ou de Louis XIV, on le voit d'abord par l'examen de ce que furent les papes, les souverains temporels, et les peuples qui obéissent à leur direction ou les provoquent à l'action. Innocent III, Grégoire IX, Innocent IV, Urbain IV, Nicolas IV, Boniface VIII dirigent, à peu près sans contrôle, les affaires spirituelles de la chrétienté. Parfois ils sont sur le point de régir le temporel comme le spirituel, avec l'aide des ordres mendiants, dont l'action est alors si considérable dans la prédication et dans l'enseignement, dans le gouvernement et la surveillance des esprits : 'Le pape, écrit Roger Bacon (Bridges, ii. 227), est le médiateur entre Dieu et les hommes, le législateur et le souverain pontife qui a plein pouvoir dans les choses temporelles et spirituelles, comme un Dieu humain qu'il est permis d'adorer après Dieu.' Les souverains laïques, Philippe-Auguste, Frédéric II, S. Louis, Alphonse X, Philippe le Bel, ne sont pas inférieurs aux Papes. Frédéric II aspire à créer une royauté universelle qui s'étendrait de la Baltique à la Mongolie. S. Louis est, sous la forme chrétienne, un

[1] François Picavet, *Esquisse*, ch. viii, La raison et la science dans les philosophies médiévales, pp. 178–215.

[2] *Esquisse*, ch. ix, La restauration thomiste au IX^e^ siècle, pp. 216–288 ; *Essais*, ch. xviii, Thomisme et modernisme dans le monde catholique, pp. 346–67.

des hommes qui, à travers les siècles, ont le plus aimé la justice et le plus travaillé à son triomphe. En France, en Angleterre, en Italie, en Flandre, les peuples participent de plus en plus à la vie politique.

Quant aux arts, l'époque est merveilleuse par ses cathédrales, ses forteresses féodales, ses hôtels de ville, ses beffrois et ses ponts, par bien d'autres édifices qui en sont restés. Comme au temps de Phidias, l'architecture est complétée par la peinture et la sculpture.[1] La musique, religieuse et profane, s'ajoute aux autres arts. Les langues nationales se forment en Angleterre, en Allemagne, en France, en Espagne et en Portugal, provoquant l'apparition et préparant la croissance de littératures nouvelles dont l'une au moins, avec Dante et la Divine Comédie, atteint presque du premier coup la perfection.[2]

I

C'est dans les Universités et les Écoles, dont le nombre et l'importance s'accroissent singulièrement, c'est chez les séculiers et les réguliers, surtout parmi les Franciscains et les Dominicains, que se produit le travail scientifique, théologique et philosophique. On pourrait donc distinguer les maîtres d'après le groupement auquel ils se rattachent. Mais il vaut mieux suivre la chronologie, en tenant compte tout à la fois des livres composés, des questions traitées et de l'activité des principaux personnages.[3]

[1] Sur l'art du XIII^e^ siècle, on peut voir Adolfo Venturi, *Storia dell'arte italiana*, Milano, Hoepli, vol. iii à viii ; Mâle, *L'art religieux du xiii^e^ siècle*, Paris, Colin.

[2] Sur la musique, voir Hugo Riemann, *Gesch. der Musiktheorie im ix.–xix. Jahrhundert*, 1898 ; J. J. Abert, *Die Musikanschauung des Mittelalters und ihre Grundlagen*, Leipzig, 1905 ; J. Combarieu, *Histoire de la musique*, Paris, Colin, vol. i.

[3] Douais, *Essai sur l'organisation des études dans l'ordre des Frères Prêcheurs*, Paris, 1884 ; Denifle, *Die Universitäten des Mittelalters bis 1400*, Berlin, 1885 ; Denifle et Chatelain, *Chartularium Universitatis Parisiensis*, Paris, 1889–97, 4 vols. in-4° ; H. Felder, *Geschichte*

Une première division conduit du début du XIII^e siècle à l'année 1228, où Guillaume d'Auvergne est nommé à l'évêché de Paris ; une seconde mène jusqu'en 1257, jusqu'au moment où les ordres mendiants triomphent de l'Université de Paris ; la troisième va jusqu'à la mort d'Albert le Grand en 1280 ; la dernière laisse entrevoir déjà les directions que suivront les successeurs des grands hommes du XIII^e siècle et se termine en 1315 à la mort de Raymond Lulle. Sans doute certaines questions comme celles du pouvoir spirituel et du pouvoir temporel, de l'Évangile éternel, des rapports entre Chrétiens et Juifs, ont été discutées pendant tout le XIII^e siècle ; certains hommes, que l'on place dans une période, ont aussi déployé leur activité dans les époques qui précédèrent ou qui suivirent. Mais si ces divisions ne correspondent pas d'une façon exacte à la réalité, elles ont cependant l'avantage de favoriser les recherches et de faciliter l'exposition des doctrines.[1]

Dans la première se présentent d'abord David de Dinant, Amaury de Bennes, et les Albigeois. On recueille et on rassemble les traductions d'œuvres grecques et byzantines, arabes et juives. Les Universités entrent dans leur plein fonctionnement et à celle de Paris Guillaume d'Auvergne accomplit son œuvre philosophique. S. François d'Assise et S. Dominique fondent et organisent deux ordres religieux.[2]

d. wissensch. Studien im Franciskanerorden bis um die Mitte des 13. Jahrh., Freiburg im Breisgau, 1904 ; H. Rashdall, *The Universities of Europe in the Middle Ages*, Oxford, 1895 ; Paulsen, *Gesch. des gelehrten Unterrichts*, Leipzig, 1896–7 ; Hilarin, *Histoire des études dans l'ordre de S. François*, tr. franç. du P. Eusèbe, Paris, Picard.

[1] Sur les divisions de l'histoire générale et comparée des philosophies médiévales, voir *Esquisse*, ch. iii, pp. 42–63 ; ch. viii, pp. 178–215. Sur le XIII^e siècle on peut consulter les auteurs catholiques et thomistes, Stöckl, de Wulf, comme Hauréau, *Histoire de la philosophie scolastique*, ii. 1 et 2. Voir aussi nos *Essais*, ch. i, ii, iii, iv, ix, x, xi, xii, xiii, xiv, xvi.

[2] Sur David de Dinant, on peut voir Ueberweg, ii. 26 ; Hauréau, *Histoire de la philosophie scolastique*, ii. 1, ch. iv (qui le

Pendant la seconde période disparaissent Guillaume d'Auvergne, Alexandre de Halès, Jean de la Rochelle. La poursuite et la condamnation du Talmud montrent les principes auxquels obéissent les Chrétiens dans leurs rapports avec les Juifs. Des questions fort délicates et fort complexes sont soulevées dans la lutte entre les Universités et les ordres mendiants. L'œuvre scientifique de Frédéric II et de ses collaborateurs est terminée. Aristote est devenu un des maîtres officiels ; les Universités ont en leur possession les sources dont elles disposeront pendant le reste du siècle. Mais aussi les Conciles et les Papes travaillent à formuler les règles sur lesquelles reposera l'organisation de l'Inquisition.[1]

compare à Spinoza), et *Mémoires de l'Ac. des Inscriptions*, xxix, 2e partie ; le 'Chronicon Laudun. canonici', *Recueil des Historiens de la France*, xviii, p. 715 ; 'Tractatus de unitate et uno,' faussement attribué à Boèce et restitué à Gundissalvi par Correns, *Beitr. z. G. d. Ph. des Mittelalters*, Bd. i, H. 1. Sur Amaury de Bennes et les Amauriciens, voir Ueberweg, ii. 26 ; Hauréau, ii, 1, ch. v, et *Mémoires de l'Ac. des Inscriptions*, xxix, 2e partie ; Ch. Jourdain, 'Mémoire sur les sources philosophiques des hérésies d'Amaury de Chartres et de David de Dinant,' *Mémoires de l'Ac. des Inscriptions*, xxvi, 2e partie ; le 'Chronicon' de l'Anonyme de Laon, *Recueil des Historiens*, xviii ; Guill. Brito, *Recueil des Historiens*, xvii ; Martini Poloni *Chronicon* (Spicil. de Dachery, iii, p. 184) ; Martène, *Thes. nov. anecdot.*, iv, col. 163, 164 ; *Contra Amaurianos* (analysé par Hauréau, publié par Baeumker) ; W. Preger, *Geschichte d. deutsch. Myst. im Mittelalt.*, i ; Delacroix, *Essai sur le mysticisme spéculatif en Allemagne*, Paris, Alcan, 1900. Sur les Universités, voir le *Chartulaire* de Denifle et Chatelain, Denifle, Rashdall, Paulsen (p. 57, note 3); Charles Thurot, *De l'organisation de l'enseignement dans l'Université de Paris*, 1850. Sur S. François d'Assise, voir surtout l'ouvrage de Sabatier. Les publications de la British Society of Franciscan Studies apporteront d'utiles renseignements pour l'ordre. Voir Douais, Felder (p. 57, note 3) et aussi la *Revue Thomiste* et la *Revue des études théologiques et philosophiques*.

[1] Sur Guillaume d'Auvergne, voir N. Valois, *Guillaume d'Auvergne, sa vie et ses ouvrages*, Paris, 1880 ; Baumgartner, 'D. Erkenntnissl. d. W. von Auvergne,' Münster, 1897, *Beitr. z. G. d. Ph. des Mittelalters* ; Bülow, 'De immortalitate animae, Gundissalvi et G. d'Auvergne,' *Beitr.*, ii. 3. Sur la condamnation du Talmud et les rapports

La troisième période est des plus fécondes. Albert le Grand est le maître le plus écouté de la chrétienté, avant que S. Thomas prenne la première place dans l'Église comme chez les Dominicains. Il y a lutte entre la direction thomiste et celle que Roger Bacon eût voulu donner à l'Église et à la chrétienté. Les résultats scientifiques, philosophiques et religieux des explorations du XIII^e siècle, ceux des recherches ou des méditations de Vincent de Beauvais, de S. Bonaventure, ceux qu'on doit aux savants de tout ordre, apparaissent en pleine lumière. A Constantinople les Grecs réorganisent les études. Mais les condamnations prononcées de 1258 à 1280, contre l'Évangile éternel et les spirituels, contre les Averroïstes latins, contre des Franciscains et des Dominicains, témoignent que la liberté de la recherche et de la pensée sont singulièrement restreintes.[1]

Dans la dernière période, on ne trouve plus ni Albert le Grand, ni S. Thomas, ni Vincent de Beauvais, ni S. Bonaventure. Roger Bacon ne conserve aucune chance d'agir sur ses contemporains. Il reste Henri de Gand, Duns Scot, Raymond Lulle dont l'œuvre sera terminée en 1315. On voit alors assez nettement ce qu'ont fait pendant le XIII^e siècle, en théologie et en philosophie, les Universités et les ordres mendiants, les séculiers et les réguliers, comme

des chrétiens et des juifs, voir N. Valois, op. cit. ; François Picavet, *Esquisse*, 2e éd., pp. 247–51. Sur les rapports des Universités et des ordres mendiants, voir les ouvrages relatifs aux Universités, Felder (p. 57, note 3) ; Mandonnet, *Siger de Brabant et l'Averroïsme latin*, 2 vols. des *Philosophes belges*, Louvain, 1908. Sur Aristote, voir Jourdain, *Recherches critiques sur l'âge et l'origine des traductions latines d'Aristote*, Paris, 1849 ; Hauréau, Denifle et Chatelain, op. cit. Sur l'Inquisition voir Lea, *History of the Inquisition*, tr. franç. de S. Reinach, Paris, 1902.

[1] Sur la direction thomiste et la direction baconienne, voir François Picavet, ' Deux directions de la théologie et de l'exégèse catholiques au XIII^e siècle,' *Revue d'histoire des religions*, 1905 ; *Comptes rendus de l'Ac. des sc. morales*, 1905 ; *Essais*, 1913, ch. xiv.

l'influence que tous ensemble ils ont exercée sur les arts et sur la littérature profane. Les discussions relatives au pouvoir spirituel et au pouvoir temporel, au droit canon et au droit romain, semblent suspendues pour un temps par la victoire de Philippe le Bel, dont les conséquences seront considérables dans le domaine philosophique comme dans la vie religieuse.[1]

Quel fut donc le but que poursuivirent, consciemment ou non, les penseurs les mieux doués du XIII^e siècle ? D'abord ils devaient conserver les connaissances des Latins qui les avaient précédés, puis examiner avec soin tout ce qui leur venait du monde grec et byzantin, arabe et juif. Les données scientifiques et philosophiques s'y mêlent à des conceptions religieuses ou théologiques qui, n'étant pas même toujours orthodoxes pour les Chrétiens orientaux, pour les Musulmans ou pour les Juifs, ne sauraient être pour les catholiques que des nouveautés dangereuses ou des hérésies. Mais convient-il, pour cet examen, de s'en rapporter aux traductions déjà faites ou faut-il recourir aux textes originaux et par conséquent étudier l'hébreu, le grec et l'arabe ? Quand on a éliminé, des auteurs pris en eux-mêmes ou dans leurs traductions, tout ce qui risque de nuire à la pureté de la foi, on peut recueillir les éléments d'ordre scientifique et philosophique, en notant les liens parfois divers qui les unissent et la méthode qui servit à les assembler. Puis il y a lieu de systématiser, si on le veut, les résultats, de provenance ancienne ou récente, pour en former une métaphysique cohérente dans ses parties essentielles et cohérente avec toutes ses bases

[1] Sur l'influence qu'ont exercée les œuvres philosophiques en latin sur la littérature profane de XIII^e siècle, il y a beaucoup à faire. On peut voir Gaston Paris, *La littérature française au moyen âge*, 3^e éd., Paris, 1905. Sur les arts, voir Mâle, op. cit. Sur les discussions relatives au pouvoir spirituel et au pouvoir temporel, voir Paul Janet, *Histoire de la science politique dans ses rapports avec la morale*, 4^e éd. 1913.

positives. La philosophie ainsi construite est employée à constituer une théologie plus compréhensive et plus riche, une doctrine exégétique qui transforme à son tour l'interprétation des textes sacrés. Ainsi s'enrichissent toutes à la fois les parties maîtresses de la sagesse. Mais avant de procéder à cette systématisation dont l'objet est triple, on peut étudier les méthodes mises en usage et voir, en les pratiquant soi-même, ce qu'elles valent et ce que valent les données transmises, puis les employer, qu'il s'agisse de celle des mathématiques ou de celle des sciences expérimentales, à augmenter les connaissances positives. En ce cas la synthèse philosophique, portant sur des acquisitions déjà anciennes et sur des acquisitions toutes nouvelles, devra être parfois revisée comme la théologie et l'exégèse à laquelle elle est jointe. Enfin pour l'utiliser dans ces matières essentiellement religieuses, on se dira peut-être qu'il faut, pour les livres sacrés comme pour les livres profanes, connaître les langues dans lesquelles ils sont écrits et ne pas se contenter uniquement de traductions dont on ne saurait contrôler la valeur.[1]

Or presque tous les penseurs du XIII[e] siècle ont voulu user de leur raison [2] et en même temps rester chrétiens [3] ou l'être mieux que leurs prédécesseurs. Si Joachim de Flore travailla à l'avènement de l'Évangile éternel, si les Amauriciens et les Albigeois voulaient promouvoir le règne de l'Esprit Saint et auraient ruiné, s'ils avaient réussi, l'Église existante, ses institutions, ses sacrements, sa

[1] Ce sont à peu près toutes les questions que s'est posées Roger Bacon et qu'il a résolues d'une façon affirmative, comme on le verra par la suite de l'article.

[2] *Esquisse*, ch. viii.

[3] Sur les trois Imposteurs, voir Renan, *Averroès et l'Averroïsme*. C'est à peu près la seule formule à propos de laquelle on puisse poser la question de savoir s'il y eut au XIII[e] siècle des hommes complètement irréligieux. Car les Averroïstes latins s'inclinaient devant les affirmations portées au nom de la foi.

hiérarchie et ses pratiques, c'était pour donner, du christianisme, une forme plus parfaite, comme les Chrétiens avaient substitué, par une raison semblable, leur religion à l'antique judaïsme. C'est en s'appuyant sur la raison et plus spécialement sur le principe de contradiction que David de Dinant et Amaury de Bennes font de Dieu la matière ou l'essence des choses, qu'ils ramènent à l'unité le monde et Dieu dont seul le principe de perfection permet d'affirmer tout à la fois l'existence distincte et les rapports essentiels. C'est au nom de la raison et du même principe que les Averroïstes latins se refusent à admettre l'immortalité de l'âme dont, en croyants, ils ne doutent aucunement, qu'ils suppriment les intellects multiples, placés par Plotin, en vertu du principe de perfection, à côté de l'intellect divin.[1] Et il faut noter encore le caractère profondément religieux de tous ces hommes que l'Église combattit avec tant d'acharnement, car dans l'impossibilité pour eux de conserver l'Un et le Multiple, c'est l'Un ou Dieu qu'ils continuent à mettre en première ligne.

Pour se défendre, l'Église ne se borna pas à condamner ceux qui se mettaient en opposition avec elle dans le temps présent, elle leur chercha partout des complices. Elle frappa d'abord le nouvel Aristote et ses commentateurs. Mais quand Jean Scot Érigène eut été déclaré le vrai coupable par Honorius III en 1225, Grégoire IX ordonna, dès 1231, d'examiner si cet Aristote qu'on enseignait à Toulouse ne pourrait être débarrassé de ce qu'il y avait de dangereux en lui et étudié ainsi dans toutes les écoles. C'est ce que firent, de manière à donner toute satisfaction à l'Église, Albert le Grand et S. Thomas. Puis on s'attaqua au Talmud et aux Juifs que Roger Bacon soupçonnait,

[1] Sur David de Dinant et les Amauriciens, voir les ouvrages cités, p. 58, note 2. Sur les Averroïstes latins, voir Renan, Mandonnet, op. cit. ; François Picavet, *Revue d'histoire des religions*, 1902 ; *Esquisse*, ch. viii ; *Essais*, ch. xvi et xvii.

comme il soupçonnait les Grecs, de falsifier les livres saints avant de les remettre aux catholiques romains. Les Arabes devinrent suspects à cause des Averroïstes latins et il fallut encore le travail de S. Thomas pour montrer ce que l'on pouvait emprunter aux Arabes et aux Juifs, surtout à Averroès et à son contemporain Maimonide.[1]

Après 1280, il se forma, semble-t-il, un accord tacite tout au moins, entre ceux qui craignaient les nouveautés génératrices d'hérésies et ceux qui entendaient conserver les doctrines essentielles, en matière scientifique et philosophique, des Grecs et des Byzantins, des Arabes et des Juifs. De plus en plus on était sévère pour les ennemis du Christianisme. Après avoir fait des Croisades contre les Musulmans, on en fit contre les Grecs, contre les Albigeois, on en prêcha contre Frédéric II et bien d'autres. L'Inquisition fut chargée de rechercher les hérétiques dans tous les pays chrétiens. Elle imposa aux habitants des villes et des villages l'obligation de dénoncer *même toute personne vivant autrement que la généralité des fidèles*. D'un autre côté, les Dominicains, souvent chargés de représenter l'Inquisition, estimèrent vers 1280 que S. Thomas avait mis dans sa synthèse tout ce qui est nécessaire aux catholiques : ils défendirent donc aux membres de leur ordre d'attaquer le thomisme, puis ils travaillèrent à y gagner tous les réguliers et tous les séculiers. Ils réussirent dans cette double entreprise et, au moment de la Réforme, surtout pendant le Concile de Trente, les solutions thomistes devinrent les solutions catholiques.[2]

[1] Sur les condamnations portées à partir de 1200, sur le rôle de la papauté, voir Denifle et Chatelain, *Chartulaire* ; Hauréau, ii, 1, et *Mémoires* ; Jourdain, op. cit. ; Mandonnet, Noël Valois, op. cit. ; Renan, op. cit. ; Dr. J. Guttmann, *Die Scholastik des dreizehnten Jahrhunderts in ihren Beziehungen zum Judenthum und zur jüdischen Literatur*, Breslau, 1902.

[2] Lea, *Histoire de l'Inquisition*, permet de suivre la marche réalisée dans l'organisation des tribunaux ; Jourdain, *Philosophie*

L'obligation imposée aux Jésuites par Ignace de Loyola d'enseigner le thomisme acheva de lui donner une autorité prépondérante dans tout le monde catholique. En fait, dès que, vers la fin du XIII[e] siècle, on cessa de penser aussi librement qu'on l'avait fait pendant les quatre-vingts premières années du siècle, c'est S. Thomas, bien plus qu'Aristote, qui devint le maître dont on reproduisit et commenta les doctrines.[1]

II

Dans ce travail philosophique d'une intensité considérable, quelle fut la part de Roger Bacon ? Il faut dire brièvement d'abord ce que firent ceux dont le nom mérite surtout d'être rappelé dans ce siècle riche en penseurs de toute espèce. Un des premiers, Guillaume d'Auvergne[2] utilise les ouvrages des Byzantins et des Grecs, des Arabes et des Juifs. Profondément orthodoxe, philosophe et ami de la science, soucieux d'user pleinement de sa raison, il ne fait appel à l'autorité que si elle est en accord avec ce que lui apprennent la raison, l'expérience ou l'intuition. Sa théorie de la vision divine est d'une importance capitale pour la science et pour la philosophie, puisqu'il en cherche la source en Dieu dont les révélations se produisent incessamment.

de S. Thomas d'Aquin, montre les progrès du thomisme, vol. ii, ch. iii, iv, Canonisation de S. Thomas, La sentence de 1276 est rapportée ; ch. iv, v, vi, Le thomisme au Concile de Trente, Dans la Compagnie de Jésus, Le thomisme au XVII[e] siècle. Constitutions données par S. Ignace à la C[ie] de Jésus, P. iv. ch. xiv. 2 : In theologia legetur Vetus et Novum Testamentum et doctrina scholastica D. Thomae.

[1] C'est là un fait d'importance capitale sur lequel on ne saurait trop insister. L'union intime entre la théologie, la philosophie et la science, réalisée par S. Thomas pour les catholiques, explique, bien mieux que l'influence d'Aristote, l'opposition faite aux savants par un certain nombre de catholiques pendant le XVII[e] siècle. Nous nous proposons de revenir sur ce sujet par la suite.

[2] Sur Guillaume d'Auvergne voir les ouvrages cités, note 1, p. 59.

En soutenant l'unité de Dieu, il combat les doctrines à tendance manichéiste ; en insistant sur la personnalité de l'âme qu'il fonde sur la doctrine plotinienne de son indivisibilité et de sa parenté avec la nature divine, il établit son immortalité et détruit à l'avance la thèse des Averroïstes latins. C'est un précurseur de Roger Bacon comme d'Albert le Grand et de S. Thomas.

Alexandre de Halès, son contemporain, achève de constituer la méthode ébauchée par Abélard,[1] qui sera d'un usage constant dans les écoles et chez les maîtres jusqu'au XVII^e siècle. Dans la *Somme de théologie*, où il l'emploie, il distingue nettement, à la façon augustinienne et plotinienne, le monde sensible et le monde intelligible. Bon nombre des doctrines nouvellement arrivées en Occident y prennent place. Pour Jean de la Rochelle, son successeur, ceux qui veulent anéantir l'étude de la philosophie sont des suppôts de Satan. Il s'attache à l'étude approfondie de l'âme humaine et fait des emprunts à Aristote, aux médecins arabes et à Galien, mais surtout, par S. Augustin et les commentateurs grecs, à Plotin et à ses disciples.[2]

On ne peut séparer l'œuvre des trois dominicains, Vincent de Beauvais, Albert le Grand et S. Thomas. Dans le *Grand Miroir, Speculum Majus*, le premier corrige Abélard qui mettait sur le même plan les autorités sacrées et les autorités profanes. Au-dessus de tout, il place l'Écriture, Ancien et Nouveau Testament. Puis en première ligne, *supremum locum*, les décrétales des souverains pontifes, les canons des

[1] François Picavet, *Abélard et Alexandre de Halès, créateurs de la méthode scolastique*, Paris, Leroux, 1896 ; *Esquisse*, ch. viii, pp. 181–92.

[2] Sur Jean de la Rochelle, cf. Hauréau, ii. 1, ch. x ; Luguet, *Joannis a Rupella Summa de anima*, Paris ; *Essai d'analyse et de critique sur le texte inédit du traité de l'âme de J. de la Rochelle*, Paris, 1875 ; *La Summa de Anima di Frate Giovanni della Rochelle pubblicata per la prima volta et corredata di alcuni studi del P. Teofilo Domenichelli, Min. Oss., sotto la direzione del P. Marcellino da Civezza.* Prato, 1882.

conciles généraux, les œuvres des docteurs sacrés, c'est-à-dire de ceux qui furent canonisés par l'Église et dont les doctrines ont reçu l'approbation des conciles et du Pape. En seconde ligne viennent les docteurs prudents et catholiques, mais non canonisés ; en troisième, les philosophes, les docteurs des gentils, qui ont ignoré la vérité de la foi, mais qui ont dit sur le Créateur et les créatures, les vertus et les vices, de belles et merveilleuses choses, vraies pour la croyance catholique comme pour la raison humaine. Aux *Deflorationes* anonymes dont usèrent Alcuin et bien d'autres jusqu'à Guillaume d'Auvergne, Vincent de Beauvais substitue le *Florilège*, ou recueil de morceaux choisis dont la source est indiquée. Même il pense à faire du *Grand Miroir* une œuvre analogue à nos modernes Encyclopédies, en rangeant sous un seul titre, *Charité, Chasteté*, tous les extraits qui y auraient quelque rapport. Mais il s'est décidé à suivre l'ordre des *Sommes*, celui de l'Écriture même, en plaçant d'abord le Créateur, puis les créatures, la chute et la réparation de l'homme, les choses faites dans l'ordre des temps. Sous son nom, il donne ce que lui ont appris des docteurs modernes par leur enseignement ou leurs livres ; sous les noms de leurs auteurs, tout ce que lui-même et ses collaborateurs ont recueilli dans les œuvres antérieures.[1] Ainsi il a constitué un aide-mémoire assez ample, une introduction ou un complément à l'œuvre plus personnelle d'Albert le Grand et de S. Thomas.

Albert s'est proposé tout à la fois de faire connaître la nature et comprendre Aristote, sans séparer d'ailleurs l'Aristote authentique et l'Aristote apocryphe, sans distin-

[1] R. P. Mortier, *Histoire des maîtres généraux de l'ordre des Frères Prêcheurs*, Paris, Picard ; Boutaric, ' Vincent de Beauvais et la connaissance de l'antiquité classique au XIII^e siècle,' *Revue des questions historiques*, 9^e année, tome xvii ; Bourgeat, *Études sur Vincent de Beauvais, théologien, philosophe, encyclopédiste, ou spécimen des études théologiques, philosophiques et scientifiques au moyen âge*, Paris, 1856.

guer nettement l'un et l'autre des auteurs grecs, arabes ou juifs que connaît alors l'Occident chrétien. S'il dit parfois que connaître Aristote, c'est connaître la nature, c'est qu'il joint à Aristote tous ces penseurs, surtout les Plotiniens par lesquels il le complète. Il est si peu le singe d'Aristote, comme l'appelèrent des adversaires de la philosophie et de la théologie du XIII^e siècle, qu'il le combat et que, dans ces matières sur lesquelles ne peut porter le syllogisme, l'expérience seule lui donne la certitude. Enfin il fait une place considérable au Pseudo-Denys l'Aréopagite, aux doctrines mystiques qui lui viennent encore par S. Augustin et bien d'autres sources plotiniennes, de sorte qu'on a pu le considérer comme l'un des maîtres des Allemands, Eckhart, Tauler, Suso et l'auteur de la *Deutsche Theologie* éditée deux fois par Luther. Au témoignage de son adversaire Roger Bacon, le succès d'Albert fut immense : 'On l'invoque, dit-il, dans les écoles comme Aristote, Avicenne et Averroès, et il a eu, de son vivant, une autorité que le Christ n'a pas eue pendant qu'il vivait.' [1]

Pour des causes diverses et multiples, c'est cependant son disciple S. Thomas qui l'emporte auprès de leurs com-

[1] Voir Hauréau, ii. 1, ch. xi, xii, xiii ; Hertling, 'Albertus Magnus,' *Festschrift*, Cöln, 1880 ; R. de Liechty, *Albert le Grand et S. Thomas d'Aquin ou la science du moyen âge*, Paris, 1880 ; M. Glossner, *Das objective Princip der arist. schol. Philos., besonders Albert des Gr. Lehre vom obj. Ursprung der intellectuellen Erkenntnisse*, Regensb., 1880 ; Van Veddingen, *Albert le Grand, le maître de S. Thomas d'Aquin d'après les plus récents travaux critiques*, Bruxelles, 1881 ; G. Endriss, *Albertus Magnus als Interpret der aristot. Metaphysik*, München, 1886 ; R. P. Mandonnet, 'Les idées cosmographiques d'Albert le Grand et de S. Thomas d'Aquin et la découverte de l'Amérique,' *Revue thomiste*, 1893 ; R. P. Pierre Girard, 'La Cosmographie d'Albert le Gr. d'après l'observation et l'expérience du moyen âge,' *Revue thomiste*, 1904 ; Noble, 'Note pour l'étude de la psychophysiologie d'Albert le Grand et de S. Thomas,' *Revue thomiste*, 1905 ; A. Mansion, 'L'induction chez Albert le Grand,' *Revue néoscolastique*, 1906 ; R. P. Mandonnet, 'Albert le Grand,' dans le *Dictionnaire de théologie* de l'abbé Vacant.

muns successeurs. C'est que S. Thomas opéra, plus sûrement qu'aucun de ses contemporains, le départ entre ce qui pouvait être adapté au catholicisme et ce qui y répugnait dans ce qui venait d'arriver à l'Occident latin. Pour Aristote, en particulier, il a joint à ses œuvres capitales des commentaires qui en donnent une bonne interprétation littérale, pour laquelle il consulte diverses versions, gréco-latines ou arabico-latines, quelques-unes faites à son intention, peut-être même vers la fin de sa vie les manuscrits grecs, et toujours les commentateurs qui ont travaillé à l'éclaircir. A cette interprétation littérale il ajoute une interprétation plotinienne et chrétienne par laquelle il attribue à Aristote les doctrines auxquelles les Chrétiens tenaient le plus et qu'on rencontre le moins chez l'Aristote authentique, la Création, la Providence, l'immortalité de l'âme. Avec ce qu'ont transmis au XIII[e] siècle les Latins et les Grecs, les Arabes et les Juifs, avec ce qu'ont rassemblé Vincent de Beauvais, Albert le Grand et leurs contemporains, avec le secours de nombreux collaborateurs qui sont toujours à sa disposition, S. Thomas construit, d'un point de vue orthodoxe et avec une habileté singulière, la synthèse philosophique qui s'accorde avec les dogmes et comprend les éléments scientifiques et philosophiques dont disposent alors les Occidentaux. Ce système, dont la valeur persistera tant que les recherches expérimentales n'auront pas fourni la matière d'une synthèse nouvelle, S. Thomas le fait entrer tout entier dans la théologie, qui fournira ainsi au Concile de Trente des réponses jugées, alors et aujourd'hui encore, satisfaisantes, par les catholiques, aux questions et aux objections des Réformateurs. Pour l'histoire et l'exégèse, S. Thomas accomplit une œuvre analogue : la *Catena aurea* relie les quatre Évangiles comme s'ils étaient le travail d'un seul docteur ; les commentaires sur chacun des livres saints, même sur le Psautier, le Décalogue, le Symbole, l'Oraison dominicale, montrent qu'ils contiennent en germe tout ce

qui se trouve dans la *Somme* et par suite toute la philosophie thomiste. Ainsi une direction est donnée à l'Église catholique : elle l'accepte officiellement, en théologie et en exégèse, au Concile de Trente ; elle la reprend, en philosophie, avec Léon XIII, en 1879.[1]

A S. Bonaventure on doit une doctrine mystique et orthodoxe qui développe tout ce qui vient de Plotin et de S. Augustin, du Pseudo-Denys et des Victorins, de S. Bernard, des Byzantins, des Arabes et des Juifs : *l'Itinéraire de l'âme vers Dieu* en est la partie essentielle.[2]

De nombreux savants travaillent au XIII^e^ siècle à s'assimiler les données positives qui leur sont offertes. Il y en eut en Angleterre autour de Robert de Lincoln, en France autour de Pierre de Maricourt, le maître des expériences. Il y eut en Italie une école d'alchimistes, étudiés par Berthelot, qui font les expériences indiquées par les anciens et en imaginent de nouvelles, qui remontent des pratiques aux doctrines et provoquent les progrès de la technique que révèlent alors les arts de toute espèce. Des physiciens constituent, les uns, un groupe à Oxford, les autres, un groupe à Paris. Certains médecins font appel à l'expérience et à l'alchimie pour prolonger la vie humaine et retarder les accidents de la vieillesse. Il y a des opticiens, maître Pierre, Vitellion, moins géomètre et moins physiologiste que Roger Bacon, commenté par Képler au début du XVII^e^ siècle ; il y a des mathématiciens célèbres, Sacrobosco dont le *Traité de la Sphère* sera si souvent commenté, Léonard de Pise qu'on dira le plus grand mathématicien du moyen âge, maître Pierre et Jean de Londres, maître Campanus de Novare et maître Nicolas, mentionnés par Roger Bacon. Presque tous ces savants conservèrent

[1] Sur S. Thomas, voir Jourdain, op. cit. ; Sertillanges, *La philosophie de S. Thomas*, Paris, Alcan. Sur la restauration thomiste, *Esquisse*, ch. ix ; *Essais*, ch. xiii ; Bibliographie dans Ueberweg, ii.

[2] *Opera omnia edita studio et cura P. P. collegii a S. Bonaventura*, ad Claras Aquas prope Florentiam, à partir de 1882.

bien des doctrines métaphysiques et esquissèrent des conceptions relatives à la philosophie des sciences, qu'on reprendra surtout au XVII^e siècle. Pour la même raison, il convient de rappeler Carpini, Rubruquis et Marco-Polo qui augmentèrent les connaissances que leurs contemporains avaient de la terre et préparèrent, avec de nouvelles découvertes, un agrandissement[1] de la science sous plusieurs de ses formes.

La dernière période marque une décroissance dans la spéculation théologique et philosophique. Henri de Gand, adversaire de S. Bonaventure et de S. Thomas, rappelle surtout S. Augustin, parfois les Arabes et Guillaume d'Auvergne, avec la théorie de l'illumination spéciale, comme il annonce Duns Scot et Guillaume d'Occam par celle de la volonté supérieure à l'intelligence. Duns Scot s'inspire de tous les franciscains ses prédécesseurs, y compris Roger Bacon, attaque la plupart de ses contemporains, proclame en Dieu la prédominance de la volonté. Avec le Plotinien Ibn Gebirol—*ego autem ad positionem Avicembrolis redeo*—Scot soutient que toute substance créée, corporelle ou spirituelle, participe de la matière et que cette matière est une en tous. Sa doctrine, d'une subtilité singulière, sera souvent opposée au thomisme. Avec Raymond Lulle apparaît le *Grand Art*, la méthode logique qui combine des idées générales pour en faire sortir des solutions métaphysiques ou théologiques. Mais c'est aussi un mystique curieux, dont les doctrines, mal connues encore, mêlent le plotinisme et le christianisme.[2]

[1] Berthelot, *Les origines de l'alchimie ; Science et Philosophie ; Collection des anciens alchimistes grecs ; Introduction à l'étude de la chimie des anciens et du moyen âge ; Histoire des sciences, La chimie au moyen âge*, 3 vols. François Picavet, *La science expérimentale au xiii^e siècle en Occident*, Moyen Age, novembre 1891 ; et *Esquisse*, ch. viii, pp. 202–9.

[2] Prantl, *Gesch. der Log.*, iii ; Hauréau, *Histoire de la scolastique*, ii. 2 ; Pluzanski, *Essai sur la philosophie de Duns Scot*, Paris, 1887 ;

III

Roger Bacon a exposé, d'une façon fort ample sinon toujours fort précise, ce qui méritait d'être poursuivi et réalisé non seulement par lui et ses contemporains, mais aussi par leurs successeurs, sous la direction de la papauté, avec l'aide des grands, des princes et des rois. Il faut, dit-il dans l'*Opus Majus*, faire l'étude parfaite de la sagesse, arriver avant tout à la possession de la vérité, puis se servir de la vérité trouvée pour le gouvernement de toutes choses. Avec elle et par elle, on doit ordonner l'Église de Dieu, organiser la république des fidèles, travailler à la conversion des infidèles et repousser du monde chrétien, mieux que par l'effusion du sang, ceux qui refusent de se convertir. Comme un moderne, Roger Bacon fait de la recherche de la vérité le but suprême et ultime ; comme un chrétien du XIII[e] siècle, il entend qu'elle serve à gouverner, à étendre et à protéger la Cité fondée sur les principes évangéliques.[1]

Mais l'acquisition de la vérité est difficile et notre intelligence est faible. Il importe donc d'écarter les causes et les occasions d'erreur, surtout les quatre obstacles qui se dressent devant tous, l'autorité sans force et sans dignité, la longueur et la puissance de l'habitude, les préjugés du vulgaire, la tendance à cacher son ignorance sous une sagesse apparente — d'autant plus que, de l'ignorance ou

Reinhold Seeberg, *Die Theologie des J. Duns Scotus*, Leipzig, 1900 ; M. de Wulf, *Histoire de la philosophie scolastique dans les Pays-Bas et la principauté de Liège*. C'est Guardia, dans la *Revue philosophique*, qui a surtout appelé l'attention sur le mystique, dont nous ne connaissons l'œuvre qu'imparfaitement. Probst a soutenu en 1913 à Grenoble une thèse sur Raymond Lulle.

[1] C'est le point de vue auquel se place Roger Bacon, non seulement dans les trois ouvrages envoyés à Clément IV, mais encore dans le fragment publié par Gasquet, *Historical Review*, xii, 1897, dans le *Compendium* de philosophie publié par Brewer et dans le *Compendium* de théologie édité par Rashdall dans la *British Society of Franciscan Studies*, vol. iii.

de l'erreur, découle la corruption des mœurs.[1] Comme il n'y a qu'un Dieu, il n'y a qu'une sagesse parfaite. Elle est contenue dans les Écritures. Mais pour l'en tirer, pour constituer la théologie sous forme de sagesse complète, il faut recourir au droit canon et à la philosophie, dans laquelle sont comprises toutes les sciences. Par l'histoire, par des faits, par des raisonnements et par des textes, Roger Bacon établit que la théologie et la philosophie sont les deux aspects de la suprême vérité, que, si les patriarches et les prophètes en ont eu la révélation dans son intégralité, les philosophes, les poètes, les sibylles et tous ceux qui se sont adonnés à la sagesse en ont eu une révélation suffisante ; elle l'a été certainement pour Aristote et pour Avicenne.[2]

Or pour connaître Dieu, le monde et l'homme, Roger Bacon estime que cinq choses sont nécessaires et suffisantes. D'abord il faut, pour la pratique comme pour la spéculation, étudier les langues étrangères par lesquelles la sagesse est venue en partie aux Latins et par lesquelles elle peut leur arriver complète. En second lieu, il faut recourir aux mathématiques, fondement de toutes les sciences, d'abord à ce qu'on peut appeler la métaphysique des mathématiques, puis aux quatre sciences spéculatives, géométrie, arithmétique, astronomie, musique ou acoustique, et aux quatre sciences pratiques qui leur correspondent, c'est-à-dire en somme à neuf sciences totalement ignorées des Latins. Ensuite Roger Bacon fait intervenir l'optique, qui suppose la multiplication des espèces, identifiée par certains modernes avec notre propagation actuelle de la force, la science expérimentale, qui emploie, avec l'expérience humaine

[1] Pour ces causes de l'erreur, il ne serait pas sans intérêt de comparer Roger Bacon et François Bacon.

[2] Toute cette théorie de Roger Bacon — qu'on retrouve pendant tout le moyen âge, et qui permet aux chrétiens d'utiliser d'autres livres que les Écritures — a pour point de départ l'Évangile de S. Jean où il est dit que le Verbe est la lumière qui éclaire tout homme venant en ce monde.

et philosophique, l'expérience par illumination intérieure, c'est-à-dire une révélation permanente et individuelle. Et il termine par la morale, la plus noble des parties de la philosophie, qu'il ne distingue guère d'ailleurs de la métaphysique et de la théologie. Car la théologie expose, en faisant appel à la foi au Christ, ce que la morale et la métaphysique tirent des autres sciences et d'une révélation spéciale.[1]

Dans l'*Opus Minus* et dans l'*Opus Tertium*, Roger Bacon achève d'indiquer au Pape la direction que l'Église devrait suivre. Dans le premier, Roger Bacon signale les parties de l'*Opus Majus* qui lui paraissent les meilleures, et il passe en revue ce qu'il appelle les sept péchés de la théologie. D'abord elle est dominée, dit-il, par la philosophie dans les écoles et chez les maîtres dont il fait une si vive critique. Puis elle n'utilise pas les sciences les meilleures et celles qui lui seraient les plus précieuses, les langues étrangères au latin dont elle devrait sortir tout entière, la mathématique et l'optique, la science expérimentale et morale, déjà indiquées dans l'*Opus Majus*, l'alchimie qu'il met sur le même plan ; elle se borne à employer des sciences viles, la grammaire des Latins, une logique incomplète, la partie la moins valable de la philosophie naturelle et une partie seulement de la métaphysique. Bien plus, ces sciences d'une valeur inférieure, les théologiens les ignorent, acceptant une infinité de choses fausses, prenant pour certain ce qui est douteux, pour clair ce qui est obscur, recherchant le superflu et omettant le nécessaire, comme on peut le voir par l'exemple des maîtres les plus célèbres, Alexandre de Halès qui est mort, et Albert le Grand dont l'influence est encore si considérable et si pernicieuse. En cinquième lieu, les théologiens préfèrent le *Livre des Sentences* à l'Ancien et au Nouveau Testament. Et dans les Écritures, dans la Vulgate qui est entre leurs mains, le sens littéral présente des fausetés infinies, des doutes intolérables qui empêchent d'at-

[1] Voir plus loin la théorie de la double expérience.

teindre la vérité et qui emportent les mêmes erreurs et les mêmes incertitudes pour l'interprétation allégorique : tout cela provient de ce qu'ils ignorent l'hébreu, le grec, l'histoire naturelle, le latin même, mais surtout la propriété des choses qui figurent dans les Écritures. Enfin ils ne savent pas davantage la génération des choses dont l'histoire, partout diffuse dans l'Écriture, est le fondement de la philosophie naturelle et de la médecine : si l'on connaissait, dit-il en soulevant un certain nombre de questions relatives à l'alchimie, les propriétés de toutes les choses, on saurait l'Écriture, la philosophie et par conséquent toute la sagesse divine et humaine.[1]

A maintes reprises Roger Bacon proclame, dans l'*Opus Tertium*, l'originalité de son œuvre et la nécessité de suivre la direction qu'il indique. Comme les sciences sont connexes, il faut en donner une vue compréhensive, il faut soumettre aux maîtres l'esquisse générale et les objets de la connaissance, préparer à l'étude de la philosophie dont on ne peut avoir que l'idée la plus fausse et la plus pernicieuse par les deux maîtres vantés dans les écoles, Alexandre de Halès et Albert le Grand. L'erreur et la confusion dans la théologie et la philosophie sont surtout causées par l'ignorance des langues. Mais aussi il y a trop peu de maîtres pour les mathématiques — Roger Bacon n'en connaît que deux parfaits et deux bons ; il n'y en a pas trois non plus qui sachent l'optique. La multiplication des espèces, qu'il a travaillée pendant dix ans, est aussi importante que l'optique elle-même ; l'alchimie spéculative et l'alchimie opérative, fort peu étudiées, ont des rapports considérables avec la physique ; l'expérience est le seul témoin certain pour les sciences et toutes sont ses servantes ; la morale

[1] Voir dans Émile Charles, *Roger Bacon, sa vie, ses ouvrages, ses doctrines*, Paris, 1861 ; et Bridges, i, pp. lxxiv–lxxviii, ce qui est dit de l'alchimie chez Roger Bacon. Voir aussi la publication de Duhem.

a une grande importance comme fin et comme règle de toute connaissance. Pour l'avancement de la philosophie, un seul homme ne peut suffire : il y faut l'aide des princes et des prélats, il faut de l'argent pour les livres, pour les instruments, pour les tables mathématiques et astronomiques, pour l'étude des langues, pour la recherche et l'achat des livres, pour les expériences et pour la formation de collaborateurs de toute espèce. En analysant l'*Opus Majus*, Roger Bacon rappelle que la sagesse véritable, unique et parfaite, est dans les Écritures, que toute philosophie vient de Dieu par son action sur l'intellect de l'homme, que toute la sagesse a été donnée d'abord par Dieu aux patriarches et aux prophètes ; que les philosophes et les sages eurent des illuminations spéciales par lesquelles ils furent instruits sur Dieu et le salut de l'âme, peut-être plus pour les chrétiens que pour eux-mêmes, mais que la philosophie est vaine si elle n'est pas jointe à la sagesse de Dieu et ne lui obéit pas. A propos de l'étude des langues, Roger Bacon expose la puissance miraculeuse de la parole, surtout si l'influence des astres y est jointe, l'imposition des mots et leur puissance significative, les signes artificiels et les signes naturels. La logique est connue sans apprentissage et tous les hommes raisonnent naturellement. Des mathématiques, la plus noble est l'astronomie spéculative et pratique, qui fait connaître les choses célestes dont dépendent tous les changements terrestres. C'est la géométrie qui explique ces changements et qui explique aussi la multiplication des espèces, en ligne droite ou par des rayons accidentels, par réfraction ou par réflexion. Et Roger Bacon donne ses idées sur la matière, qui n'est pas égale à Dieu, sur les figures des corps, sur le monde, le temps, le mouvement et l'éternité, sur le vide, même sur les explications populaires de la transsubstantiation, parce que tout cela a rapport à la quantité que le géomètre considère. L'astronomie apparaît comme le fondement assuré de la chrono-

logie : aussi donne-t-elle le moyen de réformer le calendrier. A propos de la musique, Roger Bacon traite de l'accentuation, du chant, de la psalmodie, de l'harmonie, du mètre et du rythme, de la prédication et de la rhétorique, continuant ainsi à élargir le trivium et le quadrivium de l'époque antérieure.[1]

Ce qui caractérise peut-être le mieux Roger Bacon comme penseur, c'est qu'il est le représentant le plus complet de la spéculation au XIII^e siècle, puisqu'il a poursuivi la connaissance sous toutes ses formes alors accessibles, c'est qu'il peut être rapproché par conséquent de tous ses contemporains, mais qu'il peut l'être tout aussi bien des hommes de la Renaissance, de la Réforme et des temps modernes.

Sans doute il veut qu'on s'applique à l'étude de la grammaire latine ; mais il recommande qu'on apprenne le grec, l'hébreu, le chaldéen, l'arabe et même la plupart des langues que parlent les peuples avec lesquels les Latins sont en relations. A la façon des érudits de la Renaissance, qu'il surpasse même par l'ampleur de ses recherches, il compose une grammaire grecque, une grammaire hébraïque, peut-être des vocabulaires ; il est en quête de manuscrits et il écrit un latin bien plus voisin du leur que de celui de S. Thomas. Comme les partisans de la Réforme, il entend qu'on lise les Écritures dans l'original et qu'on tâche d'avoir un texte correct. En moderne il signale les avantages de l'étude des langues étrangères pour le commerce, pour les relations politiques avec les différents peuples, pour la conservation ou le rétablissement de la paix, il pratique l'exégèse, il apparaît ainsi comme un des fondateurs de la philologie comparée, de la philosophie du langage et de la critique sacrée.[2]

[1] Il faut rapprocher les fragments publiés par Gasquet, par Little et par Duhem de l'*Opus Tertium*.

[2] Tout cela a déjà été établi en bonne partie par Émile Charles, op. cit., 2^e partie, ch. ii, ' Essai d'une renaissance au XIII^e siècle ' ; 4^e partie, I. Caractère philosophique attribué à la grammaire, Bacon,

Il n'ignore pas la logique démonstrative de l'*Organon* qu'il connaît tout entier. Mais il croit que le raisonnement est naturel à l'homme, que les termes seuls par lesquels on en fait la théorie sont à apprendre dans les livres. Surtout il met le raisonnement au-dessous de l'expérience et vante une forme de raisonnement dont le germe est dans la Rhétorique, la Poétique d'Aristote et leurs commentateurs, mais qui ressemble, en plus d'un point, à ce que nous nommons la logique du vraisemblable et aussi à ce qu'est pour M. Ribot la logique du sentiment.[1]

Pour les mathématiques, il n'est pas inférieur à ceux qui en font une étude spéciale et il dépasse les philosophes qui s'en tiennent à l'antique quadrivium. Comme Descartes, il les applique à la physique et en tire l'explication de toutes choses. Tout ce que savent les astronomes et les astrologues de son temps, il le sait. Mais il expose, sur le calendrier, des idées qui ne seront réalisées qu'en 1582. En examinant, à la suite des Arabes, la durée attribuée à diverses formes religieuses, il esquisse une histoire comparée des religions où il ne tient pas compte uniquement de celles que comparent les controversistes juifs, chrétiens et musulmans. En géographie, il utilise ce qu'ont transmis les Grecs, les Latins et les Arabes, mais il consulte les récits des voyageurs du XIII^e^ siècle et, quand il le peut, les voyageurs eux-mêmes. Les pages que Pierre d'Ailly a reproduites textuellement, sans citer d'ailleurs Roger Bacon, n'ont pas été sans influ-

un des fondateurs de la critique sacrée ; IV. De l'érudition de Roger Bacon. Voir Hirsch, ' Early English Hebraists, Roger Bacon and his Predecessors,' *Jewish Quarterly Review*, October 1899, vol. xii ; J. L. Heiberg, ' Die griechische Grammatik Roger Bacons,' *Byzantinische Zeitschrift*, vol. ix, Leipzig, 1900, pp. 479–91 ; Edmond Nolan et Hirsch, *The Greek Grammar of Roger Bacon and a Fragment of his Hebrew Grammar*, Cambridge, at the University Press, 1902.

[1] Roger Bacon insiste sur cette forme de la logique qui mettrait au second plan la logique démonstrative, Charles, p. 140. Voir Th. Ribot, *La psychologie des sentiments ; La logique des sentiments*, Paris, Alcan.

ence sur la découverte de l'Amérique. En optique, Roger Bacon résume Ptolémée, Avicenne, Alhazen, mais il est supérieur à Witelo que Képler commente au début du XVII[e] siècle. Les savants utilisent les deux parties de l'*Opus Majus*, que Combach publie en 1614, comme les travaux de Scheiner et de Képler. Et l'on rappelle Roger Bacon quand Descartes traite de la dioptrique et des moyens de prolonger la vie humaine.[1]

Avec Albert, Roger Bacon vante l'expérience; avec les hommes de son temps, il croit à l'action toute-puissante de Dieu, mais il ne doute ni du pouvoir de la nature, ni du pouvoir de l'homme, et il a une confiance illimitée dans l'observation et dans l'expérience pour déterminer en dernier ressort la valeur des conceptions actuelles et des affirmations antiques. Son alchimie et celle de ses contemporains rassemblent tout ce qui a été trouvé par les Grecs et les Arabes, mais c'est en les continuant que le XVII[e] et le XVIII[e] siècle feront enfin naître la chimie positive. Pour la morale, Roger Bacon s'inspire des moralistes latins et grecs, notamment de Sénèque ; il trouve chez eux les principes métaphysiques et théologiques du christianisme, même la puissance spirituelle et temporelle du Pape, vicaire de Dieu et Dieu humain. Il pose, comme l'idéal suprême, l'union mystique avec Dieu, qui produit, autant que cela

[1] Charles a insisté sur toute cette partie de l'œuvre de Roger Bacon que nous connaîtrons mieux quand nous aurons une édition complète des œuvres. Voir aussi pour la géographie ce que dit Bridges dans les notes sur l'*Opus Majus*, en particulier i. 290 pour la découverte de l'Amérique et aussi, pour l'optique, ii, pp. 1 et 2. Voir aussi *Essais*, ch. x. Ce chapitre synthétise trois articles qui ont paru dans le *Journal des Savants* en juillet 1905, en septembre et octobre 1912. C'est dans le *Discours de la Méthode*, 6[e] partie, que Descartes expose, sur les moyens de prolonger la vie humaine et de reculer les accidents de la vieillesse, des idées qui rappellent celles de Roger Bacon. En ce qui concerne l'histoire des religions, nous avons développé les idées de Roger Bacon dans nos conférences des Hautes-Études.

est possible en cette vie, la christification et la déification de l'individu, tout en exposant bien des solutions pratiques pour la vie actuelle. Pour l'éducation, il considère comme indispensable la méthode des écoles, conférences entendues et prononcées, discussions auxquelles on prend part ou qu'on dirige, mais il juge sévèrement la plupart des procédés dont usent les maîtres et, pour sa part, les transforme complètement.[1]

Par l'ensemble de sa direction scientifique, par le soin qu'il prend de proclamer la connexité de toutes les sciences, parties d'un tout qui accomplissent leur œuvre propre en s'aidant cependant les unes les autres, par la place qu'il fait à la science pratique ou à l'industrie, Roger Bacon est devenu pour Hauréau et Renan, Littré et Bridges, un ancêtre d'Auguste Comte, un précurseur du moderne positivisme. Mais il ne s'est pas borné à la recherche exacte et scientifique ; il n'a condamné ni la théologie, ni la métaphysique. Au contraire, les acquisitions scientifiques doivent servir à les constituer d'autant plus parfaites l'une et l'autre que les sciences seront elles-mêmes plus compréhensives et plus riches en vérités incontestées. Et cela surtout distingue Roger Bacon des thomistes postérieurs à 1280, plus encore que de S. Thomas, pour qui la tâche du théologien et du philosophe sera à peu près terminée quand il aura fait la synthèse des connaissances antérieurement rassemblées. D'un autre côté, l'utilité pratique, par les applications industrielles, n'a pour lui qu'un rôle secondaire : le but suprême, c'est la possession de la sagesse d'où résultera l'éternelle béatitude.[2]

[1] Pour la morale, dont le texte a été publié pour la première fois par Bridges, il faut se souvenir de ce qu'a écrit Émile Charles qui avait consulté tous les manuscrits de Roger Bacon. Sur l'éducation telle que l'entend Roger Bacon, voir *Essais*, ch. xii et ch. xiii, et notre article de la *Revue des Deux Mondes*, du 1er juin.

[2] Sur Roger Bacon mystique, on peut voir ce qui va être dit des deux formes de l'expérience.

Pour mettre pleinement en lumière l'homme original et le penseur qui tient par toutes ses inspirations au XIII^e^ siècle, il semble qu'il suffise de montrer, avec un peu plus de précision, quelle fut pour Roger Bacon la méthode par excellence de la recherche et de l'enseignement et ce qu'il fait, pour la théologie et l'exégèse, de la philosophie qu'il a ainsi acquise.

Comme sources de nos connaissances, Roger Bacon admet l'autorité, le raisonnement et l'expérience.[1]

Personne, pas même Albert le Grand ou Vincent de Beauvais, n'a recherché les ouvrages du passé avec autant de soin, n'a moins épargné son argent et ses peines pour rassembler des manuscrits et en augmenter sans cesse le nombre. Mais s'il fait appel à l'autorité et au témoignage, il n'admet que l'autorité qui vient de Dieu ou celle des hommes saints et sages ; il condamne l'autorité qui s'attache à des gens qui ne le méritent ni par l'emploi des procédés propres à trouver la vérité, ni par un genre de vie qui fasse supposer que Dieu leur a accordé des révélations spéciales. Aussi annonce-t-il l'intention de vérifier par l'expérience les affirmations qu'il doit à l'autorité humaine, et il n'hésite pas à déclarer fausses celles qu'elle contredit. Roger Bacon ne se contente pas des documents écrits, il s'efforce toute sa vie de nouer des relations avec ceux qu'il estime capables de lui fournir des connaissances nouvelles, maîtres savants ou hommes dédaignés par eux, Latins, Grecs ou Hébreux. Personne, dans ce XIII^e^ siècle qui use tant des Universités et des Écoles, n'a eu une confiance plus grande dans la puissance de l'enseignement et de la parole. Mais il se réserve d'examiner la valeur des leçons comme celle des

[1] Les textes relatifs à l'expérience ont déjà été relevés en partie par Charles, pp. 111–15, comme ceux qui concernent le raisonnement et l'expérience. Voir aussi *Essais*, ch. xi, Le maître des expériences, Pierre de Maricourt ; xii, Jean, disciple de Roger Bacon ; xiii, Ceux que combat Roger Bacon.

écrits, en se servant de l'expérience et de l'observation toutes les fois que cela sera possible.[1]

Roger Bacon admet bien, comme ses contemporains, qu'on utilise les traductions faites depuis le temps de Boèce jusqu'au XII^e^ et au XIII^e^ siècle. Il félicite Robert de Lincoln d'avoir voulu en augmenter le nombre et il indique, mieux qu'on ne fit jamais, à quelles conditions doit répondre une bonne traduction : il faut connaître la langue dans laquelle est écrite l'œuvre originale, celle dans laquelle on veut la faire passer et la science même dont il y est traité. Mais, comme des traducteurs Boèce seul a connu les langues, Robert de Lincoln seul a connu les sciences, il n'y a pas de traductions qui répondent aux conditions requises. Même il en est — en particulier d'Aristote — de si mauvaises qu'il vaudrait mieux qu'elles n'existent pas ou que personne ne les consulte. En toute circonstance, il est donc préférable de recourir aux originaux grecs et hébreux, arabes et syriaques — d'autant plus qu'une foule d'œuvres scientifiques, philosophiques et théologiques n'ont jamais été mises en latin. Aussi apprend-il lui-même les langues qu'il juge bon de savoir. Aussi insiste-t-il tout à la fois sur la nécessité d'avoir des collaborateurs qui les sachent, des protecteurs riches et puissants, pape, princes, rois et seigneurs, qui lui procurent l'argent nécessaire à la recherche et à l'achat des livres ignorés des Latins afin d'y recueillir, dans toute leur pureté,[2] les connaissances transmises.

Roger Bacon emploie le raisonnement. Mais non seulement il pense que la logique est connue naturellement, qu'il y a une autre façon de raisonner que celle dont on trouve la théorie dans l'*Organon*, il affirme, en outre, que les conclusions les plus certaines laissent à désirer, si elles ne sont pas vérifiées. Supposez, dit-il, qu'on ait prouvé par

[1] *Essais*, ch. xii et ch. xiii.

[2] Voir notre article dans la *Revue des Deux Mondes* du 1^er^ juin sur la formation intellectuelle de Roger Bacon.

des arguments suffisants que le feu brûle, endommage les choses ou les détruit. L'esprit ne sera pas en repos tant que l'expérience n'aura pas établi ce qu'enseignait l'argument. Quand elle l'aura fait, l'âme, ayant acquis la certitude, se reposera dans la splendeur de la vérité. Même dans les mathématiques, où la démonstration est la plus puissante, l'expérience est indispensable pour que l'adhésion pleine et entière soit donnée à la conclusion. Si Aristote définit la démonstration comme le syllogisme qui fait savoir, il entend la démonstration avec accompagnement d'expérience.[1]

Ainsi Roger Bacon vante l'expérience comme Albert le Grand. Il veut, en plus, qu'on l'emploie à vérifier la valeur des connaissances qui viennent par l'autorité ou plutôt par des témoignages, qui lui apparaissent comme une observation indirecte. Avec les alchimistes, avec certains physiciens, surtout ceux qui étudient la multiplication des espèces et l'optique, avec certains médecins et astronomes, Roger Bacon pratique l'observation et l'expérience, mais il en tire un parti infiniment plus considérable, car il en utilise les résultats pour la constitution d'une philosophie des sciences, d'une métaphysique et d'une morale, d'une exégèse et d'une théologie, c'est-à-dire d'une sagesse parfaite qui implique la connaissance des choses divines et humaines.

Des trois modes de connaissance, l'expérience a seule une valeur par elle-même, l'autorité et le raisonnement ne valant que par l'expérience. Celle-ci est double, elle est externe ou interne. La première est naturelle et imparfaite, quand elle n'a pas conscience de sa puissance, quand elle ne se rend pas compte de ses procédés ; elle est à l'usage, non des savants, mais de ces artisans qu'interrogent avec tant de soin et de profit maître Pierre et Roger Bacon. La seconde, humaine et philosophique, est la science des observations qui ne sont ni débiles ni incomplètes. Elle

[1] Voir note 1, p. 78.

s'étend de l'observation proprement dite, de la soumission patiente et perspicace à la nature, jusqu'à l'expérience qui la met à la question pour lui arracher ses secrets. Elle use des sens ; elle y joint des instruments dont Roger Bacon voudrait qu'on augmente le nombre et la portée ; elle utilise le raisonnement par analogie, comme les modernes, en particulier pour l'explication de l'arc-en-ciel et pour la découverte des moyens propres à prolonger la vie humaine. Le témoignage intervient comme une observation indirecte pour nous apprendre, si elle est dirigée par des sages, ce qui se passe là où nous ne sommes pas. Ainsi nous avons la raison et la cause en même temps que le fait. Au-dessus de toutes les sciences spéculatives, de tous les arts, sinon au-dessus de la philosophie et de la théologie, l'expérience a, par rapport aux autres sciences, trois grandes prérogatives : elle examine et confirme leurs conclusions, elle fournit des résultats nouveaux qui entrent dans les sciences existantes, elle provoque dans la science de nouvelles divisions, elle produit la connaissance du présent, du passé et du futur, elle amènera ces inventions merveilleuses plutôt entrevues ou imaginées que réalisées à cette époque, emploi de la poudre à canon pour l'attaque et la défense des forteresses, instruments pour naviguer sans rameurs, pour nager et rester sous l'eau, pour voler à la façon des oiseaux, voitures pour rouler sans attelage, ponts sans colonnes et sans piles, miroirs comburants, verres qui utilisent le pouvoir grossissant de surfaces diverses et conduiront au microscope et au télescope, etc.[1]

[1] Il faut consulter, en même temps que l'*Opus Majus*, l'*Opus Minus* et l'*Opus Tertium*, le fragment de Gasquet, l'*Epistola fratris Rogerii Baconis de secretis operibus artis et naturae, et de nullitate magiae* (Brewer). La réimpression ou la publication des opuscules de Roger Bacon nous fournira, il faut l'espérer, des renseignements complémentaires sur la théorie de la double expérience chez Roger Bacon. Comparez aussi notre 'Note pour l'Académie des Sciences,' *Comptes rendus*, p. 615 du tome clvii, séance du 13 octobre 1913.

Mais l'expérience humaine et philosophique est cependant insuffisante, parce qu'elle ne fournit pas pour les corps une pleine certitude et qu'elle n'atteint aucune des choses spirituelles. Il faut donc que l'intellect humain soit aidé par d'autres moyens, par des illuminations intérieures, par des inspirations divines qui portent sur le monde sensible comme sur le monde intelligible, qui achèvent la science comme la philosophie et la théologie. Au premier degré sont les illuminations purement scientifiques qui complètent, en les expliquant, les résultats de l'expérience externe. Puis ce sont les vertus qui clarifient l'esprit, de façon qu'il comprend plus facilement les choses morales et celles d'ordre scientifique. Roger Bacon rejoint ainsi Plotin par l'intermédiaire de S. Augustin et d'Algazel ; au lieu de dire que la science est la condition nécessaire et suffisante de la vertu, que tout méchant est un ignorant, il soutient que la vertu est la condition indispensable de la science, que le méchant ne peut arriver à la possession de la vérité. Au troisième degré sont les sept dons du S. Esprit dont parlent Isaïe et S. Paul et qui caractérisent les perfections nouvelles dans l'homme illuminé par Dieu. Puis ce sont les béatitudes, qui présentent les mêmes résultats sous une forme nouvelle. Ensuite les sens spirituels fournissent de l'Écriture des interprétations allégoriques avec lesquelles la théologie reconstruit le monde intelligible. L'un des fruits en est la paix de Dieu qui surpasse tout ce que donnent les sens. Enfin se produisent les ravissements, les extases qui unissent l'homme à Dieu, en lui faisant voir beaucoup de choses dont il n'est pas permis de parler, en lui donnant la certitude, pour lui et pour les autres, sur les choses spirituelles et les sciences humaines, en le christifiant et en le déifiant.[1]

Pour l'enseignement, Roger Bacon ne cesse de recom-

[1] Il faut rapprocher ce qui est dit de la science expérimentale de ce qui est dit de la morale, puis des affinités de la théologie et de la philosophie.

mander la méthode qui a pris avec Alexandre de Halès sa forme définitive : on ne saurait connaître ce que l'on veut saisir par son intelligence si l'on n'a entendu et fait des conférences, si l'on n'a pris part aux discussions et si on ne les a soi-même dirigées. Et c'est pour cette raison qu'il accuse d'ignorance ceux qui se sont créés maîtres avant d'avoir été écoliers, qu'il les rend responsables du mauvais état des études et de la corruption des mœurs. Mais ces exercices nécessaires, il ne les juge pas suffisants. Roger Bacon n'est pas plus satisfait de la manière dont on enseigne la vérité que de la façon dont on la cherche. Le maître devrait rédiger un manuel pour les étudiants et leur faire des leçons orales dont l'importance est grande, en raison même de la puissance naturelle et surnaturelle qui est attribuée à la parole. On y joindrait des conseils, une direction constante. On suivrait l'ordre indiqué au Pape en enseignant les langues, les mathématiques, la multiplication des espèces et l'optique, la science expérimentale et morale, la philosophie, le droit canon et la théologie ; on ferait pratiquer l'expérience externe et interne. Le disciple doit, avant tout, avoir le cœur pur ; il doit être docile et attentif, travailler d'après les principes qui lui sont donnés et les mettre en pratique dans des recherches personnelles.[1]

Pour les philosophes du XIII[e] siècle, la science maîtresse est la théologie, dont la philosophie et les sciences sont les servantes ou les vassales. Et Bacon use d'expressions analogues. Mais c'est aussi, selon lui, la science qui a besoin, pour se constituer, du droit canon et de la philosophie, des mathématiques sous toutes leurs formes, de la multiplication des espèces et de l'optique, de la science expérimentale et de la morale. De sorte que si la théologie est au premier plan, comme il convient à la science qui traite de Dieu, la philosophie et les sciences prennent une valeur singulière, puisqu'elles sont indispensables à l'acquisition de la parfaite

[1] *Essais*, ch. xii et ch. xiii.

sagesse. Et comme la science comporte, pour Roger Bacon, les connaissances déjà rassemblées et celles qui restent à découvrir, le théologien doit faire appel à l'expérience externe et à l'expérience par illumination intérieure pour être de plus en plus renseigné sur le monde sensible et sur le monde intelligible. Au lieu de se constituer définitivement comme elle le fut, dans ses grandes lignes, par S. Thomas, la théologie serait sans cesse en progrès ou en accroissement du fait de ses propres acquisitions, comme du fait de l'augmentation des connaissances positives et philosophiques.[1]

Et comme Roger Bacon veut que le théologien apprenne les langues pour consulter à la source les textes sacrés et leurs commentaires, on en eût acquis une compréhension d'autant plus exacte qu'on eût pris des langues une connaissance plus approfondie et plus précise. L'exégèse, comme la théologie, eût été dans un progrès constant — d'autant plus qu'elle aurait utilisé comme elle toutes les données nouvelles qu'on aurait recueilli dans le domaine scientifique et philosophique.

* * *

Dans une de nos premières publications relatives à Roger Bacon, nous écrivions en 1904 que, si l'Église avait suivi la direction dans laquelle il voulait l'engager, il n'y aurait eu place ni pour une Renaissance parfois hostile au christianisme, ni pour une Réforme qui se séparât complètement du catholicisme, ni pour une lutte ouverte ou une rupture complète entre les théologiens, les philosophes ou les savants, entre les exégètes et les partisans de la critique historique. On pourrait tout aussi bien marquer l'originalité de Bacon en disant qu'on ne saurait négliger de rappeler son nom et son œuvre quand on parle du but poursuivi par les hommes

[1] Les recherches sur la théologie et l'exégèse de Roger Bacon ont été faites à la section des sciences religieuses de l'École pratique des Hautes-Études (*Histoire des doctrines et des dogmes*). Voir *Essais*, ch. i et ch. xiv.

de la Renaissance ou par les Réformateurs, par Descartes ou Képler, par la Société royale et les Académies qui ont groupé les chercheurs de toute espèce, par les observateurs et les expérimentateurs qui ont réalisé tant d'inventions merveilleuses, par les positivistes qui ont proclamé la corrélation et la hiérarchie des sciences, comme la nécessité d'une philosophie scientifique, par les exégètes qui profitent des progrès réalisés par les sciences physiques, les sciences morales et historiques comme par l'étude des langues. S. Thomas, par son œuvre qui a triomphé dans le monde catholique, avait absorbé dans la philosophie toutes les connaissances antérieurement acquises pour en constituer l'exégèse et la théologie. Roger Bacon a esquissé une œuvre qu'il n'a pas achevée, mais dont les parties réalisées nous permettent de juger le but et l'ampleur. La philosophie y eût joué un rôle analogue à celui qu'elle a eu chez S. Thomas ; elle eût rassemblé tous les résultats obtenus par les sciences dans leur développement successif et elle eût avec elle constitué une exégèse et une théologie qui nous aurait fait approcher de plus en plus de la sagesse parfaite, capable de guider l'homme dans ce monde et de lui procurer la béatitude éternelle. Si les savants, les philosophes, les réformateurs religieux se réclament de préférence de Roger Bacon, tandis que l'Église catholique s'est toujours attachée

S. Thomas, on ne peut s'empêcher de penser que les nouveaux thomistes songent, après Léon XIII, à réunir les avantages qu'on peut retirer des deux méthodes, quand ils veulent accroître les connaissances anciennes par des recherches nouvelles — *vetera augere novis.*

IV

ROGER BACON AND THE LATIN VULGATE

By Cardinal GASQUET

The work of Roger Bacon in regard to the Vulgate is well known. His opinions as to the state of the text in the ordinary Bibles of the thirteenth century, and his suggestions as to the principles which should regulate any revision have been frequently set forth by those interested in the history of the Latin Vulgate, whilst many modern writers, amongst whom I may name M. S. Berger,[1] the Abbé Martin,[2] the Franciscan Father Theophilus Witzel,[3] and others, have written specially upon this subject. Little therefore remains to be done but to follow in their footsteps.

From one point of view the whole of Roger Bacon's encyclopaedic works may be regarded as leading up to the revision of the Latin Bible, which he considered so important. The necessary scientific correction of the text was the main reason impelling him to demand a more accurate study of languages and more correct knowledge of science. Throughout all his various treatises, or parts of his great work, Bacon constantly returns to the same central idea, namely, that the theologians of his day, and in particular the teachers in the great University of Paris, had neglected to ground themselves sufficiently in matters of language and science to the great detriment of their special studies.

[1] Samuel Berger, *De l'histoire de la Vulgate en France*, Paris, 1887.

[2] J. P. P. Martin, *La Vulgate latine au XIII^e siècle d'après Roger Bacon*, Paris, 1888.

[3] Theophilus Witzel, O.F.M., 'De Fr. Rogero Bacon eiusque sententia de rebus biblicis,' in *Arch. Franc. Hist.*, iii. 3–22, 185–213.

It is clear that the Franciscan had expressed these views as to the decadence of theological studies to Pope Clement IV, before the elevation of the latter to the Papacy, and as a consequence that Pope in the second year of his pontificate communicated to the friar his desire that he should write fully his criticism of the state of ecclesiastical studies at the time, and make whatever suggestions he thought useful to remedy the evils he perceived. In 1267, therefore, Bacon replied with his *Opus Minus*, in which the tract 'The Seven Capital Sins of Theology' sets forth clearly the points wherein he considers the training then given to ecclesiastics was at fault.

The fourth of these 'Capital Sins' Bacon declares to be the practical abandonment of the scientific study of the sacred Scriptures in favour of the *Book of the Sentences* of Peter the Lombard, upon which in the University of Paris all theological training was then based. He writes: 'When any one has read that (i.e. the *Book of the Sentences*) he thinks himself a Master in Theology, though he has not studied (*non audiat*) a thirtieth part of his Text (i.e. the Sacred Scriptures).'[1] That by the word 'Text' Bacon means the Bible is made clear by what follows, for in the context he complains that whereas other faculties use the text proper to their studies as the basis of the teaching in the schools, theology leaves its text practically on one side.

In the forefront of his work, written by direction of the Pope and presented to him, Roger Bacon pleaded for 'a more thorough and scientific teaching of the Holy Scripture'. In his opinion there was an imperative need for a change in this matter in the schools of the Paris University. Some readers of his words may perhaps be inclined to regard his expressions as not justified in fact, but the whole passage is worth quoting as giving the best available evidence. 'At Paris and elsewhere', he says, 'the Bachelor, who takes the

[1] *Op. Minus*, ed. Brewer, p. 328.

readings of the Text (i.e. the Bible), gives place to the lecturer on the *Sentences*. The latter is always honoured and preferred before the former. He who gives lectures on the *Sentences* takes the best hour according to his pleasure; he has also a socius (or assistant) and his own room, if he is a friar. But the one who reads the Bible has not these advantages. He has to beg for whatever hour the lecturer on the *Sentences* may be pleased to give him, &c. Am I not right, therefore, in saying', Bacon concludes, 'that the Text of the faculty of theology gives place to the *Sentences*?'[1]

But even this evil, which he deplores, the learned Franciscan did not regard as so serious as the state of the sacred text itself in what he calls the received Bible, used in the University of Paris. In this, he says, 'the text is for the most part horribly corrupt,[2] and it is so uncertain that great doubt must arise as to the true reading. As a consequence, those who wish to correct the text dispute with each other as to the real meaning. There are, in fact, almost as many "correctors" as readers, and they really should more truly be called "corruptors" than "correctors", since every one of them presumes to change what he does not understand, which would not be permitted in the case of the works of the poets.'[3]

This unjustifiable treatment of the sacred text, we are told, is made without knowledge or discretion, and in this regard Bacon cites with approval the dictum of St. Augustine (*Cont. Faust.*, xxxii. 16), that 'when Latin codices disagree, recourse must be had to many and those the oldest MSS., since ancient texts are to be preferred to modern, and numbers to a few'. In stating this principle of criticism, Bacon declares that there is ample evidence to show that in numberless passages the Paris Bible of his day has incorporated readings quite opposed to those to be found in the oldest

[1] Ibid., pp. 328–9.
[2] Ibid., p. 330.
[3] Ibid.

authentic manuscripts. In these ancient codices, he says, may be seen the readings held as authentic by the Roman Church; that is, he adds, 'the translation of St. Jerome, as St. Isidore declares in his book *De Officiis* (i. 12)'.

If, he continues, after recourse has been had to the ancient manuscripts there still remains a doubt as to the proper rendering of a passage in the sacred text, according to the teaching of St. Augustine, St. Jerome, and indeed of 'all the doctors' of the Church, 'recourse must be had to the language from which the Latin text has been translated' to determine whether it has rendered the meaning of the original exactly or no. As an example in point Bacon takes the words of Mark viii. 38, which in the Latin run: 'qui me *confessus* fuerit . . . *confitebitur*,' &c., which should be '*confusus* fuerit . . . *confundetur*' according to the Greek manuscripts, which have a Greek word meaning 'being ashamed of'.

That this is the true reading, Bacon confirms by an instructive use of the Eusebian Canons. In the second of these Canons are noted the passages in which three of the Evangelists agree. Amongst these the passage in Mark viii. 38 is seen to agree with parallel passages in Matthew and Luke. In the former the words used are, 'who shall *deny* me,' and in the latter, 'who shall *be ashamed* of me;' thus confirming the opinion that the word used in the Latin version of Mark should be *confusus* and not *confessus*.

Roger Bacon does not apparently consider the defective nature of the Bible made use of in the schools of Paris as so very extraordinary. For forty years, he says, many theologians and Paris booksellers have been copying and selling the corrupt text. A great number of careless scribes have added to the confusion by making changes of words, &c., according to their own judgement. Theologians have no means of examining the text critically, and so rely upon it as correct. Later, when perhaps they became conscious

that there was something wrong or unsatisfactory, they wished to change what they imagined to be wrongly translated. But 'because they had not the ability, each one made what corrections he pleased'. 'This', our author says, 'is still being done', and as each one has his own opinion as to what corrections should be made, the result is to introduce 'an almost endless diversity of readings'.[1] The result is uncertainty, and the case is really similar to that described by St. Jerome writing to Pope Damasus: 'Where there is diversity the truth cannot be known.'

The origin of the difficulty resulting in the defective Paris text was, in Roger Bacon's opinion, simply this: that those who did not hesitate to correct, made no attempt to seek for the readings to be found in the most ancient Latin texts, and were ignorant of the Greek and Hebrew languages from which the Latin version was derived. Even, he says, a good grammar would help them and save them from trying to change 'the old grammar which St. Jerome, who translated into Latin, knew so well, since he was a pupil of the great Donatus and the greater Priscian'. Contrary to what theologians have said, the text of the Latin Church is not a mixed one. It was translated by St. Jerome from the Hebrew, except the Psalms, which are from the Septuagint. The Psalter, indeed, remained in the translation from the Greek because the Church was accustomed to its use and would not accept the version made by St. Jerome from the Hebrew, which was the only one he himself thought to be correct.

In this same part of his *Opus Minus* Roger Bacon gives a full account of the translations that had been made of the Holy Scripture before the time of St. Jerome. In this he manifests an extent of knowledge surprising in the thirteenth century, and which indeed could hardly be surpassed in these days. His conclusion is that the translation of

[1] *Op. Min.*, p. 333.

St. Jerome was excellent in every way, and that it is the only one recognized by the Latin Church, and a return to which must be the end of all revision.

He calls the Pope's attention to the fact that the Septuagint Greek is not wholly trustworthy, as that text too has been corrupted by scribes and others. This St. Jerome had noted in his day, as for example in Ezekiel xlii. 2, where the word *cubitorum* has found its way into the text, where the Greek has nothing, and where St. Bede notes that the word should be *calamorum*. Before leaving this matter, he again insists that the ancient Bibles are the only true tests of correctness, and he warns students against paying too much attention to the passages of Holy Scripture used in the Divine Office and other liturgical services, since changes have been made for the sake of greater clearness and for aids to devotion.[1]

The need for possessing some knowledge of Greek in order to make corrections safely is also well illustrated by Roger Bacon. He takes the words of Matthew xii. 31, *spiritus blasphemiae*, where the word *spiritus*—usually understood as meaning the Holy Spirit—is shown by the Greek to be in the genitive case with *blasphemiae* as *blasphemia*.[2]

In the *Opus Majus* Bacon again insists upon the necessity of examining the oldest Latin manuscripts 'existing in monasteries and not yet glossed or retouched', which afford the true version made by the authority of the Roman Church. 'According to the testimony of these old Bibles the Paris edition should be corrected.'[3] Seeing the real danger to religion by the circulation of a text of the Bible into which many errors had crept, the learned Franciscan, in this as

[1] *Op. Min.*, p. 347.

[2] A great many manuscripts have this mistake, as may be seen in the list of authorities for this reading in Wordsworth and White's great work on the New Testament.

[3] *Opus Maj.*, ed. Bridges, iii. 95.

in many other matters far in advance of his age, begs the Pope to take seriously into consideration the question of a thorough revision. Three centuries before the Council of Trent Bacon wrote to Clement IV : ' I cry to you against this corruption of the Text, for you alone can remedy the evil.'

The Franciscan was also seriously concerned at the private attempts being made in the thirteenth century to correct the sacred text. He considered that the only result of the work of these correctors will be to make confusion worse confounded.

Every teacher, he says, ' in the Order of Minorites corrects as he pleases ; and the same is the case among the Friars Preachers and Seculars. Each one changes what he does not understand. The Preachers have chiefly occupied themselves with this kind of correction. Twenty years ago and more they presumed to make a *correctorium* and set it forth in writing. But later they made another to supersede it : now they hesitate (as to the corrections) more than others do, not knowing where they are. In this way their corrections are the worst kind of corruption and the destruction of God's Text. It is a much less evil and indeed without any comparison to make use of the uncorrected Paris Bible than to accept their corrections, or those of any others.' [1]

Bacon's opinion was expressed strongly against the substitution of words and phrases for the original text, no matter how much better and clearer they might appear to those who used them. In several places in his works he complains of this tendency of the correctors of his age. They never do this ' when they read the poets ' is his argument more than once repeated, but in the case of Holy Scripture ' every *lector* makes whatever changes he pleases '. [2]

He complains also of the absence of unity and method in making corrections, which was manifest in all the attempts made in his time. The correctors were not agreed as to

[1] *Op. Tertium*, ed. Brewer, p. 93.
[2] *Op. Min.*, ed. Brewer, p. 330.

what text they had to restore. Theologians as a body seemed even to think that the text used by the Latin Church was not St. Jerome's translation at all, but a mixed version compiled from many different sources. For this reason with great liberty they introduce whatever words they desire to use. 'But it is certain that the Latin Church uses St. Jerome's translation, except in the Psalter, the translation of which is taken from the Septuagint.'[1] In principle, therefore, Bacon determines that every revision or correction must have for its scope the restoration of St. Jerome's text; whereas the thirteenth-century correctors make use of other translations and even take their text from commentators, from the ecclesiastical liturgy, and even from the works of Josephus.[2]

For these reasons Roger Bacon begs the Pope to use his supreme authority and prohibit these private attempts at correcting the sacred text, and to commit this difficult and laborious task to men who possessed adequate learning and who were skilled in the languages necessary for attempting the important work. The two things the learned Franciscan chiefly condemns are: first, the Paris text; and, secondly, the attempts at correction which had been made, chiefly by the Franciscans and Dominicans, in the first half of the thirteenth century, some forty years or so before he himself denounced these attempts to the Pope and implored him to put a stop to them.

His condemnation of the majority of the correctors is based on several important considerations, amongst which are the following: they have no adequate knowledge of the ancient Bibles; their knowledge of Hebrew and Greek from which the Latin is derived is insufficient; they are unacquainted with the best Latin grammarians, and in particular with the works of Donatus and Priscian, the masters of St. Jerome; and they were not *au courant* with the various versions

[1] *Op. Min.*, ed. Brewer, p. 334. [2] Ibid., p. 347–8.

which were in existence in the Latin Church, nor had they studied their origin and history.

By the expression 'ancient Bibles' Bacon meant those which had come down from the age of St. Gregory the Great, St. Isidore of Seville, and Alcuin, 'and numberless other Bibles', he writes, 'scattered in various countries, contemporary with St. Isidore or before his time, which are free from alterations. They are the same in all things, except for the faults of copyists, from which no writing is free.' [1]

The account of the origin of the Vulgate text given by the learned Franciscan is of great interest as showing not only the extent of his knowledge on this particular part of his subject, but his entire familiarity with the works of the Fathers of the Church and of St. Jerome in particular.

'St. Jerome', he says, 'found the (Latin) translation of the Septuagint disfigured not only by the errors of the scribes, but by having from the first many faults of omission of necessary things and addition of things superfluous. He (St. Jerome) perceived that truth was in this detained as a captive, and for this reason he resolved to give the Latin Church a version made from the Hebrew. He translated the Hebrew as well as he could and as exactly as he dared, for he had no wish to frighten his readers by too great novelties. Denounced, as he was, as a falsifier and corruptor of the Scriptures, he did not dare to translate everything exactly as he wished, as may be seen in what he has written. Thus through human frailty or the rapidity with which he worked he dictated or wrote things sometimes inexactly, as he himself confesses in his letter to Magnus and in his commentaries on Isaias, where he desires to correct what he had translated badly.' [2]

Later in the same part of his work Bacon adds to this account the following:

'Knowing that his (St. Jerome's) first translation (from the Hebrew) was not sufficiently exact, wishing to set forth the truth and to satisfy the desires of students, he resolved

[1] *Op. Min.*, ed. Brewer, p. 335. [2] Ibid., p. 336.

to leave another translation in private writings. This he could do so as not to scandalize the faithful, since this second edition has never been used by the people or by the Church. At all times, indeed, very few have used the original writings of St. Jerome on the Bible. For instance, Rabanus (Maurus) and Cassiodorus, two most learned men, have declared that they could not find all his works. Rabanus says this expressly in his commentary on Jeremias.' [1]

To enforce his conclusion that the only version adopted by the Latin Church is that which St. Jerome made under the authority of Pope St. Damasus, Roger Bacon adds this reflection :

' So great a work could not have been accomplished either by the doctors of Paris or by any other person without the authority of the Holy See. It could not have been and ought not have been done without this authorization : it would have been improper. Can it be said now that this work has been concluded with this authorization either by the Paris doctors or by others or by some sovereign Pontiff ? But there is no document, no Register of any Pope, no chronicle or history which says this. We expect this in matters of small moment : and therefore with greater reason must look for it in so grave a business, which serves for the foundation of all ecclesiastical discipline.' [2]

It is unnecessary to examine more fully the connexion of the great Franciscan doctor, Roger Bacon, with the revision of the Vulgate. He shows in his works that he fully and entirely realizes the importance of the critical examination he advocates, and he lays down the true principles on which any critical correction must proceed. His proposal to Pope Clement IV was to appoint a commission of capable men with the avowed object of restoring the text of St. Jerome. The methods he suggests are the scientific methods employed to-day in the production of a critical text. The oldest manuscripts were to be sought for, examined, weighed, and compared, and the evidence of the best and oldest codices for any reading was to be taken as against the less worthy

[1] *Op. Min.*, ed. Brewer, p. 344. [2] Ibid., p. 342.

and the more modern. Finally the readings, even when they were almost certainly those of St. Jerome, were to be controlled by the original Greek or Hebrew, from which this version of St. Jerome has been translated.

What must strike any reader of Roger Bacon's works in regard to the Holy Scripture is the grasp the learned doctor had in the thirteenth century of the whole subject of Biblical revision, and how true and clear were the critical principles he laid down so many centuries ago.

V

ROGER BACON AND PHILOLOGY

By S. A. HIRSCH

Roger Bacon lived from the very commencement of his career in a circle which was calculated to develop those tendencies for research which were innate in him. Robert Grosseteste was during the beginning of the thirteenth century the champion of learning. His perseverance was indomitable, his attainments in science considerable for the time in which he lived, and his endeavours to promote the study of the ancient languages induced him to invite numbers of Greek scholars into England for the purpose of initiating himself and his followers into the mysteries of classical learning. He took pains to collect as many books as could be laid hold of, including treatises on Greek grammar.

Under Grosseteste's direction, Nicholaus Graecus translated the 'Testaments of the Twelve Patriarchs' from a manuscript which had lately been brought from Athens by his archdeacon, John of Basingstoke.

Nicholaus must have been one of those *veri Graeci*,[1] several of whom lived in western Europe even before Grosseteste; one of the very few who were able to impart a correct knowledge of grammar.[2] He became an inmate of Grosseteste's household.

John of Basingstoke was an excellent Greek and Latin scholar. In Athens he became cognizant of many things the existence of which was unknown to the Latins. He says that, although he had studied for a long time at Paris, he had derived his real knowledge from the tuition of the

[1] *Comp. Stud. Phil.*, vi. 434 (Brewer); *Greek Grammar* p. 31.

[2] *Opus Tertium*, x. 34 (Brewer).

learned Constantina, who was alleged to have been the daughter of the Archbishop of Athens.[1] He translated a Greek grammar, which he called the Greek Donatus.[2]

Bacon must also have received a considerable stimulus towards the study of the ancient languages from the veteran scholar, his older contemporary whose name is unknown to us, and who is designated by him by such a term as *homo sapientissimus*. Bacon declares that he was a consummate Greek and Hebrew scholar who had for over thirty years—or, as Bacon says elsewhere, for nearly forty years—brought his linguistic knowledge to bear upon the correction of the Vulgate and the exposition of its literal meaning; that he knew Latin grammar thoroughly according to Priscian, and Greek and Hebrew sufficiently well to understand the principles and method of correcting, and the way to justify his corrections. Compared to him all others were but idiots.[3]

The intercourse with the circle of students who were gathered round Grosseteste, and his acquaintance with such men as Edmund Rich and his reputed pupils, Adam Marsh, Thomas Wallensis, and others, cannot but have imparted a powerful impulse to a mind predisposed by nature to immerse itself in the depths of philological research.

[1] See, however, Sir J. E. Sandys, *A History of Classical Scholarship*, i. 413.

[2] Another work of his which commences *Templum Domini, 'in quo particulae sententiarum per distinctiones dilucidantur'* (Matthew of Paris, *Chron. Maj.*, ed. Luard, v. 284–7), *may* have been a work on Syntax, but I rather believe that it was a commentary on Peter Lombard's *Sentences*. Cf. Bacon's *Greek Grammar*, &c., Introduction, p. xlviii.

[3] *Opus Tertium*, xxv. 88, 89, 94 (Brewer). Mr. A. G. Little has communicated to me his doubts as to Denifle's identification of *homo sapientissimus* with William de la Mare, on the ground that the latter was too young. These doubts are of considerable force in view of this passage: *Et adhuc 'aliqui senes perdurant' qui sciunt multum ut homo sapientissimus*, &c. The figures 30 years, 40 years, in Bacon's writings must not be taken too literally.

Roger Bacon held that the knowledge of languages was the first gate that led to the acquisition of wisdom.[1] It was particularly indispensable to the ' Latins ', whose entire acquaintance with theology and philosophy was derived from channels other than Latin. He did not recognize the study of languages to be important for its own sake ; it was not a *scientia principalis*, like, for instance, mathematics. It was, like logic, only accidental to philosophy.[2] But he did not for that reason minimize its importance. Recognizing as he did that grammar, in the narrow sense of the word, as it was taught to boys, was to music what the work of the carpenter was to geometry,[3] he yet demanded an independent and scientific research into the origins and the fundamental bases of languages.

It would be idle to say that Bacon has arrived at any striking results in the study of comparative philology, of the structure of the individual languages with which he was concerned, or of a comprehensive knowledge of their literary products. These subjects, and the topics connected with them, form nowadays separate disciplines, every one of which is treated on its own merits, and is calculated to engross the life-long attention of the student. It would be futile to expect Bacon to have reached anything approaching the standard of proficiency in these subjects which is demanded at the present day even of mediocrities. But it would be an error to imagine that many of the questions which have risen to such prominent importance in recent times did not agitate Bacon's mind to a large extent. They had certainly attracted his attention, and it cannot be denied that, given the status which such questions occupied at his time, the scanty apparatus at his disposal, and the meagre attainments of his contemporaries, he far surpassed

[1] *Opus Tertium*, xxviii. 102 (Brewer).
[2] *Opus Majus*, I. iv. 99 (Bridges).
[3] *Opus Tertium*, lix. 231 (Brewer).

the latter in his speculations upon the nature of language, in his insight into the structure of the several tongues that formed the subject of his researches, and his acquaintance with their literatures, in so far as they were accessible to him.

All such disciplines as are, in modern times, comprehended in the term ' philology ' were termed by Bacon ' grammar '. Even such topics as the investigation of the origin of speech are declared by him to belong solely and exclusively to the science of grammar.[1]

Bacon holds [2] that a systematic investigation into the theory of ' signs ' was indispensable to the knowledge of the composition of languages. He voices his usual complaint that this part of grammar had not been touched upon by the Latins, who did not even possess any translations of more ancient works on the subject. This was the more surprising, seeing that it was of the utmost utility in the study of all speculative truths of philosophy and theology.

In reference to the theory of ' signs ', Bacon declares that his own investigations had led him to the same conclusions which his subsequent studies showed him to have been arrived at by Augustine. A sign may be either natural or imposed by the mind. Signs imposed by the mind either signify naturally, or are imposed at pleasure and voluntarily. The latter is the case in human language: words are imposed by the mind. Their signification is arbitrary, and a word signifies nothing before imposition. A word can be imposed upon itself, and thus become significant, e. g. ' white ' may be used in the sense of the word ' white ', or in the sense of a ' white ' thing. When a word is applied to a thing outside the mind, it signifies the thing itself and nothing else (i. e. not the ' species ' of the thing in the soul).

[1] *Opus Tertium*, xxvii. 101, 102 (Brewer).

[2] Ibid., 100; *Comp. Stud. Theol.*, pp. 38 ff.; Mr. Rashdall's Summary in his Introduction, pp. 6 ff.

A name imposed upon a thing outside the mind can at the same time signify other things outside the mind which can then be said to be ' co-intellected ' or ' connoted '. The name of an ' aggregate ' or concrete thing signifies both the formal cause of the aggregation (i. e. the meaning of the concrete form) and the constituent elements of the aggregation. But a distinction must be made. The name signifies the aggregate primarily and principally, and the form and matter secondarily or mediately. It signifies the aggregate by imposition, and the matter and form naturally. A word cannot signify anything common to an ' ens ' and a ' non-ens '. A word imposed upon a thing can lose its significance.

In coming to these conclusions on questions of the philosophy of languages Bacon has broken no new ground. He discusses the opinions of those who preceded him, but in doing so he shows himself, as everywhere else, the keen critic of such speculations, through which he carefully steers his own course. He weighs, and partly controverts, the results arrived at by Aristotle, Boethius, Augustine, and Averroes. He chastises, in his usual manner, Richard of Cornwall, whom he calls '*famosissimus apud stultam multitudinem*', as the worst and most stupid author of various erroneous notions.[1]

The question of the origin of speech also agitated Bacon's mind. It is needless to say that he did not approach the question from the standpoint of anthropology and evolution in the way modern science has tried to obtain some understanding about it, and, thus far, with but scanty success. But within the compass and limitations into which his age and the state of knowledge accessible to him confined him, he meditated on the origin of languages, on the primitive language, on the language spoken by Adam, and the way the latter found names for the things. He ponders on what

[1] *Comp. Stud. Theol.*, p. 52.

would happen if children were to grow up in a desert—whether they would have intercourse by speech, and how they would give expression to their mutual feelings when meeting under such circumstances.[1] He was convinced that this part of 'grammar' was indispensable to theology, philosophy, and to all wisdom.

He was not himself aware, it seems, that his philological instincts would have led him to the consideration of such topics on their own merit. He measured all matters of research that offer by the uses to which they could be put in the service of philosophy and theology. Like so many other scholars of that age, and of subsequent ages, he acknowledged only utilitarian motives of that kind. They were certainly powerful incentives to direct him to the study of languages. Whether 'the first authors of languages had invented them', or whether the diversity of tongues was 'the work of God, at the division of languages at the erection of the tower of Babel after the Flood',[2] or the result of 'diversity of locality',[3] the variety existed, and his mind was exercised by the desire of inquiring into those languages in which were couched the documents from which theology and philosophy and all wisdom were derived.

Of these motives, the theological occupied to Bacon the first and foremost rank. At the conclusion of his specula-

[1] *Opus Tertium*, xxvii. 101 (Brewer). Mr. Little drew my attention to a notice in the Chronicles of the Franciscan friar, Salimbene, in regard to experiments with babies, undertaken by the Emperor Frederick II. He forbade the foster-mothers and nurses of these children, when feeding or bathing them, to prattle or talk to them. Thus he thought he would be able to find out whether the children, when becoming older, would talk Hebrew ('that being the first language'), or Greek, or Latin, or Arabic, or the language of their parents. But the children all died, not being able to live without clapping of hands, or gestures, or lullabies. Mr. Little thinks it likely that Bacon may have heard of these experiments.

[2] *Opus Tertium*, xxviii. 102 (Brewer).

[3] Ibid., xxxvii. 120 (Brewer); *Opus Majus*, I. iv. 138 (Bridges).

tions on signs and words in the *Compendium Studii Theologiae* he exhorts the reader not to lose sight of the manifold power of the word in figurative speech. The text of the Bible was full of it. The word, he says, had, besides its literal sense, three other meanings : the allegorical, the tropological, and the more hidden meaning (. . . *praeter sensum literalem potest vox significare tres alios sensus, scilicet allegoricum, tropologicum, et anagogicum*) ; and it was necessary to consider the way in which, in Holy Scripture, the literal sense concorded with the spiritual.[1] Considerations of that kind were strengthened by Roger Bacon's propensity to mysticism.

Mysticism was, in Bacon's time, closely mixed up with religion, philosophy, magic, and physical science. He also believed in the mystical power of words ; and, like so many others before and after him, he ascribed a spiritual meaning over and above the literal sense to every word of the Bible. Besides his philosophical elucidation of the meaning and application of words, and their grammatical formation, he seriously ponders on their occult influence.

'For the same knife cuts bread and wounds a man. In the same way, the wise man works wisely by means of words, and the magician magically. But their mode of action is different. The former makes use of a natural force; the work of the other was either nothing or else the work of the devil. . . . Since the creation of the world almost all miracles were performed by words. The word is the principal product of the rational soul, and its greatest delight. Words are possessed of great power when they are the result of profound thought, great longing, fixed intention, and strong confidence. By the co-operation of these four functions the rational soul is excited to give its impress and virtue to its own body, to things external, to its actions, and, above all, to the words which are produced from within, and receive therefore more of the virtue of the soul. Nature, says Avicenna, obeys the cogitations of the soul, as is shown by the hen on whose legs a spur grew by its feeling of triumph at the

[1] *Opus Tertium*, xxvii. 101 (Brewer).

victory won by the cock. If thus nature obeys the cogitations of the sensitive soul, how much more will it obey those of the intellectual soul of those who are only one degree below the angels! Man's outward appearance and voice vary as the greater or lesser sanctity of the soul. A considerable increase in the power of either the good or the bad soul modifies the voice and the air affected by the latter. The air thus formulated by the voice, and having received a strong impetus from the rational soul, can be changed accordingly, and change, in its turn, the things it contains, be they agents or patients. It is the same with the body. Body and soul forming a unit, the body naturally obeys the cogitations of the soul; they modify its outer appearance. It again affects, and is affected by the air, which was itself affected by the voice. A further change is due to stellar influences. Whenever the voice is produced, the change wrought by it in the air is complicated by the effect of the constellations, and this again acts upon the things contained in the air. Everything depends, therefore, upon four influences: the voice formulating the air, the good or evil condition of the rational soul, the body, and the stars. When cogitating, intending, wishing, and strongly hoping for any change, a favourable condition of the heavenly bodies must be chosen in conjunction with the other influences; in the same way as a skilful physician selects suitable stellar conditions when desirous of working a cure. It was, as Avicenna says, in this way that the prophets and sages of old changed the matter of the world (*materiam mundi*), and produced rain, or drought, or other atmospheric changes by the power of words. In this consists the art of alluring or repelling men and beasts, snakes and dragons. This is the nature of every spell, and not the mere utterance of a word; the latter will have no effect unless the devil interferes. The other forces combined with the five conditions of the soul—strong thought, vehement wish, firm will, and either goodness or badness—are indispensable. The origin of songs, incantations, and various modes of writing must be traced to these influences.' [1]

This combination of the power of words in general, and the spiritual sense underlying the words of the Bible in particular, made it imperative for Bacon to devote himself to the study of Hebrew and Greek, so as to be able to find

[1] *Opus Tertium*, xxvi. 95 ff. (Brewer).

hidden truths which would elude the eyes of those who knew these writings only from translations. It was only by a knowledge of Hebrew and Greek that it was possible to grasp the spiritual meaning of the 'text'. The 'text' was to Bacon what it was to his predecessors and contemporaries, and what it is to a great many people at the present day—the Latin translation. It would be possible, he holds, to study the literal meaning of the 'text', but this could be of very little avail for the knowledge of the spiritual sense.

'Suppose even the "text" to be correct to the letter, innumerable false and doubtful notions still remain on account of the ignorance of the languages from which the translations were made. But we theologians do not know even the alphabets. Consequently, we understand neither the text nor the expositions of the saints.' [1]

Bacon supported his standpoint with numerable examples. It was impossible for any one ignorant of the numerical value of the Greek and Hebrew letters to understand the interpretations given by the saints, as, for instance, Bede's gloss regarding the names of the Beast in the Apocalypse, the numerical value of the letters of each amounting to 666; or another passage of the Bible where the numerical value both of the Greek and the Hebrew letters coincided in revealing beautiful mysteries.[2]

Another powerful motive to study languages was Bacon's disgust at the insufficiency of the existing translations. He sets forth that philosophy, religion, and science were laid down in documents which were written in languages that had fallen out of the ken of the majority of scholars of the day. Of the ancient languages, there was only one which had survived as the universal vehicle of thought and study in southern and western Europe. Latin could in Bacon's time

[1] *Opus Minus*, p. 349 f. Cf. ibid., p. 357; *Opus Majus*, I. iii. 81 (Bridges).

[2] *Comp. Stud. Phil.*, vi. 437 (Brewer); *Greek Grammar*, p. 194 f., and Introduction, p. lxxv.

still rightly be called a living language. But Bacon complained that the Latin world of priests and students, the 'Latinitas', had lost the knowledge of those very languages that formed the basis upon which everything that should interest them was reared. This would not have been so bad if the Latins were possessed of original and independent works on all branches of learning. But all wisdom had been revealed by God to nations other than Latin. Philosophy was delivered on four distinct occasions. It was delivered for the first time in Hebrew, complete in all its details, by Adam and Noah; the second time, by Solomon; but Aristotle and Avicenna, who mark the other two epochs in the history of philosophy, were only able to deliver it incompletely, because they were heathens. Wisdom was delivered by these only and by none else; it certainly had not originated with the Latins.[1]

'The Latins never originated a single text, either in theology or philosophy. All texts were composed in the first and second instance in Hebrew, in the third in Greek, and in the fourth in Arabic. . . . Waters drawn from the fountains were sweeter than those taken from turbid rivulets, and wine was purer and more wholesome when kept in the original cask than when poured from vessel to vessel. If, therefore, the Latins wished to drink the pure and wholesome liquor from the fount of wisdom, they must turn their attention to the Hebrew, Greek, and Arabic languages. It was impossible to recognize the proper form and beauty and wisdom in all their dignity except in the languages in which they were originally laid down. Oh, how delicious is the taste of wisdom to those who draw from the well of wisdom in its primary fullness and purity! All others are like those stricken with paralysis, who could not judge of the sweetness of food; like those born deaf, who are unable to enjoy the harmony of sound.'[2]

Translations cannot possibly replace the original documents.

[1] *Opus Tertium*, x. 32 (Brewer).

[2] *Comp. Stud. Phil.*, viii. 465. Cf. *Opus Majus*, Part iii, for Bacon's opinions on these points.

'Jerome says that one language cannot possibly be represented by another. That which sounds well in one tongue becomes ridiculous when expressed in another. Homer became ridiculous when translated into Latin, and that most eloquent poet could hardly be said to speak at all.' [1]

The Latins derived their theology and philosophy merely from translations. But translations were unsatisfactory. Take, for instance, Logic. The logician will not find in his vernacular terms by which to express the sense of the original. He is therefore compelled to invent new terms. The result is that he will only be understood by himself. The same obtained in all other branches of knowledge. The translator must, consequently, borrow words from the language from which he translated. Such could neither be written, nor pronounced, nor understood, except by those who understood the language of the original.[2]

In medicine the names of herbs, of spices, and other things were, for the most part, borrowed from the original languages. The same was the case with the holy text: all names of persons, localities, and numerous other things are either Greek or Arabic or Hebrew. Numbers of words were taken over from Lombardic, Spanish, and other languages that are akin to Latin. Bacon himself, when commenting in his lectures on a word which he took to be Arabic, was laughed at by his Spanish hearers, who told him that the word was not Arabic, but Spanish.[3] Such ignorance brought the Latin teachers into contempt.

Translations were powerless to remedy the evil. The requirements necessary to procure a good translation—a thorough knowledge of the languages from which and into which the translation is made, and of the subject-matter—

[1] *Opus Tertium*, xxv. 90 (Brewer).

[2] Ibid. Cf. *Opus Majus*, I. iii. 73 (Bridges).

[3] The cause was probably that the Latin was a translation of a Spanish translation of the Arabic. See Bridges's note on *Opus Majus*, I. iii. 68.

were possessed by very few indeed. All others were frauds. Robert Grosseteste belonged to the former class; but he only acquired the capacity of translating when he was an old man; and the Greeks whom he had gathered around him had translated very little. The translations furnished by Gerard of Cremona, Michael Scot, Alfred the Englishman, Hermann the German, and William the Fleming (William of Moerbecke) were sorry performances. The Bishop Hermann the German had told Bacon that he did not venture to translate books on logic from the Arabic, because he knew no logic. Not knowing logic, he could have no learning. But he did not even know much Arabic, and he was rather an assistant of translators than a translator himself. Michael Scot palmed off as his own, translations which were for the most part the work of a Jew, Andrew. Aristotle, whose works formed the foundation of all learning, had suffered most at the hands of these translators. Their versions of his logic, natural philosophy, and mathematics were such that no mortal could make head or tail of them. In consequence, the scholars squabble among themselves as to what Aristotle meant. It would have been much better if Aristotle had not been translated at all. Scholars laboured hard to understand him, and the more they laboured the less they knew. For this reason Grosseteste neglected the works of Aristotle, and dealt with several topics, guided only by his own experience and research,[1] and certainly with greater success than if he had made use of those perverse translations. If, Bacon says, he could have his way, he would have all translations from Aristotle burned. It is sheer loss of time to study them, and it leads only to innumerable errors.

Ignorance of Greek and Hebrew, together with some other causes, were responsible for the corruption of the text of the

[1] But see Sir J. E. Sandys, *A History of Classical Scholarship*, i. 553.

Vulgate. The Paris text was the worst of all. Everybody, however illiterate some of them may be, and even 'married people', presumed to interfere with the text. They knew no grammar, they did not consult Priscian, and did not know that, on many points, Jerome was better informed even than he. Nevertheless, Jerome's translation did not always reproduce the true sense of the originals. People inveighed against him because he had dared to deviate from the Septuagint, and he was termed a falsifier and corrupter of the Scriptures. He therefore adapted himself to the previous versions, sometimes to that of Aquila, sometimes to that of Symmachus, but chiefly to the Septuagint, although he knew that these translations did not always agree with the originals. Jerome, moreover, admitted to have occasionally erred from undue haste.[1]

All these reasons combined caused Roger Bacon to urge upon his contemporaries the study of the ancient languages. But he did not stop at exhortations. He threw himself into this pursuit with the same energy which characterized his efforts in the other fields of learning. It was especially the three languages—Arabic, Greek, and Hebrew, the mastery of which he considered to be a *conditio sine qua non* for all independent research in theology, philosophy, and science.

But Bacon was aware that no workman can effect anything without proper tools, which were in this case books and teachers. He says that it was necessary for the Latins to possess a short and useful treatise on the languages other than Latin, particularly on Greek, Hebrew, and Arabic; not only because all knowledge they possessed was borrowed from books written in these idioms, but because their own language (Latin) was based upon them.[2]

[1] For the foregoing sketch of Bacon's estimate on translations see *Opus Majus*, I. iii. 67 ff.; ibid., iv. 221 (Bridges); *Opus Minus*, pp. 325, 330–49; *Opus Tertium*, x. 35, xv. 55, xxiii. 75–8, xxv. 89–95; *Comp. Stud. Phil.*, viii. 465 ff.

[2] *Opus Tertium*, x. 34, xxv. 88 (Brewer).

A treatise of that kind should only contain the elements of grammar. It would be injurious to attempt too much at first. The student should not endeavour to master the learned languages completely, so as to know them in the same way as he knew and spoke his mother tongue; as he spoke English, French, and Latin. Nor was it necessary for the student to be able to translate scientific books. A third and lower standard was preferable, and this could easily be attained under a proper teacher, and with the help of good and concise manuals. But the student must be able to read Greek and Hebrew, and know the accidence according to Donatus. Once this was acquired, and a proper method followed, the construing and understanding of the words follow easily. The second degree, the capacity of translating, was much more difficult, although not so difficult as people imagined. But the first degree was very difficult indeed: it implied the capacity of speaking the language like the vernacular, and of using it for teaching and preaching and making speeches. The attempt to acquire all this would only frustrate its object; the student would soon despair, and not even reach the third degree.

'If a person were to apply himself from his youth for thirty years, he might attain all three degrees, or, at least, the two lower degrees. It is the first degree that offers all the difficulty, as we who have tried it know from experience.'[1]

The problem of finding competent teachers of the learned languages, although not a difficult one to Bacon in one sense, was far from easy in another. Bacon says that the best means was to learn Greek from the Greeks, and Hebrew from the Jews. Jews he declared to be everywhere, and their language was *in substance* the same as Arabic and Chaldaean. There were, besides, people in Paris, in France, and elsewhere who knew sufficient for the purpose. Greek

[1] *Opus Tertium*, xx. 65 f. (Brewer); *Comp. Stud. Phil.*, vi. 433 (Brewer).

accorded in most respects with Latin, and there were persons in England and France who knew enough. In many places in Italy the clergy and population were purely Greek, and it would be worth the trouble to go there for information.

And yet the matter was not so easy after all. Such of the inhabitants of southern Italy as were *veri Graeci* were not easily accessible. Some of these were still to be found in England, thanks to the efforts of Grosseteste; but the acquisition of the proper books and persons was a task that could only be undertaken by prelates and wealthy people.[1]

But for educational purposes these Greeks and Hebrews were, for the most part, useless. They knew no grammar. As there were many laymen who spoke Latin very well and yet had no notion of the grammatical rules of that language, in the same way there were only very few Jews and Greeks who were able to teach the grammar of their languages in a methodical and rational manner. Among the Latins there were many who could speak Greek, Arabic, and Hebrew, but how many of them knew, or could teach, the grammar of these languages? Not four.

Bacon must have early in life conceived the idea of supplying the deficiency, and providing his contemporaries and a future generation with, at least, elementary Grammars of the learned languages. He says that, although he had himself studied for forty years, from the time that he first learned the alphabet, he was yet convinced that within three months or half a year he could impart his own knowledge of the sciences and languages by oral teaching—provided he had first composed a text-book, and the student were earnest and willing. Under such conditions he would be able to teach in three days as much Hebrew as was wanted for reading and understanding all that was written by the saints and ancient sages in elucidation and correction of the

[1] *Opus Tertium*, x. 34; *Comp. Stud. Phil.*, vi. 434 (Brewer); *Greek Grammar*, p. 31.

sacred text. The student would, however, have to submit to the prescribed method. In three more days he would teach sufficient Greek for reading and understanding everything which pertains to theology, philosophy, and the Latin language.[1] Whatever our opinion may be as to the sufficiency of three days for the attainment of even the most elementary degree, so much is certain that Bacon himself acted upon his suggestion that Grammars should be written.

There are no traces in Bacon's works to show that he was interested in the spread of a grammatical knowledge of modern languages. There can hardly be any doubt that he was an accomplished English and French scholar ; and his remarks on the dialects of several European languages, and their grouping under distinct mother languages to which they are related, sufficiently prove that he had drawn them within the scope of his investigations. It is true he animadverts upon the commercial and international advantages which the commonwealth of the Latins might derive from the study of languages, but this fragmentary notice seems also to refer only to the general use which can be made of the ancient languages.[2] In another passage[3] he refers to the Russians as schismatic Christians, and says that, although they follow the rites of the Greek Church, their language is not Greek but Slavonic. He also makes some remarks regarding the mode of writing in use among the Tartars, and the writing in pictures in vogue with the Chinese.[4] These observations, coupled with some illustrations in Norman French, and some allusions to modern Greek, about which more below, are all the references we find in his works to the languages spoken in his time.

Bacon considered Latin his mother tongue by the side of

[1] *Opus Tertium*, xx. 65 (Brewer).
[2] *Opus Majus*, I. iii. 96 ; Supplem. vol. 119–120 (Bridges).
[3] Ibid., iv. 360. [4] Ibid. 374.

the language of the country in which he was born.[1] The Latin he employs in all his writings is that of the thirteenth century, and is clear, grammatically correct, and belongs to the best specimens of mediaeval Latinity.[2] He was thoroughly acquainted with a number of Roman authors, of whose works he makes ample use for the purpose of illustrating some rule of etymology or prosody.[3] And although he complains that the advice given by Boethius and Bede to instruct youths in the writings of Seneca for the training of their morals was neglected, and that they were taught instead the fables and nonsense of Ovid, which are so full of irreligion and immorality; yet he himself did not hesitate to use Ovidian phrases and to cite his verses.[4] Bacon's proficiency in Latin grammar will again be alluded to.[5]

Bacon's intention was to compose grammatical manuals for the study of Arabic, Greek, Hebrew, and Chaldaean; for, after having indicated the necessity for the Latins to have a sufficient knowledge of the grammar of these languages, he prefaces his Greek Grammar[6] and his grammatical

[1] *Comp. Stud. Phil.*, vi. 433 (Brewer). Speaking of Greek, Hebrew, Arabic, and Chaldaean, he proceeds: *Non tamen intelligo ut quilibet sciat has linguas sicut maternam in qua natus est, ut nos loquimur Anglicum, Gallicum, et Latinum; nec ut sciamus tantum de his linguis ut quilibet fiat interpres, et transferre possit in linguam maternam Latinam scientiam de linguis illis.*

[2] Rashdall, *The Universities of the Middle Ages*, pp. 595–7; *Greek Grammar*, Introduction, p. lxxi f.

[3] Sir J. E. Sandys, *ut supra*, p. 573.

[4] *Opus Tertium*, xv. 55. Cf. Sir J. E. Sandys, *ut supra*, p. 574. In the *Opus Tertium*, i. 12, Bacon quotes a verse as taken from Ovid's *Tristia*, but which is really from Statius. See Brewer, n. 8.

[5] A grammatical work of considerable length, described as *Rogeri Bacon Summa de Grammatica*, exists in manuscript in Peterhouse, Cambridge, and in Worcester Cathedral. See Dr. M. R. James's Catalogue and Mr. A. G. Little's Appendix to Mr. Rashdall's edition of the *Compendium Studii Theologiae*, p. 98. I could only cursorily examine the Cambridge MS., but it requires a thorough investigation. Perhaps I may have an opportunity of dealing with it on a future occasion.

[6] p. 2.

treatises in the *Compendium Studii Philosophiae*[1] with the remark that he dealt first with Greek grammar because it was the easiest, and more in agreement with Latin. This implies his intention of writing also an Arabic Grammar. There is no indication in any of Bacon's acknowledged works that he had accomplished his design. Nor can we at all be sure that his proficiency in Arabic was great enough. He says that he wrote Greek, Hebrew, and Latin, but not Arabic. But as he declares his intention of dealing with Arabic on the proper occasion (*locis suis*),[2] we may rest assured that he had acquired some knowledge of that language also, albeit it amounted perhaps to no more than what he called the third degree.[3]

With Greek it is altogether different. Here we have tangible proofs of Bacon's close application, and ample data by which to estimate the standard of his knowledge.

Let us consider the judgement passed by Bacon on his predecessors. Whenever he detects faults in their works, and attributes them to their insufficient knowledge of Greek, his remarks invariably proceed from his thorough mastery of the subject. On such occasions he does not assail the subject of his criticism with kid gloves; he shows him the mailed fist. He never derides, he scourges. Bacon enumerates the various directions in which the common crowd of Latin scholars wandered astray. In the first place, they took for Latin, or Greek, or Hebrew, or *vice versa*, words which were nothing of the kind. Secondly, they were at fault in their derivations, etymologies, and interpretations. Thirdly, their pronunciation and spelling were faulty. But it was only partly their fault. They were

[1] ix. 495 (Brewer).

[2] *Opus Tertium*, xxv. 88 (Brewer).

[3] If Professor Rieu's interpretation of the words *quae vocantur Arabice Assub* be correct, the application of adjectives in the singular to a plural noun would not show a familiar acquaintance with Arabic. See *Opus Majus*, II. v. 102, n. 3 (Bridges).

led into error by their foremost authors, Papias, Hugutio, and Brito. These were one and all liars. Hugutio was the worst ; he was at pains to show that Latin texts were more reliable than Greek, and Greek more reliable than Hebrew, even though the Greek be a translation from the Hebrew, and the Latin translated from these languages. He wanted to saddle Jerome with the same absurdities of which he was guilty. He derived *dogma* from *doceo*, as if a word in an older language could have been derived from a younger; but, then, he thought *dogma* to be a Latin word. He derived the Hebrew word *Amen* from the Greek. Both Hugutio and Papias derived *parasceue* from the Latin *paro* and *coena* = *preparatio coenae*. Brito did not approve of this etymology, but he was no better ; for he explained the word *Deus* as *dans aeternam vitam suis*. He said that θεός meant fear. Hugutio and Papias said the same ; and, Bacon regrets to say, Isidore likewise. These people were all Latins, and therefore ought either to have adduced their authorities or given the *rationale* of their derivations.

Bacon himself assented to other explanations of the word θεός. Either it was derived from θέω, 'to run' or 'to go round,' because God comprised and protected the universe; or from αἴθειν, 'to burn,' because God was a fire, and consumed all wickedness (*aut dicitur ab 'ethin' quod est ardere; Deus enim est ignis consumens malitiam*); or from θεᾶσθαι, 'to look,' because God considered and perfected all things before they were created. He says that these etymologies were correct and trustworthy, because they emanated from Johannes of Damascus, himself a Greek, and who was therefore able to interpret Greek words from the Greek.[1]

[1] Bacon had not heard of the explanation given in Plato's *Cratylos*, 397 D, from θέω, because God always moves, and was first recognized, in the sun, moon, earth, stars, and heaven ; nor that in Herodotus ii. 52 ὅτι κόσμῳ θέντες τὰ πάντα πράγματα καὶ πάσας νομὰς εἶχον.

Brito, *indignissimus auctoritate*, derived the Hebrew word *Gehenna* from *ge, terra*, and *ennos, quod est profundum*, an error shared by Hugutio. They both, with other *grammaticellae idiotae*, imagined the Hebrew word *arrabon* (Genesis xxxviii. 17) to be *arra bona* (*ut res quae datur pro coniugio, vel re bona, non pro mala*). Other authors of Greek dictionaries also included this word, as if it were Greek. Hugutio and others showed what jackasses they were (*et in hoc ostendunt se esse asinos*) by averring that the purely Latin word *coelum* was *casa helios*, and Brito gave an alternative derivation of *tus, turis*, from θεός.[1] Bacon relates that Johannes de Garlandia had told him that he had blamed our trio for spelling the word *orichalcum : auricalcum*, and deriving it fancifully from *aurum* and *calcum*. He further takes these authors to task for their blunders in spelling, scansion, and etymology, and adds to them a fourth culprit, Alexander Neckham, whom Brito quoted as an authority because he was his equal in making mistakes.[2]

It cannot be denied that Bacon himself occasionally erred in the same way. Thus, in the *Opus Minus*,[3] when describing Origenes' sixfold edition of the Bible, called *Hexapla*, he took this word to be a compound of *'hex' simul ordine conscripta, et 'aplum' idem quod simul*. Later, he must have become aware that *apla* does not mean *simul*, and we find in the Cambridge fragment of his Greek Grammar :[4] *'hex' enim Graece idem est quod sex Latine, et 'aplum' idem quod simplex*, 'six translations in one', and not 'six versions simultaneously exhibited'. But he adheres to the erroneous derivation of the word. He gives the genitive of the word βωξ as βωκτος after the analogy of νυξ, νυκτος, instead of βωκός.[5] The false quantity in the

[1] Bacon then quotes Servius for the derivation of *tus* from *tundere*.
[2] *Comp. Stud. Phil.*, vii. 446–64, and *passim* in his other works.
[3] p. 337 (Brewer).
[4] *Greek Grammar*, pp. 191, 192.
[5] Ibid., p. 145.

word *mathesis* (*et ab hoc nomine mathesis media correpta*) he corrected himself.[1] But such instances are extremely rare, and his corrections of the errors of his predecessors display his thorough acquaintance with Greek forms.

It is not only this intimate knowledge of the language, but also his keen critical powers that are proved by his inexorable condemnation of most of the existing translations. It would be superfluous to multiply examples; a few remarks will suffice. His horror of translations is particularly pronounced in reference to Aristotle, and he dwells upon one passage, which touches upon an important point of mediaeval controversy. He says that most of the commentators of Aristotle's *De Anima* (iii. 5) were under the impression that he meant to convey that the *intellectus agens* and the *intellectus possibilis* were both of them parts of the soul. This, he says, was an error; what Aristotle taught was that the *intellectus agens* came from without, and was not a part of the soul. The *intellectus agens* was, in the first place, God; and in the second place, the angels. God's relation to the soul could be compared to that of the sun to the eye, and that of His angels to the stars. It was a mistake of *omnes moderni* to assume that the *intellectus agens* was a part of the soul; but those who were better informed did not share the error, such as the venerable Bishop of Paris, William of Auvergne, and Robert Grosseteste, and Adam Marsh; and when some presumptuous Franciscans asked the latter what the meaning was of *intellectus agens*, he answered that it was Elijah's raven. Bacon sets forth that the fault of these *moderni* lay in a misinterpretation of the translation of Aristotle's words. From the phrase *quoniam autem in omni natura est 'aliquid quod agat, et aliquid quod patiatur', ita erit in anima*, they concluded that the *agens* and the *patiens* were both in the soul, and that they formed parts of it. But if they had considered the whole of

[1] *Opus Majus*, I. iv. 239 n. 1 (Bridges).

Aristotle's words in their context their tenor would have shown them the real meaning.[1]

Having referred to a mistranslation in regard to the surfaces of plane and solid figures, he proceeds to point out a ridiculous mistake about the recurrence of a lunar rainbow. The words *διόπερ ἐν ἔτεσιν ὑπὲρ τὰ πεντήκοντα δὶς ἐνετύχομεν μόνον* (*Meteor.* iii. 2) were translated so as to convey the meaning that a lunar rainbow could only occur twice in fifty years, whereas it is clear that Aristotle merely said that for upwards of fifty years the phenomenon had only been observed twice.[2] It is unnecessary to give more examples of mistranslations from the Greek commented on by Bacon.[3]

Of the Grammars of the four learned languages which it was Bacon's intention to write, we possess only a tolerably complete specimen of his Greek Grammar. This may be due to the circumstance that he wrote it first 'because it was easier, and more in accordance with Latin',[4] and could not at a later time give full effect to his design. Or the reason may be that the fatality attaching to books played havoc with the others, and caused them to disappear. He desired his Greek Grammar to be useful to the Latins; a comparison of Greek and Latin grammar was therefore indispensable; and the grammar of all languages was the same *in substance*, the divergences being merely *accidental*. Besides, Latin grammar was modelled after that of Greek.[5]

It is a characteristic peculiar to Bacon that he frequently

[1] *Opus Tertium*, xxiii. 74–6 (Brewer); *Opus Majus*, i. ii. 38 ff. (Bridges). The passage in *De Anima* which Bacon refers to runs: *ἐπεὶ δ' ὥσπερ ἐν ἁπάσῃ τῇ φύσει ἐστί τι τὸ μὲν ὕλη ἑκάστῳ γένει (τοῦτο δ' ὃ πάντα δυνάμει ἐκεῖνα), ἕτερον δὲ τὸ αἴτιον καὶ ποιητικὸν τῷ ποιεῖν πάντα, οἷον ἡ τέχνη πρὸς τὴν ὕλην πέπονθεν, ἀνάγκη καὶ ἐν τῇ ψυχῇ ὑπάρχειν ταύτας τὰς διαφοράς.*

[2] *Opus Tertium*, xxiii. 77 (Brewer); *Opus Majus*, i. iv. 212 (Bridges). A lunar rainbow was observed in Huntingdonshire on the 8th of January of this year.

[3] p. 124 (Brewer).

[4] *Comp. Stud. Phil.*, ix. 495 (Brewer); *Greek Grammar*, p. 3.

[5] *Greek Grammar*, p. 27.

repeats in one work, sometimes in an amplified, sometimes in an abbreviated form, and at other times even *verbatim*, that which he has dealt with elsewhere. This is particularly the case with Greek grammar. He deals with the subject in the *Opus Tertium*;[1] a fuller treatment of the whole subject is preserved in part in the *Compendium Studii Philosophiae*,[2] and a few brief remarks occur in the third part of the *Opus Majus*. The most elaborate treatise we possess is his Greek Grammar, a great portion of which is preserved in an Oxford manuscript, while a small fragment has been discovered in the University Library at Cambridge. Thus a chapter on certain long and short vowels, intended to correct some vulgar errors, is found in exactly the same form in the Greek Grammar[3] and in the *Compendium Studii Philosophiae*.[4] Another section in the Greek Grammar, dealing with the same matter, is nothing but an amplification of the sixty-third chapter of the *Opus Tertium*. Some points of orthography and scansion are dealt with in the *Compendium*[5] and reproduced in the Greek Grammar,[6] as is also another lengthy discussion on a similar topic. The lacuna in the Oxford manuscript at the end of Part II contained probably rules on punctuation, and may be filled in from the sixty-second chapter of the *Opus Tertium*. A further number of parallel passages will probably be found when the Toulouse manuscript, of which Samuel Berger has given some extracts, will have been published.[7] For whether some parts of the contents of that work be ascribed to Roger Bacon, or to one of his followers, it is certain that the leading points originated with Bacon.

Such repetitions, such overlapping, are due to his own method of working, to a careless intercourse with friends,

[1] lx. 236–8 (Brewer).
[2] vii. 451–519 (Brewer).
[3] pp. 98 ff.
[4] pp. 461–4 (Brewer).
[5] pp. 454–9 (Brewer).
[6] pp. 101–4.
[7] Samuel Berger, *Quam notitiam linguae Hebraicae habuerint Christiani medii aevi in Gallia*, Paris, 1893.

and to frauds of unscrupulous copyists.[1] He says that many copyists were required, and many proofs had to be prepared, before the final copy could be completed in a finished form.[2] He was very careful in the revision of the proofs, and it was often only the fourth or fifth that met with his final approval. But some of the copyists were not trustworthy, and occasionally kept the copies, or gave them away to strangers.[3] Before delivering his works to the professional copyists, he was in the habit of composing several drafts of what he intended to publish ; they were frequently disconnected jottings, written for the use of pupils, or at the request of friends. Not attaching much importance to them, he neglected them and did not retain them. But worst of all was the treachery of fraudulent copyists.[4]

In the case of Bacon the further distinction must be made between cursory treatises on the subjects that came under his consideration and their exhaustive esoteric treatment that was to form his *Scriptum Principale*. His intention was to supply both classes of writings, and a repetition of the same matter must needs follow.

The Greek Grammar preserved in Corpus Christi College, Oxford, and published in 1902, is in the main a treatise on the comparative grammar of the Greek and Latin languages.[5] Youths, when taught Latin, are first introduced to the elements of writing, reading, and construing easy sentences ; the same method should be followed in Greek. Bacon therefore started with the Greek alphabet, classifying the letters, and giving their shapes, their names, and their numerical values. We must be rather doubtful as to the share the copyists bear in the shaping of the letters. They

[1] *Greek Grammar*, Introduction, p. xxxvi f.

[2] *Opus Tertium*, xvi. 57 (Brewer).

[3] Ibid., ii. 13 (Brewer).

[4] F. A. Gasquet, ' An Unpublished Fragment of a Work by Roger Bacon,' in the *English Historical Review*, xii. (1897) 500, 501.

[5] Brewer, *Opera Inedita*, Introduction, p. lxiv.

differ in form from those given in the manuscripts of the *Opus Majus*[1] and in the Cambridge fragment.[2] It is of interest to compare them with the characters exhibited in his specimen of Greek palaeography, at the end of the *Compendium Studii Philosophiae*, 'the earliest in all probability extant in Western Christendom,' and 'an instance of the minute accuracy with which he prosecuted these philological studies, and the care he had taken in examining manuscripts'.[3]

The alphabet is followed by the accents and abbreviations in writing (pp. 9–12); the article, some directions regarding writing and reading, and, as reading lessons, the Greek text of '*Pater noster, Ave Maria, Credo, Magnificat, Nunc dimittis, et Benedictus, quae sunt fundamenta fidei*', with transliteration and translation (pp. 12–24). Then follow the letters of the alphabet and their numerical values. The names given to the numerals are, roughly, the same as in modern Greek: e.g. *ena, dio, tria, tessara*, &c.; *icossi, trianda, salanda, pindinda*, &c. (pp. 24, 25). Here Bacon takes the opportunity of complaining of the ignorance of bishops of even the letters of the Greek alphabet, which tends to interfere with a proper performance of an important rite of the Church.[4] It is the duty of the bishop, when consecrating a church, to write with his pastoral staff the letters of the Greek alphabet in small heaps of sand or ashes. But, in their ignorance, they perverted the shape of the letters, with which, besides, they jumbled up the numerals.[5]

[1] For those in the Vatican MS., see frontispiece to *Opus Majus*, vol. iii, ed. Bridges; and those in the Cottonian MS., S. A. Hirsch, *A Book of Essays*, p. 65.

[2] *Greek Grammar*, pp. 184, 185.

[3] Brewer, *Opera Inedita*, p. lxiii.

[4] Bacon is much concerned about this. He vents his dissatisfaction three times in this Grammar (pp. 25, 81, 83), and alludes to this, and the errors arising therefrom *quod esse non potest sine injuria sacramenti*, in the *Opus Majus*, I. iii. 94 (Bridges).

[5] *Greek Grammar*, Introduction, p. lxxiii.

Before proceeding with the rules of accidence, Bacon makes some remarks on idioms, on the necessity of comparing Greek and Latin grammar, on distinctions in reference to the ' voice ', and on the difference between *elementum* and *litera*.

An idiom is the distinct way in which a race of men make use of a language, according to their customs (*Idioma est proprietas linguae determinata qua una gens utitur juxta suam consuetudinem*), another race using the same language in a different way. Each language has as many idioms as there are races that use it. All languages spoken between Apulia and Spain are *in substance* Latin, and diversified only as idioms.[1] Chaldaean and Hebrew are idioms of the same language, in the same way as Picardian, Norman, Burgundian, Parisian, and French are idioms of the common language, French.[2] It is the same with the Greeks ; they had one language in substance, but various ways of using it. Of these, five idioms were especially famous: Attic, Aeolic, Doric, Ionic, and the idiom in use among the Boeotians. It was of the utmost importance to know this, because of its utility to the Latins. For, after all, Latin grammar was based upon that of Greek, and a comparison of Greek and Latin grammar is imperative for the understanding both of Greek and of Latin grammar ; *and this consideration was the chief motive for writing the present treatise* (p. 27).

In regard to the division of words, Bacon rejects some of Priscian's definitions and prefers those of Boethius, who was *majoris auctoritatis et in linguis et in scientiis.* A word (*vox*) is *articulate* when it can be written down in letters, whether it convey a meaning or not. It is then a λέξις. A letter, in writing and shape, is the smallest part of an articulate word ; but its sound is an *element.* The sign *a*, when put down in ink, or by means of the style, is a *letter*,

[1] *Opus Tertium*, xxv. 88 (Brewer).

[2] Cf. *Comp. Stud. Phil.*, vi. 438. Cf. *Opus Majus*, I. iii. 66 (Bridges).

but the sound with which we express that letter by the voice is an *element* (pp. 28, 29). Of course we must go back for such distinctions of Bacon's to the grammatical disquisitions of the Stoics. After this Bacon deals in detail with both Latin and Greek letters, with the classification of vowels and consonants, with spelling and similar matters (pp. 29–56).

The next chapter is devoted to a critical examination of a treatise on Greek grammar, which professes to be a translation of a work by Aristotle. Bacon proves that it could not have been written either by Aristotle or by any Greek; it was nothing but a compilation by some Latin author out of his own head. He investigates the order of sciences, in order to arrive at grammar. But grammar came first in the curriculum of instruction; it was therefore impossible for a pupil when learning grammar to understand the properties of other branches of learning which are taught at a later stage, and only a fool would begin his instruction in grammar with a division of other sciences. Everything set forth by that author, Bacon avers, was either false or futile or absurd; and this could be easily gathered from his (Bacon's) treatise on Metaphysics, and some other of his dissertations on the division of sciences. He would omit pointing out the errors the author committed in some of his high-sounding remarks on the effects of the celestial bodies on sound and voice. They had been refuted elsewhere, and, moreover, did not belong to grammar in the narrower sense of the word.[1]

In a large section of his Grammar (pp. 59–95) Bacon exposes numbers of errors in writing and speaking certain Greek words, particularly such as have a *y*, although other words are also considered. The passage also deals with computation by means of Greek letters, and gives ample rules about the diphthongs. In his remarks about words

[1] On an apparent contradiction between this passage and Bacon's observations in *Opus Tertium*, xxvi. 97, see *Greek Grammar*, Introduction, pp. xxviii–xxix.

with *y* he follows an alphabetical order, but in regard to other words he states that he would not continue alphabetically, but put down the words as they occurred to him, as he intended to compose an alphabetical vocabulary of all Greek words that were in use with the Latin scholars (p. 68).

We cannot say whether he completed it, but it is certain that he commenced it, for the grammatical treatise inserted in the *Compendium Studii Philosophiae* contains an alphabetical list of Greek words in common use with the Latins, another list of ecclesiastical terms, and a number of grammatical, logical, mathematical, and similar terms, without alphabetical order.[1]

A lexicon in the possession of the College of Arms in London (Arundel, ix) was thought to be the vocabulary in question.[2] But Dr. M. R. James, in a description and analysis of this manuscript, decides against the assumption.[3] Dr. James is of opinion that there was no evidence to show that Roger Bacon was concerned with this lexicon ; nor did the lexicon show any traces of borrowing from his works, and more especially his Greek Grammar. Dr. James supposes the author, or rather the compiler, to have been a member of Robert Grosseteste's circle ; not Grosseteste himself, but a younger contemporary.

Another large portion of the Greek Grammar is taken up by Bacon's treatment of accentuation and prosody (pp. 95–144), and no wonder![4] The subject was of particular interest to him. Besides many other authorities he particularly refers to Augustine, who said that the rules concerning length

[1] *Comp. Stud. Phil.*, vi. 441 ff. (Brewer).

[2] *Greek Grammar*, Introduction, p. xxxvi.

[3] 'A Graeco-Latin Lexicon of the Thirteenth Century,' in the *Mélanges offerts à M. Émile Chatelain . . . par ses élèves et ses amis*, Paris, 1910, pp. 396 ff.

[4] The subject is also dealt with at length in the *Opus Tertium*, lx–lxiv. 234–8, and *Comp. Stud. Phil.*, vii. 461–4. Cf. *Opus Majus*, I. iii. 90 (Bridges).

and brevity of vowels belonged rather to the theory of music than to grammar. The musician provided the art, the grammarian was the mechanic.[1] Not only song, but also metre, rhythm, and accentuation were properties of the human voice. Consequently length and brevity of the vowels, and everything appertaining to proper pronunciation, were parts of the science of music.[2] But, Bacon complains, it would be much easier to impart to the people a sufficient knowledge of *Perspective*, although it be one of the important disciplines of which they knew nothing, than to teach them this particular branch of music, although everybody learned the much slighted science of grammar from his youth.[3]

Bacon follows up some definitions and rules with a list of errors commonly committed in metre in which Brito, Papias, and Hugutio come in for their customary share of vituperation. He corrects erroneous notions on the quantities of a number of words in use among the Latins, on quantities of vowels when followed by consonants, and on aspiration and accentuation.

Of the third part, which follows next, the first and second *distinctiones* and a portion of the third are missing in the manuscript. They must have contained the rules about the declension of nouns. What we possess of it is a continuation of the rules on the *genitive*. He mentions the system of declension, which is that of the κανόνες εἰσαγωγικοί of Theodosius, i.e. 35 masculine declensions, 12 feminine, and 9 neuter. He does not, however, quote Theodosius by name, but only says that the system is in use among the *Graeci moderni*. He himself prefers a simpler system of three declensions. An account of the *synaeresis* follows.[4]

[1] *Opus Tertium*, lix. 231 (Brewer).
[2] *Opus Majus*, I. iv. 237 (Bridges); *Greek Grammar*, p. 96.
[3] *Opus Tertium*, lx. 234 (Brewer).
[4] Which is out of place here. See *Greek Grammar*, p. 147, n. 2.

Compound nouns, nine classes of derivative nouns, pronouns, and the verb are discussed at length (pp. 158–82).

In reference to the verb, Bacon assumes, after Priscian, thirteen conjugations, which he describes *seriatim*, and deals with the voices, moods, and tenses. He modifies his first intention of giving paradigms of all the classes of verbs. This, he says, was undesirable, first, on account of their number, and, secondly, because of the difficulty of understanding them; that this grammar was only elementary, and no beginner would be able to master them all. He refers students to his larger treatise, if they should want more information. The present one was written to serve the requirements of the Latins, so as to enable them to understand any Latin text, the expositions of the saints, the grammarians, the poets, and the other sages; and such students did not want to study all conjugations. He would therefore give only one conjugation in Greek letters, and another in Latin characters. He gives the forms of τύπτω, following one of those manuals in which the rules laid down by Dionysius Thrax and his immediate followers were rendered in the form of a catechism (ἐρωτήματα). He calls its author simply *Graecus*.[1] No more has been preserved in the manuscript.

It is unnecessary to give a description of the Cambridge fragment of Bacon's Greek Grammar. It is evidently a draft of some passages occurring in the third part of the *Opus Majus*, or of his Greek Grammar. There is, however, one point of interest. In the interlineary reading lessons in the Oxford Grammar, the Greek text forms the lowest line, the transliteration in Latin characters the middle line, and the Latin translation the first line. Whenever the article

[1] *Greek Grammar*, p. 173: *Sicut igitur Graecus ante formationem coniugationis secundum hoc verbum, quaerit de hoc vocabulo, cutus sit partis orationis, et cuius modi, et cuius significationis*, &c. . . . *Quaerit igitur Graecus*: τύπτω, ποίου μέρους λόγου ἐστί; ῥήματος· ποίας ἐγκλίσεως; ὁριστικῆς, &c., winding up with the usual form: κανονίζεται. Cf. *Greek Grammar*, Introduction, pp. lxii ff.

occurs in the Greek text it is transliterated in the middle line, but in the first line it is only indicated by a blank space.[1] But in the Cambridge fragment the Greek article is indicated by the syllable *ar* = *articulus*, e. g. *In nomine ar Patris, et ar Filii*, &c. It is noteworthy that the same method is followed in the Toulouse manuscript ;[2] and in the literal translation of the Hebrew Bible, a work of the second half of the thirteenth century, portions of which are extant in Oxford and Cambridge, this syllable is used not only to indicate the article but also the particle *eth* ; for instance, *Creavit Deus* ar *celum et* ar ar *terram*.

It should also be observed that Bacon's pronunciation of Latin was that common on the Continent. Both his transliterations of Greek and of Hebrew show this. On rendering the Latin equivalents of the Hebrew vowels, he says that they have the sounds *quinque vocalium nostrarum a, e, i, o, u*, implying the sounds these letters have abroad.[3]

This leads to the question of Bacon's pronunciation of Greek. It has already been observed that the names he gives of the numerals are, on the whole, those of the Greeks of his day. The same is the case with his pronunciation of Greek. Two centuries after Bacon, Johann Reuchlin, one of the representatives of the more successful renaissance of letters, introduced the style of pronouncing Greek which has since received the name of *Itacism*, and which was commonly called the Reuchlinian pronunciation, in distinction from the *Etacism*, introduced by Erasmus. Both modes of pronunciation were known to Bacon, and he gives the preference to the former, in spite of the tradition of the Latins.[4]

[1] *Greek Grammar*, p. 14 : *Secundum tamen quod articuli non construuntur hic sicut reliquae dictiones, quoniam in Latino non sunt, et ideo Latinis literis tantum scribuntur in secunda linea, sed in prima nihil eis respondet.* [2] Samuel Berger, *ut supra*.

[3] S. A. Hirsch, *A Book of Essays*, pp. 61, 62.

[4] *Greek Grammar*, pp. 31, 32, Introduction, p. xx ; Bridges, *Introduction to the Opus Majus*, p. 1, n. 1.

Bacon's indebtedness to his Greek acquaintances should not be overrated. He owed them much, but he owed much more, in the first place, to the analytical powers of his vast intellect, and, in the second place, to his study of books on grammar.

The former enabled him to perceive the formation and construction of words and sentences when endeavouring by their means to arrive at the true meaning of the works he read. Hence his trenchant criticisms of such mistaken interpretations as might have been avoided if an adequate knowledge of the language had guided the reader or translator. His scrutiny of such Greek works as were accessible to him was carried on with conscientious care, both regarding the letter and the spirit. He was aware how limited a portion of Greek literature was at his disposal; and he never ceased to appeal for the search for and the acquisition of new books. He seems to have had no copy of Homer in the original; many other works he knew only from translations; but he had an intimate knowledge of the few Greek books that were within his reach, in particular some of the authentic and a few of the spurious works of Aristotle. His Latin reading had a much wider range.[1] Hence it is that in his Grammar he demonstrates his observations on Greek orthography and prosody by quotations from Latin and not from Greek authors.[2]

Bacon gives a list of the principal authorities on grammar consulted by him, and of the authors whose productions he refers to as standard works.[3] He names Bede, Priscian, Donatus, Servius, Lucan, Juvenal, Statius, Horace, Persius,

[1] Sir J. E. Sandys, *ut supra*.

[2] A verse of Callimachus, quoted by Bacon from Priscian, led to a curious misunderstanding (*τὼς μὲν ὁ Μνησάρχειος ἔφη ξένος, ὧδε, συναινῶ*) . . . *Callimachus poeta Graecus, Omnes, quod est nomen proprium viri in Graeco, breviavit, sicut docet Priscianus. Greek Grammar*, p. 40; cf. p. 95, and Introduction, p. lxxiv.

[3] *Greek Grammar*, p. 37.

Juvencus, Arator, Prudentius, Paulinus, Prosper, Sedulius, Isidore, and Plinius. This list is not exhaustive, but he cites these ' as ancient and reliable authorities, who had a thorough knowledge of Greek grammar, and, consequently, of Latin grammar '. But he refuses to acknowledge Hugutio, Papias, and Brito as authorities. Priscian's name appears almost on every page of his Grammar, but he does not blindly follow him. He declares him to be more of a compiler than an author, saying that he reproduced the opinions of others, from which he selected what he deemed to be correct, but that he sometimes, though rarely, made mistakes, and should not be followed in every case.[1] Servius, whom Priscian frequently cited, was a greater authority; so was Boethius; and whenever the latter differed from Priscian, his view should be adopted.[2] But Bede's authority surpassed all of them. He was most learned in languages and grammar.[3] Bacon thought him to have been older than Priscian. Neither among the ' Latin ' poets nor among grammarians was there anybody greater than he ; he was a much greater scholar than Priscian, both in theological and secular subjects.[4]

Bacon also made use of other grammatical works, which he does not quote by the names of their authors, but simply alludes to as *Graeci auctores in grammatica eorum*. But whilst citing them, he deems it necessary, at the same time, to explain Priscian's rules, so as to save misunderstandings.[5] Several of such manuals must have been included in those which Grosseteste had caused to be imported from Greece.[6] The knowledge of some of these grammarians must have been rather feeble ; for, misled by the similarity of the

[1] *Opus Tertium*, lxi. 245 ; *Greek Grammar*, p. 131.
[2] *Greek Grammar*, pp. 28, 29. Cf. *Opus Tertium*, x. 33 ; *Opus Majus*, I. iii. 67 (Bridges).
[3] *Opus Minus*, p. 332 (Brewer).
[4] *Greek Grammar*, p. 41.
[5] Ibid., pp. 165, 169.
[6] *Opus Tertium*, xxv. 91 (Brewer).

shape of some letters, they turned the *aorist* into *loriston*, and ὁ αὐτός into ολιτος.[1]

Some of the manuals that were used by Bacon undoubtedly followed the traditions of the Byzantine school. There are some points of likeness between his Grammar and those of Constantine Lascaris and Chrysoloras; but in other points they differ. Professor Heiberg[2] urges that in the reading lessons the *Symbolum* particularly betrayed the Byzantine origin, because it tallies almost verbally with Lascaris, and Bacon reproduced even from his source the phrase ἐκ τοῦ πατρὸς ἐκπορευόμενον, without adding, as Lascaris did, the words καὶ τοῦ υἱοῦ, according to the Latin dogma. But there are also important discrepancies; as stands to reason, considering Bacon's critical scrutiny of his predecessors; and, besides, he had probably access to some of the more ancient works upon which the later systems of grammar were based. We have already seen that Bacon rejected the κανόνες εἰσαγωγικοί of Theodosius (*c.* the end of the fourth century), Lascaris and Chrysoloras having other numbers.[3] It is improbable that Bacon had any direct knowledge of Theodosius; if he had, he would have quoted him instead of the *moderni Graeci*. He seems, however, to have had some knowledge of Herodian (*c.* 160). He quotes him twice in his Grammar (pp. 46, 55), and the latter passage displays a close acquaintance with at least a part of his works (. . . *sed necessaria est ratio scribendi quam hic volo inserere secundum quod in grammatica Graeca Herodiani diligenter interscripsi*).

The paradigms Bacon uses were, for the most part, the same which were in use from the earliest times. The verb

[1] *Greek Grammar*, pp. 164, 170.

[2] *Byzantinische Zeitschrift*, ix. 479; xii. 343. Cf. *Greek Grammar*, Introduction, pp. lx, lxi.

[3] These canons were also followed in the Graeco-Latin Lexicon; Dr. James, *ut supra*, p. 407.

τύπτω was used probably since the time of Dionysius Thrax (*c.* 100 B.C.) ; the paradigms for *verba contracta* and verbs in -μι, and at least some of the examples for the declensions, have remained the same ever since Theodosius, and the subjunctive is always given with ἐάν. The rare word βῶξ was also a standard example ; it was used by Herodian and Theodosius, and commented upon by Choeroboscus.[1] The latter was also quoted in the afore-mentioned lexicon, whose author either had access to a copy of that author, or, as Dr. James presumes in reference to his citations from Pausanius the Atticist, derived his knowledge from some work in which Choeroboscus had been quoted. It has already been mentioned that Bacon had before him a grammatical catechism, similar to that of the Wolfenbüttel *Erotemata*. Dr. James informs us that a *liber de erotematibus* is also quoted in the Graeco-Latin Lexicon. It is therefore evident that such catechisms were known to the scholars that belonged to Grosseteste's circle.

From the introductory sentence in Bacon's Greek Grammar, it appears that he harboured the idea of including a Chaldaean Grammar in his *Opus Principale*, but there is no sign that it was written. He had a thorough knowledge of Biblical Aramaic, and knew the passages in the Bible written in that language. When reading the—for his age—modern expositions of more ancient commentators, he kept a critical eye on such passages as referred to Aramaic. In this way he was able to correct a gross misconception. These expositors had read in Jerome's prologue to the Book of Daniel that one ' pericope ' of Jeremiah was written in Aramaic.

' All theologians understood that " pericope " to mean the Book of Lamentations ; that word bearing the meaning of " small part ", and the Book of Lamentations being the smaller of Jeremiah's books. These writers have themselves to thank for making such blunders ; they will follow the

[1] See *Greek Grammar*, Introduction, p. lxii.

vile and imaginary authority of Brito. Every Hebraist knew that the Book of Lamentations was written in Hebrew. Jerome's remark applied to one verse in the tenth chapter of Jeremiah (verse 11).' [1]

Bacon reproduces the verse in the original Aramaic, with a Hebrew translation, and supplies both with an interlineary transliteration and a Latin translation.[2] He observes that Chaldaean and Hebrew are merely different dialects of the same language; where the Hebrew says *Elohim* for *God*, *lo* for *no*, and *Samayim* for *heaven*, the Chaldaean says *Elaha* for *God*, *la* for *no*, and *Samaya* for *heaven*.[3]

There are more data by which to gauge Bacon's attainments in Hebrew. We cannot tell whether he realized his wish of writing a Hebrew Grammar, but we know that he attempted it. The fragment discovered by the Reverend E. Nolan in the University Library at Cambridge is undoubtedly his work.[4] The incentives to enter zealously upon the study of Hebrew were powerful for a man of Bacon's frame of mind. He was actuated at the same time by scientific, religious, and mystical motives. Science directed him to Greek and Arabic, religion led him, moreover, to Hebrew.

He was convinced that Hebrew was the language in which God had revealed to mankind His will and His wisdom.

[1] *Opus Tertium*, vi. 438 (Brewer). The passage occurs also in the *Opus Majus*, iii. That passage was omitted by Bridges in his first volume, but inserted in the supplementary volume, pp. 91, 92, to which a reduced facsimile from the Vatican MS. forms the frontispiece. That manuscript gives the words correctly except for the omission of the אלה. The Cottonian MS. gives them in an irregular order; a reduced facsimile appeared in S. A. Hirsch's *Book of Essays*, p. 65.

[2] The passage appears in the Toulouse MS. See Berger, *ut supra*, p. 39.

[3] '. . . la *pro* non, *et* Samaya *pro* caelo.' Thus it ought to read in *Comp. Stud. Phil.* vi. 439 (Brewer). Cf. *Opus Majus*, I. iii. 72 (Bridges).

[4] Printed after the *Greek Grammar*, pp. 198–203.

'God has revealed philosophy to His saints, to whom He also gave the Law. He did so because philosophy was indispensable for the understanding, the promulgation, the adoption, and the defence of the Law, and in many other ways also. It was for this reason that it was delivered, complete in all its details, in the Hebrew language.'[1] 'The whole wisdom of philosophy was given by God, who, after the creation of the world, delivered it to the patriarchs and the prophets. . . . They possessed wisdom in its entirety before the infidel sages obtained it, such as the famous poets, or the Sibyls, or the seven wise men, or the philosophers after them. . . . All their information about heavenly bodies, about the secrets of nature and the superior sciences, about sects, God, Christianity, the beauties of virtue, and the rectitude of the Laws, of eternal reward and punishment, resurrection of the dead, and all other questions, were derived from God's saints. The philosophers did not find them out; God had revealed them to His saints. . . . Adam, Solomon, and the others testified to the truth of the faith, not only in holy writ, but also in books of philosophy, long before there were any philosophers so-called.'[2] 'Philosophy was developed by Noah and his sons, particularly by Shem; and all philosophers and great poets lived after them, and after Abraham. . . . Zoroaster invented the magic arts; he was the son of Ham, the son of Noah. Io, who was afterwards called Isis, the daughter of Inachus, the first king of the Argives, a contemporary of Jacob and Esau, taught the Egyptians to write. Minerva, the inventress of many things, lived about the same time. Under Phoroneus, Inachus's son, moral philosophy was first introduced among the heathens. Prometheus was the first teacher of philosophy, and his brother Atlas the first great astrologer. But he was preceded by the great astronomers, the sons of Noah, and by Abraham.'[3]

In this way, Bacon continues tracing the chain of transmission of philosophy, based upon the writings of his predecessors, mixing up biblical and mythological personages, and treating them after the method first introduced by Euhemerus of Crete.

[1] *Opus Tertium*, x. 32 (Brewer).

[2] Ibid., xxiv. 79. Cf. ibid., viii. 24; *Comp. Stud. Theol.*, 33 (Rashdall).

[3] *Opus Majus* (Bridges), i. 46.

All this wisdom, Bacon was fully persuaded, emanated primarily from the wisdom that was revealed by God in Hebrew. Besides, King Solomon, who was the second promulgator of philosophy, was possessed of great wealth, and was thus enabled to complete his philosophical work in Hebrew. No wonder, therefore, that Bacon was eager to gain a more intimate knowledge of the divine tongue.

There was another aspect of Bacon's religious convictions which turned his mind to Hebrew. It was his disgust at the corruptions that had crept into the text of the Bible, i.e. the Vulgate, which consists of the Latin translation of the Septuagint translation of the Psalms, and of Jerome's translation of all other books. The 'text' was overrun with errors, and worst of all in the Parisian copy. The eradication of errors from that translation was considered tantamount to the purging of 'the text of the Bible'. Even at the present day the term 'Biblical criticism', which denotes quite a different procedure, is sometimes applied to the correction of Jerome's translation. Before Bacon's time there had been no lack of *Correctoria* which attempted to restore the original form of the 'text'. It seems that in Bacon's time these attempts ran riot. He complains that everybody interfered with the text; whenever any one did not understand it, he altered it. Both the correction and the understanding of the text imperatively demanded the study of the original languages.

The mystical element in Bacon's nature also turned him to the study of Greek, and, much more so, to that of Hebrew. important mysteries were concealed in the numerical values of the letters;[1] the spiritual meaning of the text was indissolubly bound up with the literal sense, and both suffered equally if the text was corrupt in most parts and dubious in many others.[2]

[1] *Vide supra*, p. 109.

[2] *Opus Minus*, p. 349.

As Bacon had turned to Greeks for instruction in Greek, so he consulted Jews for information on Hebrew. In both cases he points out the deficiency in grammatical knowledge on the part of most of that class of teachers. His estimate of the amount of knowledge attainable was the same for both languages ; as is also his tripartition of the degrees of proficiency, his estimate of a sufficiency of three days of close application for the acquisition of the lowest degree, provided a manual had first been prepared, and the necessity of earnest study for thirty years, if a mastery of the highest degree were desired.

The extent of Bacon's knowledge of Hebrew may be gauged by those passages in his works in which he alludes to matters Hebrew, and by his fragmentary Hebrew Grammar. The evidence derived from the former source might induce us to form a low estimate of his Hebrew learning, but the question is whether we possess all the data from which to judge.

Two points offer themselves for consideration in this respect, both based on the fair assumption that Bacon was not behind his contemporaries in whatever knowledge of Hebrew they possessed. There was, in the first place, Bacon's elder contemporary, the *homo sapientissimus*, whom he described as a good Hebrew scholar, ' whose difficulties were very great on account of the want of Greek and Hebrew Bibles and dictionaries, which, it is true, existed in England and France, but were not accessible to him.' [1] But if Denifle's assumption be correct,[2] that this *homo sapientissimus* was the author of the *Correctorium Vaticanum*—whether his other assumption, that he was identical with William de la Mare,

[1] Abbot Gasquet's ' Fragment ', in *English Historical Review*, July 1897, p. 516.

[2] Denifle, ' Die Handschriften der Bibel-Correctorien des 13ten Jahrhunderts ', in the *Archiv für die Literatur- und Kirchengeschichte des Mittelalters*, herausgegeben von P. Heinrich Denifle und Franz Ehrle, iv. (1888) 278.

be correct or not [1]—he must have had such books at his disposal at a later date, for the *Correctorium* displays an intimate acquaintance with works of that kind. Its author had read the *Targum* (the old Aramaic translation); he quotes the *Peruš*, the 'Commentary', by which he either meant that of Rashi, or the commentary which existed before him, and was known under the name of *Peruš*. He knew the Maḥberet, Menaḥem ben Saruk's Hebrew lexicon. He had consulted the Hebrew manuscripts of Spain, and distinguished between 'modern' Hebrew texts, 'old' Hebrew manuscripts of France, and 'old' Hebrew manuscripts of Spain.

It is unthinkable that Bacon, enjoying the personal acquaintance of a scholar of such eminence, and bent upon the same pursuits, should not have benefited by the opportunity, and made himself acquainted with some of the sources which the scholar he so much admired had made use of. It was only intercourse with Jews that could have brought such works to the notice of that author, and Bacon made ample use of that same medium of information.

This view is, in the second place, singularly supported by the latter portion of the afore-mentioned Toulouse manuscript. It contains a collection of letters, in which a questioner, or some questioners, ask for information on Hebrew subjects, and are answered by the other correspondent. The questioners did not know much Hebrew, some did not even know the Hebrew letters. It was quite different with the respondent. He not only knew Hebrew, but he also quotes the Rabbis, especially Rashi. Berger does not venture to say that this scholar who was consulted as an oracle was Roger Bacon, although there are many almost *verbatim* parallels in the latter's acknowledged writings. But if not Bacon, it was some one so closely connected with him that he might easily

[1] On William de la Mare, see Mr. Little's *Grey Friars in Oxford*, p. 215 f.

be taken for him. Both Denifle and Berger came to the conclusion that the respondent was the Franciscan friar, William de la Mare, whom they identified at the same time with Bacon's *homo sapientissimus*, and the author of the *Correctorium Vaticanum*. If William de la Mare was the respondent, it is clear that Bacon had been the master who was mainly responsible for the learning displayed in the letters. The concurrence of the responses with many passages in Bacon's works is too obvious to doubt it. And how can we be certain that the learned correspondent was not the master himself?

Roger Bacon deals, in his *Opus Majus* (iv), elaborately with the subject of lunations, and explains that the Jews used the Metonic cycle of 19 years, or 235 lunations, and the mean lunation was therefore 29 days, 12 hours, and $\frac{793}{1080}$ of an hour. He added a Hebrew table, which has not been preserved, and is full of praise for the Jewish way of fixing the calendar. In the Toulouse manuscript it is said that the calendar and the lunations had been more fully investigated by the Jews than by the Greeks or the Arabs. He, the respondent, had had some Hebrew books sent him from Germany by a learned Jew, who knew him only by reputation, and with whom he carried on a regular correspondence in Hebrew. If this was written by Bacon himself, it would corroborate his statement that he was able to write Hebrew. The respondent proceeds to say that these books were composed by Abraham, that they contained much information, and were provided with many tables. They were more useful on astronomical subjects than any which he had seen before. He had long desired to possess such Jewish books, and had written to a certain Jew in Toledo, in Spain, whom he knew, to procure them for him, but in that city no complete copy could be found. Berger conjectures that the book on the new moon was the *Kidduš Haḥodeš*, a treatise on the calendar, forming a portion of one of the larger works

of Maimonides. The Abraham mentioned here must have been Abraham bar Ḥija, the author of *Sefer Ha-'ibbur*.

All this could very well have been written by Roger Bacon, and serve as evidence how hard he tried to obtain books, and how strong his desire was to obtain information from the Jews. It would show at the same time his acquaintance with such Hebrew works as are nowhere mentioned in his known writings. But suppose the correspondent to have been his pupil, the one passage on the calendar sufficiently indicates the source whence he had drawn his information. And it was only from Jewish students of Maimonides' works that this writer could have known of the division of the Pentateuchal injunctions into 'laws', 'testimonies', 'judgements', and 'precepts'. It is further noteworthy that these letters contain the Aramaic verse in Jeremiah, transliterated and translated into Hebrew and Latin in the same way as we find it in the *Opus Majus*. The description of the Hebrew final letters (*men aperta, men clausa*, &c.) is identical with that in the fragment of Bacon's Hebrew Grammar, as are also a few other grammatical points.

But apart from such indirect evidence, Bacon's acknowledged works amply show that he was competent to satisfy his own demands on a third-rank, and even a second-rank Hebrew scholar. Although he has added nothing to the stock of information, and not a single observation of his can perhaps be called original, he yet speaks with authority, and knowledge of the subject, when he explains derivations of words from the Hebrew, or exposes blunders made by some scholars. That he had a good notion of Hebrew grammar is sufficiently proved by his remarks in the third book of the *Opus Majus*, and by the fragment of a Hebrew Grammar discovered in Cambridge.[1]

In the latter Bacon gives the names of the letters of

[1] *Greek Grammar*, pp. 199–208. Cf. Hirsch, *A Book of Essays*, pp. 58 ff.

the Hebrew alphabet and their sounds. He describes the ordinary and final letters in terms which answer to those used by the Jewish grammarians.[1] True to his doctrine that there is only one grammar in *substance*, he tries perforce to find an analogy between Hebrew and Greek in his exposition of genders, cases, numbers, the article, diphthongs, and the preposition.

Accustomed as he was to classical and occidental languages, where each consonant is accompanied by a separate letter, which indicates the sound, he seems not to have had a clear understanding of the system in use in Hebrew. In that language only the consonants are written; the sound is only occasionally indicated by 'vowel letters', but usually by some strokes or points under or above the consonants, except in copies of the Bible designated for ritual use and books written for the learned, where such signs of vocalization are entirely absent. Such lack of understanding would be all the more strange if he really had been the Arabic expert he describes himself. He mentions the signs, and at the same time calls the letters '*aleph, ain, he, heth, iot, vaf*,' vowels, giving the word 'vowel' the same sense as in Latin and Greek: *a, e, i, o, u*. Thus, when the occasion arises, he inserts one of these letters where it is quite inadmissible, e.g. בנאך for בנך; אלאהים for אלהים, Bacon gives a fantastic explanation of the absence of vowel letters in the Bible. The Hebrews, he avers, omitted them because they did not want other nations to read their books, and when some 'wise philosophers who understood Hebrew' tried to translate the holy history, God punished them, as Josephus teaches us.[2]

[1] In the Cottonian MS.: *uverte, close, draite, torte*. In the Vatican MS.: *uverte, clase, dreite, torte*. In the *Opus Minus*, p. 350 (Brewer), and in the Cambridge Grammar, these letters are simply designated by the terms *primum* and *secundum*.

[2] *Antiq.* xii. 2, 14.

He ascribes to such secretiveness the circumstance that Babel is called Šēšak, according to the explanation given by Jerome, who had himself followed the Rabbis. He fully understood the scheme of transposition of the letters of the Hebrew alphabet on which this interpretation rests.[1]

As in Greek, so in his transliteration of Hebrew words Bacon gave the Latin vowels the sounds which they have on the Continent. The Hebrew vowels, he observes, have the sounds *quinque vocalium nostrarum, a, e, i, o, u,* implying the sounds these letters have abroad.

In Hebrew, there are two principal styles of pronunciation : the *Sephardic*, which was in vogue in Spain, Portugal, Italy, and the East, and the *Ashkenazi*, in use in central, north-east, and western Europe. Bacon follows, on the whole, the former mode of reading, which he must have derived partly from Jews, and partly from Jerome's commentaries. Might he not, perhaps, have seen a copy of the *Hexapla*,[2] of which he gives so accurate a description, and been partly guided by the transliteration found there ? He transliterates בָּ, בֶּ, בִּ, בֹּ, בֻּ into *ba, be, bi, bo, bu* ; once only ח and ט are rendered in the Cottonian manuscript *heis* and *teis* ; in all other cases they are described as *cheth* and *teth*, and we always find *bet* and *tav*. Whatever pronunciation the Jews of England may have used before the Expulsion, it is evident that those consulted by Bacon had the *Sephardic* mode of reading.

It has already been noticed that Bacon considered it in the light of a religious duty to utilize Hebrew and Greek towards the establishment and understanding of an authentic text of the Vulgate translation. He sets forth that Jerome

[1] *Greek Grammar*, p. 206 ; *Opus Minus*, pp. 350 ff. The scheme is

א ב ג ד ה ו ז ח ט י כ
ת ש ר ק צ פ ע ס נ מ ל

[2] *Opus Minus*, p. 337 (Brewer) : *Origenes famosissimos libros composuit, in quibus . . . opus interpretis cujuscunque descripsit, ut primo ipsa Hebraica Hebraicis literis poneret, secundo loco per ordinem Graecis literis Hebraica verba describeret*, &c.

referred in his expositions to Hebrew and Greek at almost every word, and was always at pains to demonstrate his exegetical remarks by the languages.[1] Bacon had adopted this principle, and adhered persistently to it. His intimate acquaintance with the text of the Hebrew Bible is especially conspicuous in a passage of the *Opus Majus*,[2] in which he rectifies some of the innumerable errors of the Paris text, particularly in the matter of figures, e.g. that Arpaḥsad lived after the birth of Šelaḥ 303 years, instead of 403 years; or that Re'u lived 35 years, instead of 32 years, &c. The whole passage is, as Mr. Bridges justly remarked, 'one of the many proofs of the care with which Bacon had collated the Septuagint and the Hebrew text.'

Much in advance of his age as Bacon was, he had yet as little idea of modern Bible criticism as he had of modern comparative philology. He urged the necessity of Hebrew for the correct understanding of the Bible, but he did not for a moment admit that it was allowable to alter a word of the Vulgate, even at the instance of a comparison with the original. He could not have approved of Stephen Harding's method of purifying the text. The latter knew no Hebrew, and therefore consulted the Rabbis; and he erased from the Latin text all such passages and verses as were not found in the original. The *Correctorium Parisiense* was the work of Hugo de S^to^ Caro, a man thoroughly familiar with the Hebrew language, who all along refers conscientiously to the Hebrew. The Dominicans continued his labours, in which they also displayed tolerable knowledge of Hebrew. But Bacon did not approve of such methods; to him it was not correcting the text, but corrupting it, and making it incurable; for it was not the question of applying Hebrew or Greek, but of the restoration of Jerome's text.

It was in this spirit that the author of the *Correctorium*

[1] *Opus Minus*, p. 349 (Brewer).
[2] i. 221 (Bridges).

Vaticanum—whether he was or was not the *homo sapientissimus* or William de la Mare—pronounced the warning that 'one must not be unfaithful to the Latin text on the testimony of the Hebrew or the Greek'. He opposed the correctors, especially Hugo de S^to^ Caro, who altered the Latin on the sole authority of the Hebrew, without the support of the manuscripts; and in the same sense he said, 'Beware of attaching yourselves too much to the Jews.'

This principle, not to be influenced by the Hebrew to such a length as to meddle with Jerome's text, closely linked Bacon to the author of that *Correctorium*. In adherence to this principle, Bacon praises and scolds at the same time a certain Andrew (*Andreas quidam*), whom he considers to have sinned in that way.[1] I consider him to be identical with the Englishman Andrew, an Augustinian monk, who lived about 1150; he was a pupil of Hugo de S^to^ Victore, and is said to have written learned commentaries on the Bible and the Apocrypha.[2] Bacon discusses the ambiguity of the Latin translation of Genesis ii. 1, 2. The Latin words may be forced to mean: 'These are the generations of heaven and earth when they were created, on the day when God made heaven and earth. And all the vegetation of the field had not come forth yet,' &c. Or they may mean: 'These are the generations, &c., . . . on the day when God made heaven and earth and the vegetation of the field, before it had come forth on the earth, and all the herbs of the field before they were grown.' Bacon considers the latter meaning to be more in accordance with the Latin, but it would contradict the narrative of the first chapter of Genesis. He says that in the phrase *omne virgultum agri antequam oriretur in terra* the words *omne virgultum* were in the nominative, and in the sentence *omnemque herbam regionis priusquam germinaret* the word *terra* had to be supplied or understood

[1] *Comp. Stud. Phil.*, viii. 482 f.

[2] Hirsch, *A Book of Essays*, pp. 11–15.

as the subject to *germinaret*. Bacon adopts this interpretation, not only for the purpose of harmonizing the two chapters, but also in order to reconcile the Latin translation with the Hebrew text, and adds that the sense would be much clearer if we had the word *herba* in the nominative.

Bacon then mentions ' a certain Andrew ' who had written the word *herba* in the nominative and inserted a negative particle to the verbs *oriretur* and *germinaret* ' quite in accordance with the Hebrew text '. How did Andrew, Bacon complains, dare to make his translation, which is not *nostra translatio*, appear as if it were ours, the authorized Latin text? His was neither a commentary nor a translation; it was nothing but a literal construing of the Hebrew. The worst of it was that many people attributed to Andrew an authority which he did not possess. Nobody since Bede had obtained the sanction of the Church to expound Scripture; and although Andrew was undoubtedly a well-read man, and probably knew Hebrew, yet for all that he enjoyed no authority; he could not be credited, but the Hebrew text must be consulted to see whether he was right or wrong. If he were right, credence was due to the Hebrew, but not to him; if wrong, he involved us in the danger of taking his text for ours. Nevertheless, Bacon proceeds, Andrew had the great merit of inducing us to consult the Hebrew, whenever we meet with some difficulty in our translation. Thus, in our passage, and in many others, but few people would have thought of the true meaning if it had not been for Andrew. We see how Bacon's love for the investigation of the Hebrew original neutralized his orthodoxy to a considerable extent.

In the same way as Bacon exposes misconceptions in reference to Greek, he also corrects false notions on Hebrew words. The seventh chapter of the *Compendium Studii Philosophiae* contains a list of words and names which were considered of Latin or Greek origin, but which were really derivations from the Hebrew. He sometimes exposes

such absurdities in his usual robust style; for instance, as has already been remarked, when Hugutio and Brito and other idiotic grammarmongers explain *arrabon* and *Gehenna* as *arra bona* and *ge ennos*. All these instances exhibit Bacon as a thorough Hebrew scholar. The greater part of them refer to misunderstood passages in the writings of the exegetes, especially those of Jerome.

In one case, however, he discards his usual bitterness and contumely, and is even at pains to palliate the fault; and no wonder! It is this time an error committed by no less a person than Pope Gregory the Great. Bacon held Pope Gregory in great veneration, and fully believed that the latter's works, which were, after his death, in danger of being burned, were saved 'by a beautiful miracle of God'.[1] Pope Gregory had quoted Job xlii. 4 thus: 'And he called the name of one *Dies*, and the second *Casia*, and the third *Cornustibii*.' These are meant to be the renderings of the Hebrew names, *Q'ṣiah*, *Yemima*, and *Keren Happuk* (קציעה, ימימה, קרן הפוך). Gregory thought *Cornustibii* = *Cornus tibii*, a compound of two words denoting musical instruments (trumpet-fife), and observes that

'the translator rightly took care not to insert these names as they are found in the Arabic, but to show their meaning more plainly by translating them into Latin. For who does not know that *Dies* and *Casia* are Latin words! But as to *Cornustibii*—although it is not *cornus* but *cornu*, and the pipe of the singers is called *tibia* and not *tibium*—I suppose he preferred to state the thing as it was without keeping the gender of the word in the Latin, and to preserve the peculiarity of the language from which he translated. Or also, since he formed one compound word out of the two—*cornu* and *tibia*—he was at liberty to put both words, which are translated into Latin by one part of speech, in whatever gender he liked'.

Bacon says[2] that it was clear to any one able to compare

[1] *Opus Majus*, I. i. 19 (Bridges).
[2] *Comp. Stud. Phil.*, vi. 440 (Brewer).

the original Hebrew, that the text used by the Pope was corrupt; that the second part of the compound word was *stibii*, and not *tibii*; that the name was *Cornu stibii*, meaning a horn or receptacle for stibium. Bacon correctly traces the etymology of the name from the Hebrew, and adds that the term used here was the same as 2 Kings ix. 30, where we are told that Jezebel dyed her eyes with stibium. Bacon finds excuses for the Pope; the holy man's time was fully occupied, and he had not the leisure to collate many copies of the Bible to see what the Greek and Hebrew texts offered. Bacon reserves the indignation which he could not vent on the Pope for the 'crowd of modern theologians who disputed about things they did not understand, and persisted in defending Gregory's rendering'.

Bacon fell himself occasionally, though very rarely, into errors of the same description. Thus he warns his readers [1] not to confound Horeb, the mountain of God, with the stone 'Oreb in R'phidim, from which Moses had drawn water; the former name being written with a *Heth*, but not the latter. As a matter of fact, the latter name is also written with a ח (Exod. xvii. 6), and Bacon evidently confused that rock with the rock of 'Oreb, צור עורב of Judges vii. 25.[2]

Bacon nowhere mentions the Hebrew accents by name, the 'tonic accents' as they are called. As in Greek, he refers also to accentuation, aspiration, punctuation, and prosody in regard to Hebrew. He says that the Hebrew text contained many kinds of metre, and complains that the Latin

[1] *Opus Majus*, I. iv. 327 (Bridges).

[2] In the *Compendium Studii Philosophiae*, vii. 445, we read: *Hieremias, Hierico, Hierusalem, Hieronymus et hujusmodi debent aspirari in principio*. This seems, at first sight, to be an error, such as he always censures in others, for how does the name *Hieronymus* come to be included in a list of names derived from the Hebrew? But the sentence is an abbreviated reproduction of *Opus Tertium*, lxi. 247, and is out of place here.

translators lacked that sense for music which was possessed by the patriarchs and the prophets. 'The only way in which theologians could obtain a knowledge of Hebrew metres and rhythms was by recurring to the Hebrew original, and by studying that branch of music.' [1]

But there is evidence to show that Bacon knew the accents. On mentioning Jerome's etymology of the name of Israel, as denoting 'Master with God', and not as others before Jerome had explained it as 'a man who saw God', Bacon enters into the reasons, which prove the latter derivation to be untenable. Since *Is* meant 'man', *Ra* 'seeing', *El* 'God', these commentators thought the patriarch's name to be a compound of these three words. Jerome, Bacon says, rightly objected to this derivation, because the name contained the five letters *Iod, Sin, Resh, Aleph, Lamet,* making up the name ישראל, 'Israel.' The other compound would have to consist of eight letters: *Aleph, Iod, Sin, Resh, Aleph, He, Aleph, Lamet,* forming the word אישראהאל. This would be 'Iserael', a word of four syllables ,whereas the name had only three, because a dot under a letter denoted the vowel *i*, two (horizontal) dots *e*, and a stroke with a dot under it *a*; but the strongest argument was the sense of the word, which is explained in the verse itself. Bacon illustrates this further by reproducing the whole verse in Hebrew. The Cottonian manuscript not only gives the vowel points, but also most of the accents. Now it is well known that the copyists did not much relish copying Greek, much less copying Hebrew, and supplying of their own free will a Hebrew text with accents must have been the last thing any of them would have dreamed of doing. We may therefore safely assume that Bacon himself had added them. He dealt with this point in the *Opus Majus*; and in the *Compendium Studii Philosophiae,* where he repeats the

[1] *Opus Majus,* I. iv. 237 (Bridges); *Opus Tertium,* lxiv. 267 (Brewer); *Hebrew Grammar,* p. 208.

discussion,[1] he modestly declares that a fuller explanation of this difficulty would carry him too far, and he was, at present, neither obliged nor competent to enter into all the niceties of Hebrew grammar connected with the question.

Philology was only one of the many branches of learning that exercised Bacon's mind. Keeping this in view, and considering the scanty supply of books in their original languages which were at his disposal, and the conditions of linguistic proficiency of his time, his achievements must be looked upon as truly wonderful. He proved himself an independent thinker in his treatment of the philosophy of languages, but only within the groove in which the philosophers of his age moved : starting from *a priori* assumptions, and arriving at unverifiable conclusions. He showed himself a keen critic in passing in review the grammatical products which his contemporaries adopted as authorities, and on questions of etymology none of them was his equal.

His attainments, whether in classics or Semitics or comparative philology or the philosophy of languages, do not by a long distance approach the results of modern research and thought. It would be a sad testimonial to the progress of learning if they did ; if six centuries and a half had failed to change the aspect of these disciplines beyond all recognition. It is so with all subjects of knowledge ; given favourable circumstances, no one of them will remain the same, even after the lapse of a comparatively short period. This fact, instead of detracting from Bacon's greatness as a philologist, serves the more to throw his efforts into stronger relief Forty years ago Huxley said that ' our " Mathematick " was one which Newton would have to go to school to learn '. Then, at what shall Isaac Newton's ' mathematick ' be rated, when those who come after us shall be celebrating the septingentenary anniversary of his birth !

[1] *Opus Majus*, I. iii. 82 (Bridges) ; *Comp. Stud. Phil.*, vi. 436 (Brewer).

VI

THE PLACE OF ROGER BACON IN THE HISTORY OF MATHEMATICS

By DAVID EUGENE SMITH

I. Various Types of Genius in the History of Mathematics

When we consider the names that stand out prominently in the history of mathematics, we find that the type of genius having place upon this particular roll of honour is very far from being uniform. Not every man whose name is here recorded was a profound mathematician, for Plato has a merited place only because he laid deep the foundations of the science. Not every one was master of his subject, for Thales ranks high, although his knowledge may have covered less than a half-dozen of the theorems of geometry. Some are there because they were great teachers and inspired their pupils to high achievement, as was the case with Pythagoras at Crotona. Others are known for compilations of the works of their predecessors, as witness Euclid, the author of the *Elements*. One man will be known for pure theory, as was Apollonius of Perga, while another, like Archimedes, will be esteemed chiefly because he put the theory of mathematics into practice. Not every one who holds an honoured place created a new science as Newton did when he stood on the shoulders of giants, or Descartes when he laid aside his work in philosophy to write his little classic on geometry, or the youthful Galois when he first imagined the theory of groups.

It is necessary that we keep this fact in mind when asking ourselves whether Roger Bacon deserves to rank among those who have made the science of mathematics what it is to-day.

Unless we do this we shall lack that judicial attitude of mind which is necessary for a just conclusion. It is this lack which leads some writers to be severe to the point of injustice in their judgement of the Middle Ages, and others to be enthusiastic to the point of illusion,[1] and that might easily lead us to dismiss the name of Bacon as unworthy of serious consideration in the history of this branch of knowledge.

II. The Problem to be Considered

The problem suggested by the title of this paper is not merely to find what Bacon knew of mathematics, and in particular what he may have discovered. It is quite as much to consider the mathematics of his time, the state of the science at Paris where he studied, and at Oxford where he imbibed his first knowledge and where he spent so many years in teaching; to examine the works of his contemporaries and pass judgement upon the contributions which the Golden Era of the Middle Ages made to the renaissance of learning. We must consider the range of Bacon's knowledge, the atmosphere in which he worked, his appreciation of mathematics, and the efforts put forth by him to elevate the science, as well as his own contributions to its advance. It is only by taking such a view of the problem that we shall be in a position to weigh, for mathematics, the justice of the title which the world bestowed upon him, the title which ranks him as 'Doctor Mirabilis' in the domain of science.

III. The Mathematics of Bacon's Time

Whatever may be our judgement as to the puerility of the mathematics of the thirteenth century, it is well agreed that the century itself represents the reawakening of the world after a long period of intellectual torpor. The universal Zeitgeist was showing itself even in the Far East in a remarkable revival of the study of algebra in China; it was in

[1] A characteristic noted by M. Charles in his Life of Bacon.

evidence in India, where Bhaskara's works were beginning, a generation or so after his death, to spread their influence abroad; and its power was felt in even greater measure in every part of intellectual Europe. The Arabs, in their poetic fashion, speak of an orange grove as made up of 'lanterns of light in a dark night', and one may not inappropriately characterize the thirteenth century by this same phrase. It was not a century of great beacon lights, but it was one in which 'lanterns of light' were hung out in all the thoroughfares of the West, promises of the great illumination that was to come to the world three hundred years later.

It is naturally to Italy that we turn for the first lighting of these lanterns of the intellect—to Italy which was still the world's centre of learning. And here we find, in mathematics, the name of Leonardo Fibonacci (*c.* 1175–1250); Leonardo Pisano, the greatest genius in mathematics of all the Middle Ages—his epoch-making *Liber Abbaci*[1] appeared only thirteen years before Bacon was born, and the youthful English monk had already taken his doctor's degree at Paris long before the great Pisan was laid at rest in the Campo Santo beyond the Duomo; Campanus (*c.* 1260), sometime chaplain to Urban IV and later canon of the Sainte Chapelle at Paris, was translating or editing Euclid, and writing on the calendar and the *sphaera*; Guglielmo de Lunis (*c.* 1250) was helping to make known to the Western world the algebra of the East; Bartolomeo da Parma (*c.* 1294) was soon to take up his teaching at Bologna, and to write the *Tractatus de Sphaera*, which was destined to be so popular as a text-book of the subject; and in all the important schools a revival of mathematics was beginning to be apparent.

In France the newly-founded University of Paris was making its influence felt. Alexandre de Villedieu (*c.* 1250) was teaching at the Sorbonne about the time that Bacon was attending lectures. It is he who wrote the *Carmen de*

[1] As he spells the title.

Algorismo, which did so much to popularize the new arithmetic, and his works *De Sphaera* and *De Computo Ecclesiastico* were also well known. Vincent de Beauvais, who died in 1265, was working on his *Quadruple Miroir* in Bacon's student days, giving, in this humble forerunner of the *Margarita Philosophica*, some popular knowledge of the various branches of mathematics. About this period there were also written the oldest manuscripts extant in the French language that explain the Hindu-Arabic numerals, numerals which were already beginning to attract no little attention in Italy. One Petrus de Maharncuria,[1] in Picardy, is also mentioned by Bacon, with the statement that he was one of the two leading mathematicians of his time, but no mathematical works of importance bear out this tribute, and he is now known only for his work on the magnet and for a few references in one of the books of his English admirer.[2]

Nor was Germany behind in her encouragement of mathematics in the thirteenth century. Jordanus Nemorarius [3] appears to have written his *Algorismus demonstratus*, *Arithmetica decem libris demonstrata*, *Tractatus de Sphaera*, and *De Triangulis*, and his more important *Tractatus de Numeris datis*, while Bacon was yet a youth. Albertus Magnus (1193 or 1205–80), a Dominican, in his later years Bishop of Regensburg, taught mathematics and medicine at Padua, and metaphysics in various places, and was lecturing on dialectics at Paris in Bacon's time. Hermannus Alemannus, one of the first of the Germans to be interested

[1] Méricourt. He was also known as Petrus Peregrinus. There is a Méricourt-sur-Ancre (Méricourt-l'Abbé) and a Méricourt-sur-Somme, both in Picardy, but it is quite likely that Maharncuria is the modern hamlet of Méharicourt.

[2] *Opus Tertium*, cap. xi. For manuscripts of the *De Magnete*, see Father E. Schlund, O.F.M., in *Archiv. Franc. Hist.*, v. 22–40.

[3] The identification of him with Jordan of Saxony, second Master-General of the Dominican Order, though it has the authority of Nic. Trivet (*Annales*, ed. Hog, p. 211), is doubtful. Cf. Denifle in *Hist. Jahrbuch der Görres-Gesellschaft*, x. (1899) 566.

in the Arabic literature on Aristotle, was studying among the Saracens at Toledo about the time that the young English scholar was in Paris, and doubtless others in the schools of Germany were awakening to the need for a broader knowledge of the science of the Greek and Arab civilizations.

In England the desire for mathematics had already been manifest before the thirteenth century dawned. A well-known couplet, referring to geometry, relates that

> Thys craft com ynto England, as y ghow say,
> Yn tyme of good kyng Adelstones day.

This was three centuries before Bacon was born. Whether it is true or not, we know that Adelhard of Bath (*c.* 1180) studied in Spain and translated some parts of Euclid's works from the Arabic in the twelfth century, and that Daniel Morley, a man with considerable taste for mathematics, was studying at Oxford in 1180. In Bacon's time Johannes de Sacrobosco[1] (*c.* 1200–56) was teaching mathematics and astronomy in Paris, writing the most popular work, *De Sphaera Mundi*, that had as yet appeared upon the subject, and doing more, through his *Tractatus de Arte numerandi*, to make the numerals of algorism known than any other writer of his time, not even excepting Alexandre de Villedieu. John Peckham (*c.* 1230–92), possibly a pupil of Bacon's, and later (1279) Archbishop of Canterbury, was no mean scientist. His work entitled *Perspectiva communis* was looked upon as a classic for three hundred years, and his influence at Oxford, where he taught theology and philosophy, must have been a salutary one. Among the Oxford men of about this period mention should also be made of John of Basyngstoke, not merely for his general learning,[2]

[1] John of Halifax, known also by such variants of Sacrobosco as Sacrobusto, Sacro Bosco, and Sacrobosto.

[2] He died in 1252. Under this date Matthew Paris remarks: 'Obiit magister Johannes de Basingestokes, archidiaconus Legrecestriae, vir in trivio et quadrivio ad plenum eruditus,' *Historia Anglorum*, in the Rolls Series, iii. 119.

but because he acquired Greek in Athens (1240) and took back to England some knowledge of the numeral system and perhaps of the other mathematics of classical times. A little before this ' the wizard Michael Scott ' also studied at Oxford and Paris, and went to Spain (*c.* 1217) to acquire the learning of the Saracens. And besides all of these there was still a better scholar than any of them, Robert Greathead, student at Paris, student and teacher at Oxford, and finally Bishop of Lincoln. The influence of such a man upon the learning of his day could not have failed to be great, and although not primarily a mathematician he was sympathetic with the advance of the science and with its applications to the field of physics.

This list contains the name of no great genius in mathematics. Not one stands out for having created a new theory or for having improved in any noteworthy manner upon the work of the ancient scholars. But when we compare these men with those of the centuries immediately preceding, we see that theirs was a period of activity and of laying the foundations for better things.

IV. Personal Associates who may have Influenced Him

When we consider the world activities in mathematics in the thirteenth century we are naturally led to inquire whether Bacon was in a position to know of them, and then to take account of his knowledge of the science and his appreciation of the work of his contemporaries. We are so apt to impersonate the Middle Ages as a human being looking with lacklustre eyes that it requires some effort to realize that the twelfth and thirteenth centuries saw not merely a revival of peripateticism in matters intellectual, in the study of Aristotle, but also its revival in a physical sense, in the wandering of scholars from university to university. Books could not readily circulate and carry the world's learning

to scholars, and so the scholars circulated and disseminated the intellectual oxygen throughout the body of awakening Europe. And thus, even while Bacon was a student at Oxford, he might easily have known of the new interest in mathematics in the South. For about this time there arrived in this university the first of the Franciscans, men from Pisa, Florence, Treviso, and other Italian towns, who might easily have given some intimation of the work of Fibonacci and of the commercial arithmetic of which the Lombards and Tuscans were then the masters. There was also a certain 'Thomas de Hispaniâ' who may have told of the astronomy of the Saracens, and there were others whom Bacon might have met at Oxford, and still more with whom he must have come in contact in Paris, from whom he would have known of the efforts made to revive the study of mathematics in other parts of Europe. He knew Campanus, and very likely learned from him to appreciate Euclid's works. He was a friend of William of Shirewood, whom he ranked much wiser than Albertus Magnus. Among his intimates was Nicholas, preceptor of Amaury de Montfort,[1] from whom he must have learned many things. And besides these men with whom he came in contact there were others, such as Hermann the German and John Peckham, both of whom have already been mentioned, Thomas de Bungay,[2] Albertus Magnus, a mysterious John of London,[3] and others whose names will be mentioned later in this paper.

[1] 'Master Nicholas, the teacher of Lord Amaury de Montfort,' as he describes him in the *Opus Tertium*.

[2] See Anthony à Wood, p. 73. 'He seems like Roger to have attached a great importance to mathematics,' Little, *The Grey Friars in Oxford*, p. 153.

[3] See Montague Rhodes James, *The Ancient Libraries of Canterbury and Dover*, Cambridge, 1903, p. lxxiv; Brewer's edition of the *Opus Tertium*, cap. xi, xix, and xx; Charles, op. cit., p. 11; Little, p. 211, who says that the youthful John who was Bacon's favourite pupil 'was certainly not John of London, or John Peckham'.

V. Knowledge of the Classics of Mathematics

Whether through contact with such men as these, or from his other teachers at Oxford and Paris, in one way or another Bacon became familiar with several of the great classics of mathematics. He quotes from all the works of Aristotle, he knew the *Elements* and *Optics* of Euclid,[1] he was familiar with the *Almagest* and *Optics* and two minor works of Ptolemy,[2] he had read Theodosius on the *Sphere*, and he knew more or less of the works of Hipparchus, Apollonius, and Archimedes, not to speak of the minor writers among the Greeks. He seems not to have known the works of Heron, however, and his knowledge of Nicomachus came only from a secondary source.

The Roman civilization having contributed so little to the progress of mathematics, it is not strange that he knew the works of only a few Latin authors, notably Boethius and such late writers as Isidorus, Cassiodorus, and Bede, and the mediaeval scholar Jordanus Nemorarius.[3]

The Arab writers with whom he was familiar were chiefly those whose major interest was in astronomy and optics. His list of these scholars includes the names of Ibn el-Haiṭam[4]

In the Digby MS. of *De communibus mathematice*, fol. 51, b, 1, it is difficult to determine whether it is Johannes Londoniensis or Johannes Baudoun.

[1] In *De communibus mathematice* he refers to a 'special edition' of the *Elements* by Adelhard of Bath, in addition to the latter's *Elementa*: 'et Alardus Batoniensis in *sua edicione speciali super Elementa Euclidis* ait.' This edition is at present unknown and may well merit the attention of scholars who have access to manuscripts of Adelhard's works. He mentions this edition eight times, but speaks of Adelhard's *Commentum super Elementa Euclidis* only twice.

[2] He mentions him five times in *De communibus mathematice.*

[3] He mentions *De triangulis* twice and the *Arithmetica* once in *De communibus mathematice.*

[4] Abû 'Alî el-Ḥasan ibn el-Ḥasan ibn el-Ḥaiṭam, of Baṣra. The transliterations given by Suter in vol. x of the *Abhandlungen zur Geschichte der Mathematik* (Leipzig, 1900) are followed in the writing of all Arabic names.

(*c.* 965–1039), who wrote more than a hundred works on mathematics, astronomy, and physics ;[1] Ibn Sînâ[2] (980–1037), one of the greatest physicians and philosophers among the Arabs ; el-Kindî[3] (*c.* 800–74), prominent in the field of astronomy ; Ṯâbit ibn Ḳorra,[4] who wrote on the theory of numbers and geometry, as well as astronomy, and who made numerous translations from the works of the Greek mathematicians ; Averroës[5] (*c.* 1126–98), the celebrated commentator on Aristotle ; Al-Fargani,[6] one of the first of the Bagdad astronomers of note ; Al-Battani[7] (*c.* 850–929), whose table of fixed stars (A.D. 911) was well known ; besides numerous others of lesser importance. He was not, however, acquainted with the works of Mohammed ben Musa,[8] although somewhat familiar with algorism,[9]

[1] A partial list is given in F. Woepcke's translation of Omar Khayyám's algebra, *L'Algèbre d'Omar Alkhayyâmî*, Paris, 1851, p. 74, and in Suter, loc. cit., p. 91.

[2] Commonly known as Avicenna. His complete name was El-Ḥosein ibn 'Abdallâh ibn el-Ḥosein (or Ḥasan) ibn 'Alî, Abû 'Ali, el-Šeich el-Ra'îs, Ibn Sînâ. His chief contribution to mathematics was in the field of astronomy.

[3] Abû Jûsuf Ja'qûb ibn Isḥâq ibn el-Ṣabbâḥ el-Kindî, also called Alkindi. He was known as ' the philosopher of the Arabs '.

[4] Abû' l-Ḥasan Ṯâbit ibn Ḳorra ibn Merwân, el-Ḥarrânî, commonly known as Tabit ben Korra.

[5] Muḥammed ibn Aḥmed ibn Muḥammed ibn Rošd, Abû Welîd. He was born in Cordova. In *De communibus mathematice* the name appears both as Averroys and Averrois (Sloane MS., fol. 76, a, 2).

[6] Aḥmed ibn Muḥammed ibn Keṯîr el-Farġânî. He died in 833.

[7] Muḥammed ibn Ğâbir ibn Sinân, Abû 'Abdallâh, el-Battâni, also known as el-Raqqî.

[8] Muḥammed ibn Mûsâ el-Chowârezmî, Abû 'Abdallâh. He taught in Bagdad *c.* 825, and wrote the first work bearing the title of algebra—*'ilm al-jabr wa'l muqabalah*. From his name, el-Chowârezmî, or al-Khowārazmī, came the word *algorism*, meaning arithmetic based on the Hindu-Arabic numerals, a word appearing in such varied forms as augrim, augrym, and alghorisme.

[9] ' Vias algorithmi, scilicet quomodo conjugantur numeri et dividuntur, secundum omnem speciem algorithmi,' as he says.

probably from the works of Gerbert and Bernelinus,[1] nor did he know anything of the Persian algebra of Omar Khayyám or of the mathematics of India and the Far East. Of algebra he knew little beyond the name,[2] nor does he mention a single work on the subject ; but he shows a worthy knowledge of the other important lines of activity then occupying the attention of the Arab writers.

We may therefore conclude, with respect to Bacon's knowledge of the masterpieces of mathematics, that he was familiar with a considerable number of the great classics, and was in a position to pass judgement upon the work of his contemporaries and even to add to the stock of human knowledge if his mental attainments permitted and his tastes allowed.[3]

VI. Contempt for the Mathematics then taught

With respect to Bacon's judgement of the mathematics of his day it may be said that it was one of profound and vociferous contempt. Indeed, it is in the expression of this contempt that we find one cause of his failure to influence the education of his time as much as might have been expected from his learning and undoubted ability. Instead of soberly going about the work of construction he raves about the shortcomings of most of his contemporaries. For

[1] In speaking of fractions he says : ' De hiis vero tractatur in sciencia abbaci. Abbacus autem est mensa geometrica Pithagorica. In qua Pithagoras deposuit omnes istas fractiones ut sciretur in quot quelibet res divideretur in istas. Scripsit autem de hiis primo dominus Papa Gebertus quem omnes doctores sequuntur et cum dictis explicavit et explanavit. Inter quos precipue Bernelius domino Amelio episcopo Parisiensi conscripsit ' (Sloane MS., fol. 91, a). He goes on to say that while he knows of various works he follows Bernelinus chiefly : ' Sequor autem Bernellum principaliter.'

[2] ' Algebra quae est negotiatio, et almochabala quae est census,' as he says in the *De com. mathem.*, quoted by Bridges, *Opus Majus*, I, p. lvii.

[3] In *De communibus mathematice* he mentions Boethius twenty-five times, Jordanus twelve times (but not his *De numeris datis*), Adelhard ten times, Euclid often, and other writers more or less frequently.

a follower of the lovable St. Francis of Assisi he was filled with a bitterness that is hard to explain, and that militated against his success, not merely among his contemporaries but for at least three centuries after his death.

It must be said, however, that this contempt was justified, even if he was undiplomatic in its expression. He saw the noble science of mathematics being debauched by those who merely sought to make it immediately instead of potentially practical, and he cried aloud to prevent them.[1] He saw even the philosophers, who should have led the people to cherish lofty ideals, consenting to this debasement of the science, and he spoke out in no uncertain terms.[2] He found the teachers so poorly equipped and so unsympathetic with learning that a boy did well who mastered the fifth proposition of Euclid, the *fuga miserorum* which later became the *pons asinorum* of the schools.[3] This he asserted to be due solely to poor teaching and not to any general lack of capacity on the part of the youth who frequented the schools. Although he had devoted forty years to a study of the sciences and the languages,[4] he asserts that the whole ground could have been covered in from three to six months had

[1] ' Sed quia homines nesciunt utilitates philosophiae primas, ideo despiciunt multas scientias magnificas et pulcherrimas, et dicunt, " Quid valet haec scientia, vel illa ? " deridendo, et non ut addiscant.' *Opus Tertium*, cap. iv (Brewer).

[2] ' Nam philosophantes his diebus, quando dicitur eis quod sciant perspectivam, aut geometriam, aut linguas, et alia multa, quaerunt cum derisione, " Quid valent haec ? " asserentes quod inutilia sunt. Nec volunt audire sermonem de utilitate ; et ideo negligunt et contemnunt scientias quas ignorant ' (Ibid.). How history repeats itself !

[3] ' Sic est hic quod isti qui ignorant utilitatem alicujus scientiae, ut sit geometriae, statim, nisi sint pueri qui coguntur per virgam, resiliunt et tepescunt, ut vix volunt tres vel quatuor propositiones scire. Unde ex hoc accidit quod quinta propositio geometriae Euclidis dicitur *Elefuga*, id est, fuga miserorum ; *elegia* enim Graece dicitur, Latine *miseria* ; et *elegi* sunt *miseri*.' *Opus Tertium*, cap. vi.

[4] *Opus Tertium*, cap. xx.

the conditions been wholly favourable.[1] He maintains that the roots of the difficulty are (1) the teaching of a large amount of worthless matter,[2] and (2) the fact that the world needs to have

'excellent mathematicians, who should not only know what exists, original or translated, in connexion with the sciences, but be able to make additions to them, which is easy for good mathematicians to do. For there were only two perfect mathematicians, Master John of London, and Master Peter de Maharn-Curia, a Picard.[3] There are two other good ones, Master Campanus de Novaria,

[1] 'Et tamen certus sum quod infra quartam anni, aut dimidium anni, ego docerem ore meo hominem sollicitum et confidentem, quicquid scio de potestate scientiarum et linguarum, dummodo composuissem primo quiddam scriptum sub compendio.' *Opus Tertium*, cap. xx.

[2] 'Quoniam autem libri et doctores mathematice insistunt multiplicacioni conclusionum et demonstracionum, ideo nullus potest pervenire ad noticiam illius sciencie secundum modum vulgatum nisi cum ponat 30 vel 40 annos, ut planum est in eis qui floruerunt in hiis scienciis, sicut Dominus Robertus felicis memorie nuper episcopus Lincolniensis ecclesie, et Frater Adam de Marisco, et Magister Johannes Londoniensis [Baudoun ? The manuscript is difficult to read], et hujusmodi. Et ideo pauci student in hac sciencia, et sine hac sciri non possit odie, ut superius demonstravi. Quapropter studentes Latini habent maxima impedimenta sapiencie propter multiplicacionem conclusionum et demonstracionum mathematice, et precipue quia huic multitudini est annexa crudelis et horrenda difficultas in modo demonstrandi, ita quod studentes spernunt hanc scienciam non solum quia eis ingeritur multiplicacio conclusionum et demonstracionum inpertransibilis, set quia difficultas adicitur infinita.

'Superfluunt igitur omnes demonstraciones conclusionum superfluarum, et hoc est respectum multitudo (!) demonstracionum que docetur, quia paucitas conclusionum utilium inveniatur. Et nisi esset hec superfluitas et difficultas dampnabiles introducte in studio mathematice, quilibet posset infra annum scire quantum modo aliquis noverit infra 20 annos, et quantum eis sufficeret in eternum, et hoc planum est per experienciam omni homini qui hunc tractatum mathematice consideravit diligenter.' *De communibus mathematice*, Digby MS., fol. 56, b, 1 and 2.

[3] See pp. 35, 43, and 46 of the *Opus Tertium*.

and Master Nicholas, the teacher of Amaury de Montfort. For without mathematics nothing worth knowing in philosophy can be attained. And therefore it is indispensable that good mathematicians be had, who are very scarce. Nor can any one, except it be the Pope or some great prince, obtain their services, especially those of the best one of them. For he would hardly condescend to live with any one, since he wishes to be the lord of his own studies, and prosecute philosophical investigations at his pleasure.'

Not only, in his eyes, had most of his contemporaries no gift for teaching, but few among them even knew their subjects. To him they were mere charlatans, posing as scholars but in reality shams with some happy power of discourse. Such was the way in which he looked upon Gerard of Cremona, who posed as a translator of Euclid from the Arabic,[1] and upon Gerard's friend, Hermann the German.[2]

'When I questioned him (Hermann) about certain books of logic, which he had to translate from the Arabic, he roundly told me that he knew nothing of logic, and therefore did not dare to translate them;[3] and certainly if he was unacquainted with logic, he could know nothing of other sciences as he ought. Nor did he understand Arabic, as he confessed, . . . for he kept Saracens about him in Spain, who had a principal hand in his translations. In the same way Michael the Scot claimed the merit of numerous translations. But it is certain that Andrew, a Jew, laboured at them more than he did. And even Michael, as Hermann reported, did not understand either the sciences or the tongues. And so of the rest, especially the notorious William Fleming, who is now in such reputation. Whereas it is well known to all the *literati*

[1] We are quite uncertain as to the first translator of Euclid from the Arabic into Latin. It is said that Adelhard of Bath, Gerard of Cremona, and Campanus all made translations, but there seems reason to believe that they all depended on some earlier translator whose name is now lost.

[2] He studied at Toledo, as already stated, and translated the *Ethics* of Aristotle (1243), the *Encyclopaedia* of Muḥammed ibn Muḥammed ibn Ṭarchân ibn Auzlag, Abû Naṣr, el Fârâbî (*c.* 950), and the Averroës version of the *Poetics*.

[3] 'Dixit ore rotundo, quod nescivit logicam, et ideo non ausus fuit transferre.'

at Paris, that he is ignorant of the sciences in the original Greek, to which he makes such pretensions ; and therefore he translates falsely, and corrupts the philosophy of the Latins.' [1]

Although he has a good word to say for his friend Grosseteste, he returns again to his attack on the rest, saying : ' But all the others were ignorant of the languages and the sciences, and above all this William Fleming, who has no satisfactory knowledge of either, and yet has undertaken to reform all our translations and give us new ones. But I have seen [his] books, and I know them to be faulty, and that they ought to be avoided,' a judgement that seems too bitter to be taken as sound, especially in view of the work which his rival seems to have accomplished.

Of all those who taught at Paris he has only ill to say, asserting that no one among them could have written such a treatise as his on perspective,[2] and that the works of the greatest of them (probably Thomas Aquinas)[3] are characterized by four glaring defects—infinite and puerile vanity, ineffable falsity, voluminous superfluity, and the omission of many parts of philosophy of great utility and beauty.[4]

Such harsh judgements characterize Bacon himself rather

[1] The translation is Brewer's. For the original see Brewer's edition, p. 471, it being part of cap. viii of the *Compendium Studii. Phil.* This Fleming was William of Moerbecke, known also as Guilielmus Brabantinus or Flemingus. He was chaplain to Clement IV, at whose instigation Bacon wrote the *Opus Majus*, and afterwards was also chaplain to Gregory X. He translated parts of the works of Aristotle under the direction of Thomas Aquinas, the *Catoptrics* of Heron of Alexandria (ascribing the work to Ptolemy), and the writings of Archimedes on floating bodies. It is thought that Tartaglia took his translation of Archimedes (1543) from William of Moerbecke. See Cantor's *Geschichte der Mathematik*, vol. ii (2), p. 514.

[2] ' Assero igitur vobis quod nullum invenietis inter Latinos, qui sicut nec usque ad unum annum hanc partem sapientiae persolvet, sic nec usque ad decem.' *Opus Tertium*, cap. ii.

[3] [Probably Albertus Magnus.—A. G. L.]

[4] *Opus Tertium*, cap. ix. See also Brewer's edition, p. lix, and cap. viii of the *Comp. Studii Phil.*

than the men of whom he writes. He speaks slightingly of Jordanus Nemorarius, and yet Jordanus was unquestionably his superior in the details of mathematics. He has little good to say of Albertus Magnus, and yet Albertus was perhaps a greater physicist than he. Disappointment had embittered him, a domineering and impatient nature had warped his judgement, and he who might have been a great beacon light was, by his own manner of writing and speaking, snuffed out, for the time being, like a mere candle in the gloom.

VII. His Appreciation of Mathematics

Although Bacon has little of good to say of any of his contemporaries, his works are full of appreciation for mathematics itself.[1]

'The neglect of it for thirty or forty years', he writes,[2] 'has nearly destroyed the entire studies of Latin Christendom. For he who knows not mathematics cannot know any other sciences; what is more, cannot discover his own ignorance or find its proper remedies. So it is that the knowledge of this science prepares the mind, and elevates it to a well-authenticated knowledge of all things. For without mathematics neither antecedents nor consequents can be known; they perfect and regulate the former, and dispose and prepare the way for that which succeeds.'

Again (p. 64, Jebb; i. 108, Bridges):

'These reasons are of universal application; to descend to particulars would be nothing more than to show how all parts of philosophy are learned by the application of mathematics; in other words, that the sciences cannot be known by logical and sophistical arguments, as is ordinarily the case, but by mathematical demonstrations descending into the truths and operations of other sciences, and regulating them, for without mathematics they cannot be understood or set forth, taught, or learned.'

[1] For example, see fol. 73, b, 1, of the Sloane MS. of *De communibus mathematice*, with quotations from Boethius, Cassiodorus, and others.

[2] *Opus Majus*, p. 57 of the Jebb edition; vol. i, p. 97 of Bridges' edition: translated by Brewer, p. lxxiii.

And so continually throughout his works we find the praise of mathematics as the key to all the other sciences.[1]

[1] ' Sine mathematica non possunt sciri scientiae istae.' *Opus Majus*, cap. ii, p. 59 (Jebb) ; i. 99 (Bridges).

' Sed constat praedicamentum quantitatis cognosci non posse sine mathematica. Nam sola mathematica constituitur de quantitate cognoscenda.' Ibid., p. 60 ; i. 102.

' Et ideo in sola mathematica sunt demonstrationes potissimae per causam necessariam. Et ideo solum ibi potest homo ex potestate illius scientiae devenire ad veritatem. . . . Et ideo in sola mathematica est certitudo sine dubitatione.' Ibid., p. 63 ; i. 106.

' Quare patet, quod si in aliis scientiis debemus venire in certitudinem sine dubitatione, & ad veritatem sine errore, oportet ut fundamenta cognitionis in mathematica ponamus, quatenus per eam dispositi possumus pertingere ad certitudinem aliarum scientiarum, & ad veritatem per exclusionem erroris.' Ibid., p. 63 ; i. 106.

' Quapropter manifestum est, quod mathematica est omnino necessaria & utilis aliis scientiis.' Ibid., p. 64 ; i. 108.

His *Distinctio Secunda*, of the fourth part of the *Opus Majus* (p. 65 ; i. 109), begins : ' In qua ostenditur, quod res hujus mundi requirunt mathematicam.' He asserts : ' Nam impossibile est res hujus mundi sciri, nisi sciatur mathematica.'

Nor was he wide of the mark when he said : ' Postquam manifesta est necessitas mathematicae in rebus hujus mundi & in scientiis humanis, nunc potest istud idem ostendi in divina. Et hoc est magis considerandum, quia humana nihil valent nisi applicentur ad divina. Cum igitur ostensum sit quod philosophia non potest sciri, nisi sciatur mathematica, & omnes sciunt quod theologia non potest sciri nisi sciatur philosophia, necesse est ut theologus sciat mathematicam.' Ibid., p. 108 ; i. 175.

' Et ideo post linguarum necessitatem pono mathematicam esse in secundo loco necessariam, ad hoc ut sciamus quae scienda sunt ; quae non est nota nobis per naturam ; sed tamen est prope cognitionem naturalem inter omnes scientias quas scimus per inventionem et doctrinam.' *Opus Tertium*, cap. xxix ; Brewer, p. 105.

' Homines enim semper sunt parati reprobare quod nesciunt, et quae non sunt vulgata, nec consueta, nec exemplis declarata. Et maxime accidit hic casus apud homines respectu mathematicae. Et hoc procuravit Diabolus, quia nulla utilitas sapientiae, theologiae, et philosophiae, nec istius mundi, per vias sapientales procurari potest sine beneficio mathematicae, ut patet ex dictis, sed planius ex dicendis.' Ibid., cap. lxv ; p. 268.

He sought the support of the Church by showing the service of mathematics in the study of theology,[1] and by recalling to memory the holy men who, in earlier times, had contributed to the development of the science.[2] And indeed, with all the praise which Bacon gave to the science, it must be confessed that it was not so much mathematics for its own sake which he championed, but mathematics as a handmaid to theology or the natural sciences. He represented seven centuries ago, as Aristotle did in the golden age of Greece, and as so many educators attempt to do to-day, the field of applications and the possibilities of correlation, as against the science itself.[3] But with all of his antagonism to the ultra-scientific side, he recognized the culture phase of the subject to the extent of asserting that the educated man ought to be familiar with the famous theorems of the science. To this end he favoured the demonstration of such propositions, even though this might lead to no particular applications.[4]

Among the applications which are related to the affairs of the Church, Bacon calls attention to the importance of mathematics in regulating the calendar, thus fixing properly

[1] See *Opus Tertium*, cap. liii, lviii, and lxvi; Brewer, pp. 199, 226, 228, 270.

[2] 'Sed sancti non reprobant mathematicam, quae est pars philosophiae, sed quae pars est artis magicae, ut manifestum est per sanctos. Nam Isidorus in tractatu Astronomiae dicit, quod astronomia duplex est; una est naturalis, et alia superstitiosa; et mathematica una derivatur a *mathesi*, media correpta, et illa est pars philosophiae; altera dicitur a *μάθησι*, media producta, et illa est et haec sola maledicta imponit necessitatem rebus et libero arbitrio.' *Opus Tertium*, cap. ix; Brewer, pp. 25 seq.

[3] 'Nichil enim est necessarium Christiano nisi propter anime salutem, et ideo pauciora de partibus philosophie eis concedenda sunt quam philosophis infidelibus, qui a veritate multipliciter erraverunt.' *De communibus mathematice*, fol. 56, b, 1.

[4] 'Unde est cum propter proposiciones famosas, quarum demonstracionem ignorare vile est quia sunt in ore cujuslibet; ut "Quod triangulus habet 3 angulos equales duobus rectis".' Ibid., fol. 56, b, 2.

the great religious festivals,[1] a subject to which, as we shall presently see, he devoted serious attention.

Bacon's repeated championing of the cause of mathematics would seem superfluous were we not aware of the opposition which it encountered as a species of the Black Art. To many it was nothing more than astrology of the lowest type, such as we find to-day in parts of India and elsewhere in the Far East. It was this antagonism which Bacon sought to remove by showing the science in some of its real nobility, although, it must be confessed, without the success which a master of the subject would have met even in the thirteenth century. In spite of his defects, however, it must be said that mathematics found no more zealous champion in this century than Bacon, and perhaps his influence in restoring it to an honoured place in the schools was greater than we have means at the present time of knowing.

VIII. Bacon's Knowledge and Conception of Mathematics

For a long time Bacon was known as 'the great mathematician'. In an edition of one of his essays published in 1590[2] he is spoken of as *doctissimus mathematicus*, an appellation which could have been little more than traditional since none of his important works had as yet appeared in print and his manuscripts were but little known. When the mathematical part of the *Opus Majus* came from the press, in 1614, there was some basis for judgement, and the mathematicians of the seventeenth century, if they looked at the work at all, must have wondered that such a title should have been given to its author.[3] In the eighteenth century,

[1] For an appreciation of this position see Bridges, *The Opus Majus of Roger Bacon*, preface, p. ix.

[2] The *Libellus de retardandis senectutis accidentibus et de sensibus conservandis*, Oxford, 1590; English translation, London, 1683.

[3] John Wallis, following Vossius in the main, speaks of him as 'profundae eruditionis vir, studiisque hujusmodi admodum intentus,

when the history of mathematics began to attract some attention, scholars set about to examine the book and to weigh up the claims which might be advanced to rank its author as a mathematician of power. Heilbronner [1] was one of the pioneers in the making of histories of this field of activity, and while he speaks of him in general terms of praise, and has much to say of his efforts to reform the calendar, he recognized, as every student must, that he contributed nothing to the pure science.[2] In France, Montucla, while testifying to Bacon's erudition, did not hesitate to express himself as having little respect for him as a contributor to real mathematics.[3] Bossut, the first edition of whose history appeared in 1802, speaks well of his work in optics, but has nothing whatever to say of his work in mathematics itself.[4] In Germany, Kästner [5] followed the same course, admitting Bacon's genius in optics, but finding nothing worthy of commendation in his know-

in Arabica literatura item versatus, virisque modo dictis non ignotus ; non putandus est hujus artis [i.e. algorismi] ignarus'. But this condemns his real ability in mathematics with very faint praise. See *De Algebra Tractatus*, Oxford, 1693, pp. 6, 13.

[1] *Historia Matheseos Universae*, Lipsiae, 1742, pp. 465–71.

[2] 'Vir tam vastae doctrinae, ut Anglia, imo orbis, ea re nihil haberet simile, aut secundum.'

[3] 'Il n'en est point dans ce siècle qu'on puisse comparer à Roger Bacon. Né avec un esprit avide de connoissances, il étendit ses vues sur toutes les sciences, et en particulier sur les mathématiques. . . . Doué d'un génie digne d'un meilleur temps, il sentit bientôt qu'on avoit entièrement manqué la vraie route pour faire quelques progrès dans la philosophie. . . . Nous ne pouvons cependant dissimuler que Roger Bacon mérite plus d'éloges pour avoir senti l'utilité des mathématiques dans la philosophie naturelle, que pour avoir fait des découvertes qui les aient étendues. On ne peut lui refuser de grandes vues, mais souvent moins justes que gigantesques, et plus séduisantes que solides, comme l'examen de quelques-unes de ses inventions le montrera.' *Histoire des mathématiques*, 2e éd., p. 513.

[4] See the London edition, 1803, p. 189.

[5] *Geschichte der Mathematik*, 1797, ii. 288–91.

ledge of the pure science. Humboldt, while characterizing him as ' the greatest apparition of the Middle Ages ', went so far as to assert that Bacon's chief defect was his lack of mathematical knowledge. And so we may say that writers on the history of mathematics did not hesitate, during a period of two centuries, to take issue with tradition and to assert that Bacon had no claim whatever to recognition in this field. New light has been thrown upon the question during the past half-century, however, first by Brewer's publication of the *Opus Minus* and *Opus Tertium*; secondly by the new edition of the *Opus Majus*, with notes by Bridges, in 1897, and finally by Steele's work (not yet printed) on *De communibus mathematice*,[1] so that we now have at hand the evidence upon which to pass a more well-considered judgement.

Perhaps Bacon's concept of the range of mathematics can best be obtained from the last named of these treatises. In the *Distinctio tercia* he discusses the nine parts into which the science is divided.[2] He also asserts that, besides these, there are two general divisions, *de communibus* and *de propriis*, a classification which he tells us was suggested by Alpharabius.[3] The first of these two divisions, he claims, should not be classified as geometry, arithmetic, and so on, but as the elements, thus suggesting the breaking down of the barriers between subjects in the same spirit as that which prompts many educators at the present time to follow

[1] Mr. Steele kindly placed at my disposal his manuscript copy and complete set of photographs of the *De communibus mathematice* (Sloane and Digby MSS.).

[2] ' Primum est de divisione mathematice in partes novem cum ordine earum.' Sloane MS., fol. 82, a, 1.

[3] Muḥammed ibn Muḥammed ibn Ṭarchân ibn Auzlag, Abû Naṣr, el-Fârâbî (*c.* 870–950), the commentator on Aristotle and Ptolemy, and the author of an Encyclopaedia. ' Et mathematica habet duas partes principales, quarum quedam est de communibus et alia de propriis, et hanc divisionem ponit Alpharabius in libro De Scienciis.' Sloane MS., fol. 82, a, 1.

a similar plan in the earlier stages of instruction.[1] Of the second of his two divisions he makes two great subdivisions, the speculative and the practical, each of these being further divided into four parts—geometry, arithmetic, astrology, and music. In each case he puts the speculative before the practical in order of teaching.[2] Another division is not without interest because of the terms employed—that of practical geometry into altimetry, planimetry, and superiometry, the third of these relating to the measure of depths and solids.

As to the *Opus Majus*, it is evident that it is not a treatise on mathematics. A few references are made to the classics on this subject, and much is said in appreciation of the science, but as to any specific treatment of mathematics itself there is none. Moreover, in the *Opus Tertium*,[3] Bacon shows clearly that mathematics meant to him little more than astronomy. For, speaking of the difficulty of securing mathematicians, and of the cost of maintaining them, he says:

'And besides these expenses, other great expenses would have to be incurred. Without mathematical instruments no science can be mastered; and these instruments are not to be found among the Latins, and could not be made for two or three hundred pounds. And besides, better tables are indispensably requisite, for although the certifying of the tables is done by instruments, yet this cannot be accomplished unless there be an immense number of instruments, and these are hard to use and hard to keep, because of rusting,[4] and they cannot be moved from place to place without danger of breaking.'

[1] 'Et hec pars mathematice non debet vocari Geometria nec Arismetica nec Astrologia nec Astronomia nec Musica sed de elementis et de radicibus totius mathematice que debent premitti ante partes speciales.' Sloane MS., fol. 82, a, 1.

[2] 'Geometria vero speculativa est prior quam sua practica quia operacionem addit supra nudam speculationem, et universaliter finis speculative est practica et difficilior et nobilior et longe utilior sicut finis se habet ad ea que sunt ad finem.' Sloane MS., fol. 83, a, 1.

[3] Cap. xii.

[4] 'Propter rubiginem.' This is strange, since it suggests that brass and bronze instruments were not common, the larger pieces being of

This means, as already stated, that mathematics in Bacon's mind was little more than astronomy; but it tells us a great deal more than this. It gives us a view of the astronomical observatory of the thirteenth century, with its large celestial spheres and great astrolabes, both made of iron. It shows us that, in the massive instruments on the walls of Peking and in the observatory at Jeypore, we see to-day the outfit of the mathematician of Bacon's time—instruments which are the 'contemporary ancestors' of Greenwich and Mount Wilson. It shows us, too, that science in the period of mediaeval awakening depended on the workman from the Orient for its astrolabes and spheres, since 'these instruments are not to be found among the Latins'.[1]

Not in the *Opus Majus* nor in the *Opus Tertium*, then, do we find any evidence of a serious study of mathematics, nor any appreciation of what the science really is. We turn, then, to the *Compendium Studii Philosophiae* which Bacon planned, and in which the second of the four volumes was to be on mathematics. His *De laudibus mathematicae*[2] may have been intended as an introduction to this part of the work, but at any rate the first part of the volume is preserved and will shortly be edited by Mr. Steele from the Sloane MS. (No. 2156) and the less complete one in the Digby collection.[3]

iron. Such astrolabes of the Middle Ages as we possess, however, are of some form of alloy.

[1] The reader will hardly need to be reminded of the excellent treatise on the astrolabe written by Chaucer a century later, but the casual visitor to the British Museum may welcome the suggestion that he should look among the astrolabes for the very fine one which Chaucer may have used when he prepared it.

[2] The *Opus Majus* contains one version.

[3] The Sloane MS. begins: 'Hic incipit volumen vere mathematice habens sex libros. Primus est de communibus mathematice et habet tres partes principales. Prima pars continet quedam communia preambula ad interiora mathematice et habet [quinque] distinctiones.

'Prima distinctio comparat mathematicam ad metaphysicam et

In this part Bacon begins with a description of mathematics as distinguished from logic and magic. He recognizes the necessity for the exact definition of such terms as limit, continuity, infinity, and dimension. But when he comes to stating the nature of geometry we see again how limited was his grasp of the meaning of mathematics.[1] There is, to be sure, mention of theoretical geometry, but Bacon's interest was in minute questions concerning the definitions of terms,[2] sometimes with flashes of real genius,[3] or concerning axioms and postulates.[4] There is little else to his

separat eam a falsa mathematica et dat intencionem ejus et libros hujus sciencie tocius determinat et causas universales errorum humanorum in hac sciencia sicut in aliis excludit. Dat eciam mathematice laudes et utilitates per duas vias, reservans secunde distinctioni et aliis cetera que ad laudes et utilitates mathematice requiruntur. Et hec distinctio prima habet vij capitula.

'In primo fiunt tria que in principio enumeravi. Nam in primo comparo mathematicam ad metaphysicam, secundo ad magicam, tercio replico numerum et ordinem librorum que de integritate illius sciencie componuntur.'

This quotation gives some idea of a work that is not mathematics but is about mathematics.

[1] In *De communibus mathematice* the only subjects of geometry mentioned are the definitions and assumptions.

[2] For example, consider his criticism of Euclid's definition of a surface as bounded by lines, and therefore finite, whereas 'Superficies igitur in universali est quantitas continua habens duas posiciones sine profundo, plana vero superficies non est ab una linea ad aliam extensio in extremitates suas eas accipiens'. Sloane MS., fol. 78, b, 1.

[3] As when he accepts the definition of angle as a portion of space: 'Angulus autem in communi est spacium contentum inter plures lineas in puncto aliquo concurrentes quarum applicacio est indirecta. Angulus vero superficialis seu planus est spacium contentum inter duas lineas concurrentes in punctum unum quarum applicacio in una superficie est indirecta quia cum directe opponitur una linea alii non est angulus sed tanquam linea.' Sloane MS., fol. 79, a, 1 and 2. The second statement is as narrow as the first is broad.

[4] Speaking of such an axiom as 'Omne totum est majus sua parte et hujusmodi' he says: 'Et hec dicuntur concepciones vel dignitates vel maxime proposiciones vel auxiomata secundum Alardum super Elementa Euclidis. Unde Boetius dicit in Ebdomadibus quod con-

theoretical geometry, but on the other hand genuine sympathy is shown with the practical phase of the work, including architecture and both mechanical and civil engineering, and the construction of astronomical, optical, and even surgical instruments. All this reminds us of a passage in the *Opus Tertium* in which practical geometry is described :

' Then there are other instruments and tables of practical geometry, and practical arithmetic, and music, which are of great utility and are indispensably required. But more than any of these it would be requisite to obtain men who have a good knowledge of optics (*perspectiva*) and its instruments. For this is the science of true vision, and by vision we know all things. This science certifies mathematics and all other things, because astronomical instruments do not work except by vision, in accordance with the laws of that science. . . . But this science has not hitherto been read at Paris or among the Latins ; except twice at Oxford in England ; and there are not three persons acquainted with its power.' [1]

In *De communibus mathematice* Bacon also speaks of algorism,[2] the new arithmetic based upon the Hindu-Arabic numerals which were already well known to the astrologers,[3] and he even mentions algebra. While he states the uses of practical arithmetic in the construction of tables, mensuration, alloys and coinage, partnership, and other commercial

cepcio est quam quis probat auditum et Alardus Batoniensis in sua edicione speciali super Elementa Euclidis ait : " Concepciones sunt que ultimo (aliter primo) occurrunt humane intelligentie in quibus non est exigendum propter quid." ' Sloane MS., fol. 89, b.

Similarly with respect to postulates he says : ' . . . et peticiones et supposiciones in omnibus scienciis, ut in Geometria " a puncto ad punctum rectam lineam ducere " et idem est peticio et supposicio secundum Anaricum in Commentario Elementorum Euclidis. Sed quia magister petit a discipulo ut credat illa, vocantur peticiones et quoniam discipulus debet illa credere, et hoc est supponere, vocantur supposiciones que non potest in principio intelligere set credere donec fuerit excercitatus in sciencia cujus sunt.' Ibid.

[1] p. 37 of the *Opus Tertium*. See Brewer, p. lxxvi.

[2] ' Vias algorithmi.'

[3] Smith and Karpinski, *The Hindu-Arabic Numerals*, Boston, 1911.

operations, he gives no evidence of his own proficiency in calculation, nor does he show any conception of the nature of algebra. He distinguishes between axioms, postulates, and definitions, and this, with some comments, makes up most of the geometry in *De communibus mathematice*, but he makes no attempt to advance the science or to prove a single theorem. He gives some attention to integers and fractions, and to arithmetical, geometrical, and harmonical ratio, and mentions the great mediaeval game of Rithmomachia,[1] but there is nothing in any of this that he could not have found in Boethius and other writers with whose works he was evidently familiar.[2] He shows that he knows the works of Apollonius,[3] and he mentions the three conic sections, stating that one of them is used in the construction of burning mirrors. Indeed, it is in his optics that one must look for whatever of geometry Bacon knew, beyond his numerous references to Euclid.[4]

IX. His Relation of Mathematics to other Sciences

When we come to consider Bacon's real conception of mathematics, the application of the science to astronomy and optics, there is cause for ranking him higher in the scale. His work on the calendar was, for the time, note-

[1] ' Hic ludus sapiencie vocatur Rithmimachia, id est, numerorum pugna. Nam ad "rithmo" Grece "numerus" est Latine, et "machia", media producta, "pugna" dicitur in Latina, et hec traduntur in libris propriis per singulas practicas nominatis, ut in libro Rithmimachie et in Algorismo completo in integris et fractionibus, et in Algebra que est "negociacio" et in Almagabale que est "census", et in libro Abaci [Could he have meant Leonardo Fibonacci's work ?], et in aliis practicis Arismetice.' Sloane MS., fol. 85, a, 1.

[2] In *De communibus mathematice* there is little more of theoretical arithmetic than is found in Euclid and Boethius.

[3] In the Digby MS., fol. 71, b, there is a reference ' ex *libro piramidis* Apollonii '.

[4] He mentions him thirty times in *De communibus mathematice*. See also Brewer, p. lxxiv ; Vogl, pp. 67–88 ; Charles, p. 291.

worthy, as was also his work in optics. These topics are, however, not the proper subject of this paper, and may therefore be dismissed with brief mention. In so far as he sought ' per vias mathematicae verificare omnia quae in naturalibus scientiis sunt necessaria ' [1] he is deserving of great credit, for here he enters upon territory that was generally unknown in his day.[2] But even here he placed mathematics relatively in the background, insisting that its conclusions should be verified by experiment. For it was the experimental science that was the mistress of all the rest, ' domina est omnium scientiarum praecedentium.'

His *Optics* is based mainly on the *Thesaurus Opticae* of el-Ḥasan ibn el-Haitam,[3] a work made known to European scholars in the twelfth century, probably first through the translation of Gerard of Cremona. He made an advance on el-Ḥasan ibn el-Haitam in his study of parabolic mirrors, and his study of the geometry of the microscope and his apparent belief in the possibility of the telescope are both noteworthy.[4]

In this connexion mention may properly be made of his suggestion of the possibility of the aeroplane, of high-speed

[1] *Opus Majus*, Jebb ed., p. 64.

[2] So in *De coelestibus*, cap. i, or more correctly *De coelestibus*, part ii, cap. 2 (Steele, p. 342), quoted by Charles (p. 137, n.) from the Mazarine MS., he says : ' Naturales mundi [Steele, nudi] sciant quod languebunt in rebus naturalibus [et cecucient : Steele], nisi mathematicae noverunt [noverint : Steele] potestatem, in quam blasphemant, ex infinita ignorantia, et propter ea omnium [rerum naturalium] carent certitudine.'

[3] See p. 11.

[4] ' Et cum voluerimus et longe posita videantur propinqua et e contrario. Ita ut in incredibili distancia videremus arenas et litteras minias minutas, et ut altissima videantur infima et e contrario, et occulta viderentur in aperto et aperta occultarentur, et quod unum videretur innumerabilia et e contrario, ita ut plures soles et plures lune viderentur per artificium hujusmodi Geometrie.' Sloane MS., fol. 84, a, 2. Cf. *Opus Majus* (ed. Bridges), ii. 164–6 ; *Opus Tertium* (ed. Little), 41.

engines, of self-propelled ships, and of machines of wonderful power.[1] These are, however, the ideas of the mathematician as seer and poet, not of the mathematician as scholar. To see in such suggestions any great discoveries is to see in Bacon's belief in the possible transmutation of metals the modern theory of ions and electrons,[2] and to see in his

[1] 'Et quinta [pars] est de fabricacione instrumentorum utilitatis mirabiliter excellentis, ut instrumenta volandi et deferendi in curribus sine animalibus in incomparabili velocitate et navigandi sine remigatoribus velocius quam estimari possit per manus hominum fieri. Hec enim facta sunt diebus nostris ne aliquis subrideat vel stupescat. Et hec pars docet formare instrumenta per que possunt incredibilia pondera elevari et deprimi sine difficultate et labore, ut homo per se possit seipsum et quicquid vellet elevare et deprimere, et de carcere se erigere in sublime et erectum in alto deprimere sicut vellet.' Sloane MS., fol. 83, b, 1 and 2.

To this extract should be added the following sentences from *De secretis operibus artis et naturae*, cap. iv,—*De instrumentis artificiosis mirabilibus* :

'Currus etiam possunt fieri ut sine animali moveantur cum impetu inaestimabili, ut existimantur currus falcati fuisse quibus antiquitus pugnabatur.'

'Possunt etiam fieri instrumenta volandi, et homo sedens in medio instrumenti revolvens aliquod ingenium, per quod alae artificialiter compositae aerem verberent, ad modum avis volantis.'

'Possunt etiam fieri instrumenta ambulandi in mari et in fluviis ad fundum sine periculo corporali. Nam Alexander magnus his usus est, ut secreta maris videret, secundum quod Ethicus narrat astronomus.' (Compare also *Opus Tertium*, Little ed., p. 18. À propos of this quotation, there is in San Marco, Venice, a mosaic 'La Leggenda di Alessandro' of which Bacon may have heard. It follows closely the legend given by the pseudo Callisthenes, with which Bacon was familiar, and represents Alexander as having harnessed two-winged griffins, before which two pieces of meat are held.)

'Et certum est, praeter instrumentum volandi quod non vidi nec hominem qui vidisset cognovi, sed sapientem qui hoc artificium excogitavit explicite cognosco.'

[2] 'Quinto modo dicitur abstractio a transmutacionibus naturalibus, et materia sit [fit ?] transmutabili[s], scilicet secundum generacionem, concepcionem, alteracionem, augmentum, diminucionem et loci mutacionem que est causa dictarum transmutacionum.' Sloane MS., fol. 88, a, 2.

reference to the atomic theory some conception of the infinitesimal calculus.[1]

This is not the place to speak at any length of Bacon's work as a cosmographer. It is proper, however, to mention the fact that he knew the earth to be spherical, and that he believed the radius to be 3,245 miles. He thereupon computed the circumference to be 20,400 miles, using $3\frac{1}{7}$ for π, and basing his work upon that of Alfraganus (el-Farġânî).[2] This led him to assert the possibility of voyaging westward from Spain to India,[3] in a passage that was inserted,

[1] The reference is interesting. It shows Bacon at his worst, both in breadth of mind and in clearness of reasoning. 'Non sit mundus compositus ex infinitis corporibus et indivisibilibus athomis, ut posuerunt Democritus et Leucippus et Epicurus et multi alii, set erunt corpora mundi finita et divisibilia. Nam aliter sequeretur quod dyametri essent commensurabiles coste, et non solum commensurabiles set equales, quorum utrumque est prius reprobatum et demonstratum super septimam proposicionem decimi *Elementorum* Euclidis, et Aristoteles et omnes nunc fatentur quod hec commensuracio non est possibilis.

'Quod vero hec consequencia sit vera planum est cuilibet scienti potestatem geometrie, et ideo ignorans eam recurrat ad priora antequam ad postremum conetur. Ad evidenciam tamen describatur quadratum cum dyametro, et sint latera 10 punctorum, trahantur ergo 10 a singulis punctis unius lateris ad singula puncta alterius lateris oppositi, tunc ille linee occupabunt totum spacium quadrati et totam dyametrum, et sic dyameter non habebit nisi 10 puncta, et ita non solum habebit communem mensuram set equalem.' *Secundus Liber Communium naturalium, qui est de celestibus*, Steele's edition, 1913, p. 317.

[2] See note on p. 161.

[3] 'Dicit Aristoteles quod mare parvum est inter finem Hispaniae a parte occidentalis et inter principium Indiae a parte orientis. Et Seneca libro quinto dicit quod mare hoc est navigabile in paucissimis diebus, si ventus sit conveniens. Et Plinius docet in Naturalibus quod navigatum est a sinu Arabico ad Gades : unde refert quendam fugisse a rege suo prae timore et intravit sinum maris Rubri qui vocatur Arabicus, qui circiter spatium navigationis annualis distat a mari Indico secundum Hieronymum in epistola, ut inferius exponetur. Et ideo latitudo terrae per quam decurrit mare Rubrum est magna valde ; ex quo patet principium Indiae in oriente multum a nobis distare et ab Hispania, postquam tantum distat a principio

without acknowledgement of its source, in the *Imago Mundi* of Cardinal Petrus Alliacus.[1] Humboldt believed that this, which Columbus quotes in a letter to Ferdinand and Isabella (1498), had more to do with the discovery of America than the Toscanelli letters.

It is, however, in his work upon the calendar that we find something tangible in Bacon's mathematics. Here he had a definite task to perform, one requiring not merely accuracy in observation, but the verifying of old tables and probably the constructing of new ones, and a considerable amount of computation.

With respect to his suggestions for the reform of the calendar we are not left in the dark, since they are set forth in the *Opus Majus* [2] and therefore have long been known to the world. In this work addressed to Clement IV in 1267, he asserted that the length of the year of the Julian calendar is too great by one day in 125 years.[3] This was a remarkable statement for the time, the great Alphonsine tables, which had been completed only a few years earlier, having asserted that the error was one day in 134 years 2 months. He therefore suggested dropping one day from the Julian calendar every 125 years, stating that all the learned world was aware of the error in the Christian reckoning and that the Church was thereby the subject of ridicule on the part of the Saracens, Jews, and Greeks.

It is hardly worth while to enter into the details of Bacon's proposed reform.[4] Suffice it to say that he himself does

Arabiae versus Indiam. A fine Hispaniae sub terra tam parvum mare est quod non potest cooperire tres quartas terrae.' From the Bridges edition of the *Opus Majus*, i. 290.

[1] He died in 1425. His work was first printed at Louvain in 1480.

[2] As also in the unpublished *Computus* in MS. Royal 7 F. viii.

[3] He first said 130 years.

[4] The reader will find it helpful to consult Professor De Morgan's article in the *Companion to the British Almanac* for 1846, p. 11. On the question of the authenticity of his calendar, consult J. O. Halliwell, *Rara Mathematica*, London, 1841, p. 114.

not tell how he reached his conclusion as to the Julian calendar being too long by one day in 125 years, a closer approximation than any that is known to have been suggested before his time. At any rate Clement's death, or possibly the antagonism generally aroused by Bacon, put an end to any plans for reform, and it was not until Clavius was called to Rome, and bent his energies to further the project of the Gregorian calendar, that a fairly satisfactory system was evolved.

X. Conclusion

And finally, in view of all that has been said, what is the conclusion as to Bacon's mathematical talents? One is liable to be led away by enthusiasm when writing upon the occasion of the seven hundredth anniversary of any great leader, to read into his works what is not there, and to ascribe to him abilities which he never possessed. Against this tendency it is always necessary to be on guard. On the other hand, we who are cast in Nature's smaller moulds tend by our own inferiority to depreciate the greatness of the world's leaders. To weigh in well-balanced judicial scales the merits of any man, and particularly of any genius, is a very difficult task.

If we ask ourselves the question whether Bacon was *doctissimus mathematicus*, we must first define our terms. If we mean to inquire if he was justified, by his wide knowledge of mathematics and by any great discoveries, in assuming the attitude of superiority which he showed towards most of his contemporaries, there can be but one answer, and that a negative one.[1] If, on the other hand, we use the terms relatively, referring to Bacon as a scholar and a leader of scholars in the thirteenth century, then the answer is unquestionably an affirmative one. No one in his generation,

[1] On the paucity of his geometry, consult also Steele's edition of the *Opera hactenus inedita Rogeri Baconi*, Oxford and London, 1910–13.

few men in any generation, certainly no man in mediaeval England, showed such sympathy with mathematics, such familiarity with the standard authors available, such clear perception of the possible applications of the science, and such conviction of the value of the subject in a liberal education. Jordanus was his superior in detail, but was relatively a pigmy in general power; Albertus Magnus seemed to accomplish more in physics and chemistry, but Roger Bacon gave a formula which freed intellect from brute force—the formula for gunpowder; Alexandre de Villedieu and Bartolomeo da Parma were better known in astronomy, but it was Bacon's computations which gave to the Middle Ages the best calendar as yet devised, and which led him to set forth with perfect assurance the possibility of circumnavigating the globe. It is not for his treatises nor for his discoveries in the realm of pure mathematics, but for his appreciation of the science, for his knowledge of what the world had done, and for his vision of what the future had in store, that for seven centuries he has borne with justice the title of *doctissimus mathematicus*, a title by which he may rightly be known even in our own time and in the centuries to come.

VII

ROGER BACON UND SEINE VERDIENSTE UM DIE OPTIK

VON EILHARD WIEDEMANN

DREIMAL haben hervorragende englische Gelehrte in weitreichender Weise das Wesen der in den Naturwissenschaften benutzten Methoden eingehend erörtert. Roger Bacon im dreizehnten Jahrhundert in verschiedenen Werken, vor allem in dem *Opus Majus* und *tertium*, Bacon von Verulam am Ende des sechzehnten und Anfang des siebzehnten Jahrhunderts in seinem *Novum Organon*, und endlich Whewell im neunzehnten Jahrhundert in seiner Geschichte und seiner Philosophie der induktiven Wissenschaften. Alle drei haben die Bedeutung der induktiven Methode gegenüber und neben der der deduktiven betont ; sie haben sie aber nicht erfunden. Stets haben die Naturforscher bewusst und die Vertreter der übrigen Wissenschaften unbewusst auch das induktive Verfahren eingeschlagen, und umgekehrt geht man in den Naturwissenschaften auch deduktiv vor, so wenn nach Aufstellung einer Hypothese deren Konsequenzen in einer Theorie durchgeführt werden. Die induktive Methode geht in ihrer Grundform philosophisch auf Sokrates zurück. Bei den oben erwähnten drei Forschern treten neben den methodologischen und philosophischen Untersuchungen eigene experimentelle Arbeiten zurück. Bei Roger Bacon spielte hier sicher der von ihm selbst beklagte Mangel an Hilfsmitteln eine grosse Rolle, Bacon von Verulams Zeit war mit ganz anderen Aufgaben erfüllt, als dass er sich langwierigen Versuchen hätte widmen können, und

für Whewell hatte wohl, nachdem er sich einmal philosophischen Problemen zugewandt hatte, die Kleinarbeit im Laboratorium einen Teil des Reizes verloren ; eine Erscheinung, die auch sonst beobachtet wird. Alle lebten aber in einer Zeit, in der eine Fülle von experimentellem Stoff vorlag, dessen Bedeutung von den Vertretern der sog. Geisteswissenschaften und vor allem von denen der Theologie nicht entsprechend geschätzt wurde. Dies galt vor allem von R. Bacon, dessen gelehrte Zeitgenossen als Scholastiker sich ganz in philosophische Spekulationen vertieften und von einem starken Autoritätsglauben erfüllt waren, wie wir dies später in dem Kampf der Aristoteliker gegen die Forschungen Galileis wieder beobachten. Vor allem gegen diesen Autoritätsglauben wandte sich R. Bacon und erregte dadurch mannigfachen Widerspruch ; indes stand er darin nicht allein ; wie er, so betont auch der um 1300 lebende Theodoricus Teutonicus in seiner Schrift über den Regenbogen, dass man dem Experiment mehr als dem Aristoteles vertrauen sollte. Dies sticht sonderbar ab von der Art, wie später Scheiners Entdeckung der Sonnenflecken durch seine Oberen abgelehnt wurde.

Anregungen zu der induktiven Art des Arbeitens und Vorläufer in dieser Richtung fand R. Bacon zahlreiche vor. Die aus der Antike überlieferten, ihm fast nur aus Uebersetzungen aus dem Arabischen bekannten, Werke boten hier nur sehr wenig. In der klassischen, abgeklärten Form treten vor allem in der Optik des Euklid, wie in dessen Elementen, die Wege, auf denen die Resultate gewonnen waren, ganz zurück ; etwas anderes liegen die Verhältnisse in der Optik des Ptolemäus. Dagegen enthielten die R. Bacon bekannten arabischen Werke eine Fülle experimentellen Materials und experimenteller Methodik, so vor allem die optischen Schriften von Ibn al Haiṭam, dem oft von ihm zitierten Alhacenus. Bei Roger Bacon finden wir, wie bei zahlreichen muslimischen Forschern, noch eine andere

Methode ausgebildet, deren Bedeutung auch R. Bacon betont und als deren Begründer er oft angesprochen wird, nämlich die Anwendung der Mathematik auf naturwissenschaftliche Probleme. In der Optik von Ibn al Haiṭam, in dessen Schriften über den Brennspiegel, in dem Werk über den Qarastûn, in Kâmal al Dîns Schrift über den Regenbogen u.s.w., findet sich aber diese Methode auf das glänzendste durchgebildet und benutzt, viel eindringender als bei R. Bacon selbst. So wird auch das Urteil verständlich, das A. Gogava im Jahre 1548 fällte. Eine Schrift über die Eigenschaften der Parabel und den Brennspiegel wurde neu entdeckt und nach deren Urheber geforscht. Man denkt dabei auch an R. Bacon, demgegenüber bemerkt Gogava :

' Die Namen des Verfassers können wir nicht angeben, da sie sich nicht in unserem Exemplar finden. Einige meinten, es sei Roger Bacon, da dieser über diesen Gegenstand geschrieben hat. Zu beachten ist, dass in allen Werken Rogers sich keine Spur des Geistes der Geometer und des mathematischen Scharfsinnes zeigt, die man in diesem Schriftchen erkennen kann.'[1]

Zu beachten ist noch, dass Ibn al Haiṭam zwar in den Schriften über den Brennspiegel im wesentlichen mathematisch vorgeht und die Resultate dann ohne eingehende experimentelle Prüfung zur Konstruktion der Spiegel in trefflicher Weise verwendet, dass er aber anderseits in seiner Schrift über die Schatten die theoretisch abgeleiteten Resultate Schritt für Schritt durch den Versuch prüft.

Will man aber R. Bacon in seinen Bestrebungen die Mathematik zu verwenden im Vergleich zu den Arabern gerecht werden, so darf man nicht vergessen, dass die letzteren sehr früh eine hoch entwickelte Mathematik besassen, dass Ibn al Haiṭam freier über die Lehre von den Kegelschnitten verfügen konnte als R. Bacon, wenn diesem überhaupt die Uebersetzung des Apollonius bekannt war.

Soweit die bisherigen Forschungen reichen, hat R. Bacon

[1] [Cf. Appendix, nos. 44, 45.—A. G. L.]

aber als erster eine Art der Behandlung benutzt, die in seiner Schrift *de Speculis* uns entgegentritt. Nach einer geometrischen Konstruktion Euklids sollte der Brennpunkt im Mittelpunkt des sphärischen Hohlspiegels, nach R. Bacon selbst aber weiter nach dem Spiegel zu liegen. Unter nur geringer Benutzung mathematischer Schlüsse werden aus Betrachtungen allgemeiner Art die beiden Resultate, die zunächst beide richtig zu sein scheinen, eingehend diskutiert und die tatsächliche Lage des Brennpunktes gefunden. Wir haben hier ein allgemeineres Verfahren als das von den Vorgängern R. Bacons geübte ; es trägt, wie mir scheint, einen Charakter, der sich dann bei abendländischen Gelehrten immer wieder findet.[1]

Der Stoff, an den die Gelehrten in der Zeit R. Bacons und dieser selbst anknüpfen konnten, war einmal aus dem Altertum gekommen und teils durch direkte Tradition übermittelt, teils aus den arabischen und hebräischen Uebersetzungen, die selbst wieder in das Lateinische übertragen wurden, zugänglich geworden. Vor allem waren es aber die Ergebnisse der muslimischen Gelehrten, die für R. Bacon von Bedeutung waren ; er zitiert selbst deren eine ganze Reihe. Von anderen hat er sicher gehört. Zeigt sich doch, je mehr wir Kenntnis von den Leistungen der arabisch sprechenden Nationen erhalten, wie weit diese fortgeschritten waren, und wie viel von ihnen an das christliche Abendland mitgeteilt wurde. So fusst ja Papst Sylvester in seinen geodätischen Arbeiten auf allgemein im Orient verbreiteten Methoden, so lässt sich Friedrich II. von ägyptischen Gelehrten belehren, Alphons von Castilien entnimmt ihnen seine Weisheit, weiter lassen sich viele Notizen in Leonardos Werken auf Uebersetzungen aus dem Arabischen zurückführen. Gross ist die uns bekannte Zahl von solchen ; vieles spricht aber dafür, dass daneben noch zahlreiche andere, z. B. in das Italienische, vorhanden waren. Neben den theoretischen

[1] Vgl. die Arbeit von J. Würschmidt in diesem Bande.

Ergebnissen sind aber auch teils durch Geschenk, teils als Beute, Proben der Wunderwerke der Technik, wie sie die Orientalen schufen, so die Automaten und die kunstvollen Uhren, in das Abendland gebracht worden, von anderen haben Kaufleute und Kreuzfahrer berichtet. Von solchen Werken hat auch R. Bacon gehört oder sie gesehen, so erklären sich manche seiner mechanischen Konstruktionen und seiner Pläne nach dieser Richtung, die der Zeit entsprechend über das mögliche hinaus weiter gesponnen werden.

Um die Leistungen R. Bacons neben denen gleichzeitiger und früherer Gelehrten in der muslimischen Welt richtig zu würdigen, muss man die ganz verschiedenen Verhältnisse, unter denen sie wirkten, beachten. In der muslimischen Welt hatte eine Schar von Gelehrten zunächst unter dem Schutz der Chalifen das Erbe der Antike aufgenommen und weiter entwickelt. An den verschiedensten Orten entstanden Schulen, die einzelnen Forscher traten in den regsten Wechselverkehr, und ganz abgesehen von dem intellektuellen Interesse an Mathematik und Astronomie wiesen die praktischen Bedürfnisse, die Bestimmung der Gebetszeiten, die Aufgaben der Architekten auf sie hin. Mochte auch in späteren Zeiten die Orthodoxie sich zu den exakten Wissenschaften wie zu gewissen philosophischen Richtungen feindlich stellen, ja deren Werke verbrennen, so war das doch nie in dem ganzen Reich der Fall. Gerade in solchen Zeiten wurde die grosse Sternwarte in Marâġa gegründet, Naṣîr al Dîn al Ṭûsî leitet sie, und neben ihm wirkten andere. Selbst ein durch seine sufischen Bestrebungen theologisch so gefährdeter Mann, wie Omar al Chajjâmî, konnte Werke ersten Ranges schaffen. Ueberwog etwa in einem Sultanat die orthodoxe Richtung zu sehr, so boten andere Höfe den Gelehrten eine willkommene Zufluchtsstelle. Dadurch waren alle Bedingungen für eine emsige wissenschaftliche Tätigkeit des einzelnen gegeben. Ganz anders lag dies bei R. Bacon. Er war unter seinen Zeitgenossen

fast der einzige, der sich naturwissenschaftlichen Problemen zuwandte; statt der sorgfältigen vielfach kommentierten arabischen Uebersetzungen aus den alten Sprachen standen ihm nur die durch eine doppelte Uebertragung oft sehr verderbten Texte zur Verfügung. Als Franziskaner stand er unter der strengen Aufsicht des Ordens, und wenn dieser etwas für irrig oder verwerflich erklärt hatte, so war ein Arbeiten in der gleichen Richtung sehr erschwert, ja, wenn der Papst sich dessen Anschauungen anschloss, unmöglich gemacht. Gerade diese Umstände haben R. Bacon stets und stets gehindert. Nur im äussersten Süden, in Sizilien, hätte er freier arbeiten können. Wir müssen daher doppelt anerkennen, dass er trotz alledem so viel geleistet hat.

Gegenüber den früheren Gelehrten und auch einem Teil der späteren hat R. Bacon aber das grosse Verdienst, in systematischer Weise auf die Bedeutung der Erfahrung hingewiesen und gezeigt zu haben, dass wir auf zwei Arten erkennen, durch den Schluss (*argumentum*) und durch den Versuch (*experimentum*). Dabei betont er, dass man ohne den Versuch oder, was oft an dessen Stelle tritt, die Beobachtung (*experientia*) bezw. Erfahrung, in vielen Fällen zu keinem sicheren Resultat gelangen kann. Bei dem damaligen Stand der Wissenschaft ist es natürlich, dass besonders zahlreiche Beispiele der Optik entnommen sind. Ein weiteres typisches Beispiel aus einem anderen Gebiet sei wenigstens erwähnt. Es wird berichtet, dass der Diamant nur unter Zuhilfenahme von Bocksblut zerkleinert werden kann ; ein Versuch lehrt R. Bacon, dass das nicht der Fall ist, sondern der Diamant nur durch den Diamant zerkleinert wird.

Im folgenden sollen die physikalischen Kenntnisse und Leistungen R. Bacons auf einem von ihm besonders gepflegten Gebiete, nämlich dem der Optik, etwas eingehender gewürdigt werden.

Von allen Zweigen der Naturwissenschaften können, wenn wir von der Astronomie absehen, im Mittelalter als Wissen-

schaften im modernen Sinn nur zwei angesehen werden: einmal die Mechanik, als die Lehre von dem Schwerpunkt, dem Hebel und den einfachen Maschinen einschliesslich der verschiedenen Formen der Wage, als Schnellwage und als gleicharmige Wage; hier schliesst sich die Lehre vom Schwimmen und von spez. Gewicht an. Das zweite Gebiet ist die Optik ; hier liessen sich die relativ einfachen Gesetze leicht scharf fassen, oder doch wenigstens wie bei der Brechung die numerischen Grundlagen in Tabellen zusammenstellen. Die Probleme auf den anderen Gebieten waren zu kompliziert, die Erscheinungen zu zahlreich, als dass man damals schon hätte einfache Gesetze oder Gesetzmässigkeiten aufstellen können, trotzdem vielfach die Forschung in wissenschaftlicher Weise geführt wurde und zahlreiche bedeutungsvolle Einzelheiten gewonnen wurden. Ein typisches Beispiel hierfür ist die Chemie, der schon ein grosses Tatsachenmaterial zur Verfügung stand, in der schon Ansätze zu einer quantitativen Untersuchung der Körper vorhanden waren ; wissenschaftlich wurde sie aber erst, als Lavoisier die Wage zu dem Instrument der Chemiker machte und die Erkenntnis allgemein wurde, dass alle Substanzen sich aus einer beschränkten Anzahl wohl definierter Körper, den Elementen, nach bestimmten Verhältnissen zusammensetzen. Gegenüber der Mechanik, die nur in einer Zweigwissenschaft, der Pneumatik, eine grössere Mannigfaltigkeit darbot, hat die Optik den grossen Vorzug, in der strengen Gesetzmässigkeit des Strahlenganges den Verstand zu befriedigen und in der grossen Fülle der Erscheinungen, sowohl auf der Erde wie am Himmel, die Phantasie und den Forschertrieb immer von neuem anzuregen.

Durch ihre Doppelstellung als mathematische und physikalische Wissenschaft erregte die Optik schon im Altertum weitgehendes Interesse, das noch durch die zu ihr gehörigen optischen Täuschungen gesteigert wurde. Ihre Bedeutung charakterisiert Kamâl al Dîn dadurch, dass er von ihr sagt,

dass sie nicht nur einen Zweig der Mathematik, sondern ihren Gipfel bildet. Bacon selbst schildert sie nach der Ausgabe von Combach in der Einleitung zur *Perspectiva* etwa folgendermassen :

' Ich möchte Dich und andere der Wissenschaft würdige Männer für die Wissenschaft der *Perspectiva* begeistern. So wisse denn, dass zahlreiche Männer über diese Wissenschaft geschrieben haben, einige wie Euklid und Jacobus Alkindi haben nur allzuwenig geschrieben, andere haben Abhandlungen über einzelne Teile der Perspektiva verfasst, wie das Buch über das Sehen, dasjenige über die Spiegel und noch andere. Alhazen (Ibn al Haitam) war sowohl dem Stoff wie der Darstellung nach gar zu weitschweifig, während Ptolemäus recht mittelmässig verfuhr. Auf Deinen Wunsch hin will ich nun das Wesentliche aus allen Schriftstellern zusammenfassend darstellen. Dabei muss man aber mein Werk über die Spezies stets zu Händen haben, da man sonst nicht das Wertvolle der Perspektiva verstehen kann.

' Diese Wissenschaft ist weit schöner und nützlicher als andere und auch ergötzlich, da unser Ergötzen hauptsächlich auf dem Sehen beruht. Licht und Farbe sind im Verhältnis zu den anderen Dingen, die uns durch die Sinne zugetragen werden, von besonderer Schönheit ; aber nicht nur um Schönheit handelt es sich dabei, sondern auch um den Nutzen und die Erfüllung von Bedürfnissen. Aristoteles sagt ja im ersten Buch der Metaphysik, dass der Blick allein uns die Unterschiede in den Dingen aufweist ; denn durch ihn gewinnen wir sichere Erfahrungen über alle Dinge, die im Himmel und auf der Erde sich finden. Durch zum Sehen eingerichtete Instrumente betrachtet man die Erscheinungen am Himmel, wie Ptolemäus und die anderen Astronomen lehren ; ebenso ist dies bei den Dingen der Fall, die in der Luft erzeugt werden, so den Kometen, dem Regenbogen und ähnlichen Erscheinungen. Denn deren Erhebung über den Horizont, ihre Grösse, Gestalt, Menge und alle ihre Eigenschaften werden durch die Betrachtung mit dem Auge unter Zuhilfenahme von Instrumenten sicher gestellt. Was sich aber auf der Erde findet, das lernen wir durch den Gesichtssinn kennen, denn der Blinde kann über diese Welt keine wertvollen Erfahrungen sammeln.'

(Hieran schliesst sich ein Vergleich mit dem Hören, Riechen, Fühlen, dann wird fortgefahren.)

'Nur das, was nützlich ist, und zahlreiche und herrliche Wahrheiten umfasst, kann eine Wissenschaft für sich bilden, sonst genügt es, den Gegenstand als einen Teil einer anderen Wissenschaft zu behandeln. Nun haben die Philosophen von allen Sinnen nur für das Sehen eine besondere Wissenschaft geschaffen, die *Perspectiva*; daher muss die Erkenntniss durch diesen Sinn einen weit höheren Nutzen als durch einen anderen Sinn bringen. Was ich soeben im Allgemeinen ausgeführt habe, soll im folgenden im Einzelnen betrachtet werden, indem ich die Wurzeln dieser schönsten Wissenschaft aufdecke. Eine andere Wissenschaft mag höher stehen, keine bietet aber so viel an lieblichem und schönem Nutzen dar.'

Die Ergebnisse seiner optischen Forschungen hat R. Bacon an verschiedenen Stellen unter verschiedenen Gesichtspunkten zusammengestellt. Eine Einzeluntersuchung über die Hohlspiegel gibt der *Tractatus de speculis*, dann behandelt Bacon die Optik zweimal im *Opus majus*. In der *Perspectiva* lieferte er eine knappe, geistvolle Uebersicht über den damaligen Stand dieser Wissenschaft, die im Herausheben der wesentlichen Punkte, im Zurückdrängen des rein Mathematischen und in der Ersetzung langatmiger Beweise durch anschauliche Betrachtungen uns einen wertvollen Einblick in die grosse Klarheit des Denkens unseres Gelehrten liefert. Im Grossen und Ganzen folgt Bacon der Disposition des Stoffes wie sie Ibn al Haitam in seiner Optik gegeben. Mag auch fast Alles älteren, vor allem arabischen, Quellen entnommen sein, Form und Auffassung sind modern, nicht mehr scholastisch.

Die Lehre von den Spezies, vor allem diejenige von deren *Multiplicatio*, wird höchst charakteristisch nicht in abstrakter Weise behandelt, sondern vielfach unter Anschluss an optische Erscheinungen. Endlich zieht Bacon, um den Wert der Mathematik nachzuweisen, vielfach Beispiele aus der Optik heran. In dem Abschnitt über die *Scientia Experimentalis* dient endlich der Regenbogen zur Erläuterung der experimentellen auf die Anschauung gegründeten Methodik.

Wenden wir uns nun zur Optik selbst! Sie wird von R. Bacon, wie von seinen Vorgängern, wesentlich als eine Lehre vom Sehen behandelt, d. h. die Probleme werden vom physiologischen bezw. psychologischen Standpunkt aus erörtert. Nicht der Gang der Strahlen ist das, was in der *Perspectiva* zunächst untersucht wird, sondern es wird gefragt, welche Eindrücke, Täuschungen, Bilder erhält das Auge bei geradlinig fortschreitenden, reflektierten und gebrochenen Strahlen. Die Strahlung selbst und ihre *Zerlegung* bei Reflexion und Brechung dienen als Beispiel für die Lehre von der *multiplicatio specierum*, hier freilich in so ausgiebiger Weise, dass dieser Abschnitt bei R. Bacon eine Optik in unserem Sinn darstellt; er ist zu ergänzen durch den Traktat über die Spiegel oder richtiger über die Hohlspiegel. Diese Art der Behandlung dürfte noch einen besonderen Grund haben; in den meisten Fällen sind die von uns wahrgenommenen Bilder nicht *reelle*, die durch das Schneiden wirklich vorhandener beobachtbarer Strahlen entstanden sind, sondern es sind *virtuelle* Bilder, also im Sinne der älteren Optiker optische Täuschungen; in anderen Fällen handelt es sich, z. B. bei dem Betrachten der Gegenstände in gerader Richtung, gar nicht um Bilder, sondern um die Beurteilung der Grösse, Gestalt und Bewegung von Objekten.

Daneben wird auch der Strahlengang selbst beobachtet und betrachtet, wenn er sich durch besondere Erscheinungen kenntlich macht, zunächst bei der geradlinigen Fortpflanzung. Diese beweist, wie R. Bacon erwähnt, al Kindî durch die Schattenlinien der Körper und Alhazen durch die sichtbaren Linien, die entstehen, wenn Licht in ein Zimmer eindringt, in dem sich staubige Luft befindet. Weiter werden die Lichtstrahlen eingehend verfolgt bei den Brennspiegeln, sowohl den sphärischen, wie den parabolischen in ihren verschiedenen Formen, und endlich bei der Brechung, sei es dass die Abhängigkeit von Einfallswinkel und Ablenkungs-

winkel beim Uebergang aus einem dünneren in ein dichteres Medium und umgekehrt festgelegt wird, sei es dass der Strahlengang in brechenden Medien und die Brennwirkung einer Kugel untersucht wird.

Das sich *geradlinig fortpflanzende* Licht braucht dazu eine, wenn auch für die Sinne nicht wahrnehmbare, Zeit ; ein Schluss, der aus allgemeinen Betrachtungen abgeleitet wird. Die Strahlen können sich kreuzen und gehen dann in gerader Richtung weiter, wie dies durch einen Versuch nachgewiesen wird.

Von den bei dem geradlinigen Sehen auftretenden *Täuschungen* erwähnt R. Bacon unter anderen die folgenden : Schnell bewegte Körper erscheinen grösser, als sie wirklich sind. Sieht man grelle Farben und wendet dann das Auge nach einem hellen Ort, so wirken die Farben nach. Wird ein Gegenstand durch ein feines gefärbtes Tuch mit kleinen Oeffnungen betrachtet, so erscheint die Farbe des Gegenstandes mit denen des Tuches gemischt. Die Farbenspezies von Objekt und Fäden nähern sich hier in diesem Fall im Auge auf einen nicht mehr zu unterscheidenden Abstand. Der Abstand zwischen Auge und Objekt wird, falls sich zwischen beiden keine Gegenstände befinden, oft falsch geschätzt. Eine auch sonst besprochene Erscheinung ist die, dass eckige Gegenstände in grosser Entfernung rund erscheinen. Weiter erörtert R. Bacon die Fälle, wo Gegenstände sich scheinbar bewegen, während sie eigentlich ruhen und nur Gegenstände in ihrer Nähe sich bewegen. Auch die von Ptolemäus erwähnte Erscheinung des Zusammenfliessens der Farben zu einer einzigen beim Farbenkreisel wird erwähnt.

Bei der Lehre von *der Reflexion* wird zunächst das Reflexionsgesetz aufgestellt, nach dem der Winkel des einfallenden Strahles gleich dem Winkel des zurückgeworfenen ist ; die beiden Winkel sind diejenigen zwischen den Strahlen und der reflektierenden Fläche. Die genauere von Ibn al

Haitam angegebene Bestimmung, dass einfallender Strahl, reflektierter Strahl und Einfallslot in einer Ebene liegen müssen, fehlt. Zugleich wird nach Alhazen ein Apparat beschrieben, um das Reflexionsgesetz zu prüfen.

Das *Bild* liegt da, wo die Sehstrahlen, die nachher nach dem Objekt reflektiert werden, bei ihrer Verlängerung sich mit der Kathete, d. h. dem vom Objekt auf die spiegelnde Fläche gefällten Lot schneiden. Daraus folgt, dass bei ebenen Spiegeln das Bild ebenso weit hinter diesem liegt, wie der Gegenstand vor ihnen.

Als Spiegel benutzt R. Bacon solche aus Erz, gutem Stahl, Silber und mit Blei hinterlegtem Glas.

Spiegelarten gibt es nach R. Bacon und den Gelehrten, die sich mit der Perspektiva befasst haben, sieben: Den ebenen, den sphärischen, den pyramidenförmigen (kegelförmigen) und den zylinderförmigen, die jeweilig innen oder aussen poliert sind, also von der Innen- oder Aussenfläche das Licht zurückwerfen. Dazu kommt dann der parabolische Spiegel, den Ibn al Haitam ebenso wie Roger Bacon für sich behandelt.

Bei den ebenen Spiegeln werden die auftretenden Grössen sehr scharf definiert. Bei ihnen ist der Irrtum im Verhältnis zu anderen Spiegeln am kleinsten, da die Dinge in entsprechender Form und Grösse auftreten. Nur die relative Lage ist geändert, das rechte wird zum linken (im senkrechten Spiegel), das obere zum unteren (im horizontalen). Mit allen Spiegelarten haben die ebenen das gemeinsam, dass weder die Dinge selbst an ihrer wahren Stelle erscheinen noch dass der Ort der Bilder dort liegt. Hier betont nun R. Bacon, dass der Ort der Bilder ein *nicht wirklicher* ist; er sagt: ‘Wenn wir vom Ort des Bildes sprechen, verstehen wir darunter *nur* die Erscheinung des Dinges und nichts anderes.’

Nachdem die Gesetze der Reflexion festgelegt sind, können die an Spiegeln auftretenden Erscheinungen eingehend

behandelt werden. Durch passende Anordnung von solchen kann ein Gegenstand mehrfach erscheinen, also in Winkelspiegeln. Hierbei weist unser Gelehrter auf die mannigfachen Kunststücke, die man mit solchen Spiegeln ausführen kann, hin : dass Gegenstände da erscheinen, wo sie nicht sind u.s.w. Hier mischen sich abergläubische Vorstellungen ein. Die Dämonen sollen durch Spiegel den Menschen wunderbare Dinge zeigen und verborgene Dinge an das Tageslicht bringen.

Weiter wird aus dem Reflexionsgesetz geschlossen, dass das Mond- und Sternenlicht nicht reflektiertes Sonnenlicht sein kann, da dieses bei den als vollkommen glatt vorausgesetzten kugelförmigen Gestirnen nur nach einer Richtung reflektiert werden würde. Die Kraft der Sonne wirkt vielmehr auf die Gestirne und erzeugt das Leuchten.

Die Tatsache, dass, wenn man einen belegten Glasspiegel unter Wasser legt, man zwei Bilder von der Sonne und dem Mond sieht, wird im Unterschied von anderen richtig erklärt.

Aus der Angabe, dass, wenn man auf hohen Bergen gegenüber von feindlichen Staaten und Heeren Spiegel aufstellt, man alles, was in beliebiger Entfernung geschieht, erkennen kann, ist auf die Entdeckung des Spiegelteleskopes von R. Bacon geschlossen worden, was natürlich ganz ausgeschlossen ist.

Bei den sphärischen Spiegeln tritt an Stelle der ' Kathete ' der durch den Gegenstand gelegte Kugeldurchmesser ; das Bild entsteht da, wo der Sehstrahl, der als eine von einem punktförmigen Auge ausgehende Linie gedacht ist, und der am Spiegel reflektiert wird, diesen Durchmesser schneidet. So ergeben sich ohne weiteres die Lagen der Bilder, wenn eine spiegelnde Hohlkugel gegeben ist. Ist in der Figur *a* das Auge und das Objekt auf dem Durchmesser *lo* gelegen, so liegt das Bild auf dem Schnittpunkt der rückwärtigen Verlängerung der nach *a* reflektierten Strahlen mit *lo*. Im speziellen Fall, wo der reflektierte Strahl *ae* parallel zu *lo*

verläuft, also diesen erst in der Unendlichkeit schneiden würde, verlegt R. Bacon das Bild nach *e* selbst. Sonst entsprechen den Lagen des Objektes *m*, *k*, *q* die Bildpunkte

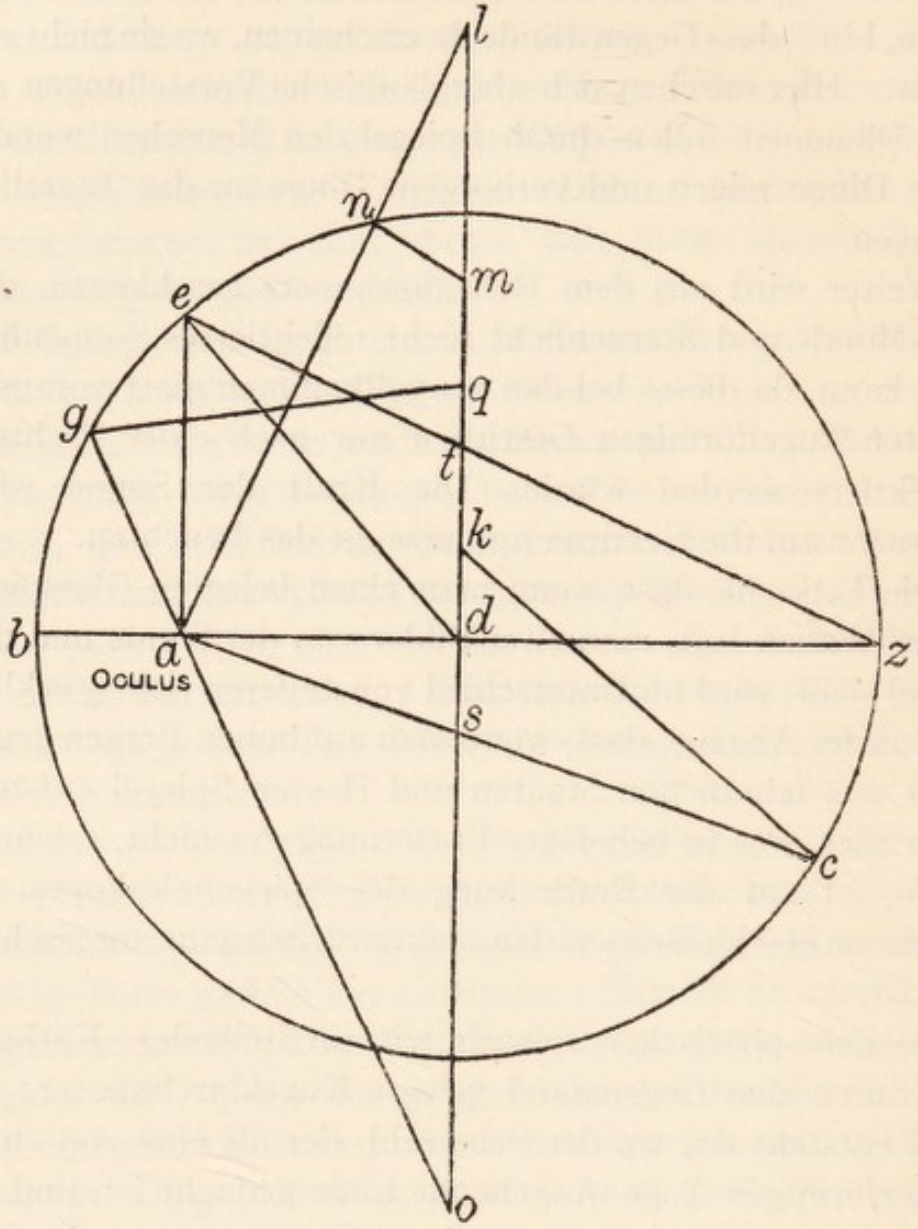

FIG. 1.

l, *s*, *o*. Liegt der Gegenstand im Mittelpunkt, so liegt das Bild auch dort.

Bei der Lehre von der Lage des Bildes in sphärischen Spiegeln ist aber von R. Bacon wie auch von anderen älteren Gelehrten der Nachweis *nicht* geliefert, dass alle

Strahlen, die von einem Punkt ausgehen, sich wiederum in einem Punkt schneiden.

Anschliessend an diese Betrachtungen und an Ibn al Haitam wird bemerkt, dass man je nach der Lage des Auges von einem Gegenstand im Hohlspiegel vier, drei, zwei oder auch nur ein Bild erhalten wird ; dabei weist R. Bacon darauf hin, dass wir beim Sehen mit zwei Augen eigentlich zwei Bilder sehen müssten ; da diese aber sehr nahe aneinander liegen, so sieht man doch nur eines. Von Interesse ist endlich die Bemerkung, dass je nach dem Abstand der Gegenstände in Hohlspiegeln verschiedene Bilder entstehen ; dabei betont R. Bacon, dass er hier eine Ableitung in der Katoptrik verbessert habe. Die Zylinder- und Kugelspiegel werden nur ganz kurz erwähnt.

Die bekannte Aufgabe von Ibn al Haitam, den Reflexionspunkt bei einem der obigen Spiegel zu finden, wenn Auge und Objekt gegeben sind, behandelt R. Bacon nicht. Auf die wichtigen Ausführungen über die parabolischen Hohlspiegel wird Herr Dr. Würschmidt eingehen.

Auch die Frage, ob die Farben am Schweif des Pfaues und am Hals der Taube wirkliche Farben sind, oder ob sie nur von verschiedenen Einfallswinkeln u.s.w. herrühren, wird behandelt.

Im Anschluss an Ptolemäus erörtert R. Bacon die Brechung des Lichtes, und zwar sowohl an Kugelflächen, als auch an einer ebenen. Zunächst wird der allgemeine Satz aufgestellt, dass beim Uebergang aus einem dünneren in ein dichteres Medium der gebrochene Strahl zwischen die geraden Strahlen und das Lot im Brechungspunkte fällt, beim Uebergang aus einem dichteren in ein dünneres Medium aber der gerade Strahl zwischen Lot und gebrochenen Strahl fällt.

Messungen über die Abhängigkeit des Ablenkungswinkels — dieser war es der den alten Optikern zuerst entgegentrat — von dem Einfallswinkel teilt R. Bacon nicht mit ; direkt

erwähnt er auch den Apparat von Ptolemäus und Ibn al Haitam nicht, deutet aber vielleicht in *Op. majus*, i, S. 113 (Ausgabe von Bridges), auf ihn hin.

Weiter wird das Bild eines Punktes, der sich in einem anderen Medium als dem Auge befindet, dorthin verlegt, wo der zum Auge gelangende Strahl bei seiner Verlängerung die Kathete, d. h. das von dem Objekt auf die Grenzfläche gezeichnete Lot, schneidet. Bei sphärischen Spiegeln ist diese Kathete der durch den betreffenden Punkt gehende Radius.

Wie andere, so beschäftigt auch R. Bacon die Frage nach dem Grund, warum ein Stab im Wasser geknickt und eine Münze im Wasser gehoben erscheint ; er geht im Anschluss an seine Vorgänger richtig vor und verlegt das Bild eines Punktes des Objektes in den Schnittpunkt der Kathete mit der Verlängerung des Sehstrahles, der zum Objekt hin gebrochen wird.

Fast zu derselben Zeit hat Friedrich II. dies Problem aufgeworfen und sich an ägyptische Gelehrte um Auskunft gewendet. Diese haben ihm aber eine ganz ungenügende, rein spekulative Antwort gegeben. So sehen wir, wie in Aegypten die Kenntnis der bedeutenden Leistungen von Ibn al Haitam verloren gegangen war, während sie im christlichen Abendland durch Uebersetzungen bekannt waren und von R. Bacon benutzt wurden.

Bei sphärischen Flächen zwischen zwei Medien wird bei der Untersuchung angenommen, dass sich Auge und Mittelpunkt auf einem Radius befinden. Durch Zeichnungen werden die Fälle erläutert, dass die dem Auge zugekehrte Fläche konvex oder konkav ist, und dass das Auge zwischen Mittelpunkt und Kugelfläche oder auf der anderen Seite des Mittelpunktes gelegen ist.

Bei der Untersuchung der Brechung im Auge werden, was wichtig ist, nicht nur die von einem Objekt senkrecht auf die Hornhaut und Linse fallenden Strahlen untersucht, sondern

auch die schräg auftreffenden ; so wird gezeigt, dass von einem Punkt nicht nur *ein* Strahl zu der Linse, die als das eigentliche perzipierende Organ betrachtet wird, gelangt, sondern eine ganze Schar, die beim Auftreffen auf die Hornhaut entsprechend abgelenkt werden.

Die Brennkugel behandelt R. Bacon zweimal in *Opus Majus*, Bd. i, S. 113, und ii, S. 471. Da es sich um einen Versuch von R. Bacon selbst handelt, so soll die Stelle mitgeteilt werden :

Wir nehmen einen sphärischen Kristall oder ein rundes Glasgefäss, füllen es mit Wasser und lassen die Sonnenstrahlen hindurchfallen ; dann ergibt sich auf der Seite, welche der

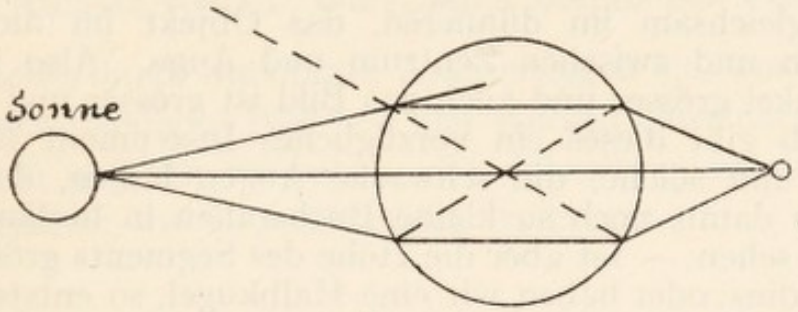

FIG. 2.

Sonne abgewendet ist, ein Brennpunkt, der leicht entzündliche Stoffe zum Brennen bringt. Dies wäre nicht möglich, wenn nicht beim Uebergange des Strahles in verschiedene Mittel Brechung einträte. Der durch den Mittelpunkt des Gefässes gehende Strahl wird nicht gebrochen, da er lotrecht zum Glase, zum Wasser und zur umgebenden Luft ist. Dabei gilt das Zentrum der Kugel zugleich als Mittelpunkt für die inneren und äusseren Medien. Alle anderen Strahlen, die nicht durch das Zentrum gehen, fallen schief auf und werden beim Eintritt in die Kugel zum Einfallslot und beim Austritt aus derselben über den geraden Gang hinaus gebrochen, so dass der gebrochene Strahl den durch das Zentrum gehenden Achsenstrahl schneidet. In denselben Schnittpunkt fallen dann auch noch unzählige andere Strahlen, so dass ein Brennpunkt entsteht.

Zu beachten ist, dass die von R. Bacon gegebene Figur nicht richtig ist ; der Irrtum kommt daher, dass in ihr die Divergenz der Strahlen, die von der Sonne kommen, eine

viel zu grosse ist ; daher werden die Strahlen in der Kugel untereinander parallel. Die ganze Ableitung und Behandlung steht hier weit hinter derjenigen zurück, die Ibn al Haitam in seiner Schrift über die Brennkugel gegeben hat ; diese hat R. Bacon offenbar nicht gekannt.

Im Anschluss an die Brechung an sphärischen Flächen hat R. Bacon auch die vergrössernde Wirkung von Kugelsegmenten genau erkannt und sich von ihrer Ursache Rechenschaft zu geben gesucht. Er sagt :

Nimmt man ein Kugelsegment aus Kristall oder Glas und ist die Höhe des Segments kleiner als der Radius, so sieht man Buchstaben und kleine Gegenstände grösser, wenn man die konvexe Seite dem Auge zukehrt. Denn das Auge ist dann gleichsam im dünneren, das Objekt im dichteren Medium und zwischen Zentrum und Auge. Also ist der Sehwinkel grösser und auch das Bild ist grösser und näher. Deshalb gibt dieses ein vorzügliches Instrument für alte Leute und solche, die schwache Augen haben, denn sie können damit noch so kleine Buchstaben in hinlänglicher Grösse sehen. — Ist aber die Höhe des Segments grösser als der Radius, oder haben wir eine Halbkugel, so entsteht der Fall, dass das Objekt ausserhalb des Zentrums des Mediums zu liegen kommt. Das Bild rückt in die Ferne und wird ebenfalls grösser. Nimmt man Kristallkörper mit ebener Fläche, so treten ähnliche Erscheinungen zu tage, doch ist die konvexe Form besser.

Weiter sagt R. Bacon :

Durch das Sehen nach gebrochenen Strahlen können sich auch sehr grosse Dinge als sehr klein darstellen. Ebenso kann, was sehr weit entfernt ist, ganz nahe gesehen werden und umgekehrt. Denn es können durchsichtige Medien (*perspicua* ; hier nicht Spiegel) so für das Auge und das Objekt angeordnet werden, dass die Strahlen dorthin gebrochen werden, wo und unter welchem Winkel wir wollen, so dass wir ein Ding in der Nähe und in der Ferne sehen können. Und so können wir aus unglaublicher Entfernung die kleinsten Buchstaben lesen. Und da wir den Sehwinkel beliebig vergrössern können, so muss ein Knabe wie ein Riese, ein Mann wie ein Berg erscheinen und ein Heer als riesig gross erscheinen und ebenso, was weit entfernt ist, ganz nahe und

umgekehrt. Ja, wir würden Sonne und Mond gleichsam vom Himmel herabziehen und damit die Feinde schrecken können.

Neben den Erscheinungen der physiologischen und physikalischen Optik hat R. Bacon sich auch eingehend mit der Lehre vom *Regenbogen* befasst und bilden diese Untersuchungen einen wesentlichen Teil der *scientia experimentalis*. Wir heben nur heraus, dass er den Regenbogen auf eine Reflexion von Strahlen zurückführt, aber nicht auf eine solche von ebenen Spiegeln, sondern von Konvexspiegeln, die von den Wassertropfen geliefert werden.

Die interessanten Angaben über die Lochkamera werden in dem Aufsatz von Dr. Würschmidt besprochen werden.

Ich hoffe, durch die obigen Ausführungen ein, wenn auch nur unvollständiges, Bild von den Werken eines derjenigen Gelehrten gegeben zu haben, die, je mehr man sich mit ihnen befasst, um so bedeutender erscheinen.

VIII

ROGER BACONS LEHRE VON DER SINNLICHEN SPEZIES UND VOM SEHVORGANGE

Von SEBASTIAN VOGL

I. Die Spezieslehre

Seit dem höchsten Altertum galt in einigen philosophischen Schulen der Grundsatz: Nichts ist im Verstande, was nicht vorher im Sinn war: *nihil est in intellectu, quod prius non fuerit in sensu.*

Im Mittelalter nahmen ihn die Scholastiker an, unter denen ganz besonders Roger Bacon mit seiner eingehenden Erörterung über die Fortpflanzung der Spezies und ihre Wahrnehmung im Sinnesorgane hervorragt.

Auch in der Neuzeit hat es nicht an Verteidigern obigen Satzes gefehlt. Insbesondere haben sich die gelehrten Landsleute Roger Bacons, nämlich Bacon von Verulam, Hobbes und Locke, der Erforschung dieses Prinzipes gewidmet und gerade letzterer ihm eine besondere Erklärung gegeben, nach der man ihn als den Vater des neueren Sensualismus betrachtet.

Da Locke wie seine Vorgänger noch in den Theorien der Scholastik gebildet war, von denen aus sie sich zu ihrer selbständigen Auffassung durchrangen, so mag es nicht ohne Interesse sein, Spezieslehre und Sehvorgang, diese wichtigen Momente für die Erkenntnislehre, nach dem berühmten Franziskanermönch Roger Bacon kennen zu lernen.

Wir wollen zunächst einen kurzen Ueberblick über die Spezieslehre bei den Scholastikern überhaupt geben und dann Roger Bacons Theorie in den Hauptzügen aufführen.

Zur Zeit der Hochscholastik bildete Aristoteles die Grundlage für die Erkenntnistheorie. Genau wie bei ihm ist es Grundlehre, dass jeder Begriff nur mit Hilfe sinnlicher Vorstellungen von den äusseren Dingen gewonnen werden kann. Beim Gesichtssinn wäre der das Auge treffende Reiz eines Baumes, die Fortleitung dieses Reizes zum Gehirn und weiterhin die Umwandlung desselben in den psychischen Akt der Wahrnehmung des Baumes, die Vorbedingung für das Entstehen des Begriffes Baum. Die vom Gegenstand ausgewirkten Formen, die sich im psychischen Akte zum Bilde gestalten und auch später wieder Nachbild und auch ohne unmittelbare Wahrnehmung nur durch das Vorstellungsvermögen wieder erneuert werden können, nennen die Scholastiker *species sensibilis*: Spezies, weil es gleichsam das Bild des Baumes ist; sensibel, weil es mittels des Sinnesorganes gewonnen resp. festgehalten oder erneuert wird. *Species sensibilis* ist also eine anschauliche Bezeichnung des Eindruckes, der vom Reize auf das Sinnesorgan ausgeübt, und vom Organe, das beseelt ist, aufgefasst wird. Wir können *species sensibilis* mit Bild oder Erkenntnisbild übersetzen; dies ist aber nicht so gemeint, dass das Ding draussen und ein Bild von ihm drinnen in der Seele ist, sondern so, dass das Bild draussen und drinnen zugleich ist, draussen in seinem ganzen Dasein, drinnen als Bild, gleichsam durch eine ideale Repräsentation. Dasjenige, wodurch das Ding Bild wird, ist sein eigentlicher Wesenskern, den es bei Abstreifung der Materialität und beim Einzuge in unser Inneres beibehält.

Für die Art und Weise, wie sich das Denken der sensiblen Spezies bemächtigt, sei nur kurz darauf verwiesen, dass die sensible Spezies selbst etwas, wenn auch nicht gerade Körperliches, so doch Körperhaftes ist, das im körperlichen Organ als seiner Bedingung für die Wahrnehmung haftet. Das Denken aber ist eine rein geistige Tätigkeit. Da helfen sich die Scholastiker dem Aristoteles folgend dadurch aus der Schwierigkeit, dass sie an dieser Stelle des Ueber-

ganges nicht den Körper auf den Geist, sondern umgekehrt den Geist auf den Körper wirken lassen. Das Sinnliche muss seiner rohen Formen entkleidet werden und gleichsam durch den Schmelztiegel des tätigen Verstandes (*intellectus agens*) hindurchgehen; hier erst, durch dieses Licht, wie sie es nannten, gewinnen die sensiblen Spezies den Charakter der Intelligibilität.

Wenden wir uns nun der Spezieslehre bei Roger Bacon zu. Derselbe widmet ihr einen ausführlichen Traktat: *De multiplicatione specierum*; ausserdem nimmt auch die *Perspectiva* vielfach Bezug darauf.

1. *Name und Begriff der Spezies*[1]

Jedes Wirksame, so führt Bacon aus, sei es eine Substanz oder ein Akzidens, eine körperliche wie eine geistige Substanz, betätigt sich durch seine Kraft, die es auf die ihr unterstellte Materie ausübt, und zwar die Substanz mehr als das Akzidens, die geistige Substanz mehr als die körperliche. So wirkt das Sonnenlicht (*lux*) seine Kraft in der Luft als Licht (*lumen*), das sich über die ganze Welt hin ergiesst. Und diese Kraft hat verschiedene Namen. Sie heisst Aehnlichkeit (*similitudo*) und Bild (*imago*) mit Rücksicht auf das, wovon sie ausgeht, dem sie ähnlich ist und das sie nachahmt; *species* mit Rücksicht auf die Sinne und den Intellekt, wie auch Aristoteles und die Naturkundigen sie gebrauchen; *idolum* in Bezug auf die Spiegel; *phantasma* und *simulacrum* bei den Traumerscheinungen, weil diese Spezies die Sinne durchdringen und bis zu der inneren Seele gelangen und in den Träumen wie die Dinge selbst erscheinen, von denen sie stammen und denen sie ähnlich sind; *forma* heisst die Spezies im Sprachgebrauch des Alhacen (Ihn al Haitam), des Autors der Optik; *intentio* im gewöhnlichen Sinn der Naturkundigen, indem sie sagen will, dass sie nicht das Ding selbst ist, sondern nur eine

[1] Bridges, *Opus Majus*, i. 109 ff.; ii. 409 ff. (*De multiplicatione specierum*): Brewer, *Opus Tert.*, cap. 31 ff.

Beziehung zu dem Dinge, d. i. die Aehnlichkeit; *umbra philosophorum: umbra,* weil die Spezies nur in einem zweifachen Falle gut wahrnehmbar ist, nämlich an einem Strahl, der durch eine Oeffnung in einen dunklen Raum fällt, und wenn die Spezies stark gefärbt ist, d. h. wenn Licht durch ein stark gefärbtes Glas fällt, so sieht man im abgekehrten, schattigen Raum die Farbe des Glases — *philosophorum,* weil nur die tüchtigen Philosophen ihre Natur und Wirkung erkennen. Sie heisst ferner Kraft (*virtus*) mit Rücksicht auf Entstehen und Vergehen. Wie die Sonne ihre Kraft auf die Dinge der Welt erstreckt, um Entstehen und Vergehen zu bewirken, so sagen wir von jedem Agens, dass es seine Kraft auf ein Patiens auswirkt. Eindruck (*impressio*) heisst die Spezies, weil sie den Eindrücken ähnlich ist, weshalb Aristoteles ihre Entstehung mit dem Eindrucke vergleicht, den ein Siegelring auf Wachs macht, wenn dies auch nicht überall zutrifft. *Passio* endlich wird sie genannt, weil das Medium und der Sinn bei Aufnahme der Spezies eine Veränderung in ihrer Substanz erleiden. Spezies ist aber hier nicht als eines der Aristotelischen Prädikabilien zu fassen, welche die Scholastiker Universalien nennen, sondern als der erste Effekt eines natürlichen Agens.

Unter Spezies versteht demnach Bacon das von einer wirkenden Ursache Ausgewirkte, und zwar zunächst dasjenige, was von der wirkenden Ursache kraft ihrer eigenen Natur ausgewirkt wird und somit eine Aehnlichkeit mit ihr hat. Es ist also nicht mehr lediglich die Bedeutung, die *Species sensibilis* in der Scholastik sonst hat, obwohl diese der Ausgangspunkt ist, sondern überhaupt jede Wirkung.

2. *Das Wesen der Spezies*[1]

Hinsichtlich des Wesens der Spezies ist zu sagen, dass sie dem Agens ähnlich ist in der spezifischen Wesenheit, in der Wirkung und in der Begriffsbestimmung. Denn das Agens hat das Bestreben, sich das Patiens zu assimilieren.

[1] Bridges, ii. 410 ff.; i. 119.

Ist das Agens Feuer, so macht es das Patiens zu Feuer, ist das Agens Wärme, so macht es das Patiens zu Wärme, ist es Licht, so zu Licht u.s.w.[1] Daraus, sowie aus dem Beispiele, bei dem das Licht durch eine Oeffnung fällt, und dem anderen, bei dem das Licht durch ein stark gefärbtes Glas hindurchgeht, ersieht man, dass die Spezies des Lichtes wieder Licht ist, die Spezies der Farbe wiederum Farbe, die Spezies der Wärme wiederum Wärme. Aber die Spezies, die der Mensch wirkt, ist nicht Mensch; denn ist auch die Spezies von derselben spezifischen Natur, so ist sie es doch auf einer unvollständigen Seinsstufe, die im letzteren Falle gar nicht vollständig werden kann. Farbe, Licht und Wärme können aber ihrer Natur nach eine stärkere Spezies wirken als alle anderen Dinge.

Daraus ergibt sich eine weitere Wahrheit, nämlich dass der Effekt, der dem Agens im Wesen ähnlich ist, nur einer sein kann. Dieser heisst der *effectus univocus* und seine Entstehung *generatio univoca*. Es gibt aber noch andere Effekte, die *effectus aequivoci*, und deren Entstehen *generatio aequivoca*, heissen. So ist das Licht in der Luft oder an einem Stern, das von der Sonne kommt, ein *effectus univocus*, Verwesung und Tod, die aus dem Sonnenlichte folgen, sind *effectus aequivoci*.[2] Aber am Anfange, solange der Effekt unvollständig ist, spricht man nur von Spezies, Kraft u. dgl., und das so lange, als das Patiens in seiner spezifischen Natur verbleibt; assimiliert sich aber das Patiens dem Agens mit Hilfe jener Spezies und Kraft, wie wir beim Holze sehen, das durch Aufnahme der Feuerspezies Feuer fängt, so wird die spezifische Natur des Patiens aufgehoben und der komplette Effekt hervorgerufen; dann spricht man nicht mehr von Spezies, sondern bezeichnet es mit dem Namen des Agens selbst. Das Holz wird dann Feuer, Flamme, Kohle. Die Spezies von Feuer und das Feuer selbst unterscheiden sich nur wie komplett und inkomplett.

[1] Bridges, ii. 411. [2] Ibid. 413–4.

Dies gilt aber nur bei den irdischen Dingen, die der Zerstörung unterliegen. Bei den (nach scholastischer Auffassung) unzerstörbaren Himmelskörpern kann ganz wohl die Spezies zu einem kompletten Effekt vervollständigt werden, ohne dass das Agens selbst dort entsteht. Sonne und Mond sind geschaffen, ein vollkommenes Licht zu haben.[1] Bei der Mondfinsternis, bei welcher der Mond im Schatten ist, bemerkt man noch ein rötliches Licht ; das ist eine schwache Spezies des Lichtes, die von dem Lichte kommt, das an den Schattengrenzen vorübergeht. Nachher wird das Licht auf dem Monde wieder komplett und klar. Es wird aber der Mond nicht zur Sonne. Das Licht kann sich vervollständigen, aber nicht die Spezies der Sonnensubstanz.

Bacon erörtert ferner eingehend die Frage, was denn alles eine Spezies wirkt.[2] Es sind dies in erster Linie die eigentlichen sensiblen Qualitäten wie Licht, Farbe, Ton, Kälte, Wärme. Sie üben einen Reiz auf die Sinnesorgane aus und ganz allgemein nimmt der Sinn die Spezies derselben auf. Eigenartig ist es beim Schall, was hier nicht eingehender erörtert werden soll. Andere Prädikamente wie Grösse, Lage, Bewegungszustand, Relation (Zusammenordnung mit anderen Dingen) u.s.w., die durch den *sensus communis* (das Zentrum, welches alle Sensationen empfängt, die Einheit des sensitiven Bewusstseins ermöglicht und die Sensationen miteinander vergleichen kann) wahrgenommen werden, wirken keine Spezies. Grösse und Gestalt folgen aus den Spezies von Licht und Farbe, die von den Objekten ausgehen. Auch die Materie ohne Form wirkt keine Spezies, weil sie nur leidend ist.

Um das Wesen der Spezies genauer zu bestimmen, muss man die *potentia activa* eines Dinges von seiner *potentia receptiva* unterscheiden. Letztere kommt hier nicht in Frage, denn sie ist dasjenige, vermöge dessen die Materie die Form vom Schöpfer aufnehmen konnte. Würde in der Materie nur eine *potentia receptiva* für die Spezies angenom-

[1] Bridges, ii. 415 ; i. 128. [2] Ibid., ii. 418 f. ; vgl. ii. 56, 72 f.

men, so müssten wir die wirkende Ursache als Geberin der Form, die Spezies als Form ansehen, was sie nicht ist. Sie ist auch nicht anzusehen wie etwa der Abdruck eines Siegels im Wachse, sondern sie entsteht im Patiens *per naturalem impressionem et eductionem de potentia materiae patientis* und zwar *per eductionem de potentia activa materiae patientis*, wobei die *actio naturalis* bis in die Tiefe des Patiens vordringt, wie aus dem Kapitel über die Art und Weise der Fortpflanzung der Spezies noch klarer ersichtlich sein wird.

Die Spezies einer Substanz ist Substanz, die eines Akzidens ist Akzidens, die eines Kompositums ist Kompositum, die Spezies eines Einfachen ist einfach, die Spezies der Materie ist Materie, die einer Form ist eine Form, die eines Universale ist universal und die eines Singulare singular.

Von grossem Interesse ist das Kapitel, das Roger Bacon der Substanz widmet.[1] Nach ihm wirken auch die Substanzen eine Spezies. Diese Lehre ist den übrigen Scholastikern fremd. Auch Aristoteles scheint die Ansicht zu vertreten, dass die Substanzen nicht aus sich selbst heraus wirken, sondern durch ihre Grundqualitäten.

Es kann ja, wie Bacon ausführt, ein Akzidens nicht erzeugt werden, ehe nicht sein Subjekt erzeugt ist. Also muss immer zuerst die Substanz ihre Spezies erzeugt haben, ehe das Akzidens daran seine Spezies heften kann. Die Spezies der Substanz kann allerdings nicht von den Sinnen und auch nicht vom *sensus communis* erkannt werden, aber sie wird durch einen gewissen geistigen Vorgang erfasst, welcher demjenigen verwandt ist, vermöge dessen das Lamm im Wolfe seinen natürlichen Feind erkennt und vor ihm flieht. Das Lamm, sagt Bacon, nimmt die Spezies der Komplexion des Wolfes wahr, die das Organ des Wahrnehmungsvermögens (*aestimativa*) infiziert und verletzt; deshalb flieht es den Wolf beim ersten Anblick, wenn es ihn auch früher nie gesehen hat. Das ist die Spezies der Substanz, die

[1] Ibid., ii. 419 ff.; vgl. ii. 75.

dem Lamme selbst schädlich und feindlich ist. Dagegen bestärkt die Spezies einer freundlichen und ansprechenden Substanz von Seiten eines anderen Lammes das Organ der *facultas aestimativa* und darum flieht ein Lamm das andere nicht. Deshalb kann die sensitive Seele ganz gut die Substanz durch deren Spezies wahrnehmen, wenn auch nur wenige dies einsehen und der gewöhnliche Haufe der Naturkundigen behauptet, dass die substantielle Form keinen Einfluss auf den Sinn ausübt. Es wird diese Spezies nicht von den fünf äusseren Sinnen und auch nicht vom *sensus communis* aufgenommen, sondern nur von der *vis cogitativa* und *aestimativa* als den Teilen der sensitiven Seele. Von den fünf Sinnen und vom *sensus communis* werden nur die Akzidentien erfasst, obgleich die Spezies der substantiellen Formen durch sie hindurchgehen. Und da jede geschaffene Substanz aus Materie und Form zusammengesetzt ist, muss die Spezies der Substanz von der ganzen Zusammensetzung ausgehen, also von der Materie und der Form, nicht von der Form allein.

Nach Thomas von Aquin nimmt das Tier in den sinnlichen Objekten etwas wahr, was keiner besonderen Sensation entspricht. Das Lamm flieht den Wolf, nicht seiner Hässlichkeit wegen, sondern weil es ihn als gefährlich erkennt; der Vogel sucht das Reisig nicht um seiner Schönheit willen, sondern weil es ihm zum Bauen des Nestes dient. Die Fähigkeit, diese Beziehungen (*intentiones*) wahrzunehmen, heisst *facultas aestimativa*. Sie ist bei den Tieren von rein instinktartigem Charakter, im Menschen aber von psychologischer Art und hat den Namen *vis cogitativa* oder *ratio* (Vernunft)*particularis* (weil sie sich nicht auf das Allgemeine wie der Verstand bezieht).

Bacon entgegen lehrte später Locke die Unerkennbarkeit der Substanz, ähnlich wie die der Kraft. Sie sind nach ihm nur Hilfsbegriffe unseres Verstandes, wodurch wir uns die bei den Naturerscheinungen beobachtete Gesetzlichkeit

verständlich zu machen suchen. Wir können weder die Substanz für sich, ausserhalb ihrer Eigenschaften oder von diesen gesondert erkennen, noch können wir eine Kraft direkt und von ihren Wirkungen getrennt wahrnehmen. Gleichwohl würde aber ohne die Idee von Substanz und Kraft die objektive Welt unseres Bewusstseins sozusagen in Staub zerfallen (Schultze).

Wichtig für die Sehtheorie Bacons ist die Annahme, dass auch die Sinnesorgane eine Spezies wirken. Jede körperliche Substanz, sagt er, kann eine Spezies wirken, also auch die Sinnesorgane. Beim Auge ist dies an sich klar.[1] Wir sehen das Auge eines anderen und unser eigenes im Spiegel. Viele leugneten, dass vom Auge etwas ausgehe, auf die Annahme hin, dass das Sehen nur durch Aufnahme nach innen sich vollziehe und nicht durch Aussenden, überhaupt nicht dadurch, dass irgend etwas vom Auge entstehe, das wirke und zum Sehakte beitrage. Dass das aber falsch ist, erhellt aus der Metaphysik des Aristoteles (!) ausdrücklich, dann aus Tideus *de Aspectibus* ganz klar und aus der ganzen Optik des Ptolemaeus, und dies hält gegen alles stand, was Alhacen, Avicenna und Averroes dagegen lehren wollen. Wie die leblosen Dinge eine leblose Spezies wirken, so wirkt das Belebte eine Spezies, die gewissermassen eine Kraft der Seele hat. Denn wie sich ein lebloser Gegenstand zu seiner Spezies verhält, die ihm ähnlich ist, so das beseelte Wesen zu der ihm ähnlichen Spezies. Daraus folgt nicht, dass das Medium (Luft oder sonst etwas Durchsichtiges) beseelt wird, sondern es wird nur dem beseelten Wesen durch die aufgenommene Spezies assimiliert.

3. *Art und Weise der Fortpflanzung der Spezies*[2]

Die Physik der Scholastik war wesentlich antiatomistisch. Nichts erklärte sie durch rein mechanische Mittel, auf alles dehnte sie die Begriffe des Aktes, der Form und der Kraft

[1] Bridges, ii. 65 f. [2] Cf. Bridges, ii. 429 ff.; vgl. ii. 14.

aus. Die Araber hingegen huldigten mehr der atomistischen Welterklärung. Diese leuchtet auch bei Bacon durch, indem er die Art und Weise der Fortpflanzung der Spezies nach dem Muster des Arabers Alhacen erklärt.

Die Lehre Alhacens über die Fortpflanzung der Spezies kommt unserer Auffassung von einem Netzhautbilde äusserst nahe. Alhacen nimmt nämlich an, dass die Gegenstände punktweise auf das Auge wirken, so dass jeder Punkt von Licht und Farbe des Objektes auf der Netzhaut sich abbildet und dort wahrgenommen wird durch das *ultimum sentiens*, wobei die Sehkraft über die ganze Retina wirksam gedacht ist. Er sagt: Hat der Gegenstand eine einzige Farbe, so wird jener Teil des hohlen Nervs (Netzhaut), als eines empfindenden Körpers, auch nur *eine* Farbe haben. Sind aber die Teile des Sehobjektes von verschiedener Farbe, so werden auch die Teile jener empfindenden Stelle der Netzhaut von verschiedener Farbe sein und das *ultimum sentiens* nimmt die Farbe des Objektes aus der Färbung wahr, die es an jenem Teile vorfindet.

Hören wir nun Bacon: Alhacen, schreibt er, lehrt im zweiten Buche seiner Optik, dass in der Höhlung des *nervus communis* (nach der *Perspectiva* ist damit die Retina gemeint) der beiden Augen und ebenso auf dem Teile des empfindenden Organs, nämlich der *anterior glacialis*, welche der vordere Teil der Pupille ist, die Umrisse des Objektes abgebildet werden. Diese Umrisse gehören zu dem allgemein Wahrnehmbaren, wie aus demselben Buche hervorgeht, weshalb Quantität und Gestalt u.s.w. einen Eindruck und eine Spezies im Organe zu wirken scheinen, und zwar vorher schon in der Luft. Dies findet aber nach Alhacen nicht deshalb statt, weil die Grösse eine Spezies wirkt, sondern weil von der ganzen Oberfläche des Dinges die Spezies der Farbe und des Lichtes kommt. Dabei werden die Spezies von Farbe und Licht, die von den einzelnen Teilen des Dinges kommen, nicht in einem Teile der Pupille vermischt, sondern werden auf der Oberfläche der Pupille unterscheidbar angeordnet in wahrnehmbarer Quantität und nach der Zahl der Teile des Objektes, damit das Auge unterschiedlich die ganze Farbe oder das ganze Licht des-

selben erfasse. So also wird in der Pupille die Grösse des Objektes abgebildet, d. h. die Farbe der ganzen Grösse oder das Licht in der Weise, dass dort nur die Spezies der Farbe oder des Lichtes auf der Pupille angeordnet ist und nicht die Spezies der Grösse selbst. Ganz ähnlich findet die Abbildung der Umrisse des Gegenstandes und ihre Abzeichnung auf dem empfindenden Gebiet (Linse) und dem *nervus communis* (Netzhaut) in der Weise statt, dass Farbe oder Licht der Umrisse ihre Spezies wirken, die sich abbildet und im Organ und Medium anordnet, aber nicht die Umrisse selbst. So nämlich will der Autor verstanden sein.

Auf Grund dieser Annahme finden wir es nur folgerichtig, wenn Bacon weiterhin[1] die Fortpflanzung der Spezies wie eine Strahlung auffasst, die nach allen Linien, Winkeln und Figuren stattfinden kann, je nachdem die Naturgesetze es verlangen. Als Grundlage hierfür dient ihm ein Traktat ‘ über die physikalischen Linien, Winkel und Figuren, nach welchen alle Wirkungen der Natur sich vollziehen,’ von seinem Lehrer Robert Grosseteste, dem nachmaligen Bischof von Lincoln. Und zwar findet die Strahlung von jedem Punkte oder kleinsten Teile eines Dinges statt und dazu nach allen Richtungen hin, so dass jeder Lichtpunkt gleichsam unzählige Strahlen nach allen Richtungen hin entsendet, nach oben und nach unten, nach vorne und nach rückwärts. Wo also auch das Auge sich befinden mag, überall wird es von einem Strahle getroffen, wenn nicht ein Hindernis dazwischen liegt. Das Auge sieht aber nur durch die Spezies, die herankommt; also muss zu ein und demselben Punkte eine strahlenförmige Spezies (*species radiosa*) kommen.

Die Fortpflanzung findet ferner nach *geraden* Linien statt. So verlangt es die Natur und durch Versuche lässt sich dies augenfällig zeigen. Bacon beruft sich dabei auf Alkindi, der in seiner Optik den geradlinigen Strahlengang an dem Schatten nachweist, den die Körper werfen, und an den Strahlen, die durch ein Fenster einfallen.

Die geradlinige Fortpflanzung findet indes nur so lange

[1] Bridges, ii. 458; vgl. i. 117.

statt, als sie in einem gleichmässig dichten Medium verläuft. Aendert sich die Dichte, so werden die Strahlen von ihrer Richtung abgelenkt oder ganz geknickt, d. h. sie folgen den Gesetzen der Refraktion und Reflexion.

Wie aber findet die Fortpflanzung des Strahles im Medium selbst statt? Sind es vielleicht kleinste Teilchen, die sich ablösen und fortgeschleudert werden? Letzteres kann nicht sein; die Fortpflanzung findet nicht durch Emission statt, sondern, wie schon gesagt, durch Eduktion aus der aktiven Potenz der Materie. Die Aktion der Körper aufeinander übt sich nach der Lehre der Scholastiker nicht durch die blosse lokale Bewegung aus, sondern vielmehr durch die Eduktion der Potenz in den Akt. Die vorherrschende Idee in dieser Theorie ist, dass die physische Welt nicht durch die blosse Ausdehnung erklärt wird, sondern dass die Natur der Körper die Annahme von Aktualitäten und Kräften fordert, die nicht durch blosse geometrische Grössen gemessen werden können. Durch die Geometrie erklärt man die Phänomene nur bis zu einem gewissen Grade; viele Dinge aber bleiben übrig, von denen man nur Rechenschaft geben kann, wenn man sich auf den Dynamismus oder die Theorie der Aktivitäten beruft. Bacon lehnt die Emanationstheorie der alten Philosophen Epikur und Lukretius ab, die später Newton in verfeinerter Form wieder zur Erklärung der Fortpflanzung des Lichtes annahm. Seine Ansicht ist somit näher verwandt mit der von Young.

Hören wir nun seine Erklärung selbst:[1]

Wenn öfters Ausdrücke gebraucht werden wie 'eine Spezies entsenden' u. dgl., so darf man sich das nicht so vorstellen, als ob vom Agens sich etwas ablöse, das weiter geht. Beim Agens haben wir nur Substanz und Akzidens, etwas Mittleres gibt es nicht. Nun kann aber kein Akzidens seinen Träger verändern und kein substantieller Teil wird verändert, ohne dass die ganze Substanz korrumpiert wird. Würde vom Agens etwas herausgehen, so müsste eine Zerstörung und Auflösung erfolgen, wie es bei den riechenden

[1] Bridges, ii. 431–43; vgl. 457.

Substanzen, z. B. beim Moschus oder Weihrauch, der Fall ist, wo beim Auflösen oder Verbrennen Teilchen frei werden und ausströmen. Anders ist es beim Licht. Die Himmelskörper, die am meisten Licht verbreiten, sind nicht korruptibel (nach mittelalterlicher Ansicht). Also kann die Spezies nicht etwas sein, das vom Agens fortgeht, und das Patiens kann nicht etwas aus dem Agens aufnehmen.

Das Agens erzeugt aber die Spezies auch nicht aus dem Nichts, ebensowenig bekommt es die Spezies irgendwoher ausserhalb seiner und ausserhalb des Patiens, um sie in das Patiens zu ergiessen. Sie muss also entweder durch Impressio entstehen, ähnlich wie Aristoteles nach dem Vorbilde des Siegelabdruckes in Wachs annahm, oder durch natürliche Veränderung und Eduktion aus der Potenz der Materie des Patiens. Nun reicht aber die Impressio auch nicht zur Erklärung hin, denn diese findet nur auf der Oberfläche des Patiens statt, wo durch Aufdrücken sich die einen Teile heben, die anderen senken, während doch die Wirkung bis auf den Grund des Patiens gehen muss. Uebrigens würden wir ja die eindrückenden Dinge selbst nicht sehen, während durch die Spezies die Dinge selbst sichtbar werden.

Es bleibt also nur übrig, die Entstehung der Spezies durch Veränderung (*immutatio*) oder Eduktion aus der aktiven Potenz der Materie des Patiens zu erklären. Das Agens wirkt seinen Effekt nicht durch Vereinigung seiner Substanz mit dem Patiens, sondern durch Reizwirkung auf die verborgene Aktivität der Materie des Mediums, die mit dem Agens verbunden ist. Dabei wirkt das Agens als Ganzes nach der Tiefe des Patiens und nicht bloss derjenige Teil des Agens, der das Patiens berührt. Sonst müsste ja ein kleiner Körper die gleiche Wirkung äussern wie ein grosser und es wäre gleich, wenn man die Hälfte der Sonne hinwegnähme. Es kann aber das Agens nicht im Grunde des Patiens sein hinsichtlich der Substanz, wohl aber der Kraft nach, um aus der Potenz des untersten Teiles des Patiens etwas zu erzeugen. Wir haben uns demnach den Verlauf der Fortpflanzung in der Weise zu denken, dass sich die Oberflächen von Agens und Patiens berühren. Dadurch entsteht Aktivität auf dem ersten Teil des Patiens und diese pflanzt sich fort bis auf den Grund dieses Teilchens, das ein Körper ist, so klein wir ihn auch nehmen wollen. Ist das erste Teilchen in Bewegung gesetzt, so hat es die Spezies aktuell und übt seine Wirkung auf das zweite Teilchen aus, dieses wieder auf das dritte und so fort bis zum Schlusse. Und so muss es sein, weil das Agens sich

nicht mit dem zweiten und den nachfolgenden Teilchen in Verbindung setzt und sie nur mittelbar anregt.

Mit dieser Auffassung hängt auch die weitere zusammen, dass die Spezies zwar materieller Natur, aber doch kein eigentlicher Körper ist, dennoch aber drei Dimensionen hat.[1]

Alhacen und Alkindi schreiben der Spezies Länge, Breite und Tiefe zu, woraus man entnehmen möchte, dass sie ein Körper sei. Dem ist aber nicht so. Denn die Spezies zerteilt nicht die Wände des Mediums, in dem die Fortpflanzung stattfindet. Auch können nicht zwei Körper an ein und demselben Ort sein. Da die Spezies aus der Potenz des Mediums, also aus einem materiellen Prinzip erzeugt wird, so kann sie keine andere Natur haben als die des Mediums selbst und wir müssen annehmen, dass sie dieselbe Natur mit dem Medium gemeinsam hat. Endlich existiert die Spezies nicht für sich, sondern in einem anderen Ding, das seine spezifische körperliche Natur beibehält sowie seinen Ort. Nur dort, wo das Medium die Spezies empfängt tritt eine Alteration ein. Der Strahl ist also eigentlich nichts, sondern nur ein momentan durch das Agens modifizierter Teil des Mediums und hat keine andere Dimension als diejenige, die dieser modifizierte Teil besitzt.

Nun entsteht eine Schwierigkeit. Nehmen wir an, das Medium sei in Ruhe und eine Spezies schreite im Medium fort und nehme verschiedene Orte ein. Dann möchte man meinen, die Spezies müsse ein Körper sein, da nur ein Körper in einem anderen ruhenden Körper eine Ortsveränderung hervorbringen kann. Darauf ist zu sagen : Weder das, was am ersten Teil sich befindet, verlässt diesen Teil, noch geht das, was am zweiten ist, auf den dritten über, sondern jeder Teil bleibt an seinem Platze. Es bewegt sich also nicht etwas von Ort zu Ort, sondern es findet vielmehr eine ununterbrochene Erneuerung statt, ähnlich wie beim Schatten, der stets neu und neu hinsichtlich des Ortes entsteht. Es findet keine eigentliche Ortsveränderung desselben Subjektes statt, sondern eine Erneuerung des Subjektes selbst ; denn die Spezies ist eine *passio medii* und hat keinen bestimmten Platz, wo sie gerade wäre.

Nehmen wir weiter an, das Agens sei andauernd in einem durchsichtigen Medium. Bleibt dann auch die erste Spezies,

[1] Bridges, ii. 459, 502.

solange das Agens gegenwärtig ist, oder vergeht sie und wird immer wieder durch eine neue ersetzt ? Nach Alhacen vergeht sie und entsteht immer wieder neu, und zwar sehr schnell. Sonst müsste die Brennstelle bei einem Spiegel noch viel intensiver sein, als wir sie wahrnehmen. Es gewinnt also die Natur des Mediums die Oberhand über die Spezies und vernichtet sie jedesmal sofort, wenn sie entstanden ist, und zwar in einem unmerklichen Zeitmoment. Uebrigens ist diese Zeit grösser bei einem dichteren, als bei einem dünneren Medium infolge des grösseren Widerstandes.

Wenn die Spezies kein eigener Körper ist, ist sie dann vielleicht geistiger Natur, wie manche glaubten ?[1] Sie ist materiell, denn sie entsteht aus einem Körper, befindet sich in einem körperlichen und materiellen Medium und hat auch materielle Wirkungen, wie Wärme, Fäulnis u.s.w. Sie ist von derselben Wesenheit wie der komplette Effekt, in den sie schliesslich übergeht. Der komplette Effekt aber ist materiell und folglich auch der inkomplette, die Spezies.

Da nun die Spezies materieller Natur und in den Dimensionen eins mit dem Medium ist, so möchte man meinen, sie müsste durch Luftbewegung[2] hin- und herschwanken, was beim Strahl durchaus nicht der Fall ist. Er bleibt ganz und gar an seinem Platze. Dies erklärt sich dadurch, dass jedes Luftteilchen, in dem sich die Spezies befindet, zwar fortwährend durch ein anderes erneuert wird, dass aber auch die Spezies sich auf dem Gange von Teilchen zu Teilchen erneuert. Diese Erneuerung fände auch statt, wenn die Luft in Ruhe wäre. Wechseln die Luftteilchen an derselben Stelle, so vergeht die Spezies sobald das Teilchen aus der Richtung des Strahles gekommen ist, und entsteht erst wieder wenn ein anderes an diese Stelle tritt.

4. *Kreuzung und Vermischung der Spezies*[3]

Da die Spezies materieller Natur sind, so müssen sich die gleichartigen, falls sie sich schneiden, vermischen und vereinigen können. Dabei gewinnt entweder die eine über die andere die Oberhand, wie beispielsweise ein starkes Licht ein schwaches überstrahlt, oder es wird ein mittleres daraus, wie es bei den Farben zu sein pflegt, oder sie wirken in

[1] Bridges, ii. 43 ff. ; 50 ff. ; 507 ff., vgl. i. 43.
[2] Ibid., ii. 504.
[3] Ibid., ii. 39–46, 511 ff.

gleicher Weise und verstärken sich, wie annähernd gleich starke Lichter ihren Effekt vergrössern können.

Treffen zwei oder mehrere Spezies zusammen, so haben sie im allgemeinen im Vereinigungspunkte verschiedene Richtung. Von diesen verschiedenen Richtungen sei nun eine lotrecht zum Auge, die anderen schief, dann kommt der lotrechte Strahl als Hauptstrahl, die schiefen aber nur durch die akzidentellen Strahlen, die sie verbreiten, zum Auge. Der Hauptstrahl übertrifft jedoch alle akzidentellen, so dass in Wirklichkeit kein gemischter Strahl wahrgenommen wird, wenn auch eine gemischte Spezies zum Auge gelangt, weil letztere nur akzidenteller Art ist.

Stellen wir, wie es Alhacen getan, vor eine kleine Oeffnung drei Lichter, und zwar so, dass die Strahlen von verschiedener Seite her sich in der Oeffnung vereinigen müssen, so können wir beobachten, dass die Strahlen nach der Vereinigung von einander unterschieden in der gleichen Richtung wie vorher weitergehen. Von einer Vermischung gewahren wir nichts. Trotzdem findet in der Oeffnung eine wahre Vermischung statt; da aber das Licht sich geradlinig fortpflanzt, so geht es auch jenseits des Loches in derselben Richtung weiter. Die Nebenstrahlen, die von den drei Hauptstrahlen ausgehen, werden von letzteren verdunkelt.

Bacon rollt hier das Problem auf, das erst Bernoulli (1738) richtig deutete, nämlich wie es möglich sei, dass Licht-, Wärme-, und Schallwellen ohne gegenseitige Störung auf unsere Sinne wirken können. Er glaubt dies dadurch erklären zu können, dass stets die lotrechte Wirkung wahrgenommen werde, die alle anderen übertreffe.

Die lotrechte Wirkung besitzt nach Bacon[1] überhaupt die grösste Kraft. Ein Stein, der lotrecht zur Erde fällt, habe eine viel grössere Wucht, als wenn er auf der schiefen Ebene hinabrollt, wobei ihn freilich der Augenschein täuscht.

[1] Bridges, i. 120–4; ii. 468, 539 f.: vgl. ii. 41: *Opus Tert.* (Brewer), 114.

Weiters wirkt dann ein gerader Strahl stärker als ein gebrochener, da der gebrochene an der Brechungsstelle ein Hindernis erfährt, das ihn schwächt. Der gebrochene ist wieder stärker als der reflektierte, weil bei letzterem das Hindernis grösser ist als bei ersterem. Gehen wir vom Punkte zum Körper über, so müssen wir annehmen, dass sich bei diesem die Wirkung nach einer Strahlenpyramide[1] vollzieht, deren Basis die Oberfläche des Objektes und deren Spitze in einem Punkte des Auges liegt. Die Achse der Pyramide (Kegel) ist dann der lotrechte Strahl, nach welchem die Wirkung am stärksten ist. Dabei wirkt ein kürzerer Kegel stärker als ein längerer, da der Abstand des ersteren vom Auge kürzer ist und deshalb die Kraft nicht so geschwächt wird. Dieser Grund überwiegt auch den, dass ein spitzer Kegel sich mehr der senkrechten Richtung nähert als ein stumpfer.

5. *Der Gang des Lichtes erfordert Zeit*[2]

Empedokles hatte gelehrt, dass das Licht Zeit braucht zur Fortpflanzung. Aristoteles widersprach ihm, indem er sich vom Scheine täuschen liess. Ihm folgten die meisten anderen, darunter Seneca und Heron, die Araber Alkindi, Averroes, später auch Leonardo da Vinci und sogar noch Bacon von Verulam und Descartes. Eine Ausnahme machten besonders der Araber Ihn al Haitam (Alhacen) und Roger Bacon. Aber erst O. Römer (1673) erbrachte den sicheren Beweis, dass das Licht zur Fortpflanzung Zeit braucht.

Bacon kennt, was seine Vorgänger lehren. Alkindi z. B. argumentiere: Wenn ein gewisser Raum in einer unmerklichen Zeit durcheilt wird, so muss ein doppelter Weg in einer doppelt so langen Zeit zurückgelegt werden u.s.f. Deshalb müsste doch die Zeit, die zum Wege von Osten nach Westen nötig ist, wahrnehmbar sein. Wir merken

[1] Bridges, ii. 39. [2] Ibid., ii. 67–74, 525–9.

aber nichts daran, also muss das Licht in einem einzigen unteilbaren Moment entstehen.

Demgegenüber sei jedoch zu bemerken dass das Entstehen der Spezies zwar schnell und in unmerklicher Zeit vor sich gehe, aber zwischen den einzelnen Momenten noch ganz unmerkliche Abstufungen möglich seien. Dass auch die ganze Zeit, die das Licht von Osten nach Westen braucht, unter der Schwelle der Sinneswahrnehmung bleiben könne, wie das erste Zeitteilchen, erkläre sich daraus, dass unser Auge überhaupt eine merkliche Zeit braucht, um einen Eindruck wahrzunehmen. Auch Alhacen lehre, dass jede natürliche Veränderung, also auch die Lichtfortpflanzung, in der Zeit vor sich gehe. Denn wenn das Licht in einem bestimmten Momente am Anfange eines Raumes ist, so könne es in demselben Momente nicht auch am Ende desselben sein. Das Licht lege in einem Augenblicke einen Punkt zurück, eine Strecke aber in der Zeit.

Die Fortpflanzung der Spezies in der Zeit folgert Bacon auch aus dem Widerstande im Medium, den sie auf dem Gange zu überwinden hat. Er schreibt :

Nach Alhacen entsteht im Medium immer Verdünnung und Verdichtung, wobei das Dünne dem Verdichten widerstrebt. Dadurch wird die Spezies immer schwächer und schwächer, die Kraft vom Agens her wird mit der Entfernung immer geringer und das durchlaufene Medium manchmal dichter, wie z. B. die Luftschichten gegen die Erdoberfläche zu immer dichter werden. Das Medium kann sogar so dicht werden, dass der Strahl reflektiert wird. Aber nie ist es so dicht, dass nicht doch irgendwie eine Spezies hindurchginge, wenn wir es auch mit den Sinnen nicht wahrnehmen. Selbst durch dicke Klumpen von Gold und Erz gehen noch die Spezies von Schall und Wärme hindurch. Was aber die Schnelligkeit der Fortpflanzung anlangt, so wird sie auch durch die Widerstände nicht so weit verzögert, dass wir die Zeit wahrnehmen könnten. Und so müssen wir denn sagen, dass diese Bewegung die schnellste ist, die wir kennen, so schnell, dass sie mit keiner anderen verglichen werden kann.

II. Der Sehvorgang[1]

Bacon selbst berichtet, dass hinsichtlich des Sehvorganges bei den Alten und Arabern zwei Hauptansichten herrschten. Die einen lehrten nach Plato, dass beim Sehen das Auge in der Weise aktiv sei, dass es einen gewissen Ausfluss entsende um die Gegenstände zu erfassen, wie z. B. dass das Auge einen Fühlstrahl zu den Sternen schickt, der sie erfasst und dem Auge das Bild zurückgibt. Die anderen nehmen mit den Stoikern (eigentlich sind es die Aristoteliker) an, dass das Sehen sich dadurch vollziehe, dass das Auge etwas nach innen aufnimmt und nicht etwas nach aussen entsendet.

Diese Unterscheidung ist freilich nur im allgemeinen richtig, desgleichen bei Albertus Magnus, der diese beiden Theorien ausführlich in seinem Commentar zum Buche *de Sensu et Sensato* erörtert und dann die der Platoniker nachdrücklichst bekämpft.

Im grossen und ganzen können wir als Vertreter dieser hier genannten Platon'schen Richtung bezeichnen: Pythagoras, Parmenides, Empedokles, Demokrit, Epikur, Lukretius; vielfach nahmen diese an, dass durch die Fühlstrahlen sich Bilder und Formen, Häutchen oder Plättchen von den Dingen ablösen, die nach Farbe und Anordnung der Teile den Gegenständen selbst gleichen. Ferner sind nach dieser Richtung zu nennen Apulejus aus Madaura, Hipparch, Euklid, Ptolemaeus, Theon, Tideus, Augustinus, von den Arabern hauptsächlich Alkindi, auf den sich Bacon neben Euklid und Ptolemaeus besonders beruft.

Zu den Aristotelikern im Sinne Bacons gehören vor allem die Araber Avicenna, Averroes, Alhacen, wir könnten noch die getreuen Brüder Rhazes und andere nennen. Aristoteles selbst, den Bacon für seine Sehtheorie anspricht,

[1] Bridges, ii. 30 ff., 51 ff.; i. 119 ff.

erwähnt im 5. Buche *de Generatione Animalium* beide Theorien, Strahlen zum und vom Auge, ohne einer derselben einen bestimmten Vorzug zu geben. An einer anderen Stelle aber, nämlich im Traktate *de Sensu*, verurteilt er entschieden die Strahlung vom Auge.

Nach diesen allgemeinen Bemerkungen wollen wir nun die eigenartige Sehtheorie Roger Bacons selbst betrachten.

Beim Sehen, so führt er aus, handelt es sich vor allem um die Spezies von Licht und Farbe. Ohne Licht sieht man nichts und zu starkes Licht verdunkelt alles schwache Licht, schwächt das Sehen und schadet dem Auge. Dass ganz besonders die Farben auf das Sehen Einfluss haben, ergibt sich daraus, dass das Auge, wenn es beispielsweise auf hell beleuchtetem dichteren Grün geruht hat und sich dann auf einen dunklen Ort hinwendet, den Eindruck des Grünen noch eine Zeitlang beibehält, oder, wenn man es auf einen mässig beleuchteten weissen Gegenstand richtet, den Eindruck von weiss und grün gemischt empfindet. Das Licht modifiziert auch die Farbenempfindung, wie wir es bei den Farben der Taube, an der Pfaufeder, an den Schuppen der Fische und am faulen Eichenholz deutlich sehen, die durch den Wechsel der einfallenden Lichtstrahlen (!) entstehen.

Ausser Licht und Farbe gehören sodann zum Sehen noch ein gewisser Abstand des Gegenstandes vom Auge, Lage des Gegenstandes im Gesichtsfeld und eine entsprechende Grösse des Gegenstandes. Weitere Bedingungen sind, dass das Objekt dichter als die Luft und der Himmel sei, sowie eine entsprechende Dünnheit und Durchsichtigkeit des Mediums.

Das Sehen selbst vollzieht sich zunächst mittels der Strahlen eines Strahlenkegels, der seine Spitze im Zentrum des Auges hat und dessen Basis auf dem Sehobjekte liegt. Die einzelnen Strahlen des Kegels stehen auf den Kugelflächen der Augenteile senkrecht und projizieren auf der Linse gleichsam die Punkte des Objektes in verkleinertem Mass-

stabe, aber in derselben Anordnung wie am Objekte selbst. Ausser diesen von den Punkten des Objektes her senkrecht einfallenden Strahlen gelangen aber von ihnen auch noch schiefe Strahlen und schiefe Kegel zum Auge, die das Bild nicht stören, da sie ja durch ihre Richtung und durch die Brechung, die sie im Auge erleiden, schwächer sind. Ja die Brechung kann sie sogar zum nämlichen Punkte im Auge führen, wohin auch die lotrechten gelangen, wodurch die Wirkung, die von ein und demselben Punkte ausgeht, verstärkt wird. Der lotrechte Kegel heisst der eigentliche Seh- oder Strahlenkegel. Seine Basis ist mit Rücksicht auf das Deutlichsehen beschränkt. Was ausserhalb dieser Grenze liegt, wird schlecht oder gar nicht, die Stelle, auf welche die Achse gerichtet ist, am deutlichsten gesehen.

Ausser den Spezies, die vom Objekt ausgehen und auf das Auge wirken, nimmt Bacon merkwürdigerweise entgegen der klaren Lehre Alhacens und anderer mit Berufung auf Tideus, Ptolemaeus und besonders Alkindi und fälschlich auf Aristoteles einen Ausfluss aus dem Auge an, zwar nicht einen rein materiellen wie einige der Alten, sondern einen beseelten, der aber doch der Spezies von leblosen Dingen sehr ähnlich ist.

Hören wir seine Ausführungen:

Wie ein unbeseelter Gegenstand eine unbeseelte Spezies wirkt, so das beseelte Organ eine beseelte, die gleichsam an der Kraft der Seele teil hat. Man darf also nicht annehmen, dass diese Spezies sich wie ein Körper vom Auge zum Objekte hin erstrecke; auch nicht, dass die Augenspezies die des Gegenstandes an sich reisse und zum Auge führe; wir müssen die Ansicht des Aristoteles, dass das Sehen aktiver und passiver Natur sei, so verstehen, dass das Auge die Spezies des Objektes aufnimmt und zugleich seine Kraft auf das Medium bis zum Objekte in unmerklich kurzer Zeit ausübt. Wie jedes Naturding seine Wirkung durch eigene Kraft vollbringt, so erkennt auch das Auge durch seine eigene Kraft ein Ding, das ausserhalb seiner liegt. Die Spezies der Dinge bedürfen überhaupt der Anregung von

Seiten des Auges, wodurch sie präpariert und dem beseelten Organ angepasst werden.

Aehnlich wie bei den Spezies der Objekte haben wir uns also von der Linse des Auges aus unzählige Kegel zu denken, die alle dieselbe Basis haben und deren Spitzen sich auf die einzelnen Punkte des Objektes erstrecken. Unter allen diesen ist einer der Hauptkegel, dessen Achse durch alle Zentren des Auges geht. Wir haben uns also zwei Kegel zu denken, einen vom Objekt und einen vom Auge. Sie treffen an einem bestimmten Orte zusammen, wobei keine Verwirrung entsteht, da sie nicht von derselben Art sind und die Kraft der Seele den unbeseelten Strahlenkegel überwiegt. Die Natur bietet uns dafür ein Beispiel. Die Luft können wir nicht sehen, solange sie in unserer Nähe ist; erst in grosser Entfernung nehmen wir sie wahr. Der Grund liegt nicht bloss darin, dass sich viele Schichten angehäuft haben (wie ja auch ein tiefes Wasser dunkler erscheint), sondern weil die Sehkraft nicht mehr hinreicht, sie zu durchdringen. Ein weiteres Beispiel liefert Licht und Farbe des Himmels in einem Wasserspiegel betrachtet. Da möchte man meinen, es müsse die entfernte Luft eine sichtbare Spezies haben, die zum Auge vom Wasserspiegel reflektiert wird. Dem ist aber nicht so. Es existiert nur die Spezies des Auges, die sich ohne Wasserspiegel in ungebrochener Linie bis zum Firmamente fortpflanzt, hier aber reflexiv vermittelst des Spiegels in jene Ferne gelangt.[1]

* * *

Roger Bacon gehört zu den wenigen Männern, die im 13. Jahrhundert, als die scholastische Philosophie alles beherrschte, sich dem Studium der Natur widmeten. Er war ein originaler Denker. Wir haben seine Spezieslehre in den Hauptzügen kennen gelernt und im Anschluss daran seine Sehtheorie betrachtet. Aus allem tritt uns der reale, auf das Einzelne und Praktische gerichtete Sinn des Engländers entgegen. Die Spezieslehre bildet aber überhaupt den Schlüssel zum Verständnis seiner Physik, namentlich der Optik. Sie bewegt sich zwar noch ganz auf dem Boden der Scholastik, aber es leuchtet doch ein tieferes Verständnis

[1] Bridges, ii. 78, 92.

und ein klareres naturwissenschaftliches Urteil hindurch, als bei seinen Zeitgenossen im Abendlande. In mancher Hinsicht ist durch ihn der Weg, den der berühmte englische Kanzler desselben Namens, Bacon von Verulam, drei Jahrhunderte später einschlug, vorgezeichnet. Die Zeit, in der Bacon lebte, war noch nicht die der Renaissance der Wissenschaften. Gleichwohl waren seine Ideen und Versuche nicht unfruchtbar, denn sie legten in den Schoss des Abendlandes einen Keim wissenschaftlicher Erneuerung nieder, der sich dann in den späteren Jahrhunderten entwickelte.

IX

ROGER BACONS ART DES WISSENSCHAFTLICHEN ARBEITENS, DARGESTELLT NACH SEINER SCHRIFT *DE SPECULIS*

Von J. WÜRSCHMIDT

Wenn wir versuchen wollen, uns von der Art des wissenschaftlichen Arbeitens eines grossen Mannes eine Vorstellung zu machen, so werden wir nicht solche Werke betrachten, in denen er die Summe seiner Erfahrungen und Kenntnisse niedergelegt hat, sondern ein Spezialwerk untersuchen, in welchem er ein wissenschaftliches Problem sich stellt und nach allen Richtungen diskutiert. Eine solche Einzeluntersuchung Roger Bacons bezieht sich auf die Brennspiegel und ist niedergelegt in seiner Schrift *De speculis*. Während Herr E. Wiedemann[1] in einer Arbeit über die Geschichte des Brennspiegels untersucht hat, wie sich die Ergebnisse R. Bacons *historisch* einreihen, sollen die folgenden Ausführungen lehren, welches die *Arbeitsmethode* dieses 'Begründers der mathematischen Physik', wie ihn S. Vogl[2] bezeichnet, gewesen ist. Zur allgemeinen Charakterisierung des Mannes und seiner bedeutsamen Leistungen auf dem Gebiete der Naturwissenschaften sei auf die Ausführungen S. Vogls hingewiesen.

Der Traktat *De speculis* von R. Bacon wurde gemeinsam mit seiner *Perspectiva*, einem Teile seines *Opus maius*, von Johannes Combach 1614 in Frankfurt herausgegeben und beschäftigt sich, wie der Name sagt, mit der Theorie der Spiegel, jedoch wird nur die Lehre von den sphärischen und

[1] E. Wiedemann, *Wied. Ann.*, Nr. 39, S. 110, 1890.

[2] S. Vogl, *Die Physik R. Bacos*, In.-Diss., Erlangen, 1906.

parabolischen Hohlspiegeln, die wegen ihrer seit alters bekannten Eigenschaft als Brennspiegel das Interesse am meisten beanspruchen, behandelt.

Ein Blick auf die der Schrift beigegebenen Zeichnungen zeigt zunächst, dass in dem Werk scheinbar ganz verschiedene Probleme behandelt werden; nur die ersten Figuren zeigen den sphärischen Hohlspiegel und die von der Sonne ausgehenden und an dem Spiegel reflektierten Strahlen, daran schliessen sich Abbildungen, die sich auf die Schattenbildung leuchtender Körper und den Durchgang des Lichtes durch Oeffnungen beziehen. Erst die letzten Seiten des Werkes beschäftigen sich wieder mit dem Spiegel, und zwar mit dem parabolischen Hohlspiegel und seiner Konstruktion, ebenso befassen sich die dem Traktat angefügten ' Notulae de speculo '[1] mit dem Hohlspiegel. Vogl behandelt dementsprechend die einzelnen Teile in verschiedenen Abschnitten seiner Arbeit, teils in den Kapiteln über sphärische bezw. parabolische Hohlspiegel, hier im Zusammenhang mit den im *Opus maius* über dieses Gebiet niedergelegten Ansichten, teils in dem Kapitel ' über die durch eine Oeffnung erzeugten Bilder '.

Eine eingehendere Prüfung des Werkes wird jedoch zeigen, in welcher Weise R. Bacon die scheinbar ganz verschiedenen Gebieten der Optik angehörigen Gegenstände zur Lösung eines bestimmten Problemes benutzt hat. So erhalten wir einen Einblick in die wissenschaftliche Arbeitsmethode des Mannes, zugleich geht hieraus hervor, inwieweit R. Bacon von früheren Gelehrten, die sich mit diesen Problemen beschäftigten, beeinflusst ist, und wo er selbständig vorgegangen ist.

[1] Wie ich einer brieflichen Mitteilung von Professor Clifton an Geheimrat Wiedemann entnehme, ist das Oxforder Manuskript der ' Notulae ' (Bodley 874) von der gleichen Hand wie die des Werkes selbst, stammt also wie dieses aus der Zeit zwischen 1400 und 1425. Ob R. Bacon selbst der Verfasser der 'Notulae ' ist oder nicht, steht nicht fest.

Im ersten Abschnitt seiner Schrift untersucht R. Bacon die von einem Punkt der Sonne ausgehenden und an einem sphärischen Hohlspiegel reflektierten Strahlen ; hiebei wird derjenige Punkt der im Endlichen gedachten Sonne gewählt, der auf der durch den Sonnenmittelpunkt gehenden Achse des Spiegels liegt, und gezeigt, dass ein mit der Achse nicht zusammenfallender Strahl nach der Reflexion diese in einem Punkt schneidet, der zwischen dem Mittelpunkt des Hohlspiegels (Kugelmittelpunkt) und dem Spiegel selbst (Pol) gelegen ist (vgl. Fig. 1). Ferner wird bewiesen, dass

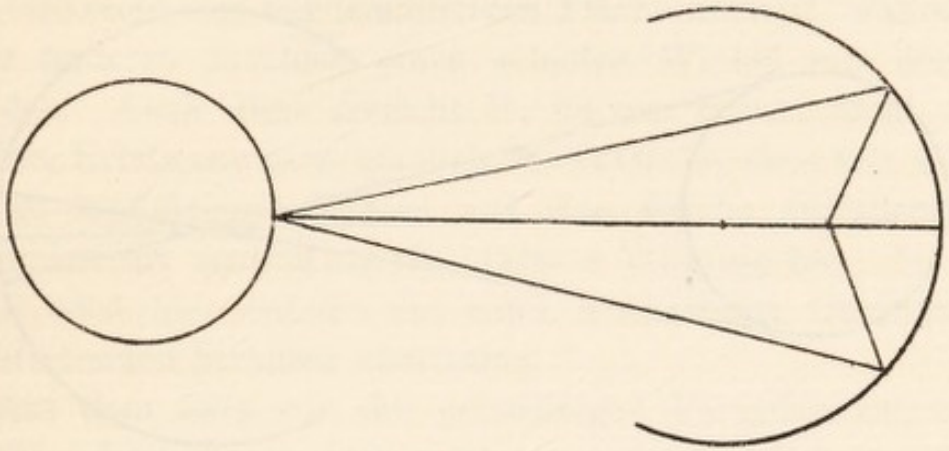

Fig. 1.

alle Strahlen, die in gleichem Bogenabstand von der Spiegelachse auffallen, nach dem gleichen Punkt der Achse reflektiert werden. Hiebei beruft sich R. Bacon auf einen früheren Autor, der über Brennspiegel geschrieben hat. Da aber von demselben Autor eine von der ersten ganz abweichende Ansicht aufgestellt wurde, nämlich dass die reflektierten Strahlen sich im Mittelpunkt der Kugel schneiden, so diskutiert er auch diese eingehend. Es werden hiezu die Strahlen betrachtet, die von verschiedenen Punkten der Sonnenoberfläche ausgehen und durch den Mittelpunkt hindurchgehen ; diese fallen senkrecht auf den Spiegel und werden in sich selbst reflektiert, wodurch im Mittelpunkt ein Brennpunkt entsteht. Der Autor, auf den sich R. Bacon beruft, ist Euklid, in dessen Katoptrik sich die beiden

Ansichten finden. Und zwar sind hier genau die gleichen Zeichnungen des Strahlenganges gegeben, wie wir sie bei R. Bacon (vgl. Fig. 1 u. 2) finden. Von der uns geläufigen Betrachtungsweise, die parallele von der Sonne ausgehende Strahlen zur Konstruktion des Brennpunktes des Hohlspiegels benutzt, findet sich hier noch keine Andeutung ; die Sonne wird nicht in praktisch unendlicher, sondern in endlicher Entfernung vom Spiegel gedacht, und es werden, wie gezeigt, im ersten Falle Strahlen von *einem* Punkt, im zweiten von *verschiedenen* Punkten der Sonnenoberfläche betrachtet.

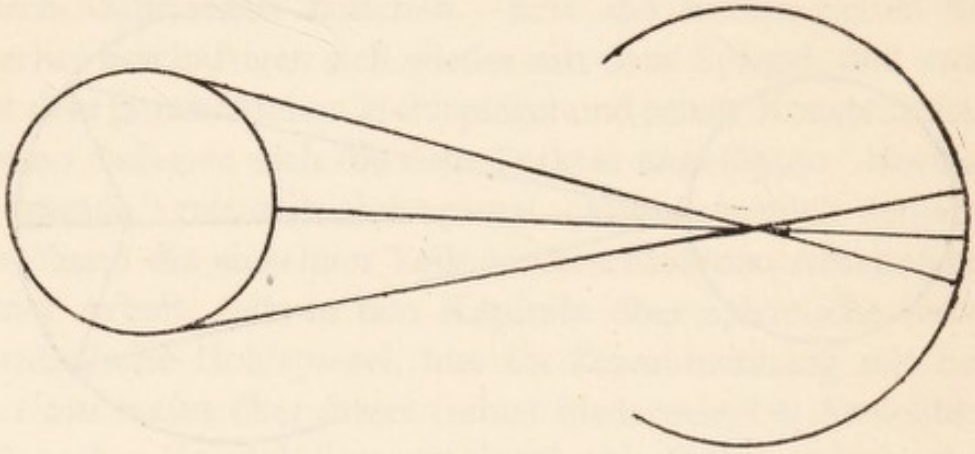

Fig. 2.

R. Bacon stellt sich nun die Aufgabe, zwischen diesen beiden zunächst scheinbar gleich berechtigten Ansichten zu entscheiden ; hier nimmt er in hohem Masse die *Erfahrung* (*experientia*) bezw. das *Experiment* zu Hilfe.

Dass von dem im ersten Falle betrachteten Punkt der Sonne Licht nach allen Punkten des Spiegels gelangen kann, ist an sich klar, da sich das Licht geradlinig fortpflanzt, und somit zu allen Punkten gelangen kann, die vor der in jenem Punkt an die Sonne gezogenen Tangente liegen. Zugleich aber folgt, dass nicht nur von diesem *einen* Punkt der Sonne, sondern von *allen* Punkten des sichtbaren Teiles der Sonne (der durch die Tangenten vom Auge an die Sonnenkugel begrenzt ist) nach dem im Pol befindlichen Auge Lichtstrahlen gelangen können. Von allen diesen

Strahlen ist aber nach einer von R. Bacon mehrfach geäusserten Ansicht der Zentralstrahl, d. h. der in der Achse verlaufende, der kürzeste und hat infolgedessen die stärkste Wirkung. R. Bacon geht also hier von der Erfahrungstatsache aus, dass die Intensität des Lichtes mit der Entfernung abnimmt, freilich wendet er sie hier in einem Fall an, bei dem infolge der grossen Entfernungen die Verschiedenheit des Lichtweges tatsächlich nicht in Betracht kommt. Der zweite Grund dafür, dass dieser Zentralstrahl die stärkste Wirkung hat, ist nach unserem Autor darin zu suchen, dass er senkrecht aus der leuchtenden Fläche austritt, während alle anderen Strahlen einen schiefen Winkel mit dieser bilden. Auch diese Ansicht R. Bacons beruht wohl auf einem Erfahrungssatz, nämlich der Tatsache, dass von allen unter irgendeinem Winkel auf eine Fläche auffallenden Strahlen der senkrechte die stärkste Wirkung hat ; dieser Fall wird hier auf die aus einer leuchtenden Oberfläche austretenden Strahlen übertragen.

Aus dem Satz von der geradlinigen Fortpflanzung des Lichtes folgt ferner, dass nicht nur nach dem Achsenpunkt (Pol) des Spiegels, sondern nach *jedem* Punkt von *allen* Punkten der Sonnenoberfläche, wenigstens von allen durch den Tangentialkegel von jenem Punkt begrenzten, Strahlen gehen. Auch in diesen Strahlenkegeln sind aus den beiden oben angeführten Gründen die Zentralstrahlen die wirksamsten.

R. Bacon ist somit zu der richtigen Erkenntnis gekommen, dass auf jeden Punkt des Hohlspiegels von allen Punkten der Sonnenoberfläche Strahlen kommen, also ein Strahlenkegel trifft ; die unendlich vielen Strahlen all dieser unendlich vielen Strahlenkegel vereinigen sich dann in einem Punkt oder, wie er ganz treffend bemerkt, auf einer kleinen Stelle, ' die nicht so breit ist wie ein Denar.'

Die Schwierigkeit, die noch darin liegt, dass ja in Wirklichkeit nicht alle Strahlenkegel nach dem einen Punkt reflektiert werden, kann er noch nicht überwinden ; jedoch

müssen wir bedenken, dass ja auch wir über diese Schwierigkeiten bei der elementaren Darstellung der Theorie des Hohlspiegels noch flüchtiger hinweggehen, wenn wir nur parallele von der Sonne ausgehende Strahlen zur Konstruktion benutzen.

Die zweite von Euklid gemachte Annahme, nämlich dass der Brennpunkt mit dem Mittelpunkt des Spiegels zusammenfalle, ist aber durch die bisherigen Ausführungen erledigt, denn durch diesen Mittelpunkt gehen von der Sonne zwar unendlich viele, aber eben nur *einfach* unendlich viele Strahlen, während durch den wirklichen Brennpunkt, wie die obige Darstellung zeigt, eine grössere Mannigfaltigkeit von Strahlen, nämlich *unendlich viele Strahlen unendlich vieler Strahlenkegel* gehen.

Wichtig ist nun zu sehen, wie diese Grundtatsache, dass nicht *ein* Punkt der Sonnenoberfläche, sondern *alle* innerhalb des Tangentialkegels gelegenen Punkte Licht aussenden, von R. Bacon unter Zuhilfenahme von Erfahrung und Experiment nachgeprüft wird.

Dass tatsächlich *alle* Punkte Licht aussenden, lehrt uns zunächst die *Erfahrung*. Dies sehen wir an den Schatten, die bei allen Gegenständen, die kleiner als die Sonne sind, konvergieren, im speziellen am Erdschatten, dessen Beobachtung bei einer Mondfinsternis möglich ist. In sinnreicher Weise untersucht R. Bacon wohl im Anschluss an andere Gelehrte an diesem Beispiele die verschiedenen anderen möglichen Fälle, nämlich dass der Schatten durch Parallele begrenzt oder divergent ist, indem er nachweist, dass in diesen beiden Fällen die Dauer der Mondfinsternis viel grösser sein müsste, als wir tatsächlich beobachten. So bleibt nur die Möglichkeit eines konvergenten Schattens. Ein einziger Licht aussendender Punkt würde einen divergenten Schatten liefern, ebenso auch ein leuchtender Körper von kleineren Dimensionen als der schattengebende, wie der Autor ausführlich an den entsprechenden geometrischen

Konstruktionen beweist; also ist zur Erzeugung eines konvergenten Schattens ein leuchtender Körper erforderlich, dessen Dimensionen grösser sind als die des schattengebenden, wie dies ja bei der Sonne der Fall ist.

Einen weiteren Nachweis für seinen Satz sucht R. Bacon durch den *Versuch* zu erbringen, nämlich mittels des Durchganges des Sonnenlichtes durch eine enge Oeffnung. Die hiebei auftretenden Erscheinungen hat er im allgemeinen richtig beobachtet, nämlich dass das Bild in kleinem Abstand von der Oeffnung dieser ähnlich ist, dagegen bei grösserer Entfernung dem leuchtenden Objekt, also der Sonne; auch der Spezialfall der teilweise verfinsterten Sonne ist ihm bekannt. Die Erklärung der Erscheinungen durch R. Bacon ist eine ähnliche, wie sie auch Vitello und sein jüngerer Zeitgenosse Johannes Pecham geben. Sie bereitet ihm, wie nicht anders zu erwarten, Schwierigkeiten, da er nicht achtlos an den möglichen Einwänden vorübergeht. Auf Einzelheiten sei hiebei nicht eingegangen, da die Einwände und Schwierigkeiten ausführlich bei Vogl besprochen werden, nur darauf sei hingewiesen, dass für R. Bacon das Experiment, die beobachtete Erscheinung, so massgebend ist, dass er bei einem Widerspruch mit der Theorie sich sofort entschliesst, diese für ungenügend zu erklären. Er macht darauf aufmerksam, dass er seinen nun folgenden Erklärungsversuch nicht für absolut richtig hält; es handelt sich bei ihm eben nur darum, die Theorie so umzugestalten, dass sie mit den Erfahrungstatsachen übereinstimmt, und er bemerkt mit Recht: 'wenn die wahre und vollständige Ursache dieses Durchganges des Lichtes durch eine Oeffnung bekannt wäre, so würde sie in eine bedeutende Kenntnis der multiplicatio des Sonnenlichtes und ihrer Folgen, der Licht- und Wärmewirkung, einführen.' Der freilich nicht gelungene Erklärungsversuch beruht darauf, dass er sowohl den auf den Mittelpunkt der Oeffnung treffenden Strahlenkegel als auch eine von der Sonne ausgehende

Strahlenpyramide untersucht, deren gleichfalls in der Sonne liegende Basis ähnlich der Oeffnung ist. (Diese wird im speziellen Fall als Dreieck gewählt.) Auch hier knüpft er wieder an eine experimentelle Tatsache, an eine Beobachtung an, nämlich dass das Licht der Sterne durch das viel wirksamere Sonnenlicht für uns am Tage ausgelöscht wird, nur vom Boden eines Brunnens könne man auch am Tage die Sterne sehen. So werde auch die Wirkung gewisser Strahlen des Kegels durch die der Pyramide übertönt und verdunkelt.

Hiemit hat R. Bacon die Untersuchung soweit fortgeführt, dass er zu seinem eigentlichen Thema, der Theorie des Hohlspiegels, zurückkehren kann. Wir wissen nun, dass für den Hohlspiegel *alle* von der Sonne kommenden Strahlen, also Strahlenkegel, in Betracht kommen und müssen den weiteren Verlauf dieser Strahlenkegel untersuchen. R. Bacon geht von den einfachsten Fällen der Reflexion aus, behandelt sie aber nicht für einzelne Strahlen, sondern gleich für die einzelnen Strahlenkegel, die von der Sonne ausgehen. Er zeigt, dass bei einem ebenen Spiegel ein derartiger konvergenter Strahlenkegel entweder in sich selbst bei senkrechter Achse zum Spiegel, oder in einen anderen Kegel bei schiefer Achse reflektiert wird, indem er das Reflexionsgesetz auf die einzelnen Strahlen der Kegel anwendet. (Die reflektierten Strahlenkegel sind natürlich divergent geworden; vgl. Fig. 3.) Dann wendet er diese Resultate auf die gekrümmten Spiegel an, die säulen- oder pyramidenförmigen Konkav- oder Konvexspiegel, die sphärischen oder parabolischen Hohlspiegel, für die er sich auf die ' Verfasser der Perspektive ' und auf ' die Verfasser der Bücher über die gewöhnlichen und Brennspiegel ' beruft. (Hiezu sei auf die Arbeit von E. Wiedemann über die Geschichte der Brennspiegel, sowie auf die Ausführungen S. Vogls verwiesen.) R. Bacon schliesst sich aber nicht an diese ihm bekannten Darstellungen der Lehre vom Hohlspiegel an, sondern setzt seine Betrachtungen ganz selbständig fort. Er bemerkt,

dass bei der Reflexion der obigen Strahlenkegel ihre Oeffnungswinkel erhalten bleiben ; er weist darauf hin, dass dieser für die Sonnenstrahlen 32′ (gleich dem scheinbaren Sonnendurchmesser) ist, und zeigt, dass ein derartiges konvergentes Strahlenbündel nach der Reflexion an einem Punkte eines Spiegels ein divergentes wird. So ist auch beim Hohlspiegel die ‘ Sammlung ’ der Strahlen in einem Punkte, dem Brennpunkte, nur eine scheinbare, denn, wenigstens für die Strahlen jedes einzelnen Kegels, bewirkt die Reflexion eine, wenn auch geringe, Zerstreuung. Nun erst macht der

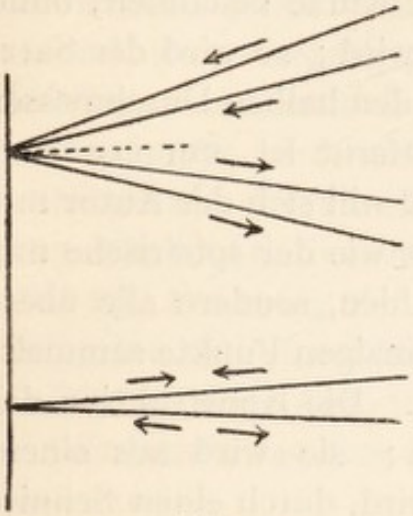

Fig. 3.

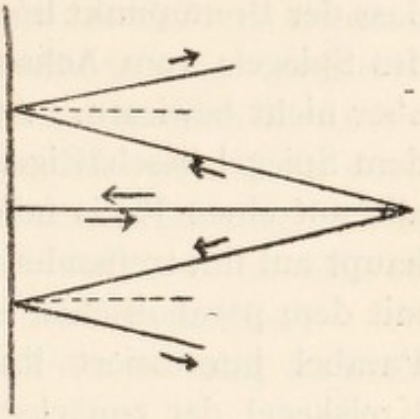

Fig. 4.

Autor den Uebergang, der uns heutzutage so geläufig ist bei der Behandlung der Probleme der geometrischen Optik : an Stelle der *Kegel* betrachtet er deren *Achsen*, die man dann in abkürzender Bezeichnungsweise ‘ Strahlen ’ nennen könne ; vereinigen sich diese genau im Brennpunkt, so werde das für die anderen Strahlen der Kegel in der Nähe des Brennpunktes der Fall sein. Nachdem so die Strahlenkegel durch die Zentralstrahlen ersetzt sind, entsteht noch die Frage, ob man diese von einem Punkt, dem Sonnenmittelpunkt, ausgehenden Zentralstrahlen durch parallele Strahlen ersetzen darf. Zur Entscheidung betrachtet der Autor wieder die Verhältnisse beim ebenen Spiegel. Hier fällt streng genommen nur ein einziger Zentralstrahl unter 90° auf, die

anderen unter spitzen Winkeln ; sie werden also nach dem Reflexionsgesetz nach aussen, nicht in sich selbst reflektiert (vgl. Fig. 4). Da aber die Winkel sehr wenig von einem Rechten verschieden sind, so ist diese Abweichung unmerklich. Wir beobachten also, dass die Strahlen in sich selbst reflektiert werden, und können somit auch die einfallenden Strahlen als praktisch parallel betrachten. Jetzt erst ist R. Bacon auf dem Punkt angelangt, von dem die Betrachtungen eines Ibn al Haitam ihren Ausgangspunkt genommen haben. Die verschiedenen Formen der Konkav- und Konvexspiegel werden nun in aller Kürze behandelt, ohne dass auf Einzelheiten eingegangen wird ; so wird der Satz, dass der Brennpunkt höchstens um den halben Durchmesser des Spiegels vom Achsenpunkt entfernt ist, nur erwähnt, aber nicht bewiesen. Ausführlicher will sich der Autor mit dem Spiegel beschäftigen, der nicht wie der sphärische nur alle auf einen Kreis fallenden Strahlen, sondern alle überhaupt auf ihn treffenden in einem einzigen Punkte sammelt, mit dem parabolischen Hohlspiegel. Die Konstruktion der Parabel interessiert ihn zunächst ; sie wird aus einem Kreiskegel, der zunächst halbiert wird, durch einen Schnitt parallel einer Mantellinie gewonnen. Mit Hilfe dieser (halben) Parabel wird dann der Spiegel selbst hergestellt, ganz ebenso, wie dies bei Ibn al Haitam beschrieben ist, und zwar entweder ein ' eiförmiger ' oder ein ' ringförmiger ' Spiegel. Die beiden Darstellungen stimmen teilweise fast wörtlich überein, nur ist die des Arabers weit ausführlicher. Ueber die Lage des Brennpunktes bei der Parabel macht R. Bacon keine Angaben ; er bemerkt, dass er hierüber nichts sicheres wisse. Hieraus geht hervor, dass er die Abhandlung Alhacens zu der Zeit, als er sein Werk schrieb, wohl nur teilweise gekannt hat, nämlich nur den Abschnitt, der sich auf die Konstruktion des Spiegels bezieht.[1]

[1] In den dem Werke angefügten ' Notulae de speculo ' werden einige spezielle Aufgaben der Theorie der Brennspiegel behandelt.

Aus der vorliegenden Darstellung geht hervor, in welcher Weise R. Bacon auf dem Gebiete der Naturwissenschaften gearbeitet hat. Er hat hier versucht, ein spezielles Problem nach allen Richtungen zu diskutieren, und zwar geht er von den überlieferten Theorien aus, prüft diese an Erfahrung und Experiment, um bei einem etwaigen Widerspruch zwischen Theorie und Erfahrung nach einer widerspruchsfreien Theorie zu suchen. Die mathematischen Hilfsmittel verwendet er, soweit es ihm der Stand seines Wissens erlaubt, indem er sie zur Erklärung der beobachteten Tatsachen anwendet ; er macht die mathematische Untersuchung aber niemals zum Ausgangspunkt seiner Betrachtungen, wie das bei den arabischen Gelehrten vielfach der Fall ist. Hiedurch unterscheidet sich seine Arbeitsmethode ganz wesentlich von der mehr das rein Mathematische betonenden der Araber; von seinen christlichen Zeitgenossen hebt er sich ab durch die stete Betonung der Wichtigkeit der Erfahrung und des Experimentes gegenüber den Ueberlieferungen der früheren Gelehrten, dem Autoritätsglauben der Scholastiker.

Wir fassen das Resultat unserer Untersuchung nochmals zusammen :

R. Bacon hat in dem vorliegenden Werk *De speculis* geradezu ein Muster für die gründliche Behandlung eines naturwissenschaftlichen Problemes geschaffen, das wertvoll bleibt, wenn auch manche Irrtümer sich in ihm finden, die durch die Weiterentwicklung der Wissenschaft überwunden worden sind.

Zunächst wird der Beweis des Satzes nachgeholt, dass beim sphärischen Hohlspiegel der Brennpunkt höchstens um ein Viertel des Durchmessers vom Achsenpunkt entfernt ist, dann wird die Konstruktion der Parabel mittels ihres Parameters L, des latus rectum, endlich werden einige sich hieraus ergebende Folgerungen besprochen. Die Darstellung schliesst sich ziemlich genau an die Ibn al Haitams an, so dass man schliessen kann, dass R. Bacon, bezw. der nicht näher bekannte Autor der 'Notulae', zur Zeit der Abfassung dieses Anhanges dessen Werke über sphärische und parabolische Hohlspiegel gekannt hat.

X

ROGER BACON ET L'HORREUR DU VIDE

PAR PIERRE DUHEM

ON a peu remarqué l'influence exercée par l'enseignement de Roger Bacon sur les doctrines physiques de la Scolastique; parfois, cependant, cette influence a été très profonde; nous voudrions en donner un exemple; nous le ferons en disant comment Bacon, au sujet de la non-existence du vide, a développé des idées à peine soupçonnées avant lui, et comment la théorie qu'il avait proposée a été adoptée dans les Universités de Paris et d'Oxford.

I. L'IMPOSSIBILITÉ DU VIDE ET L'EXPÉRIENCE. — LES ARABES

Ni Aristote, ni ses commentateurs grecs n'avaient sollicité l'expérience d'apporter son concours à l'argumentation développée par le Philosophe [1] contre la possibilité du vide; ce concours, les physiciens arabes, au contraire, n'ont pas manqué de l'invoquer.

Al Gazâli, par exemple, cite [2] ' divers signes naturels par

[1] C'est ce que nous avons établi dans : *Le Système du Monde: Histoire des doctrines cosmologiques de Platon à Copernic*, première partie, ch. V, § xiv, t. i, pp. 323–32. — Le lecteur trouvera en cet endroit l'exposé des opinions de Philon de Byzance, de Héron d'Alexandrie, d'Alexandre d'Aphrodisias, de Thémistius et de Simplicius, auxquelles nous ferons allusion dans ce qui va suivre.

[2] *Philosophia* ALGAZELIS, lib. II, tract. 1, cap. vi : Ex tribus signis probatur non dari vacuum ; ed. Venetiis, 1506, fol. sign. g 2, coll. b et c.

lesquels est détruite la science du vide.' Parmi ces signes, il mentionne ceux que manifestent les ventouses :

' Par la succion, l'air est attiré et, avec l'air, se trouve attirée la peau de l'homme auquel on veut appliquer la ventouse ; en effet, si elle n'était pas attirée, le vide interviendrait, ce qui n'a pas lieu. Il en est de même, et pour la même raison, dans le vase où l'eau se trouve retenue bien que le vase soit retourné, l'orifice en bas ; en effet, si l'eau sortait, il ne resterait plus rien au fond du vase . . . Il est donc impossible que le vide soit et que les surfaces de deux corps se séparent à moins que quelque chose ne vienne s'interposer . . . Il en est de même en une foule d'inventions ingénieuses qui prouvent l'impossibilité du vide.'

Moïse Maïmonide écrivait de même [1] :

' Sache aussi que le célèbre *Livre des Artifices*, composé par les Beni-Schâkir, renferme au delà de cent artifices qui, tous, sont appuyés de démonstrations et ont été mis en pratique ; or si le vide pouvait exister, pas un seul de ces procédés ne pourrait s'effectuer, et bien des opérations hydrauliques ne pourraient avoir lieu. Cependant, on a passé la vie à argumenter pour confirmer ces propositions et d'autres semblables.'

Ces Beni-Schâkir dont Maïmonide nous parle ici, ce sont les trois fils de Mousa-ben-Schâkir, nommés Mohammed, Ahmed et Al-Hasan ; ils florissaient au IX^e^ siècle, et avaient acquis une grande réputation de mathématiciens et de mécaniciens ; le traité de Mathématiques qu'ils avaient composé en collaboration est demeuré célèbre sous le titre de *Livre des Trois Frères.*[2]

Le *Livre des Artifices*, où les Trois Frères, prenant l'impossibilité du vide comme axiome, en déduisaient l'explication d'une foule d'appareils hydrauliques plus ou moins ingénieux,

[1] MOÏSE BEN MAIMOUN, dit MAÏMONIDE, *Le guide des égarés*, première partie, ch. lxxiii, 111, trad. S. Munk, t. i, pp. 384–5.

[2] Le texte arabe du traité de Mécanique des Fils de Mousa est conservé en manuscrit à la Bibliothèque du Vatican. [*Le livre des Appareils pneumatiques et des machines hydrauliques* par PHILON DE BYZANCE, *édité et traduit en Français par le Baron* CARRA DE VAUX (*Notices et extraits des manuscrits de la Bibliothèque Nationale et d'autres bibliothèques*, t. xxxviii, première partie, p. 40. M DCCCC II.)]

avait, sans doute, le même degré d'originalité que la plupart de traités scientifiques des Arabes ; il n'était qu'une compilation ou une adaptation des reliques de la Science grecque.

Les traités de Philon de Byzance et de Héron d'Alexandrie ont été, de bonne heure, traduits en arabe ; ils ont fourni la matière de compilations telles que celle des Trois Frères ; ils ont fourni aussi des arguments aux philosophes péripatéticiens. Ceux-ci ont rejeté les considérations par lesquelles Philon et Héron croyaient établir l'existence de pores très déliés, d'interstices vides entre les molécules qui composent les corps ; mais ils ont conservé les expériences par lesquelles ces auteurs montraient l'impossibilité de réaliser un espace vide de dimensions notables ; ces expériences, ils les ont données comme la confirmation de la doctrine du Stagirite.

Averroès n'a pas pu ignorer les divers ouvrages où les auteurs arabes s'efforçaient de démontrer par l'expérience l'impossibilité du vide ; mais il n'en a que très peu subi l'influence. Il a surtout lu les commentateurs grecs d'Aristote, et nous avons dit comment ces commentateurs faisaient complète abstraction de ce genre de démonstrations. Toutefois, malgré le désir qu'il avait, sans doute, d'imiter leur abstention, Averroès n'a pu se garder de toute allusion aux preuves expérimentales qui avaient cours chez ses compatriotes.

Aristote, puis Simplicius, avaient parlé de l'expérience de la clepsydre comme propre à démontrer que l'air est un corps ; ils n'avaient fait, en la rapportant, aucune allusion à l'impossibilité du vide. Dans ce qu'Averroès dit de la même expérience,[1] nous trouvons une telle allusion, encore que bien fugitive :

' Ils pressaient, dit-il, des outres gonflées, au point de sentir au toucher le jet de l'air qui en sort, et ils manifestaient par là que l'air n'est pas le vide, mais bien un corps. Ils en

[1] Averrois Cordubensis *In libros Aristotelis de physico auditu commentaria magna*, lib. IV, summa II, cap. i, comm. 51.

faisaient autant à l'aide de l'entrée de l'air dans les chantepleures (*in cantaploris*).[1] En effet, tant que cet instrument demeure clos par le haut, l'eau ne coule pas par le bas ; elle s'écoule dès qu'on en débouche le haut. Cela provient nécessairement de l'entrée de l'air dans l'instrument ; lorsque l'eau en sort, il ne demeure pas vide, mais l'air succède à l'eau.'

Averroès a lu le commentaire de Thémistius au *Traité du Ciel* ; son attention a été vivement attirée par la discussion entre l'auteur et Alexandre d'Aphrodisias au sujet de la succion de l'eau par les ventouses et les vases échauffés ; à son tour, il a repris en grand détail cette discussion.[2]

En exposant l'une des expériences dont parle Thémistius, Averroès y introduit une modification ; il suppose que l'on mette une chandelle dans un vase, qu'on en bouche aussitôt l'orifice, et qu'on enlève le couvercle après avoir plongé dans l'eau le col du vase. Cette modification ne s'expliquerait-elle pas par ceci qu'Averroès a sous les yeux le traité de Philon de Byzance et que, des expériences qui y sont décrites, il confond la seconde avec la première ?

Averroès prend parti pour Alexandre contre Thémistius qui, dit-il, ' a détruit les raisons d'Alexandre sans rien dire qui ait trait à la question (*et nihil dicit in hoc*) . . . Pour nous, nous dirons que la cause est ici manifeste et toute prochaine à qui prend la peine de réfléchir ; et l'on s'étonne de l'ignorance de ces hommes profonds à ce sujet.

' En effet, une partie de l'air, ayant été changée en la nature du feu, se meut vers le haut ; alors, elle est suivie par le corps qui se trouve au-dessous, que ce soit de l'air ou de l'eau . . . Au moment où l'on met dans l'eau l'orifice du vase,

[1] ' *Chantepleure*, nous dit le dictionnaire de Littré, sorte d'entonnoir qui a un long tuyau percé de trous pour faire couler les liquides dans un tonneau sans les troubler.' Il est clair que, par ce nom, on a voulu désigner ici un instrument propre à répéter l'expérience que Philon réalisait avec un œuf métallique pourvu d'un goulet et percé, dans le fond, de petits trous.

[2] Averrois Cordubensis *In libros Aristotelis de Caelo commentaria magna*, lib. IV, summa III, cap. v, comm. 39, digressio.

cette partie ignée s'élève vers la partie supérieure du vase . . . ; le vase n'est plus rempli ; c'est pourquoi l'eau suit dans l'espace vide. Un jour, j'ai brisé un vase que j'avais ainsi placé sur l'eau, et j'ai trouvé de l'eau attachée aux parois du vase. C'est aussi la cause de ce qui advient dans les ventouses où l'on met du feu ; et c'est la première cause de l'ascension de l'eau.

' Il y a une seconde cause que donne Alexandre. Après que la partie ignée de l'air aura été éteinte, l'air se refroidira, il occupera moins de place, et il attirera l'eau par la nécessité qu'il n'y ait pas de vide (*de necessitate vacui*).'

Il semble que cette explication donnée par Averroès doive beaucoup à Philon.

II. L'Impossibilité du Vide et l'Expérience (*suite*). L'Influence du Traité *De inani et vacuo* sur la Scolastique chrétienne

Instruite par les Arabes des expériences propres à démontrer l'impossibilité du vide, la Scolastique latine s'est vivement intéressée à ce genre de preuves. Nous nous proposons d'examiner sommairement comment elle les a connues et par quelles réflexions elle en a fécondé l'enseignement.

Il y aura intérêt, comme on le verra tout à l'heure, à ne pas suivre l'ordre chronologique pour exposer l'histoire de ce chapitre de Physique expérimentale. Nous plaçant d'emblée au milieu du XIV^e^ siècle, nous allons rapporter, tout d'abord, ce qu'en ont dit Jean Buridan et son disciple Marsile d'Inghen.

Jean Buridan affirme la valeur de ces démonstrations expérimentales :

' En Physique (*In scientia naturali*), dit-il,[1] il faut accorder comme un principe toute proposition universelle qui peut être prouvée par induction expérimentale, et cela de la manière suivante : En plusieurs cas particuliers de cette proposition, on trouve manifestement qu'il en est ainsi, et jamais, en aucun cas particulier, il n'apparaît

[1] Johannis Buridani *Subtilissime questiones super octo physicorum libros*, lib. IV, quaest. vii, fol. lxxiii, col. c.

d'objection. D'ailleurs Aristote dit fort bien que beaucoup de principes doivent être reçus et connus par le sens, la mémoire et l'expérience ; jamais il ne nous a été possible de savoir que tout feu est chaud.

' Or, par une semblable induction expérimentale, il nous apparaît qu'aucun lieu n'est vide. Partout, en effet, nous rencontrons quelque corps naturel, soit l'air, soit l'eau, soit quelqu'autre substance. En outre, nous constatons par l'expérience que nous ne pouvons séparer un corps d'un autre à moins qu'un troisième corps n'intervienne. Aussi, si tous les trous d'un soufflet étaient si parfaitement bouchés que l'air n'y pût pénétrer, nous ne pourrions jamais séparer l'une de l'autre les deux parois du soufflet ; et vingt chevaux, dont dix tireraient d'un côté et dix de l'autre ne le pourraient faire davantage ; jamais les deux parois du soufflet ne se sépareraient l'une de l'autre à moins qu'une rupture ou une perforation ne permît à quelque corps de se glisser entre elles. Avec un chalumeau dont vous mettez une pointe dans du vin et l'autre dans votre bouche, en aspirant l'air que contient le chalumeau, vous attirez le vin, vous le forcez à monter, encore qu'il soit grave ; il faut, en effet, que cet air que vous aspirez soit immédiatement suivi de quelqu'autre corps, afin qu'il n'y ait pas de vide. Il y a ainsi une foule d'autres expériences mathématiques.

' Nous devons donc accorder que le vide ne peut naturellement exister à titre de vérité connue par ce moyen qui suffit à poser et concéder les principes en Physique. Par cette induction, il est acquis qu'il n'y a pas de vide . . . Toujours, en effet, nous voyons les corps naturels se suivre en demeurant contigus les uns aux autres ; entre eux, il ne se forme aucun espace dépourvu de tout corps naturel, d'air ou d'eau ou de quelqu'autre substance de ce genre.'

Dans son *Abrégé de Physique*, Marsile d'Inghen nous fait entendre un écho fidèle de l'enseignement de Buridan.

' Le vide, dit-il,[1] ne peut exister naturellement ; on le prouve : En Physique (*in philosophia naturali*), on doit accorder comme un principe ce qui peut être prouvé par induction expérimentale ; or, de cette manière on peut prouver par induction expérimentale que le vide n'existe pas ; donc etc. La majeure est connue, car la Physique est fondée sur l'expérience (*Philosophia naturalis fundatur*

[1] Marsilii Inguen *Abbreviationes libri physicorum*, fol. sign. e, col. d.

super experientiam). La mineure est évidente, car l'expérience nous enseigne que personne ne pourrait séparer un corps d'un autre si un troisième corps ne s'interposait. Si les trous d'un soufflet étaient bien clos, de telle façon qu'aucun corps ne pût pénétrer à l'intérieur, l'expérience montre que cent chevaux ne pourraient séparer l'une de l'autre les parois du soufflet, à moins que l'une d'elle ne se rompît ou qu'il ne se fît par ailleurs quelque ouverture par laquelle un corps pût entrer.'

Dans ses *Questions*, Marsile d'Inghen prouve également l'impossibilité du vide :

' En second lieu, dit-il,[1] cela se prouve par les expériences qui se trouvent au *Traité du vide* (*per experientias quae ponuntur in Tractatu de inani et vacuo*). Les corps naturels, en effet, se meuvent contrairement à leurs inclinations propres, afin que le vide ne se produise pas.

' La première expérience est celle de l'eau qui monte pour éteindre une chandelle recouverte d'un vase.

' La seconde expérience est la suivante : Que l'on fasse un vase ayant deux jambes, l'une plus longue que l'autre ; si l'on plonge le plus petit bras dans l'eau et qu'on aspire l'air par le bras le plus long, l'eau montera par le bras le plus court, ce qu'elle ne ferait point si ce n'est pour empêcher qu'il n'y eût de vide.

' La troisième expérience montre qu'un grave soulevé, et que rien ne retient, ne tombe pas, afin que le vide ne se produise pas ; ainsi, dans les choses d'ici-bas, le vide ne peut être produit par un agent naturel. La prémisse se prouve ainsi : Soit un vase qui a, en bas, un grand nombre de petits trous et, en haut, un grand orifice ; on le remplit d'eau, et on bouche l'orifice supérieur ; alors, l'eau ne tombe pas par les orifices inférieurs ; cela ne saurait être, sinon pour empêcher le vide.'

Marsile d'Inghen nous rapporte donc trois expériences de Philon de Byzance, dont une est fort singulière et caractéristique ; il nous les rapporte dans l'ordre même où Philon les présente ; il ajoute qu'elles sont racontées, avec beaucoup d'autres, dans un certain *Tractatus de inani et vacuo*. Il

[1] *Quaestiones* JOHANNIS MARCILII INGUEN *super octo physicorum libros*, lib. IV, quaest. xiii.

n'en faut pas davantage pour nous amener à penser que ce traité était une traduction ou une adaptation du livre de Philon.

L'existence d'une traduction latine, faite d'après un texte arabe, des *Pneumatiques* de Philon n'a, d'ailleurs, rien d'hypothétique. En 1870, Valentin Rose a découvert et publié [1] une telle traduction, intitulée *Liber Philonis de ingeniis spiritualibus* ; c'est même de la sorte que les historiens modernes ont, tout d'abord, connu l'œuvre de Philon.

Il se pourrait, d'ailleurs, que le *Tractatus de inani et vacuo* dont Marsile d'Inghen nous a parlé ne fût pas cette traduction même de Philon de Byzance, mais quelque traité composé, sous l'inspiration du livre de Philon, par un auteur arabe. Certain texte nous donnera occasion, plus loin, de reprendre cette question et de lui donner une réponse probable.

Maintenant que nous avons constaté aux mains des Scolastiques parisiens, durant la seconde moitié du XIV^e^ siècle, l'existence d'un *Tractatus de inani et vacuo*, directement ou indirectement emprunté à Philon de Byzance, nous sommes conduits à rechercher le temps où ces démonstrations expérimentales de l'impossibilité du vide furent, tout d'abord, connues par les physiciens de la Chrétienté latine.

Qu'elles l'aient été pendant toute la durée du XIV^e^ siècle, nous n'en saurions douter.

Nous verrons en effet, que, bien avant Marsile d'Inghen, on invoquait les expériences que cet auteur déclare empruntées au *Tractatus de inani et vacuo*. Dans un moment, nous entendrons Jean de Jandun décrire quelques-unes de ces expériences. Jean le Chanoine en fera autant et, en particulier, n'omettra pas l'expérience de la chandelle.

[1] VALENTIN ROSE, *Anecdota graeca et graeco-latina*, vol. ii, pp. 299–313. Berolini, 1870. Réimprimé dans HERONIS ALEXANDRINI *Opera quae supersunt omnia*, ed. W. Schmidt, vol. i, pp. 458–89.

A celle-ci, on peut reconnaître une allusion dans le passage suivant de Nicolas Bonet : [1]

' Voici encore un sujet de doute : Peut-on avoir le vide naturellement ? La production du vide par la nature est-elle impossible ? On dit communément qu'elle est impossible, si bien que, pour qu'il n'y ait pas de vide dans la nature, un grave monte, et un corps léger descend ; on le voit par l'eau qui monte dans un vase après que l'air y a été transformé (*aëre corrupto*) et aussi par l'eau qui monte dans la clepsydre et dans la chantepleure (*in clepsedra et cantaplora*).'

Comme Nicolas Bonet, Walter Burley rapproche la clepsydre de la chantepleure ; il nous donne, en outre, la description de ces instruments :

' Le second signe par lequel on prouvait que l'air est quelque chose, c'est, dit-il,[2] le suivant : On prenait un certain instrument ou vase que l'on appelait clepsydre ou chantepleure ; [3] ce vase a plusieurs trous ; l'un de ces trous est en haut et l'autre en bas. Si ce vase est rempli d'eau et si l'orifice supérieur est bouché, de telle sorte que l'air ne puisse entrer d'aucune manière, on peut ouvrir l'orifice inférieur sans que l'eau s'écoule par cet orifice ouvert au bas du vase. Mais si l'on ouvre l'orifice supérieur, l'eau s'écoule par le trou ou par les trous inférieurs ; et l'on voit alors que l'air entre par l'orifice supérieur. Par suite, donc, de la rentrée de l'air, l'eau s'écoule ; auparavant, elle ne pouvait s'écouler, parce que l'air ne pouvait entrer ; il apparaît, par là, que l'air est quelque chose, car il faut que la cause de cet écoulement soit quelque chose.'

Burley connaît donc deux instruments propres à faire l'expérience dont il parle ; l'un présente, dans le bas, un seul orifice et l'autre en porte plusieurs. Or Philon emploie successivement ces deux sortes de vases ; le premier lui sert à montrer que l'air est un corps, le second à réaliser l'expérience que Burley vient de décrire.

[1] Nicolai Boneti *Physica*, lib. V, cap. iv ; Bibliothèque Nationale, fonds latin, MS. n° 6678, fol. 151 *r°* ; MS. n° 16132, fol. 118, col. d.

[2] Burleus *super octo libros physicorum* ; lib. IV, tract. 11, cap. i, ed. Venetiis, 1491, fol. sign. n 2, col. a.

[3] L'édition citée porte : *tantaphora*, au lieu de : *cantaplora*.

Burley pouvait bien emprunter au commentaire d'Averroès les mots clepsydre et chantepleure ; mais la description de ces instruments ne s'y trouvait pas ; il est probable que, directement ou indirectement, Burley la tenait du *Tractatus de inani et vacuo.*

Les physiciens de la première moitié du XIVe siècle ont donc connu le *Tractatus de inani et vacuo.* Remontons plus haut dans le passé ; nous pourrons, croyons-nous, déceler la présence de ce livre aux mains d'Albert le Grand.

Voici un passage [1] de la *Physique* d'Albert :

' On prouve que l'air est un corps et non point rien du tout, en se servant d'outres pour le démontrer. On montre aussi la force de l'air dans les clepsydres qui sont des instruments qui ravissent (*furantia*) l'eau ; car *cleps* est un mot grec qui signifie larcin et *ydros* signifie eau. Cet instrument est étroit par le haut ; il porte un col terminé par un petit orifice que l'on peut boucher avec le doigt ; par le bas, il est large, et le fond en est percé de beaucoup de trous. Après qu'on l'a plongé dans l'eau, si l'on bouche l'orifice supérieur, l'eau ne coule pas par le bas. Ces gens disaient que cela provient de la force de l'air qui retient l'eau. Mais ils se trompaient. S'il est vrai de dire, en effet, que l'air est quelque chose, ce n'est pas, cependant, à cause de la force de l'air que l'eau demeure immobile dans le vase ; c'est parce que rien n'est vide. Il faut donc que les surfaces des corps soient conjointes les unes aux autres ; partant, l'eau ne se sépare aucunement de la surface de l'air [qui reste à la partie supérieure du vase], à moins que cet air ne la puisse suivre dans sa chute et qu'un autre air ne puisse succéder à celui-là ; c'est ce qui a lieu lorsque l'orifice supérieur est débouché. C'est l'un des principes dont se servent les ingénieurs ; par ce principe, en effet, on combine une multitude de vases et de siphons (*Et hoc est unum principiorum quo utuntur qui faciunt ingenia ; fiunt enim multa vasa et syphones per illud principium*). Aussi, ceux qui veulent lever un grand poids avec un petit instrument rendent-ils, tout d'abord, inséparables les surfaces du

[1] ALBERTI MAGNI *Liber physicorum*, lib. IV, tract. II, cap. I : Quod physici est tractare de vacuo et quibus rationibus probatur vacuum esse, et quibus non esse, ab antiquis ; et illi qui dicebant vacuum non esse contradicebant ad problemata.

corps qu'ils veulent soulever et de l'instrument ; alors, par celui-ci, ils lèvent celui-là.'

Il n'est pas douteux qu'Albert le Grand n'ait sous les yeux, lorsqu'il écrit ce passage, le *Tractatus de inani et vacuo* traduit ou imité de Philon de Byzance ; non seulement il lui emprunte la description de l'instrument propre à l'expérience dont il parle, mais il le suit encore en affirmant que l'eau et l'air doivent demeurer conjoints sans qu'il y ait, entre leurs surfaces, aucun intervalle vide. De ce principe, il indique, d'ailleurs, une application qui ne se trouvait pas au livre de Philon ; il avait, sans doute, vu des enfants qui s'amusaient à soulever un pavé à l'aide d'une lanière de cuir, mouillée et fortement appliquée à la surface de la pierre.[1]

Saint Thomas d'Aquin avait lu le commentaire d'Albert le Grand ; nous reconnaissons, en effet, un souvenir très net de ce commentaire dans le passage que voici : [2]

' Ils démontrent encore que l'air est doué de force en pompant l'eau dans des clepsydres, c'est-à-dire dans des vases qui ravissent (*furantibus*) l'eau ; en effet, dans ces vases, en même temps que l'air est attiré, l'eau est également attirée. En outre, l'entrée de l'eau y est empêchée à moins que l'air n'en sorte.'

Si Saint Thomas d'Aquin a lu Albert le Grand, il ne paraît pas, en revanche, qu'il ait lu le Traité *De inani et vacuo*. De ce que son maître avait emprunté à ce traité il n'a rien gardé.

Au contraire, dans l'œuvre d'un disciple immédiat du *Doctor communis*, nous allons reconnaître un emprunt probable à ce traité.

Saint Thomas d'Aquin n'avait pas achevé son commen-

[1] Dans son *Traité du Ciel*, Albert le Grand parle de l'ascension de l'eau dans les vases échauffés et du sang dans les ventouses ; mais il ne fait que paraphraser le commentaire d'Averroès sans y rien ajouter (ALBERTI MAGNI *De Caelo et Mundo*, lib. IV, tract. II, cap. viii : In quo probatur quod media elementa sunt in locis suis magis gravia quam levia).

[2] SANCTI THOMAE AQUINATIS *Expositio in libros physicorum Aristotelis*, lib. IV, lect. ix.

taire au *Traité du Ciel* d'Aristote ; après la VIII^e^ leçon du troisième livre, il avait laissé tomber la plume. Son fidèle élève Pierre d'Auvergne termina ce commentaire. C'est dans l'addition de Pierre d'Auvergne que nous trouvons ce qui suit :[1]

' Que l'on prenne un vase creux dont l'orifice soit plus étroit que le fond ; qu'on y introduise une chandelle allumée ou bien encore qu'on en chauffe fortement le fond ; puis qu'on le renverse de telle façon que l'orifice en soit plongé dans l'eau ; l'eau est attirée vers le haut, hors de son lieu naturel. Au contraire, si le vase était appliqué de la même manière à de la terre, la terre ne s'élèverait pas.

' La cause du premier effet peut être la suivante : Par la chaleur de la chandelle ou encore la chaleur du vase embrasé, l'air qui se trouve dans ce vase est raréfié et transformé en feu ; transformé en feu et mû vers le fond du vase, il se contracte en un moindre volume, et cela pour deux raisons,'

dont nous passerons le très illogique détail.

' Un signe de cette condensation de l'air peut être le suivant : Si l'on brise le vase disposé comme il vient d'être dit, on trouvera de l'eau au fond ; Averroès dit qu'il en a parfois trouvé.

' Or l'air étant comprimé dans un moindre volume, l'eau se meut en même temps vers le haut, en suivant la surface de l'air, qui a avec l'eau une ressemblance naturelle ; et afin qu'il ne s'interpose aucun vide, il monte un volume d'eau égal au volume dont l'air est comprimé.

' Si alors, par l'extérieur, on échauffe le fond du vase, l'eau redescend à son lieu naturel ; par la chaleur, en effet, l'air qui avait été condensé dans le fond du vase se raréfie et revient à sa disposition première.'

Remarquons que cette expérience, telle que Pierre d'Auvergne la complète, est textuellement celle qui, au XVII^e^ siècle, devait donner le premier thermomètre. Or ce complément, rien de ce qu'ont écrit les commentateurs d'Aris-

[1] *Libri de celo et mundo* ARISTOTELIS *cum expositione* SANCTI THOME DE AQUINO, *et cum additione* PETRI DE ALVERNIA. Colophon : Uenetijs mandato et sumptibus Nobilis viri domini Octaviani Scoti Civis modoetiensis. Per Bonetum Locatellum Bergomensem. Anno a salutifero partu virginali nonagesimoquinto supra millesimum et quadringentesimum. Lib. IV, text. comm. 39, fol. 74, coll. c et d.

tote ne l'a pu suggérer ; Philon, au contraire, à sa première expérience, adjoint une contre-épreuve toute semblable.

Pierre d'Auvergne poursuit en ces termes :

' Quant à la cause pour laquelle la terre ne serait pas soulevée si l'on disposait le vase à son égard comme on l'a fait pour l'eau, c'est que ses diverses parties ont peu de continuité entre elles, en sorte qu'elle n'est pas bien contiguë à la surface de l'air ; aussi, grâce à la porosité de ses parties, ne peut-elle pas bien empêcher l'entrée de l'air extérieur. Mais s'il arrivait que la terre à laquelle le vase est appliqué fût bien continue en ses diverses parties et qu'elle ne permît pas l'entrée de l'air extérieur, il serait nécessaire ou bien que le feu n'eût pas d'action pour raréfier l'air, par exemple parce qu'il s'éteindrait, ou bien que le vase se brisât, ou bien que l'on admît l'existence du vide, ou bien que la terre fût soulevée ; et le plus raisonnable, c'est de penser que ce dernier effet se produirait, car c'est celui qui correspond à la moindre inclination en sens contraire.'

Albert le Grand avait fait une simple allusion à cette pensée : Les corps, dans la nature, se suivent toujours de telle sorte qu'il n'y ait aucun vide entre eux. Cette pensée se retrouve dans l'exposition de Pierre d'Auvergne, et sous une forme où nous reconnaissons les idées que professait Philon de Byzance touchant l'affinité entre l'air et l'eau. Cette pensée, simplement développée, va devenir une des doctrines favorites de Roger Bacon.

III. La Nature universelle et la Fuite du Vide selon Roger Bacon

Appliquons-nous à suivre le développement de cette pensée au cours des divers ouvrages que Roger Bacon a composés.

Des deux séries de questions sur la Physique que conserve le manuscrit d'Amiens, examinons, d'abord, la première. Dès la première question relative au vide,[1] Bacon va poser le principe dont il fera, par la suite, un fréquent usage.

[1] Rogeri Bacon *Questiones naturales et primo questiones libri physicorum,* lib. iv. Queritur de vacuo ; est igitur questio utrum vacuum sit. Bibl. municipale d'Amiens, ms. nº 406, fol. 22, col. b.

Il se demande si le vide existe. Selon la méthode des *sic et non*, il commence par présenter quelques raisons en faveur de la réponse qu'il a l'intention de rejeter, c'est-à-dire de l'affirmative. Puis vient une argumentation qui conclut en sens contraire :

' Rien de ce qui, pour les choses naturelles, est privation et désordre (*inordinatio*) n'est nécessaire en la nature ; or le vide est cela ; donc etc.

' En second lieu, on reconnaît qu'il n'existe pas dans la nature, car dans la nature il n'est rien d'oiseux, rien qui soit en vain ; donc etc.

' La majeure [de la première raison est évidente]. La nature, en effet, désire toujours ce qui est le meilleur ; partant, elle désire l'ordre qui est meilleur que le désordre parce qu'il est fini et a une cause. La mineure est aussi évidente, car il est écrit dans le texte que le vide serait infini s'il existait ; il manquerait donc le premier terme et le dernier terme et, par conséquent, serait sans ordre (*inordinatum*).'

L'appétit d'ordre qu'éprouve la nature universelle contraindra donc les corps à se mouvoir de telle manière qu'aucun espace vide ne se produise entre eux.

Ce principe, nous allons voir Bacon l'appliquer dès sa seconde question, qui traite ' de la clepsydre '.[1] Il va, dit-il, chercher ' le sens de ce qu'on lit dans le texte : D'une manière semblable ils démontraient, à l'aide des clepsydres, que le vide n'existe pas '. Évidemment Bacon a mal lu le texte d'Aristote ; il l'a interprété par l'intermédiaire de quelque commentaire ; à l'aide des clepsydres on démontrait, selon Aristote, que l'air était un corps, non que le vide n'existait pas.

' Il faut d'abord remarquer, ajoute-t-il, que le mot clepsydre a comme deux significations.

' Dans un sens, on appelle clepsydre un petit trou qu'on perce, dans un tonneau, à côté du grand trou (la bonde) par lequel on verse le vin ; on le perce afin que les vapeurs qui

[1] Roger Bacon, *Op. laud.*, lib. iv : Queritur de clepsedra ; MS. cit., fol. 22, col. c.

s'élèvent de l'humidité du vin, par l'effet de la chaleur naturelle, tandis que la fermentation s'accomplit, puissent sortir et ne brisent pas le tonneau . . . On appelle aussi clepsydre ce qui sert à boucher ce trou.

' En un autre sens, la clepsydre est un vase qui, dans sa partie supérieure, a un trou ou orifice unique et qui, dans sa partie inférieure, a sept trous plus petits que l'orifice supérieur. C'est de la clepsydre prise avec cette signification que nous entendons à présent parler.'

Il est clair que Bacon, lorsqu'il écrivait ces lignes, ignorait le sens du mot clepsydre ; mais il avait sans doute remarqué qu'au commentaire d'Averroès ce mot est traduit par le mot chantepleure ; aussi s'empresse-t-il de lui assigner toutes les significations que chantepleure prend en français, y compris celles qui ne sauraient aucunement convenir à clepsydre. Ce lui sera, d'ailleurs, une occasion de consacrer une bonne partie de la question de la clepsydre à exposer ses idées sur la fermentation du vin. Mais bornons-nous à ce qu'il dit de la clepsydre entendue au second sens.

' La première question est relative à ceci, qui est connu par l'expérience : Si l'on pose le doigt sur l'orifice supérieur de la clepsydre, l'eau qui s'y trouve ne s'écoule pas par les petits trous, mais si l'on enlève le doigt, tout aussitôt l'eau en descend et tombe en pluie.'

Que cet équilibre de l'eau retenue dans la clepsydre soit contraire aux principes de la Physique d'Aristote, Bacon le montre avec insistance et par divers raisonnements. De là la difficulté qu'il voulait examiner et dont il propose la solution suivante : [1]

' De l'immobilité ou équilibre de l'eau dans la clepsydre pendant que le doigt est appliqué [à l'orifice supérieur], il y a trois causes.

' La première est la petitesse ou l'étroitesse des trous inférieurs ; si ces trous étaient plus grands, l'eau tomberait au travers.

' La seconde cause est l'air qui entre ou pénètre par ces petits trous ; à cause de sa fluidité, il soutient, porte et

[1] Roger Bacon, *loc. cit.*, fol. 22, coll. c et d.

retient l'eau (*secunda causa est aer ingrediens vel subintrans hujusmodi foramina parva qui, propter sui humidum, hujusmodi aquam defert, portat et retinet*).

' Ce sont là les causes efficientes. La troisième est une cause finale ; c'est l'ordre des corps de l'Univers et la convenance de la Machine du Monde (*ordinatio corporum universi et mundi machine convenientia*), savoir : Qu'il n'y ait pas de vide, qui est, pour les choses, une cause de désordre et de destruction, comme nous le verrons plus bas.

' Il est évident par là que ces trois causes se réunissent en une cause unique, qu'elles ne font qu'une seule cause, savoir : Qu'il n'y ait pas de vide (*ne sit vacuum*) . . .

' Tout grave tend vers le bas et se meut vers le bas s'il n'est empêché et retenu ; à ce mouvement vers le bas, il est, cependant, des conditions accessoires. La nature, en effet, désire toujours le meilleur ; or qu'un grave demeure immobile en haut, supporté et retenu par l'air, il y a, à cela, moins d'inconvénient qu'à l'existence du vide qui détruirait tout l'ordre de la nature . . .

' De l'air et des autres corps, il y a lieu de parler de deux manières différentes. D'une première manière, en tant qu'ils sont en leurs lieux naturels ; en ce cas, l'air ne porte pas l'eau. D'une seconde manière, en tant qu'ils se trouvent en des lieux étrangers à leur nature ; en ce cas l'air peut soutenir l'eau qui se trouve en un lieu étranger à sa nature, et cela afin qu'un plus grand inconvénient soit évité.'

Il sera de mode, à partir du XVII[e] siècle, de plaisanter cette cause finale invoquée par Bacon à côté des causes efficientes ; mais Bacon se conformait ici aux principes essentiels du Péripatétisme qui, dans la cause finale, voit toujours la véritable cause.

Il prend, d'ailleurs, ses précautions pour qu'on n'aille pas l'accuser de faire du vide une cause efficiente, d'attribuer au vide un pouvoir d'attirer l'eau dans la clepsydre. A cette question :[1] ' Le vide est-il une cause ? ' il répond : ' Le vide n'est rien, il n'est pas une nature ; or ce qui est cause est une certaine nature ; le vide n'est donc pas une cause.'

A cette objection : ' La ventouse vide attire le sang et,

[1] ROGERI BACON *Op. laud.*, lib. iv : Queritur septimo utrum vacuum sit causa aliqua ; MS. cit., fol. 23, col. c.

si elle n'était pas vide, elle ne l'attirerait pas,' il répond en distinguant diverses sortes d'attractions. La première qu'il mentionne est celle par laquelle l'aimant attire le fer... La dernière ' est une attraction qui se fait par le vide, grâce à l'excitation et à la disposition produite par la chaleur. C'est de cette manière que la ventouse attire le sang ; voilà pourquoi on met dans les ventouses des étoupes ardentes qui y engendrent de la chaleur ; cette chaleur échauffe l'air et attire le liquide pour se conserver ; car le liquide est l'aliment de la chaleur.

' Il est donc évident qu'une attraction ne se produit jamais par le vide seul et en tant que tel, mais par quelqu'autre cause. Si l'eau est attirée et retenue dans la clepsydre tandis que le doigt est posé sur l'orifice, cela ne se fait pas par le vide mais par la nature même et l'ordre des corps, c'est-à-dire de l'eau et de l'air, afin que le vide ne survienne pas, car si ce vide se produisait, il serait pour eux une cause de désordre et de destruction.'

Dans ce phénomène, donc, le vide n'est pas cause efficiente ; les causes efficientes, ce sont les corps en présence, l'air et l'eau. Il n'est pas davantage cause finale ; la cause finale, c'est l'ordre et la conservation des corps naturels ; c'est à cet ordre que tend la nature ; et les corps se meuvent ou demeurent immobiles de telle manière que cet ordre soit sauvegardé, dussent-ils, pour cela, aller à l'encontre des lois qui règlent leurs mouvements et repos naturels.

Telle est la doctrine que Bacon formule avec une entière netteté dès la première série de ses questions sur la Physique.

Cette doctrine, nous l'allons retrouver dans la seconde série des questions sur la Physique ; nous l'y retrouverons plus développée, mais aussi plus confuse.

Dans ces nouvelles questions, en effet, Bacon expose l'étude expérimentale du vide suivant un ordre qui est conforme à la méthode au *sic et non* et aux procédés de discussions chicanières de la Scolastique, mais qui déroute singulièrement nos habitudes.

Il s'agit de présenter une expérience où le mouvement naturel, annoncé par la Physique d'Aristote, ne se produit pas, et où, par ce repos imprévu, la formation du vide est empêchée. Voici, à peu près, comment procède Bacon :

Il annonce l'expérience comme un moyen de faire le vide ; il la décrit comme si le mouvement naturel, annoncé par la Physique péripatéticienne, se produisait en réalité, entraînant la formation d'un espace vide.

Puis il énumère les diverses autres manières dont on pourrait imaginer que les choses se passassent et il argumente pour ou contre ces diverses manières, toujours sans jeter le moindre regard sur la réalité.

Alors seulement il présente, à titre de solution du débat, l'expérience telle qu'elle se manifeste aux sens, et il l'explique par l'action que la nature universelle exerce afin qu'il n'y ait pas de vide.

C'est donc au travers de ces démarches compliquées qu'il nous faut suivre la pensée de Bacon.

L'étrangeté de ces démarches se manifeste de prime abord. Notre auteur, adversaire déterminé du vide, annonce son étude expérimentale en ces termes,[1] peu propres, assurément, à nous en faire deviner la conclusion : ' Après avoir démontré par des raisonnements qu'il faut admettre le vide, on montre également, par des exemples et des expériences, qu'il faut admettre le vide.'

Bacon présente successivement cinq expériences ; allons d'abord à la cinquième ; c'est celle qui a été décrite et étudiée dans la première série des questions sur la Physique.

' La cinquième expérience[2] est celle qu'Aristote indique dans le texte. Que l'on prenne un vase plein d'eau qui a plusieurs trous dans le bas et, dans le haut, un orifice bouché. Tout

[1] *Questiones supra librum physicorum a magistro dicto* BACUUN: Ostenso per rationes quod sit ponere vacuum, item per exempla et experimenta ostenditur quod sit ponere vacuum. MS. cit., fol. 47, col. d.

[2] MS. cit., fol. 48, coll. c et d.

ce qui est hors de son lieu propre tend à ce lieu, pourvu qu'il n'en soit pas empêché et qu'il soit hors de ce lieu. L'eau qui est là tend donc en bas. Dès lors, il se produirait un vide en haut, près de l'orifice bouché, et l'eau ne demeurerait pas en repos, comme il paraît, afin d'empêcher que le vide ne se fasse. Car Aristote dit cela, que l'eau demeurerait en repos afin que le vide ne se fît pas ; et il ne paraît pas que cela soit vrai, car l'eau qui est là, étant hors de son lieu naturel, tend naturellement en bas.'

On avait bien fort accoutumé de présenter l'expérience de Philon de Byzance pour commenter la phrase où Aristote fait mention des clepsydres, car Bacon en vient à s'imaginer que l'expérience et le raisonnement de Philon sont dans le texte d'Aristote.

Après avoir ainsi mis sur le compte de l'expérience le contraire de ce qu'elle nous enseigne en réalité, Bacon nous présente des arguments contre ce que nous manifestera tout à l'heure le témoignage des sens :

' Ce que vous objectez, que l'eau ne descendrait pas afin qu'il ne se fît pas de vide, est sans valeur. C'est une pétition de principe ; il faudrait le prouver.

' En outre, une négation ne peut être la cause d'une affirmation ; or cette proposition : l'eau demeurerait en repos, est une proposition affirmative ; la cause n'en peut être cette proposition négative : afin que le vide ne se fît point.

' De même encore, la descente de l'eau est naturelle. Le concours des parois du vase est contre nature. Il vaut donc mieux admettre la descente de l'eau, puisqu'elle est naturelle, que le concours des parois ou le repos de l'eau, puisque ces deux choses sont contre nature.'

A la supposition erronée que l'eau descendrait, une nouvelle supposition erronée est venue s'ajouter d'une manière implicite : Pour empêcher la production du vide, les parois du vase pourraient se rejoindre. Au moment où Bacon nous annonce la solution du débat, il va tout d'abord parler comme s'il penchait en faveur de cette supposition erronée. C'est seulement après avoir fait ce nouveau détour qu'il nous proposera enfin l'opinion qu'il regarde comme correcte.

' Solution. Je dis qu'en vertu de l'ordre de la nature universelle les parois se rejoindraient, afin que le vide ne se fît point (*ex ordinatione naturae universalis . . . ne fieret vacuum*). Je dis que ce n'est pas, pour cela, une pétition de principe ; car dans les démonstrations nécessaires il faut postuler le principe ; cela n'est pas absurde (*inconveniens*), car c'est toujours ainsi qu'Aristote argumente contre Platon.

' A l'autre argument, je réponds qu'il n'y a pas seulement là une négation, mais qu'une chose affirmative y est jointe, savoir la distance des parois et le salut de la nature. Dès lors, il est nécessaire d'admettre que l'eau demeure en repos ; il vaut mieux admettre cela que de supposer le vide. Afin donc que le vide ne se fasse pas, afin de sauver la disposition du vase et l'ordre de la nature universelle, l'eau demeure en repos ; et ce n'est pas seulement afin que le vide ne se fasse pas ; ce n'est donc pas une pure négation.

' A l'autre argument, je réponds : Bien que le vase soit un corps continu en toutes ses parties, il est contraire à sa nature particulière que ses parois se rejoignent. Partant, il ne faut pas que l'eau tombe ; alors, en effet, la figure naturelle du vase serait détruite ou bien le vide se produirait, et cela serait contraire à la nature universelle ; il faut donc que l'eau demeure en repos.

' Que l'eau ne descende pas c'est un accident contraire à la nature. Ce repos vaut donc mieux que la destruction de la nature ou d'une disposition naturelle ; cela vaut mieux que d'admettre le vide ou la réunion des parois, car ces deux choses sont, par essence, contraires à la nature ; ce serait absolument contraire à la disposition essentielle du vase ; il peut y avoir deux sortes de réunions des parois, une réunion naturelle et une réunion contre nature ; or cette dernière réunion de deux parois est essentiellement contre nature. Il vaut donc mieux que l'eau demeure en repos, ce qui n'est qu'un accident contraire à la nature, que s'il se produisait une chose contre nature qui fût essentielle.'

Nous avons reproduit en entier la discussion de cette cinquième expérience ; non seulement, en effet, le principe de Physique que Bacon entend établir y est très clairement exposé, mais, en outre, nous y trouvons un exemple très caractéristique de la méthode que notre auteur a coutume de suivre. Nous pourrons maintenant parler d'une manière un peu plus sommaire des quatre premières expériences.

La première de ces expériences est celle-ci : Que deux disques plans soient exactement appliqués l'un sur l'autre et que l'on soulève brusquement le disque supérieur ; l'air ne pourra pénétrer instantanément au centre de l'espace compris entre les deux disques ; le vide s'y produira donc pendant un moment.

Faisons grâce au lecteur des multiples chicanes auxquelles cette proposition donne lieu. Retenons-en cependant cette phrase : [1]

' Comme si la paume de ma main touchait la Seine, *ut si palma mea tangat Secanam.*'

Elle nous apprend, en effet, que la question fut discutée à Paris. Retenons-en également ce passage, qui prépare la solution :

' D'autres disent que les disques ne pourront être soulevés s'ils gardent leur configuration, de telle manière que chaque partie [du disque supérieur] soit soulevée également. Au fur et à mesure que les diverses parties sont soulevées, l'air pénètre d'une manière successive ; à l'instant même où une partie est soulevée, l'air pénètre au-dessous, afin qu'il ne se fasse point de vide.'

Voici maintenant la solution que propose Bacon :

' Si les deux disques étaient superposés l'un à l'autre, on ne pourrait jamais soulever le disque supérieur à moins d'en incliner quelque partie. Il faut donc que quelque inclinaison se fasse avant qu'on puisse le soulever ; sinon le vide se produirait ; et cela provient de la nature universelle. Ils répondent donc bien ceux qui répondent que le disque ne peut être soulevé de la sorte.

' Cela se voit, dans l'eau, d'une manière évidente. Que l'on pose sur l'eau un verre (*cyphus*) [retourné], et qu'on le soulève en gardant la même configuration, sans l'incliner d'un côté plus que de l'autre ; il n'y a pas d'homme au monde qui le pourrait lever ; aussi, comme il est manifeste au sens, faut-il, pour le lever, l'incliner d'abord d'un certain côté. Il en est de même dans l'air, bien qu'avec

[1] MS. cit., fol. 47, col. a.

les deux disques ce ne soit pas aussi manifeste au sens qu'avec le verre. C'est pourquoi, donc, il ne faut pas admettre le vide.'

On aime à faire de Roger Bacon un adepte précoce de la méthode expérimentale ; des pages comme celles-ci nous montrent assez qu'il expérimentait seulement en imagination. Chacun sait qu'un verre plongé dans l'eau se laisse soulever sans grand effort ; au contraire, l'adhérence de deux disques plans se peut observer sans aucune difficulté. Il est clair que notre auteur n'avait tenté ni l'une ni l'autre des deux épreuves.

La troisième expérience[1] se fait au moyen d'un vase pansu que Bacon appelle une marmite (*olla*) ; mais il ajoute que l'orifice en est de petite dimension (*modicum orificium*). Que l'on remplisse d'eau ce vase, et qu'on le renverse ; si l'eau s'écoule, l'espace contenu dans la panse demeurera vide.

Que se passe-t-il en réalité ? ' L'eau doit plutôt demeurer immobile, comme l'expérience le montre.'

Cette expérience fait double emploi avec celle que Bacon avait décrite en sa première série de questions et à laquelle il va donner ici le cinquième rang ; il ne l'ignore pas, puisque, pour préparer la réponse que nous venons de citer, il écrit :

' Prenons un vase perforé dont le fond porte une foule de petits trous ; emplissons-le et bouchons l'orifice supérieur ; rien ne sortira par les trous inférieurs bien qu'ils ne soient pas bouchés, car le vide se ferait à la partie supérieure du vase ; partant, l'eau demeure en repos ; elle ne descend point ni ne se raréfie ; l'eau donc demeurera purement et simplement en repos ; elle ne se répandra pas, afin que le vide ne se produise pas en ce lieu.'

La présence, dans la discussion de Bacon, de ces deux expériences qui sont, au fond, identiques, semble pouvoir s'expliquer par la lecture du traité de Philon de Byzance ; l'expérience ' de la marmite ' serait suggérée par celle au moyen de laquelle Philon démontre que l'air est un corps.

[1] MS. cit., fol. 48, col. a.

Nous n'insisterons pas sur ce que Bacon dit de la troisième expérience et de la quatrième : ces expériences, en effet, telles qu'elles sont décrites, sont dénuées de toute signification réelle. Par exemple,[1] ' la troisième expérience est celle du tonneau de bronze plein d'eau et bien clos. Si on le garde pendant un an, on trouve qu'il contient, à la fin, moins d'eau qu'au commencement. Cependant rien n'a pu en sortir ni y entrer. Là, donc, il y a le vide.'

Dans le traité de Philon de Byzance, il ne se trouve rien qui ait pu suggérer semblable affirmation. Mais on n'en peut dire autant du traité de Héron d'Alexandrie ; là, en effet, nous lisons : [2] ' Si l'on enferme cette eau dans un récipient de verre, de bronze ou d'une autre matière solide, et si on la place longtemps au soleil, cette eau ne diminue point, si ce n'est d'une toute petite fraction (*οὐκ ἐλαττοῦται, εἰ μὴ παρὰ μικρὸν μόριον παντάπασιν αὐτοῦ*).' Serait-ce là la source de la fausse expérience affirmée par Bacon ? En ce cas, le *Tractatus de inani et vacuo* auquel Bacon, comme la plupart des Scolastiques, paraît avoir emprunté ses connaissances expérimentales ne serait pas simplement cette traduction du traité de Philon de Byzance que Valentin Rose a exhumée ; ce serait une compilation, d'origine arabe, où les souvenirs de Héron d'Alexandrie se mêleraient à ceux de Philon. De cette supposition, nous trouverons bientôt une confirmation.

Ce que Bacon a dit des expériences relatives au vide, dans ses deux séries de *Questions sur la Physique*, fournit la matière des considérations qu'il reprend dans ses divers ouvrages.

Voici, d'abord, dans l'*Opus majus*,[3] l'expérience des deux

[1] MS. cit., fol. 48, col. a.

[2] Heronis Alexandrini *Spiritualium liber* a Federico Commandino *translatus*. Urbini, MDLXXV, fol. 5, 2°.—Heronis Alexandrini *Opera quae supersunt omnia*, ed. W. Schmidt, vol. i, pp. 14–15.

[3] Fratris Rogeri Bacon *Opus majus*, ed. Jebb, pars IV, dist. iv, cap. ix : An corpora se tangant in puncto ; p. 93.

disques appliqués l'un à l'autre et qu'on ne peut séparer. Nous retrouvons, presque dans les mêmes termes, les considérations que nous avions déjà lues dans la seconde série des *Questions*, y compris celle-ci :

' Il faut dire que l'on ne peut élever l'un des disques au-dessus de l'autre en leur gardant même configuration ; pour que l'un d'eux puisse être soulevé au-dessus de l'autre, il faut qu'on l'incline ; l'air entre ainsi peu à peu. Cela se peut fort aisément éprouver au moyen d'un verre plongé dans l'eau ; car pour rien au monde (*pro mundo*) il ne peut être levé si l'on garde même configuration à ses parties ; la cause en est que l'eau doit venir peu à peu en occuper le lieu. C'est là la cause positive (*affirmativa*) en conséquence de laquelle le vide se trouve exclu.'

Dans l'*Opus majus*, Bacon n'avait parlé du vide que d'une manière incidente ; il en traite *ex professo* au cours de l'*Opus tertium*. Là, nous retrouvons [1] l'expérience du vase dont le fond est criblé de petits trous ; là aussi l'auteur rappelle qu'il a parlé, dans l'*Opus majus*, de l'adhérence de deux disques exactement appliqués l'un contre l'autre.

La raison de cette adhérence, c'est que,[2] de la séparation des deux plaques, ' résulterait une discontinuité (*discontinuatio*) de la nature et entre les parties de l'Univers, discontinuité à laquelle le vide se trouve attaché (*annexum*) . . . Aussi, qu'un homme essaye de soulever le disque supérieur en le maintenant parallèle à l'autre (*aequaliter*), il n'y parviendra jamais . . . Dans l'eau, cela apparaît bien. Si quelqu'un pose sur l'eau la concavité d'un verre, en tenant ce verre par le pied, il peut expérimenter qu'en maintenant la figure bien égale de tous côtés il ne parviendra par aucune violence à le tirer de l'eau.'

L'expérience du vase perforé donne à Bacon l'occasion d'exposer ses idées sur la fuite du vide avec une précision et une ampleur qu'il ne leur avait pas encore accordées.

[1] Rogeri Baconis *Opus tertium*, ed. Brewer, cap. xliii, pp. 155–6.
[2] Rogeri Baconis *Op. laud.*, cap. xlv, p. 166.

'Rien, dit-il,[1] n'empêche l'eau de couler ni ne le lui défend ; c'est par sa propre nature qu'elle demeure en repos bien que soulevée, en vue de la continuité de la nature commune à tous les corps, continuité qui doit être conservée [2] entre les diverses parties de l'Univers. L'eau, en effet, est une certaine nature qui a deux sortes de rapports. L'un est le rapport qu'elle a à son lieu propre. L'autre est le rapport qu'elle a en vertu de la continuité du milieu (*medii*) naturel, afin de garder cette continuité avec les autres corps naturels. Cela, elle ne le ferait pas si elle tombait, car l'air ne peut entrer par l'orifice bouché. Or le rapport qu'a l'eau à cette continuité qu'il s'agit de sauver, prime le rapport qu'elle a à l'égard de son lieu propre ; le premier de ces rapports, en effet, lui est dû en tant qu'elle est une partie de l'Univers ; le second, celui qui concerne son mouvement de descente, lui est seulement dû en tant qu'elle est apte à être logée, qu'elle peut être entourée par un lieu qui lui convient mieux qu'un autre lieu. Mais être une partie de l'Univers, c'est une propriété qui, pour l'eau, passe avant la propriété d'être logée et entourée par quelque chose qui lui convienne, une propriété qui lui est plus essentielle ; elle peut, en effet, continuer d'être de l'eau lors même qu'elle ne serait pas entourée par un tel lieu qui lui convînt ; mais elle ne pourrait continuer d'être de l'eau si elle n'était plus une partie de l'Univers. Si donc l'eau demeure immobile en l'air, ce n'est pas, d'une façon première et proprement dite, afin que le vide ne soit pas (*propter negationem vacui*) ; c'est afin de sauver la continuité de la nature dans le Monde ; et de cette continuité, la privation du vide découle à titre secondaire. Ainsi ce n'est pas une négation qui est, ici, cause d'une affirmation, mais une affirmation. Qu'à cette affirmation une négation soit annexée, cela n'a pas d'inconvénient, car toute affirmation entraîne avec elle une infinité de négations qui lui sont adjointes . . . Mais une négation ne saurait, d'une façon première et principale, importer une affirmation ; elle n'en peut être la cause ; elle en peut seulement accompagner la cause, comme il arrive ici.'

Après avoir assisté, en lisant les deux séries de *Questions sur la Physique* et l'*Opus Majus*, aux tâtonnements et aux essais de la théorie baconienne, nous la contemplons, maintenant,

[1] Ibid., pp. 165–6.

[2] Le texte publié par Brewer porte : *salvatae* ; un ms. porte : *salvande* ; il faut, croyons-nous : *salvandam*.

en son plein achèvement ; Bacon, en effet, ne la perfectionnera pas davantage ; aux *Communia Naturalium*, il formulera encore quelques propositions utiles à recueillir, mais il ne donnera plus de son système l'exposé dogmatique qu'il a présenté dans l'*Opus tertium*.

Nous retrouvons, aux *Communia Naturalium*, l'expérience des deux disques adhérents,[1] enfin débarrassée de la fausse expérience du verre renversé sur l'eau ; nous y retrouvons aussi [2] l'expérience que Philon de Byzance faisait avec un vase au fond criblé de petits trous.

C'est à propos de cette dernière expérience que sont émises les réflexions suivantes :

' Ce n'est pas d'elle-même que la nature particulière de l'eau demeure en l'air, mais par la force de la nature universelle qui, sans cesse, requiert et conserve la continuité des corps naturels, continuité que le vide dissout. On voit donc quelle est ici la cause efficiente : C'est la nature universelle à laquelle obéit la nature particulière. On voit aussi quelle est la cause finale : C'est la continuité naturelle des corps de ce Monde. Voilà l'affirmation dont résulte la négation du vide. Nous ne posons donc pas une négation comme cause d'une affirmation, mais au contraire . . .'

' Si l'on disait que l'eau ne descend pas afin que le vide ne se produise pas, ce ne serait pas une solution, car une négation ne peut être la cause d'une affirmation. Il faut dire que l'eau est retenue en l'air par la loi de la nature universelle, afin qu'il y ait continuité entre les corps de la nature ; de cette continuité, l'exclusion du vide découle à titre secondaire. C'est donc une affirmation, savoir la continuité, qui est cause d'une affirmation, savoir le repos de l'eau dans le vase.'

La doctrine dont nous avons suivi le développement au travers des écrits de Roger Bacon semble bien lui appartenir en propre. A peine, croyons-nous, en avait-il trouvé chez ses prédécesseurs un germe presque infime. Albert le Grand, répétant le propos de Philon de Byzance, s'était borné à dire,

[1] *Opera hactenus inedita* ROGERI BACONI, fasc. iii. *Liber primus communium naturalium* FRATRIS ROGERI, pars III, dist. ii, cap. vi, éd. Steele, pp. 221–3.

[2] ROGER BACON, *loc. cit.*, pp. 219–20 et p. 224.

au sujet de l'immobilité de l'eau dans la clepsydre : ' C'est parce que rien n'est vide. Il faut donc que les surfaces des corps soient conjointes les unes aux autres. *Quia nihil est vacuum ; et ideo oportet superficies corporum esse conjunctas.*'

A partir de cette minime indication, Roger Bacon a développé toute une théorie ; et, de cette théorie, il convient de marquer l'importance.

Aristote avait expliqué tous les mouvements des corps inanimés que contient l'orbe de la Lune, à partir de la supposition du lieu naturel. A chaque corps correspond un lieu propre où sa forme substantielle atteint la perfection ; ce lieu est le centre du Monde pour les corps graves, la région contiguë à l'orbe de la Lune pour les corps légers. Placé dans son lieu naturel, un corps y demeure en repos. Mis hors de son lieu, il tend à s'y rendre ; s'il n'est retenu, il se meut vers lui.

Or les expériences que décrivent Philon de Byzance ou Héron d'Alexandrie mettent constamment cette Mécanique en défaut ; on y voit des corps que rien ne retient et qui demeurent immobiles, bien qu'ils ne se trouvent pas en leur lieu naturel ; on y voit monter des corps graves et descendre des corps légers. La Mécanique d'Aristote réclame donc une modification ou un complément.

Avant d'être corps de telle nature, corps céleste, corps grave ou corps léger, un corps est, tout simplement, une partie de l'Univers corporel ; avant la nature particulière que lui confère sa forme substantielle, il a une nature universelle qui, selon la doctrine d'Avicébron, chère à Bacon, lui est donnée par la corporéité. En vertu de sa nature particulière, le corps tend à son lieu propre ; mais en vertu de la nature universelle qu'il possède il a une autre tendance ; il tend à demeurer soudé aux corps qui lui sont immédiats, afin que toutes les parties de l'Univers demeurent unies et contiguës. Comme la nature universelle surpasse, en excellence, la nature particulière, la seconde tendance est plus

puissante que la première. On peut donc observer des repos et des mouvements qui contredisent aux lois de la gravité et de la légèreté ; ces repos ont pour cause la tendance de la nature universelle, qui assure la parfaite et perpétuelle continuité entre les divers corps du Monde.

La théorie du lieu naturel, telle qu'Aristote l'avait proposée, était une bonne théorie de Physique, car, au moyen d'un petit nombre d'hypothèses, elle permettait de classer une multitude de phénomènes connus, de prévoir une foule de repos ou de mouvements.

Cependant, peu à peu, les expériences dont la théorie péripatéticienne ne pouvait rendre compte se sont multipliées et précisées. Alors, il a fallu la remplacer par une théorie plus complexe, mais plus compréhensive ; Roger Bacon a construit cette théorie nouvelle.

La théorie proposée par Roger Bacon était une bonne théorie physique ; à partir d'un petit nombre de principes simples, elle rendait compte de tous les phénomènes d'équilibre et de mouvement que l'on connaissait alors, aussi bien de ceux qu'interprétait déjà la théorie d'Aristote que de ceux dont Philon avait donné la description. Aussi cette théorie a-t-elle joui d'une faveur longue et méritée. Au milieu du XVI^e siècle, Jules-César Scaliger se plaira à la développer [1] dans ses diatribes contre Cardan.

Un jour, cependant, l'hypothèse de la continuité universelle, proposée par Roger Bacon, connaîtra le sort qu'a connu l'hypothèse du lieu naturel, proposée par Aristote ; l'observation révélera des phénomènes dont elle ne peut rendre compte ; les fontainiers de Florence remarqueront qu'une pompe aspirante ne peut soulever l'eau au-delà de trente-deux pieds ; Evangelista Torricelli réalisera l'expérience du vif-argent.

[1] Julii Caesaris Scaligeri *Exotericarum exercitationum liber XV De Subtilitate adversus Cardanum*. Exercitatio V : De materia. De vacuo.

Alors, après avoir été longtemps une bonne théorie de Physique, le système de Bacon deviendra, à son tour, une théorie insuffisante, que les faits contredisent, qu'il faut rejeter et remplacer par une doctrine plus compréhensive. Ceux qui s'obstineront à professer cette théorie en dépit du démenti de l'expérience feront preuve d'une illogique routine ; c'est ce que, durement, mais justement, Pascal reprochera au P. Noël.

Mais le temps où le système de Bacon devra être abandonné est bien éloigné de celui où l'auteur de cette théorie la formule. Voyons comment l'idée nouvelle a été accueillie par les successeurs immédiats du Franciscain anglais.

IV. La Tradition de Roger Bacon et l'Horreur du Vide

Nous chercherons d'abord la trace de la doctrine de Bacon dans cette *Summa philosophiae* que certains manuscrits attribuent à Robert Grosseteste, mais où l'on reconnaît sans peine l'œuvre d'un disciple de Roger Bacon.

Voici un premier passage intéressant,[1] que nous relevons dans ce que cette *Somme* dit du vide :

' Héron, cet éminent philosophe, s'efforce, à l'aide de clepsydres, de siphons et d'autres instruments, de mettre en évidence l'existence du vide ; ce n'est pas chose qu'il faille réprouver de toute façon. Il ne se propose, en effet, d'établir qu'une chose, c'est que, par un certain artifice, le plein peut être ôté d'un lieu ; cela fait, il faudra nécessairement que le vide reste en ce lieu. Mais c'est seulement pendant la durée instantanée de la transformation que cela se peut faire véritablement. La cause de cet effet, c'est la vertu du lieu naturel qui, de la circonférence au centre, est partout répandue.'

Ce texte nous apprend, tout d'abord, que le *Tractatus de inani et vacuo* où Bacon avait lu les expériences qui se font

[1] Lincolniensis *Summa*, cap. cxviii, éd. Baur, p. 417. [Ludwig Baur, *Die philosophischen Werke des Robert Grosseteste, Bischofs von Lincoln* (*Beiträge zur Geschichte der Philosophie des Mittelalters*, Bd. ix, Münster, 1912).]

avec des clepsydres et des siphons était donné sous le nom de Héron d'Alexandrie, ou, tout au moins, citait ce nom. Nous avons reconnu qu'il devait contenir certaines expériences faites par Philon et ignorées de Héron ; qu'il devait également décrire des expériences que Héron rapporte et dont Philon ne parle pas. Nous sommes ainsi conduits à penser que les Arabes avaient donné aux Chrétiens, sous le nom de Héron d'Alexandrie, une compilation où les emprunts faits à cet auteur se mêlaient à ceux que Philon avait fournis.

Nous voyons, en outre (et la lecture de Bacon nous le faisait déjà soupçonner), que ce traité décrivait les expériences de Héron et de Philon à l'envers, si l'on peut le dire, et, par ce retournement, présentait des effets contraires à ceux que les mécaniciens ont observé comme des artifices propres à réaliser un espace vide.

Le disciple de Bacon paraît avoir été vivement frappé par l'hypothèse de cette nature universelle à laquelle son maître attribuait les mouvements qui violentent les natures particulières afin d'empêcher le vide de se produire. Il en met la notion à la base même de sa Cosmologie.

' La nature, dit-il,[1] en tant qu'elle est même chose que la force active et que la forme, . . . est ou bien nature universelle ou bien nature particulière . . .

' Cette nature universelle, c'est une force qui réside dans la substance céleste, c'est-à-dire dans cette intelligence créée qui, au-dessous du Créateur béni, gouverne et modère toute la nature corporelle et inférieure . . .

' Avec cette nature universelle conspirent toutes les choses qui gisent au-dessous d'elle, qui plongent en elle leur racine, qui, par elle, ont reçu en partage la propriété d'agir ; ces choses conspirent avec la nature universelle au point de suspendre, parfois, les natures qui accompagnent, en elles, la nature universelle, les propriétés qui leur sont particulières, et d'empêcher les actions et les effets qui leur sont propres.

' Cette particularité qui distingue la nature particulière de la nature universelle n'est pas une particularité individuelle,

[1] LINCOLNIENSIS *Summa*, cap. ccxliv, éd. Baur, pp. 590–91.

si ce n'est, peut-être, par accident ; c'est une pure propriété opérative qui accompagne toutes les choses d'une même espèce . . . Toute espèce, en effet, peut être appelée particulière à l'égard du genre auquel elle appartient . . ., bien qu'elle soit véritablement universelle à l'égard des individus.

' La nature particulière, donc, est une force, une propriété opérative qui accompagne l'espèce, bien que l'effet qu'elle produit ne se rencontre pas toujours en tout individu de cette espèce. Par exemple, de ce que l'homme est raisonnable, il n'en résulte pas que tout homme, nécessairement et d'une manière habituelle, use de la raison, mais plutôt qu'il est naturellement apte à en user. De même, le feu, par sa nature particulière, est chaud et tend à être placé aussi haut que possible ; il se peut, cependant, que le feu soit, parfois, privé de chaleur, et qu'il se trouve en un lieu bas.'

' La nature universelle, poursuit notre auteur,[1] a une première action qui lui est propre et qui tend à un but déterminé ; mais elle a aussi une autre action qui se trouve répandue dans toute opération de la nature particulière ; celle-ci ne meut aucunement, en effet, qu'elle ne soit mue, tout d'abord, par la nature universelle.

' Ainsi, d'une manière universelle, causale, première, mouvoir et opérer sont choses qui appartiennent à la force et à la nature universelles ; mais il leur appartient également de produire des effets contraires à ceux de la nature particulière, et cela de multiple façon.

' C'est le propre de la terre d'occuper le lieu le plus bas ; il est parfois possible, cependant, qu'elle se trouve logée au sein de la sphère de l'air, voire au suprême faîte de la sphère du feu . . . L'air et le feu peuvent se trouver transportés fort loin de leurs sphères respectives ; l'eau, qui a pour propriété de surpasser la sphère de la terre, a pu être renfermée dans les entrailles de la terre, afin de laisser apparaître la terre ferme.'

De ces mouvements, contraires aux mouvements naturels, que détermine la nature universelle, notre auteur aurait pu prendre exemple en citant les expériences où cette nature universelle met obstacle à la production du vide. Ces exemples, il les laisse à son maître Roger Bacon, et il en cite un autre que nous n'avons jamais rencontré hors de sa *Somme de philosophie.*

[1] Ibid., cap. ccxlv, p. 591.

On sait comment Aristote cherchait dans l'air ébranlé la force motrice qui maintient le mouvement du projectile, après que celui-ci a quitté la main ou la machine balistique. Au XIII^e siècle, la Scolastique tout entière, y compris Roger Bacon, admettait cette étrange théorie. Notre auteur n'a pas manqué de lui donner son assentiment ;[1] et cependant, elle l'étonne. Que l'air, qui est grave, puisse porter un projectile vers le haut, cela ne saurait être un effet de sa nature particulière ; il faut donc qu'il tienne cette propriété de la nature universelle. Mais citons le curieux passage[2] où se développe cette explication :

' Aristote affirme qu'entre deux mouvements contraires, comme l'ascension d'un grave et la chute de ce même grave, un repos intermédiaire doit s'intercaler nécessairement, d'une nécessité de nature ; aussi voit-on que les graves jetés en l'air demeurent en repos lorsqu'ils parviennent au terme de leur trajectoire vers le haut. Or voilà deux choses [l'ascension et le repos en l'air] qui sont fort contraires à la nature particulière du grave.

' De même, dans le jet d'une pierre, d'une flèche ou d'un objet quelconque, mû de mouvement violent, l'air, qui est très mobile et très léger, reçoit, de la violence du premier moteur, une impression par laquelle il puisse conduire le mobile jusqu'au terme du mouvement. Suivant Aristote, à la fin du mouvement aussi bien qu'au milieu, c'est ce même air, mis en branle au début par le moteur violent, qui meut naturellement le mobile, lors même que la pierre lancée serait de la taille d'une meule de moulin ou incomparablement plus grande. Platon pensait que le premier air ébranlé en mouvait un second et ainsi de suite jusqu'à la fin ; mais un mouvement de cette sorte serait un mouvement violent. Selon ce qu'affirme Aristote, au contraire, tant au milieu du mouvement qu'à la fin, la force motrice active, en ce qui concerne l'air qui maintient le mouvement, serait naturelle. Le même Aristote et les autres Péripatéticiens attribuent à l'eau une nature qui a même facilité pour recevoir d'un moteur violent une impression quelconque, et même propriété de mouvoir ensuite par sa nature.

' Mais cela ne peut appartenir uniquement à la nature

[1] LINCOLNIENSIS *Summa*, cap. clxxxi, éd. Baur, p. 510.

[2] Ibid., cap. ccxlv, pp. 591–2.

particulière de l'air et de l'eau ; c'est une propriété que la nature universelle a imprimée à l'élément fluide.

' En effet, de deux objets opposés, il en est toujours un auquel tend la nature particulière ; la nature universelle, au contraire, regarde de même façon ces deux objets opposés ; lors donc que la nature particulière agit, la nature universelle collabore avec elle ; mais elle pourra aussi opérer en sens contraire de la nature particulière.'

C'est bien la théorie imaginée par Roger Bacon ; l'inventeur ne l'avait appliquée qu'aux expériences où les corps graves suspendent leurs mouvements naturels pour éviter le vide ; audacieusement, son disciple a tenté de la généraliser et d'en tirer une explication du mouvement des projectiles. Les physiciens qui viendront après l'auteur de la *Summa philosophiae* ne renouvelleront pas sa tentative ; comme Bacon, c'est seulement aux expériences relatives à la fuite du vide qu'ils appliqueront la notion de nature universelle ; seul, Jean de Dumbleton écrira, au sujet du mouvement des projectiles, une page où l'on pourra peut-être reconnaître un souvenir de la *Summa Lincolniensis*.

Les *Commentaires sur la Physique d'Aristote* composés par Gilles de Rome sont le premier écrit où nous remarquions, au sujet du vide, l'influence des idées émises par Bacon.

Cette influence se devine déjà, croyons-nous, dans ce que Gilles de Rome dit de l'expérience de la clepsydre.

' On prouve, écrit-il,[1] que l'air est quelque chose au moyen d'un certain vase qu'on appelle clepsydre ; il a un trou dans la partie supérieure et un grand nombre de trous dans la partie inférieure. Le vase une fois rempli, si l'on ouvre les trous inférieurs, tout en maintenant bouché l'orifice supérieur, l'eau ne s'écoule pas ; l'air, en effet, voulant entrer par ces trous, ne permet pas à l'eau de sortir. C'est par là qu'on démontrait que l'air est quelque chose ; en effet, si l'eau sortait de ce vase artificieusement combiné, et si l'air n'y entrait pas, il y resterait le vide. L'air donc, en voulant entrer par les trous d'où l'eau s'échapperait, empêche la sortie de l'eau. Partant, disaient-ils, l'eau est quelque chose.'

[1] Aegidii Romani *In libros de physico auditu Aristotelis commentaria*, lib. IV, lect. x, ed. Venetiis, 1502, fol. 76, col. a.

Dans l'insistance avec laquelle Gilles de Rome, en l'air qui veut entrer, met la cause qui empêche l'eau de sortir, peut-être reconnaîtra-t-on un souvenir de ce que Bacon disait de la clepsydre, dans la première série de ses *Questions de Physique*. Mais l'influence de Bacon se marque avec une tout autre netteté dans ce que Gilles dit de la traction exercée par le vide (*tractus a vacuo*).

' On se demanderait peut-être, écrit-il,[1] s'il y a une traction exercée par le vide . . . Il faut répondre que la traction par le vide se peut entendre de deux manières. En premier lieu, le mot vide peut désigner d'une manière positive une certaine nature, par laquelle serait exercée une attraction proprement dite ; imaginer de la sorte la traction du vide, c'est purement fantastique . . . On peut entendre d'une autre manière la traction du vide, et désigner par là une traction exercée afin qu'il n'y ait pas de vide ; de cette manière, il s'exerce, en effet, une traction du vide, car la nature ne souffre pas le vide. De cette façon, dans une foule de circonstances, il se produit une traction afin qu'il n'y ait pas de vide.

' C'est manifeste pour la ventouse; si l'on y met de l'étoupe enflammée, ce feu raréfie l'air contenu dans la ventouse ; qu'on pose alors la ventouse sur la chair ; comme le feu s'éteint, cet air se refroidit et occupe moins de place ; alors, pour que le vide ne se produise pas, il se fait une attraction de la chair.

' Toutefois, dans la ventouse où l'on met de l'étoupe allumée, il y a peut-être concours de deux attractions, celle de la chaleur et celle du vide. Maintes fois, cependant, la traction provient du vide seul ; cela se voit dans ces tuyaux recourbés (*fistulae tortuosae*) que certains appellent des serpents ;[2] si on les plonge dans un tonneau de vin, le tonneau se trouve vidé presque en entier ; cela provient de ce que ces tuyaux sont recourbés, en sorte que si l'écoulement s'arrêtait il resterait au milieu un espace vide.

' Mais peut-être concevra-t-on, en outre, le doute que voici :[3] Attirer est un certain effet positif ; à un effet positif, il faut assigner une cause positive ; quelle est donc cette cause positive qui tire afin qu'il n'y ait pas de vide ?

[1] Aegidii Romani *Op. laud.*, lib. IV, lect. x, dubitatio 5ª ; éd. cit., fol. 79, coll. b et c.

[2] Au lieu de: serpents (*serpentes*), ne faut-il pas lire : siphons (*siphones*) ?

[3] Aegidius Romanus, loc. cit., dubitatio 6ª ; éd. cit., fol. 79, col. c.

' Il faut répondre que nous ne pouvons supposer que cette cause soit quelque corps mixte ; en effet, au sein d'un élément pur, où il n'y aurait aucun corps mixte, il pourrait arriver qu'une telle traction se produisît. A cette traction, nous ne pouvons, non plus, assigner comme cause quelqu'un des éléments ; il arrive, en effet, que cette traction s'exerce de n'importe quel côté, en n'importe quelle direction ; or il n'advient à aucun des éléments d'avoir, par lui-même, un tel mouvement. Il reste donc que cette traction provienne de la force du ciel.

' Ainsi, en effet, nous devons imaginer que toute la sphère des choses sujettes à l'action et à la passion tient sa connexion de la force du ciel ; or ce qui a la propriété de conjoindre a aussi la propriété d'attirer, afin qu'il ne survienne pas quelque division là [où la connexion doit être maintenue] ; donc la force céleste, dont c'est le propre de conjoindre toutes ces choses, tire afin qu'elles ne se séparent pas les unes des autres et qu'il n'arrive pas à l'intervalle compris entre elles de demeurer vide. Ainsi, en effet, en est-il de l'aimant, qui a la propriété de s'unir le fer à lui-même ; aussi, de quelque côté qu'on le place, le fer est-il attiré par l'aimant. De même, comme le ciel a la propriété d'unir entre elles les diverses parties de l'Univers, en tout endroit où se produirait une séparation et un espace vide, en ce même endroit, par la force céleste, s'exercerait une attraction, afin que cela n'ait pas lieu.'

La Physique péripatéticienne enseignait que les corps célestes ont communiqué aux corps sublunaires deux sortes de forces, la gravité et la légèreté ; par l'une ou par l'autre de ces forces, chaque corps se meut de mouvement naturel, vers le lieu où sa forme atteint la perfection qui lui est propre. A cette action, génératrice de la gravité et de la légèreté, Gilles de Rome propose d'adjoindre une autre action, plus générale, qui a pour objet de maintenir la continuité du monde sublunaire ; cette action, dans chaque cas où une discontinuité, où un vide tendrait à se produire, met en jeu une force capable d'empêcher cette discontinuité, de prohiber le vide ; c'est à cette force qu'on donne, assez improprement, le nom de traction exercée par le vide, *tractus a vacuo*.

Cette théorie, fort logiquement reliée aux principes géné-

raux de la Physique péripatéticienne, la complétait d'heureuse manière ; elle permettait de rendre compte d'une foule d'expériences qui semblaient contredire aux lois du grave et du léger ; qu'elle ait été entièrement inspirée par la doctrine de Bacon, cela saute aux yeux.

Jean de Jandun n'est pas moins intéressé que Gilles de Rome par les expériences où l'on voit la nature fuir le vide ; mais il se montre moins affirmatif au sujet de l'explication qu'elles comportent.

' Certains disent, écrit Jean de Jandun,[1] que si deux corps absolument plans étaient appliqués l'un sur l'autre sans quelque intermédiaire que ce soit, jamais ils ne pourraient être séparés simultanément en toutes leurs parties ; pour qu'ils pussent être disjoints, il faudrait que ce fût successivement, d'abord une partie, puis une autre ; et autant il y aurait d'espace entre ces parties, autant d'air entrerait ; l'air se glisserait ainsi successivement, au fur et à mesure que ces deux corps seraient disjoints. En effet, à cause de la fuite du vide, il serait impossible que toutes les parties se séparassent également au même instant. Considérez bien cette question, car elle est assez belle. Peut-être, moyennant la supposition faite, ces deux corps ne pourraient-ils jamais être séparés l'un de l'autre ; mais peut-être aussi dirait-on que la supposition est impossible.'

Jean de Jandun rapporte une des expériences qui figuraient, nous a dit Marsile d'Inghen, au *Tractatus de inani et vacuo* :

' Qu'on fasse un vase gros et large par le bas, étroit par le haut ; qu'il ait une petite ouverture en la partie étroite et, en la partie large, plusieurs ouvertures ; si l'on plonge ce vase dans l'eau, il est manifeste que l'eau le remplira ; qu'on bouche alors, d'une manière très parfaite, l'ouverture supérieure et qu'on retire le vase de l'eau . . . Pour la cause susdite, l'eau ne pourra tomber par les trous qui sont au bas du vase. Mais qu'est-ce donc qui la retiendra ? On répondra que c'est la nature universelle, car cette nature ne permet

[1] Joannis de Janduno *Super octo libros Aristotelis de physico auditu quaestiones*, lib. IV, quaest. x : An vacuum esse sit necessarium.

point le vide qui se produirait nécessairement si l'eau tombait ; il y a moindre mal, en effet, à ce que l'eau soit ainsi retenue en haut qu'à la production du vide en ce lieu . . . '

Voici une autre expérience, dont Jean Buridan et Marsile d'Inghen se plairont à invoquer le témoignage :

' Supposons qu'en un vase très épais et très résistant il y ait une seule ouverture ; qu'en cette ouverture on introduise le bec d'un soufflet, et que ce soufflet n'ait aucun trou dans ses parois . . . Jamais aucune force ne pourrait soulever les parois du soufflet ni les séparer l'une de l'autre. Qu'est-ce qui l'empêcherait ? La nature universelle, en vue de la fuite du vide . . .

' Voilà ce qu'on peut dire au sujet de ces expériences, et je n'ai pas entendu de meilleures raisons.

' Mais quelle est cette nature universelle, qui produit ces empêchements ? Cela n'est pas absolument manifeste.'

En revanche, ce qui est absolument manifeste, c'est que Jean de Jandun emprunte aux *Questions de Physique* de Roger Bacon, et cela d'une façon presque textuelle, tout ce qu'il dit de cette nature universelle. Il ne paraît pas, d'ailleurs, qu'il ait connu l'*Opus tertium* ; il y eût trouvé des considérations propres à dissiper quelque peu le doute qui est demeuré dans son esprit.

Après Jean de Jandun, l'École de Paris ne nous présente plus, au XIVe siècle, de physicien qui ait très fidèlement suivi, au sujet du vide, l'opinion de Roger Bacon.

François de Meyronnes écrit : [1]

' Que faut-il penser de la traction du vide (*tractus vacui*), car le vide ne cause rien ? . . . Il ne semble pas qu'une intelligence produise cette traction. Je ne vois donc point de cause, à moins de recourir au premier Agent universel ; car on voit un corps de même nature se mouvoir tantôt vers le haut, tantôt vers le bas.'

Il semble par là que François de Meyronnes voie une action directe de Dieu en tout mouvement qui tend à éviter le vide ;

[1] Francisci de Mayronis *Scriptum in secundum librum Sententiarum*, dist. XIV, quaest. vi ; ed. Venetiis, 1520, p. 151, col. b.

à moins que, par premier Agent, il n'entende le ciel ; sa pensée rejoindrait alors celle de Gilles de Rome dont, visiblement, il s'est inspiré.

A l'imitation de Jean de Jandun, Jean le Chanoine énumère [1] les diverses expériences que renfermait le *Tractatus de inani et vacuo*. Comme son prédécesseur, il les présente, tout d'abord, sous la forme de procédés propres à réaliser un espace vide, puis il explique comment les choses se passeront afin que le vide ne se produise pas.

' Qu'on fixe une chandelle au fond d'un vase plein d'eau, de telle sorte que la flamme se trouve bien à la hauteur d'une palme au-dessus de l'eau ; puis qu'on la recouvre d'un vase ; on constate que la chandelle s'éteint . . .

' Qu'on prenne quelque vase de dur métal ; qu'on l'emplisse d'eau par un temps froid ; si la congélation survient, l'eau congelée occupera moins de place ; entre les parois du vase, il demeurera un espace vide . . .

' Qu'on prenne deux disques parfaitement plans et qu'on les applique l'un sur l'autre sans rien d'interposé . . . Supposons ensuite qu'on attache un fil au centre du disque supérieur ; si l'on soulève ce disque au moyen du fil, il se produira un vide dans les parties centrales ; . . . l'air, en effet, parviendra aux parties voisines de la circonférence avant d'atteindre les parties centrales.'

' Au sujet de la chandelle, je dis qu'il ne se produirait pas de vide, car l'eau monterait et l'air se raréfierait . . . — Mais cela ne peut être, car il est contraire à la nature que l'eau monte, puisqu'elle est grave. — Je réponds que l'ascension d'un grave est contraire à la nature particulière ; mais la nature particulière doit naturellement obéir à la nature universelle et au régime de l'Univers total, qui a horreur (*abhorret*) d'être dissous et interrompu ; cela se fait donc afin qu'il ne reste pas de vide.

' A propos de l'expérience suivante, je dis que s'il y avait un tel vase dans lequel l'air ne pût entrer, ce vase serait brisé par la force de l'Univers entier, car la nature aurait, à ce point, horreur du vide (*et in tantum natura vacuum abhorreret*).

[1] Joannis Canonici *Quaestiones super VIII libros physicorum Aristotelis*, lib. IV, quaest. iv, ed. Venetiis, 1520, fol. 42, coll. c et d ; fol. 43, col. b.

' A propos de l'expérience suivante, je dis . . . que l'air se raréfie, en sorte qu'avec l'air environnant il suffit à remplir l'intervalle des deux disques. Et si cela était impossible, il serait également impossible, en vertu de la force qui régit l'ensemble de l'Univers, de soulever un disque au-dessus de l'autre.'

De la bouche de Jean le Chanoine nous venons d'entendre cette expression qui, après les découvertes de Torricelli et de Pascal, excitera tant de sarcasmes : La nature a horreur du vide. Rien n'indique, d'ailleurs, que notre auteur, en usant de cette expression, sous-entende toutes les pensées ridicules qu'on y a, plus tard, reconnues ; rien ne laisse supposer qu'il fasse, de la nature, un être doué de sentiment, capable de sympathie ou d'antipathie ; il est clair qu'il n'a rien voulu signifier, sinon la théorie que Roger Bacon et Gilles de Rome avaient exposée plus en détail.

Albert de Saxe, lui aussi, use de cette expression ; mais le sens qu'il lui confère anime encore moins la nature. Il examine cette objection : [1] ' Le plein existe ; donc le vide existe ; la conséquence résulte bien de l'antécédent, car si, de deux choses opposées, l'une existe dans la nature, l'autre, dit-on, y existe aussi.' Il répond : ' On l'accorde dans le cas où la nature n'aurait horreur ni de l'une ni de l'autre de ces deux choses ; mais il n'en est pas ainsi dans le cas proposé, car la nature a horreur du vide (*natura abhorret vacuum*) ; l'objection, donc, est sans valeur.'

Or, à cette expression : ' La nature a horreur du vide,' Albert attribue exactement le même sens qu'à celle-ci : ' Par aucune puissance naturelle, le vide ne peut être.' Nous en avons l'assurance par les lignes suivantes qui se lisent entre l'objection et la réponse rapportées ci-dessus :

' Par aucune puissance naturelle il n'est possible que le vide soit (*Per nullam potentiam naturalem possibile est esse vacuum*). . . On le prouve par certaines expériences.

[1] ALBERTI DE SAXONIA *Quaestiones super libros de physica auscultatione*, lib. IV, quaest. viii.

' Premièrement, si l'on bouchait toutes les ouvertures d'un soufflet, aucune puissance ne pourrait soulever un des battants du soufflet pour le séparer de l'autre, à moins qu'il ne se fît quelque rupture par où l'air pût pénétrer ; cette rupture faite, il devient facile de soulever un des battants en le séparant de l'autre, car il y a alors quelque chose qui peut être admis entre les parois du soufflet ; cela semble un signe que la nature abhorre le vide (*hoc videtur esse signum naturam abhorrere vacuum*).

' Secondement, on peut prouver la même chose au moyen de la clepsydre.'

Albert de Saxe se borne, d'ailleurs, à cette affirmation : Aucune puissance naturelle ne saurait produire un espace vide. Pas plus que Jean Buridan, pas plus que Marsile d'Inghen, il ne spécule sur les forces que la nature met en jeu afin d'empêcher, au prix de mouvements contraires aux propres tendances des corps, la formation d'un espace vide.

Évidemment, au fur et à mesure que le XIII^e^ siècle recule dans le passé, les physiciens de Paris se montrent plus oublieux des enseignements de Roger Bacon. Peu-à-peu, toute la théorie que ce dernier avait développée se condense en cette brève formule : La nature a horreur du vide. Ce sont bien encore les pensées de Frère Roger qu'on entend confusément exprimer par cet aphorisme ; mais on ne prend plus la peine de les déclarer d'une manière explicite.

A l'Université d'Oxford, la tradition du grand physicien anglais paraît avoir, pendant plus longtemps, gardé toute sa force ; Jean de Dumbleton va nous en apporter le témoignage.

Au chapitre de sa *Summa logicae et naturalis philosophiae* où il traite de l'impossibilité du vide dans la nature, Jean de Dumbleton écrit ce qui suit : [1]

' Un corps naturel peut avoir des mouvements de deux sortes.

[1] JOHANNIS DE DUMBLETON *Summa*, pars sexta, cap. iii ; Bibl. Nat., fonds latin, MS. n° 16621, fol. 60, coll. c et d, et fol. 61, col. a.

' Un de ces mouvements lui advient parce qu'il est de telle espèce ; ainsi au feu, en tant qu'il est feu, il advient d'être mû par sa forme vers la concavité de l'orbe lunaire.

' Le second mouvement lui appartient en tant qu'il est corps naturel ; et, sous ce rapport, tous les corps se comportent de même . . .

' Pour comprendre la seconde proposition, il faut supposer ce principe tiré de l'expérience : Tout corps, lors même qu'il serait en son lieu naturel, désire être conjoint à un autre corps. Et cela se prouve de la manière suivante : Il répugne que le vide soit, tandis qu'il ne répugne pas qu'un corps se trouve hors de son lieu propre. Il est donc plus naturel qu'un corps se meuve pour demeurer au contact immédiat d'un autre corps plutôt que pour gagner son lieu propre ; la nature d'un corps est d'être conjoint à un autre corps avant que d'être en son lieu propre. Ce mouvement par lequel un corps demeure au contact immédiat d'un autre corps n'advient pas à un élément en tant qu'élément, mais en tant qu'il est simplement corps naturel. De cette manière, tout corps naturel est mobile vers tout lieu, que ce lieu soit en haut ou en bas ; tout élément est indifféremment mobile vers tout lieu afin de demeurer conjoint à un corps naturel. De même que l'aimant induit dans le fer une forme grâce à laquelle le fer suit le mouvement de l'aimant, de même le corps qui en suit un autre par ce mouvement s'arrête lorsque cet autre corps demeure en repos, comme on le voit lorsque l'eau monte dans une pipette (*in fistulam*) . . .

' Mais le but de ce mouvement n'est point naturel à un corps, si ce n'est en vue de le maintenir immédiatement contigu à un autre corps.'

C'est donc par une attraction comparable à l'attraction magnétique que tout corps qui délaisse un lieu entraîne, à sa suite, le corps qui lui est contigu, dût-il, pour cela, contrarier les tendances naturelles de ce dernier corps ; s'il en est ainsi, c'est afin qu'il n'y ait jamais, dans la nature, aucun espace vide. Cette loi ne s'impose pas seulement aux éléments ; elle régit même la substance céleste ; Dumbleton prévoit, en effet, qu'on lui adressera l'objection que voici :

' Il résulte de cette supposition qu'afin de rester conjoint à un corps le ciel est susceptible de mouvement rectiligne ; si, par exemple, le feu descendait, le ciel le suivrait, afin

qu'il n'y eût pas de vide entre eux ; en effet, l'existence du vide ne répugne pas moins au très noble corps du ciel qu'à quelque autre corps inférieur.'

Cette conséquence de sa théorie, notre auteur l'admet pleinement :

' Si tout l'élément qui se trouve au-dessous de la dernière surface concave du ciel venait à descendre, le ciel le suivrait naturellement, de telle façon qu'il serait impossible de séparer le feu d'avec le ciel ; en effet, si le ciel ne suivait pas le mouvement du feu, le vide se produirait entre eux ; et il répugne à la nature que le vide soit, plus que ne lui répugne la présence d'une partie du ciel au lieu de la terre. En ce lieu, toutefois, le ciel continuerait de se mouvoir circulairement, car le mouvement circulaire appartient au ciel en tant qu'il est d'une certaine nature spécifique.'

Au contraire, comme nous l'avons vu, s'il est capable, pour éviter la production du vide, de se mouvoir de mouvement rectiligne, ce n'est pas en tant qu'il est formé de substance céleste, mais, d'une manière plus générale, en tant qu'il est corps.

Déjà Gilles de Rome avait établi une comparaison entre les mouvements qui ont pour objet la fuite du vide et les mouvements du fer vers l'aimant ; vraisemblablement, la pensée du célèbre augustin a inspiré Jean de Dumbleton ; elle lui a suggéré l'hypothèse de cette attraction mutuelle par laquelle les corps se retiennent les uns les autres afin de demeurer contigus.

Une autre influence se devine dans les passages que nous venons de citer ; c'est celle de la *Summa* faussement attribuée à Robert Grosseteste ; peut-être est-ce cette dernière influence qui pousse Jean de Dumbleton à relier sa théorie du mouvement des projectiles à son système sur la fuite du vide. Voici, en effet, comment cet auteur explique[1] la persistance du mouvement de la pierre après qu'elle a quitté la main qui l'a lancée :

[1] Johannis de Dumbleton *Op. laud.*, pars sexta, cap. iv ; MS. cit., fol. 61, coll. c et d.

' Les projectiles suivent l'air grâce à la forme qui leur est donnée en propre, afin qu'en un tel mouvement il ne se produise pas de vide ; en effet, suivant ce qui a été démontré, tout corps est naturellement mobile afin qu'il demeure au contact d'un autre corps naturel . . . De même que l'eau suit l'eau, que la fumée, qui est un corps igné, suit la fumée, et que la flamme suit la flamme, de même les projectiles suivent l'air ou tout autre corps qui est mû devant eux, comme le fer suit l'aimant . . .

' Tout corps naturel a un double mouvement ; un premier mouvement qui appartient à ce corps en tant qu'il est de telle espèce, et un second mouvement par lequel ce corps suit un autre corps. C'est par ce second mouvement que les projectiles se meuvent en suivant l'eau ou l'air lancé devant eux ; ensuite, l'eau ou l'air suit le projectile par derrière et, par là, contribue à le pousser. Cette pierre présente une surface qui est immédiatement contiguë à l'air ; lorsque l'air qui se trouve en avant de la pierre a été ébranlée par la main et que la main est retirée, cet air continue à se mouvoir ; si la pierre demeurait immobile, l'air ne pourrait, en un instant, se précipiter dans toute l'étendue de la face antérieure de la pierre ; donc, pour que la pierre ne cesse pas d'être immédiatement contiguë à un autre corps, il faut qu'elle se meuve.'

A la fin de son exposé Jean de Dumbleton énumère quelques observations, fort contestables d'ailleurs, qui sembleraient réclamer, du mouvement des projectiles, une explication différente de celle qu'il a donnée. ' Mais, ajoute-t-il,[1] pour expliquer comment le milieu se meut lorsque l'impulsion a cessé, il faut donner une autre réponse, savoir la dernière, qui est la plus commune.'

Il était donc courant, dans l'École d'Oxford, de donner, du mouvement des projectiles, cette théorie où l'hypothèse d'Aristote reçoit un renfort de la doctrine proposée par Bacon touchant l'horreur du vide.

Réunissons en un faisceau tout ce que Roger Bacon, Gilles de Rome et Jean de Dumbleton ont dit de l'action par laquelle la nature assure la contiguïté de tous les corps de l'Univers ;

[1] JEAN DE DUMBLETON, loc. cit., MS. cit., fol. 62, col. a.

nous aurons l'exposé complet de cette doctrine qui complétait si heureusement la théorie péripatéticienne du grave et du léger, et qui devait durer jusqu'à la découverte de la pression atmosphérique. Dans la constitution de cette doctrine, le premier rôle, premier dans le temps et premier par l'importance, appartient à Roger Bacon.

XI

ROGER BACON: HIS RELATIONS TO ALCHEMY AND CHEMISTRY

By M. M. PATTISON MUIR

The art of working metals has been practised since very early times. By using mixtures of metals, men learned how to produce instruments more durable and more easily fashioned than the stone implements of very early times. They discovered that the colour, the hardness, the tenacity, the ductility, and other properties of a metal are sometimes much changed by the admixture of small quantities of other metals. Men also learned to make, from things found on the earth, other things very unlike those from which they were made. From grain, they made intoxicating liquids; from plants, they prepared substances which changed the colours of clothing materials made from other plants or from the skins or hair of animals. By heating lumps of stone, used for building shelters, they obtained material useful in agriculture, and having the peculiar property of becoming hot when rain fell on it.

Some of the strange changes effected in natural materials by human ingenuity seemed to those who were in authority in the early centuries of our era to be possible only to men who had eaten of the fruit of the tree of knowledge whereof it was unlawful to eat. The arts which changed material things into altogether different things came to be regarded as savouring of sorcery. Some of the changes were said to be too wonderful for unaided human power to accomplish; they who effected such marvellous transmutations must be in league with bad angels. But the usefulness of many of the things produced from what seemed to be useless materials

could not be questioned. A distinction was gradually made between legitimate curiosity and the pursuit of forbidden knowledge.

There always have been men who refuse to be contented with material comforts and conveniences. Such men, pondering the changes happening around them, and the changes effected by human power, were forced to inquire how these changes were accomplished. They asked, Is everything mutable? They answered, There must be an unchangeable foundation beneath the mutations of nature and the transmutations effected by art. Trying to discover the plan on which the restless world of changing appearances is arranged, and finding the ever-changing, complicated phenomena of nature too hard to understand, they turned away from external nature, and decided that nature must be fundamentally simple, and her disconcerting mutations must be coverings of an underlying unity, because the ideas of simplicity and unity brought repose to their inward longing for rest.

Is not man, they exclaimed, greater than matter? Is not the human mind a more perfect expression of the Creator's thought than plants and animals, than earth and air and sea? Man, they declared, is the macrocosm of all things. 'In the image of God created He him.' Man's function is to re-create the world of appearances in his own image, and to find in that re-created world another expression of divine unity and divine simplicity.

In the oldest alchemical writings we find exclamations such as these: 'The one is the all. By him, the all; in him, the all.' 'Of the divine water. Two natures, one essence.' [1] 'The nature of matter is both simple and compound . . . it receives a thousand names, and its essence is one.' [2]

[1] Zosimus, probably third century A.D. Quoted by Berthelot, *Les Origines de l'Alchimie*, p. 178.

[2] Stephanus of Alexandria, early seventh century. Quoted by Berthelot, loc. cit., p. 277.

The alchemical writers of the early centuries of our era found justification of their conception of nature as fundamentally simple, while superficially complex, in writings of Greek philosophers. Traditions of a like teaching came to them also from far Eastern sources. Their conception of nature's plan was in keeping with what they knew of the teaching of many wise men who had lived before them. They had the support of authority for their imaginings.

Certain Greek philosophers had taught that material things are made from four elements, earth, air, water, and fire. The alchemists developed this doctrine, and brought it into relation to their fundamental tenet of ' a primary matter ', ' a soul of bodies ', ' a tinctorial spirit ', by asserting that the primary matter works through, and by means of, the four elements, and guides their combinations and rearrangements. The aim of the older alchemy was to get control of the ' soul of bodies ', because, if this were done, it would be possible to effect very diverse material transformations. The ' soul of bodies ' was said to be hidden by the properties of bodies—that is, by the appearances which are recognized by the senses. The properties of bodies—their colour, weight, smell, texture, solidity, fluidity, readiness to become hot or cold, and the like—were regarded as vestures laid on, and concealing, the true substances of the things.

In so far as I can follow alchemical writings, I take it that the substance of a thing was thought of by the alchemists as the result of the interplay of some of the four elements. It is, of course, to be remembered that the word ' element ' was used by the alchemists in a very vague way ; the word had by no means the same connotation as it has in modern chemistry. *Element* was rather a condition of being than the descriptive name of a particular substance. The nature of the substance of a material thing seems to have been regarded as determined by the directive action of ' the primary matter ', the ' soul of bodies ', on the inter-

play of the elements, or of some of the elements, from which all things were supposed to be formed. The substance of the elements was some thing, or some condition, common to them all, and to all things produced by their interactions. Stephanus said: 'Though the qualities of the elements are contrary, their substances are not contrary.' Paracelsus spoke thus of the aim of alchemy: 'To grasp the invisible elements, to attract them by their material correspondences, to control, purify, and transform them by the living power of the Spirit—this is true Alchemy.'

That we may try to get a somewhat clearer conception of alchemical teaching about the elements, let us hear what Stephanus said:

'God has made the universe of four elements, earth, air, fire, and water. These four elements, being contrary one to another, could not combine if it were not for the intervention of a body with the qualities of the two extremes. Thus, the fire of quicksilver joins itself to the water by the mediation of the earth. . . . The water is joined to the air of quicksilver by the fire of copper. Fire, being hot and dry, produces the heat of air and the dryness of earth. The moist and cold water produces the humidity of air and the coldness of earth,'[1] and so on, and so on.

The guiding conception seems to have been that though each of the four elements has its own properties, there is something underlying the properties, some thing, some condition, which is the matrix wherein these properties are set, and that this something is common to all the elements. This hypothetical, almost intangible, underlying something must be controlled and directed. By properly manipulating this common foundation, the elements—it was taught—can be transmuted one into another. The first step in this process is to tear off the outward properties of things. Stephanus wrote thus:[2]

[1] Quoted by Berthelot, loc. cit., p. 274.
[2] Ibid., pp. 276–7.

'It is necessary to strip matter of its properties in order to draw out the soul, to separate it from the body in order to arrive at perfection. Copper is like men, it has a soul and a body. . . . The soul is the most subtile part . . . that is to say, the tinctorial spirit. The body is the thing that is heavy, terrestrial, and is endowed with a shadow. After a series of proper treatments, copper becomes without a shadow, and better than gold. . . . It is necessary to strip matter; how can it be stripped if not by means of the fiery medicine? What is it to strip matter if not to make it poor, to spoil it, to break it up, to put it to death . . . in order that the spirit . . . may be brought into a fit state for combining and so accomplishing the desired operation [transmutation]?'

I have said that the alchemists found the changes of material things too hard to unravel, and that they turned away from them, and developed a scheme on which they supposed nature must proceed, and then projected their mind-made scheme on to external nature. They found some justification of their scheme in facts which they observed. They certainly found no great difficulty in describing observed facts in the language of their introspectively constructed plan. For instance, when mercury is rubbed on a piece of copper, the surface of the copper becomes white and very lustrous; copper forms alloys with many metals, and the properties of these alloys differ from those of their constituent metals; solutions of copper in acids may be used for colouring glasses and enamels. These facts, or facts like these, seem to have been in the mind of Stephanus when he wrote:

'Copper is bleached and despoiled by mercury. The latter is fixed by its union with copper. . . . The copper does not tint, but it receives the tincture, and after it has received the tincture, it tints [other bodies].'

Having quoted these remarks, and other observations like these, from Stephanus, Berthelot says:

'Here we put our finger on the positive facts and the industrial processes which served as a foundation for the theories of the alchemists. . . . They gave precision to their idea [of

a primary matter, one, and showing many forms], sometimes by similes taken from industrial arts which produce diverse appearances from one and the same material, sometimes by more profound comparisons borrowed from the chemical industries of dyeing and making glasses and enamels.' [1]

The older alchemists turned away from natural events, too hard for them to bring into order by looking at them directly, and formed a plan on which, they said, nature ought to work, on which, therefore, nature works. They returned to natural events with their plan in their hands, and grubbed about till they found facts which could be fitted into their plan.

I suppose their argument ran somewhat thus. The human mind craves simplicity. If external nature is not a deceitful show, we must find simplicity there. All the changing and perplexing appearances which trouble us are manifestations of an underlying simplicity and unity. What is that underlying unity? Wise men of old have told us that all material things are formed by the interplay of four elements—earth, water, fire, air—dryness, wetness, hotness, coldness. The four elements are contrary one to another; knowledge of them is a step to knowledge of *The One Thing* of which they are expressions; there must be, there is, a primary matter whereof the four elements are the simplest forms. The interactions of the elements are directed by *The One Thing* which is common to them all, and to all things formed by the union of them. *The One Thing* is hidden under the four expressions of itself. The four outward forms of the internal unity are concealed by the variegated coverings which nature has laid on them, in order to incite men to search for her hidden simplicity, a simplicity she reveals only to those who are not lured from the quest by the fascinating complexity of superficial appearances. The first step in the quest of *The One Thing*

[1] Berthelot, loc. cit., p. 278.

is to destroy the outward vestments which hide that portion of the universal essence which is contained in this or that particular kind of matter. The concealing garments are many, perplexing, diverse ; when some of them have been removed, the four elements are discovered. They also must be tortured until they reveal their secret. When that secret has been grasped, and its activities have been controlled, the inquirer will be able to effect in a brief time those changes which nature accomplishes very slowly. The sage, the adept, must not hope to make whatever changes in material things his fancy may lead him to desire ; he must follow nature.

It is evident, the alchemists argued, that nature aims at perfection. To attain to perfection is to find rest, repose, immutability. 'With Him is no changeableness, neither shadow of turning.' To obtain rest in this changing world, a man must have the means of purchasing freedom from hunger, fatigue, unhealthy occupations, fretting cares, constant thought for to-morrow ; he must have the means of satisfying his intellectual aspirations, his longing for beautiful things, his desire for a comfortable home ; he must be able to shield himself from storm, from cold and heat, from the attacks of enemies, from the nagging importunities of those who profess to be his friends. Should a man obtain these defences against ill-fortune, he will still find life too short ; when he is beginning to enjoy these good things, death comes, and he must leave them all. If the perfection which human beings may hope for is to be found, the life of those who seek it must be prolonged. The two necessities of him who seeks perfection are gold, to be wisely used, and an elixir which shall prolong the time of enjoying what the wise man's gold can purchase.

The alchemists said that gold is the perfect metal. Other metals rust in the earth, and are destroyed by acrid liquids ; gold is unchanged in the earth and is untouched by acids.

Gold is the type of restful perfection; therefore nature means all metals to become gold. In his dealings with metals, the adept must try to do in a moment what nature does in ten thousand years; he must transmute them into gold. When the sage has found the instrument which effects the great transmutation, he will have found the elixir which will bestow on himself, and on other men worthy to receive it, the blessing of a long, healthful, happy life. 'For', Roger Bacon says in *Opus Tertium*, 'we die much sooner than we ought to die; and this is because of defective regimen of health from youth onward, and because our fathers give us a corrupt constitution, because of the same defect in their regimen; hence old age comes sooner, and death before the time God hath appointed.' [1]

The discovery of the elixir, and of the means of controlling it, was the central aim of practical alchemy.

In the *Speculum Alchimiae*, generally, though doubtfully, attributed to Roger Bacon, alchemy is defined thus: [2]

'Alchemy is the Art or Science teaching how to make or generate a certain kind of medicine, which is called the Elixir, and which, being projected upon Metals, or imperfect Bodies, by thoroughly Tinging and fixing them, perfects them in the highest degree, even in the very moment of Projection.'

In the *Opus Tertium*, undoubtedly written by him, Roger Bacon says (I quote from p. lxxx of Brewer's preface to *Fr. Rogeri Bacon opera quaedam hactenus inedita*):

'There is an operative or practical alchemy which teaches man how to make noble metals and colours, and many other things, better and more copiously by art than by nature. And this science is more important than all that have preceded

[1] *Opus Tertium*, xii. 40 (Brewer's edition).

[2] I quote from p. 622 of the translation of *Speculum Alchimiae* made by William Salmon, 'Professor of Physick, Living at the Blue-Ball by the Ditchside, near Holborn Bridge,' published in 1692.

[he has already spoken of many sciences] because it is productive of more advantage. It not only provides money for a State, but teaches the art of prolonging life, so far as nature will allow it to be prolonged.'

How is the Elixir to be made? How shall he proceed who seeks to produce the 'fiery medicine' (as some alchemists called it) which brings imperfect bodies to the highest degree of perfection?

The writer of *Speculum Alchimiae* begins by complaining of 'the many ways and diverse manners in which the Ancient Philosophers . . . have delivered themselves'; of 'the Aenigmas or Riddles wherewith they have wholly Clouded, and left shadowed to us, the most Noble Science, and as it were under a Veil of Desperation, have wholly denyed Us the knowledge thereof'. While admitting that the ancient philosophers had cause for hiding their secrets from 'the unlearned crew', the writer of *Speculum Alchimiae* claims that the directions which he will give can be understood by those who are fitted to understand them. He says, 'I have in the following Chapters declared (more plainly than is taught in any other writings) the whole Art of the Transformation of Metals.'

In the sequel I will quote some of Roger Bacon's directions for making the *Philosopher's Egg*. Meanwhile, let us notice his protest against those who practised magical arts, and claimed alchemy to be one of these arts. The *Epistolae Rogerii Baconis de secretis operibus artis et naturae et de nullitate magiae* appeared in English in 1659, with the title *Frier Bacon his Discovery of the miracles of Art, Nature, and Magick, faithfully translated out of Dr. Dees own copy, by T. M., and never before in English.* In that book, Roger Bacon warns his readers against being deluded by untrustworthy evidence. He says: 'When inanimate things are violently moved, either in the morning or evening twilight, expect no truth therein, but downright cheating and

cousenage.'[1] That warning should be taken to heart by all inquirers into what are called 'occult phenomena'. He speaks of ' the damnable practice ' of ' calling up wicked spirits '. Of books which deal with strange and wonderful things, he says : ' The Book which discovers natural or artificial operations, embrace ; that which is void of either, leave, both as suspitious and unworthy the consideration of any wise man.'[2] He then proceeds : ' That I may the better demonstrate the inferiority and indignity of magical power to that of Nature and Art, I shall awhile discourse on such admirable operations of Art and Nature as have not the least magick in them, afterwards assign them their causes and Frames. And first of such Engines as are purely artificial.' He says it is possible to make a chariot move ' with an inestimable swiftness . . . and this motion to be without the help of any living creature '. ' It is possible to make Engines for flying, a man sitting in the midst whereof, onely turning about an Instrument, which moves artificial Wings made to beat the Aire, much after the fashion of a Bird's flight.'[3] He describes instruments for use in optics, magnifying and reducing glasses, burning-glasses, instruments for so refining silver and other metals that at last gold is obtained ; an explosive powder which causes ' hideous cracklings ', and is able to destroy armies ; and other marvellous ' Engines '.[4]

These things are wonderful, but—Roger Bacon insists—they are not magical ; they are produced by human art applied to the results of the study of natural events. Bacon asserts that art can improve on nature. ' Nature is potent and admirable in her working, yet Art, using the advantage of nature as an instrument (experience tells us) is of greater efficacy than any natural activity.'[5] ' Nature does not know how thoroughly to cleanse, and is ignorant how to

[1] *Secrets of Nature and Art*, chap. i. [2] Ibid., chap. iii.
[3] Ibid., chap. iv. [4] Ibid., chap. vi. [5] Ibid., chap. iii.

Purifie and perfect, because it works after a simple manner upon what it hath.' Imperfect matter can be made ' more than perfect by the help of our art '.[1] ' Our art ' has nothing magical about it. He who pursues the art which, basing itself on the mysteries of nature, works more quickly and more thoroughly than nature, must separate himself from the ' unlearned crew '. In *The Secrets of Nature and Art*, Bacon says : ' That which all men, which wise and the more noted men affirme, is truth. That therefore which is held by the multitude, as a multitude, must be false ; I mean of that multitude which is distinct from knowing men.'[2] Were the mysteries of nature and art told plainly to the multitude, they would deride these mysteries, and, because of their ignorance, would use them wrongly. ' Wise and knowing men ' have, therefore, purposely obscured their writings : sometimes they have used enigmatical and figurative words ; sometimes they have written consonants without vowels ; sometimes they have mixed different sorts of letters ; sometimes they have invented letters ; sometimes they have used geometrical characters in place of letters. ' Thus we find multitudes of things obscured in the writings and sciences of men, which no man without his Teacher can unvail.' Bacon says he has given these hints about the various ways used by wise men to hide their secrets from the vulgar, because ' it may fall out, I may thorow the magnitude of our secrets discourse this way '.[3]

As illustrative of Bacon's knowledge of the human mind, it is interesting to notice that, while he strongly condemns and scorns the use of magical arts, he admits that ' figures and charmes ' may sometimes be used by physicians with good effects ' ; not from any prevalency in them, but that the raising of the soul is of great efficacy in the curing of the body, and raising it from infirmity to health, by joy and

[1] *Speculum Alchimiae*, chap. iv.
[2] *Secrets of Nature and Art*, chap. viii. [3] Ibid.

confidence done by charmes; for they make the Patient receive the medicine with greater confidence and desire, exciting courage, more liberal belief, hope and pleasure.' [1] Without saying that they act as 'figures and charmes' act in medicine, Bacon recommends the use of holy water, and other similar practices allowed by the Church.

The object of practical alchemy was held by the alchemists to be the preparation of the *Elixir*, the *Heavenly Water*, the *Fiery Medicine*, the *Phoenix*, the *Magistery*, which would bring to perfection all imperfect bodies, and confer on him who knew how rightly to use it a long, healthy, and vigorous life. How was this medicine to be made? When giving directions for making the Elixir, the alchemists never forgot that their secrets were not to be made known to the multitude. They expressed themselves in obscure, misleading language. One of their favourite devices was to hide their meaning in an allegory. As illustrative of alchemical allegories, I give a quotation from *Pretiosa Margarita*, written by Bonus of Ferrara, who probably lived in the first half of the fourteenth century. The quotation is taken from pp. 38–47 of Mr. A. E. Waite's translation, published in 1894, with the title *The New Pearl of Great Price*. I have omitted parts of the original, in order that the quotation should not be over-long:

'Three rules must be carefully observed in our art; first prepare the right substance; then carry on the work continuously, so that it may not be marred by interruption; thirdly, be patient, and follow always in the footsteps of Nature. Get (on your substance) highly purified Water of Life, and keep it; but do not suppose that the liquid which moistens all things is the bright and limpid liquid of Bacchus. For while you anxiously look about in out-of-the-way places for extraordinary events, you pass by the sparkling waves of the blessed stream. Enter the Palace in which are fifteen mansions, where the king, his brow circled with the diadem, sits on a lofty throne, holding

[1] *Secrets of Nature and Art*, chap. ii.

in his hand the sceptre of the whole world; before him, his son and five servants kneel in robes of different colours, imploring him to bestow on his son and his servants a share of his power; but he does not even reply to their request. The son, incited by the servants, stabs the father as he sits on the throne. (Let an amalgam be made with highly purified water, &c.) The son catches his father's blood in his robe. . . . A grave is dug in the fourth mansion. . . . In the fifth mansion, the son thought to throw his father into the grave, and to leave him there; but (by means of our art) both fell in together. The sixth mansion is that in which the son still strives to get out, but one . . . comes, and prevents him from so doing. While the father and the son are in the tomb, which is called the seventh mansion, there follows putrefaction in their ashes, or a very hot bath. In the eighth mansion, that which happened during the putre faction is inspected, the vase having become cold, &c. In the ninth mansion, the bones are taken from the tomb. This happens when the whole body has been dissolved by successive solution, which being done, keep it carefully. In the tenth mansion, the bones are divided into nine parts, the dissolved substance being subjected to gentle coction for nine days, till a portion of it turns black. Remove this latter, and keep it in another vessel in a hot place. Subject the water to gentle heat for another nine days. Again remove that which has turned black, and put it with the rest. Continue the operation till the water is clear and pure. Let its Water of Life be poured over the black substance in a small glass vessel, so that it shall float over it to the height of an inch, and let it stand nine days over a gentle fire, renewing the water every day, if necessary. . . . An angel is sent, who casts the bones on the purified and whitened earth. . . . In the eleventh mansion the servants pray to God to restore their king. Henceforth the whole work is concerned with his restoration. . . . A second angel is sent in the twelfth mansion, who places the other part of those bones on the earth, till they are all thickened; then a wonderful thing happens.'

The allegory then tells of the coming of many angels who cast other portions of the bones on the earth, and proceeds thus: 'Then the king rises from the tomb, full of the grace of God. His body is now all spiritual and heavenly, and he has power to make all his servants kings.'

The allegory finishes with this warning and encouragement: 'Let no impostor, greedy or wicked person, touch this glorious work with his unclean hands. Let the honest man and him of a wise heart come hither, and him who is capable of exploring the most hidden causes of things.'

The *Pretiosa Margarita* of Bonus was edited by Janus Lacinius, and published in 1546 by the Venetian press of Aldus. In his book, Lacinius includes extracts from the works of Arnald de Villanova, in which the composition of the Philosopher's Stone 'is practically and lucidly set forth'. To show what alchemists considered a lucid setting forth of the practice of their art, I give a few extracts from Arnald de Villanova, quoting from Mr. Waite's *New Pearl of Great Price* (pp. 313–16):

'Our physical Stone . . . may be obtained from all metals; but it is found in the highest perfection in gold and silver. . . . Gold is the father, and silver the mother of the proximate substance of our Stone, for out of these bodies, prepared with their sulphur or arsenic, is our medicine elicited. . . . It is found nearer to the hand, and more easily, in quicksilver, which is . . . the root of all metals. . . . That which is now our Stone is not quicksilver, but once formed part of it. . . . Do not work with anything except Mercury and the Sun for the Sun, and Mercury and the Moon for the Moon. Your first step must be to bring about the dissolution of gold and silver into quicksilver. . . . Unless the bodies become incorporeal, and the spirits corporeal, no progress will be made. . . . Bodies when dissolved become spiritual in their nature . . . solution of the body means the coagulation of the spirit, and vice versa.'

Directions are given for cleansing Mercury: 'Pound and cook with patience, and reiterate the process again and again.' At last the Mercury will be dissolved; it is then to be exposed to a gentle heat 'for its better putrefaction and digestion' 'during the space of a month of the Sages'. It is then to be sublimed, then subjected 'to a coction till it is reduced to its first nature, that is, till we have sulphur and quicksilver' (Waite's translation, pp. 319, 320, 321).

The substance—by this time the reader may well ask, what substance ?—is then washed and purified by water, and air, and fire, and is fermented, and digested, and putrefied, and at last is fixed.

I do not think it possible to translate alchemical directions for making the Stone into words which convey any definite meaning to a chemist. The terms *Mercury, Sulphur, Arsenic, Gold, Silver,* certainly did not mean to alchemists what they now mean to chemists. Take the word *Solution.* Arnald de Villanova says : ' When I speak of solution, you must not think that the elixir is to be altogether resolved into water [does this mean, is to be completely melted ?] but is only to be subtilized as far as possible to have its parts divided, that which is dry in it made humid, and that which is gross made simple, since dissolution is practised . . . for the purpose of uniting the body and the spirit ' (Waite's translation, p. 346).

Arnald concludes with the remark : ' You will not find in all the books of the Sages anything clearer and plainer than what I have told you ' (p. 349).

Let us turn to Roger Bacon, and see whether he tells us how to make the Elixir in words to which we can attach any clear meaning.

In chapter iii the writer of *Speculum Alchimiae,* who may possibly have been Roger Bacon, gives vague and elusive directions for making the *Philosopher's Egge,* as he calls the Elixir. He says that the Egg must be made from mineral substances, because they only are formed by the union of quicksilver and sulphur, and it is only by the ' joint and proportionate mixture of these two principles ' that the Egg can be produced. The inquirer must find those bodies in which the two principles are ' justly proportionated, coagulated, and joyned together in one, as their Natures require '.

Chapter ix of *De secretis operibus artis et naturae* deals with ' The Manner to make the Philosopher's Egge ' This

tractate is generally attributed to Roger Bacon; some authorities doubt the authenticity of the later chapters. The directions for making the Egg begin as follows (I quote from the English translation published in 1659):

'Make a diligent purification of the *Calx* with the water of *Alkali*, and other acute waters, grind it by several contritions with the salts, and burn it with many assations, that the earth may be perfectly separated from other elements. . . . Understand if you can. . . . Then take oyl of the form of a saffron-cheese, and so viscous as not to be smitten asunder by a stroak, divide the whole fiery virtue, and separate it by dissolution, and let it be dissolved in acute water, of a temperate acutenesse, with a slight fire, and let it be boyled till his fatnesse, as the fatnesse of flesh be separated by distillation, that nothing of the unctiousnesse may issue forth; and let this fiery virtue be distilled in the water of Urine;' and so on for three or four pages. 'Mind and search what I say, for the speech is difficult. . . . You must observe whether I speak aenigmatically or according to the truth.' The directions for making the Egg finish thus: 'Farewell: Whoever unlocks these, hath a key which opens and no man shuts; and when he hath shut, no man opens.'

In those writings which are acknowledged by all authorities to be genuine, Roger Bacon insists on the need of observation and experiment for attaining to real knowledge of natural events. For instance, in *Opus Tertium* (xiii. 43, Brewer's edition) he says: 'Besides these sciences, there is one more perfect than them all, on which the others attend, which certifies (*certificat*) them all in a wonderful way; and this is called experimental science (*scientia experimentalis*).' He declares that this science is superior to other sciences, in that it tests arguments by appealing to experience. In discussing natural phenomena, the only test, according to Bacon, is experience; argument alone is worthless. This science not only gives to those who use it a sound knowledge of nature, it also teaches the possibilities of nature and art and the nullity of magic.

Roger Bacon's mental attitude toward natural events was nearer to that of the scientific student than to that of the alchemists either before or after his time. We do not find in his writings vague talk about *stripping matter of its properties*, about *invisible elements*, about *the soul of bodies*, about *The One Thing*, and so on. He opposes the alchemical doctrine of one primary matter, as being harmful to the investigation of nature. We shall appreciate the importance of this denial of primary matter more fully as we proceed. The directions for making the Philosopher's Egg given in the *Mirror of Alchemy*, and in *The Secrets of Nature and Art*, closely resemble those contained in ordinary alchemical writings. There is in them the vague talk, the haziness, the thinking in images of words rather than in images of things, which are the marks of most books on practical alchemy. When one contrasts the directions, parts of which I have quoted, with the writings of Bacon on speculative and practical alchemy, one has grave doubts as to the genuineness of these directions; they do not read like what one would expect Bacon to have written, judging from his other works. His remarks on speculative and practical alchemy in the *Opus Minus* and *Opus Tertium* incline one to place Bacon among the chemists rather than among the alchemists. Certainly we need not go to him to find definite directions for making the wonder-working Stone of the Philosophers.

In his book *Gunpowder and Ammunition*, and also in his essay in this volume, Colonel Hime establishes a large probability in favour of regarding the chapters of *De Secretis* which profess to set forth two methods for making the Philosopher's Egg, as really containing directions for purifying saltpetre and making gunpowder, concealed in a setting of alchemical jargon. I have quoted from these chapters for the purpose of showing that no light is to be obtained from the words as they stand on the process they

are supposed to describe. It is to be remembered that no intelligible directions for making the Stone can be obtained from any alchemical writing.

What was Roger Bacon's conception of alchemy? In attempting to answer this question, it will be necessary to refer to his notions about matter, substance, form, and activity; I shall bear in mind that the exposition of his teaching on these subjects belongs more to the essays on Bacon's relations to physical science, and to philosophy, than to that on the chemical aspects of his work.

Alchemists, both before and after Roger Bacon, formed, from their intellectual and emotional longings, a scheme of nature's method of working, and then observed natural changes through the distorted glass of their imaginings. Bacon at least tried to look first at external realities, and to base his intellectual explanation of material changes on observed facts. In his *Opus Tertium* (xiii. 46, Brewer's edition) he says of experimental science: 'This science works by perfect experiments, not by arguments as purely speculative science does, not by weak and imperfect experiments as operative science does. Therefore, this is the lord of all sciences, and the end of all speculation.' Again, in the same place, he says: 'The man who rejects anything ought to know the nature and circumstances of that thing, and so reject what is false, that what is true may remain unimpaired.' In the preceding chapter (p. 41) of the *Opus Tertium*, he asserts that many labour to make metals, and colours, and other things, without a real practical acquaintance with the methods of the laboratory. 'There are few who know how to distil properly, how to sublime and to calcinate, how to separate things.' There are not three men among the Latins who have given themselves to this that they may know speculative alchemy, which cannot be known without the operations of practical alchemy. 'There is only one man', Bacon says, 'who is instructed

in all these questions ; as so few people know these things, he does not deign to communicate with others, nor to associate with them, because he regards them all as asses and fools (*asinos et insanos*) delivered over to quibbles, and as charlatans who dishonour philosophy, medicine, and theology ' (p. 41, Brewer's edition).

Bacon often insists on the necessity of beginning with the study of the simpler inanimate things, of examining how ' simple and compound liquids, gems, marbles, gold, and other metals ' are generated from their elements. It is impossible, he asserts, to gain any knowledge of the ' generation of animate things ' without having first acquired a knowledge of the generation of the simpler inanimate things. Of this preliminary knowledge, he says, ' we find nothing in the books of Aristotle ' (*Opus Tertium*, xii. 39, Brewer).

In discoursing of the many errors of medical men, Bacon lays stress on their ignorance of alchemy. A knowledge of alchemy, he says, enables men to recognize the differences between medicines, and the virtues of different medicines ; this knowledge also is necessary for the proper preparation of medicines. Here, as elsewhere, Bacon lays much importance on alchemy as a practical art which deals with real things.[1]

Bacon's leaning to the practical and useful side of knowledge should be noticed, as it is characteristic of him, and marks him off both from his contemporaries and his predecessors. In *Opus Tertium* he says that practical alchemy is more important than all the other sciences, because ' it is productive of more advantages ' than they. ' The utility of everything must be considered ; for this utility is the end for which the thing exists ' (Brewer's translation).

[1] *De Erroribus Medicorum secundum Fratrem Rogerum Bacon de ordine Minorum.* The editor of this volume has kindly allowed me to see the typescript of the forthcoming edition of this tractate.

How different this is from the gibe of the modern absolutist philosophers against the 'irrelevant appeals to practical results which are allowed to make themselves heard'! Of the many experiences which philosophers of the absolutist school say create 'a passing show of arbitrary variation', these same philosophers assert that 'they themselves, and the manner of their connexion, are excluded from the theory of knowledge'. Not only was Roger Bacon in advance of his predecessors and his contemporaries in his method of seeking knowledge, he was also far in advance of those who to-day reject the experience of the seven centuries which separate them from him.

The following quotation from *Communia Naturalium* gives a vivid picture of the genuinely scientific character of Roger Bacon. It shows clearly the great importance he placed on the careful examination of external facts, and makes us realize his skill in determining the kind of facts which ought to be studied for this or that particular purpose. Bacon divides natural philosophy into separate sciences. The fifth of these separate sciences is *agriculture*. Of this department of knowledge he writes as follows (I quote from Brewer's translation in the preface to his *Fr. Rogeri Bacon opera quaedam hactenus inedita*, p. li, note):

'Next [after alchemy] comes the special science of the nature of plants and all animals, with the exception of man; who, by reason of his nobleness, falls under a special science called medicine. But first in the order of teaching is the science of animals which precede man and are necessary for his use. This science descends first to the consideration of every kind of soil and the productions of the earth, distinguishing four kinds of soil, according to their crops; one soil is that wherein corn and legumina are sown; another is covered with woods; another with pastures and meadows; another is garden ground wherein are cultivated trees and vegetables, herbs and roots, as well for nutriment as for medicine. Now this science extends to the perfect study of all vegetables, the knowledge of which is very imperfectly delivered in Aristotle's treatise on that subject;

and therefore a special and sufficient science of plants is required, which should be taught in books on agriculture. But as agriculture cannot go on without an abundance of tame animals ; nor the utility of different soils, as woods, pastures and deserts, be understood, except wild animals be nurtured ; nor the pleasure of man be sufficiently enhanced, without such animals ; therefore this science extends itself to the study of all animals.'

In these words, Bacon draws the outlines of a true science of agriculture, based on observation and experiment, fitted to yield results useful to mankind.

By using the method of observation and experiment, and reasoning on the results obtained, Roger Bacon arrived at just and fruitful conceptions regarding plant life, the growth and nutrition of animals, tides, rainbows, the density of air, and other natural events. This method also led him to the invention of instruments of much usefulness in optics, astronomy, and other branches of physical science. Bacon often insists on the need of mathematics in the investigation of physical occurrences. He tried to form a general science which should bring the actions of bodies, and of natural agents, under the principles of mathematics. Nevertheless, he taught that the experimental sciences are more useful to men than mathematics, for they stir curiosity and make possible the understanding of many things. Without experience, he said, no satisfactory investigation is possible. Experience shields us from erroneous judgements. His own discoveries, made by experimenting and observing, had shown him, he says, that there is nothing too hard to believe either in human or divine things.[1]

Most of the alchemists appealed to the authority of men of renown who had gone before them for justification of their outlook on nature. Roger Bacon opposed the custom of

[1] Compare *Roger Bacon ord. min., eine Monographie als Beitrag zur Geschichte der Philosophie des dreizehnten Jahrhunderts,* by Dr. Leonhard Schneider (1873).

constantly discussing ideas, generalities, principles, stated by Aristotle and other ancient writers. He insisted on the need of observing and discussing facts. He said that scholastic science was too greatly concerned with intellectual definitions, and the supposed causes of natural events, and neglected the accurate observation of these events (*Non oportet causas investigare*). He altogether rejected occult causes. He taught that undue respect to worthless authority is one of the causes of ignorance, and that the conceit of learned men, which makes them hide their ignorance under a display of apparent knowledge, is another potent cause of error and mental darkness (*Opus Minus*, pp. 322–4, Brewer).

It was impossible that Bacon should shake himself quite free from the trammels of authority. He taught the need of obedience to the Church, although he was imprisoned for a supposed lack of proper humility to authority. He despised the ignorance and stupidity of the multitude. 'Men are so ready to go astray', he said, 'that they must have some trustworthy guide.' He placed theology at the head of his hierarchy of sciences, and though he appealed again and again to observation and experiment, he carried over theological methods into scientific inquiries.

Bacon was obliged to paint his mental picture of the mutations of material things with the pigments he found in his colour-box. He could not do otherwise. We all do that. He could not but use the conception of the four elements—hotness, dryness, coldness, wetness—as guides in his attempt to make an intellectual arrangement of the facts he had to set in order. Roger Bacon was necessarily influenced by the intellectual conceptions of his time. Nevertheless, Charles can justly say of him: 'His greatest discovery is that of the feebleness and faults of scholasticism; his originality is to belong as little as possible to his

own time.'[1] In the thirteenth century there were no methods, no instruments, for making minutely accurate investigations of material changes. Bacon was born into a mental atmosphere of vague principles, and grew up in that environment. Desirous of finding *how* the changes of things happen, he thought of these changes in terms of fire, air, earth, and water; for these were at once the simplest and the most ingathering conceptions which came to his hand. The instruments which he found in use, and used for investigating natural changes were not sufficiently incisive, not sufficiently plastic, not penetrative nor scarifying enough, to be completely effectual for sweeping away the images, the prejudices, the mental atmosphere, in which his intellectual life was steeped.[2] He had to do his best with the mental apparatus which he inherited. He accomplished much.

Roger Bacon divided alchemy into two departments: *speculative alchemy*, which, he says, has to do with the generation of all inanimate things from their elements, and lays bare the broad lines on which that generation proceeds; and *practical alchemy*, which is chiefly concerned with the purification of metals. When one looks to the experimental work of Roger Bacon on optical and other instruments, the magnet, the rainbow, the growth and propagation of plants, and remembers the mechanical devices which he invented, one expects to find him dealing with metals by

[1] *Roger Bacon, sa vie, ses ouvrages, ses doctrines*, by Émile Charles (1861), p. 162.

[2] It is rather perplexing to find Bacon saying in *Opus Tertium* that the four elements are sometimes to be taken literally, sometimes metaphorically. When taken metaphorically, 'they mean the four spirits, or the four humours, or the four parts of the compass, or the four seasons, or the four principal parts of an animal; because there is a complexional correspondence between each set of these things.' (*Part of 'Opus Tertium', including a fragment now printed for the first time*, edited by A. G. Little: British Society of Franciscan Studies, vol. iv. See Summary, pp. xlvii and xlviii.)

the method of observation and experiment. But one finds him hedged in by the conception of four elements or principles ; he cannot break through that barrier. His remarks on the differences between metals are more like those of the ordinary alchemist than might be expected.

In a small book, printed at Frankfurt in 1603, entitled *Sanioris Medicinae Magistri Rogeri D. Baconis Angli de Arte Chymiae Scripta*, Roger Bacon discourses of the elements, of metals, and of transmutation, more fully than in his longer writings.[1] He says that each of the four elements has its special quality ; dryness predominates in earth, wetness in water, coldness in air, hotness in fire ; but each element can receive some portion of the quality which particularly distinguishes another element (pp. 314–15). He speaks of various degrees of hotness, coldness, dryness, and wetness, and distinguishes primary, secondary, tertiary, &c., degrees of each quality (pp. 322–5). The Elixir combines in itself all the qualities of the four elements, equally and perfectly balanced. The Elixir is able to give hotness to things that need hotness, coldness to things that need coldness, wetness to things that need wetness, dryness to things that need dryness, to bring them to perfection. The aim of the alchemist is to bring things to their most perfect state ; this can be done only by using each element

[1] This book contains the following tractates by Roger Bacon : (1) *Breve breviarium fratris Rogeri Bacon ; ad Raymundum qui scripsit de viridi Leone* (pp. 95–264) ; (2) *Tractatus Trium Verborum R. Bacon* (pp. 292–387) ; (3) *Speculum Secretorum* (pp. 387–408). *Breve breviarium* deals with the composition of metals, the transmutation of metals, the nature and purification of particular metals (gold, silver, copper, lead, tin, iron), curative medicines, mineral spirits and sulphur, methods of operating with mercury and sulphur, preparation of arsenic and the effects of it, and of salts (alkali, saltpetre, nitre—*de sale nitri*—common salt, alumina, borax), and stones. *Tractatus Trium Verborum* treats of (*a*) the composition of things from the four elements, (*b*) mixing, (*c*) weights. *Speculum Secretorum* deals, very briefly, with the secret of the transmutation of things. I refer to this book as *Art. Chym.*

in its proper degree of humidity, coldness, dryness, or hotness, and by conjoining the elements in their due proportions. The Elixir is a kind of happy mean; the metals are extremes in reference to the Elixir. Some metals have too much coldness, some too much hotness, and so on. The Elixir is able to cure their sicknesses.[1]

The passages I have referred to are almost purely argumentative. In them Roger Bacon tries to refine the ordinary alchemical doctrine of the four elements. He ignores the alchemical notion of a something common to all the elements and to all things formed by conjoining elements. When one remembers how strongly Bacon insists on the superiority of observation and experiment over mere argument, as means for acquiring genuine knowledge of natural events (see, for instance, the quotation from *Opus Tertium*, p. 43, Brewer's edition, given on p. 300), one is certainly surprised to find him saying (*Art. Chym.*, p. 345): 'Dimitte experimenta; cape rationes et invenies.'

When one thinks one has obtained an inkling of Bacon's meaning, one is much nonplussed by such words as these (*Art. Chym.*, p. 301): 'Sed omne quod dico est falsum, ergo nihil dico verum . . . sed quando dico verum, intellige falsum.' Like other alchemists, Bacon feared lest the 'unlettered crew' should understand his secrets.[2]

Roger Bacon did not think of the elements as forms or expressions of a universal primary matter, but rather as particular conditions each of which acts on its own account and in its own way. He did not think of an element as a particular substance which has not been separated into unlike parts—no one thought thus of an element till

[1] *Art. Chym.*, p. 319: 'Omnia metalla sunt extrema ad Elixir. Elixir vero medium, sic ergo agit nominaliter.'

[2] In the part of *Opus Tertium* edited by A. G. Little, Bacon says (p. 81): 'Quadriga una non portaret libros alkimiae, quorum tamen omnium virtus in his paucis verbis continetur; et ideo est obscuritas nfinita.'

about five and a half centuries after Bacon's time—he thought of an element rather as a condition of being of this or that particular substance, such as gold, silver, copper, or lead. It might be more accurate to say, he thought of an element as a form of activity determining the production, from other substances, of this or that particular thing. He certainly attempted to picture material changes as causally connected with the inflowing, or with the outgoing, of more or less of this or that condition, or form, of activity. He did not seek, as almost all alchemists before and after him sought, for an inchoate something, 'the soul of bodies.' He did not regard the appearance, texture, taste, smell, relative heaviness, &c., of particular bodies as garments hiding the essential natures of the bodies; he regarded such properties rather as marks by which one material thing can be distinguished from another, as signs by which each material thing can be recognized. But these properties were not enough for Bacon. He thought that this substance has such and such properties, has a particular texture, colour, weight, taste, and so on, because it has been formed by the influence, on more remote substances, of particular quantities of two, or it may be more than two, of the four elements by the activities of which all inanimate things are produced. Bacon did not think of the generating interplay of the elements as directed by a something more vague and more universal than they, a something which other alchemists called 'primary matter', and dreamed of as the one abiding, immutable reality behind all changing appearances.

The genuinely scientific spirit of Roger Bacon appears in his endeavour to use proximate causes—the four elements—which he could in some degree control, in forming his intellectual scheme of material mutations, rather than call in a vague ultimate cause, such as *primary matter*, which no one was able to bring down into vivifying contact with observed realities.

I think it may be justly said that not many students of natural events, nowadays, have shaken themselves quite free from the fascination of the alchemical *primary matter*. Omitting the qualifying word *primary*, most men, including men of science, think of *matter* (if they think of it at all apart from special kinds of matter) as an indefinite something which is the intangible basis of phenomena. No one can say clearly what he means by *matter*. All one can say is that one gives a particular name to each definite collocation of sense-impressions, no one of which changes without others of them changing too, no one of which is present without the others being present also ; and that, for the sake of convenience and avoidance of many words, one calls each of such collocations of properties a particular kind of matter.

One word more about Roger Bacon's use of the notion of the four elements. I said that he seemed to think of an element as a condition of being of this or that particular substance, as a condition which, interacting with another condition, or with other conditions, determines the effects that the particular substance produces on the senses. Inasmuch as Bacon speaks of natural agents, and places coldness, hotness, wetness, and dryness among these, we might perhaps translate his *elements* into modern phraseology by calling them *forms of energy*. It would not, perhaps, be too fanciful to think of Bacon as groping for something which has been made more tangible by the penetrative methods of investigation, and the modes of reasoning based on the results of such investigation, that have become possible in these later times. Might one carry this fancy a little further ? Several men of science, notably Ostwald (of Leipzig), have recently set themselves the task of changing the language of physical science, and, instead of thinking and speaking in terms of matter, are endeavouring to speak and think in terms of energy. Were Roger Bacon living now, one can picture him joining in the Ostwaldian adventure.

In speaking of that particular class of things called metals, Roger Bacon uses the ordinary alchemical doctrine that metals are formed by conjoining mercury and sulphur. From the directions which he gives for purifying mercury and sulphur, it seems as if he used the words 'mercury' and 'sulphur' as names of two definite, tangible substances.[1] He taught that the relative quantities of the two components have a determining influence on the nature of a metal; and that the degree of purity, of humidity, of coldness, of dryness, of hotness of each component has an effect in determining what metal is produced by the interplay of mercury and sulphur.[2] Apparently he held that the essential nature of all metals is one and the same, that the differences between metal and metal are differences of accidents, not of essences. 'You can change the accidents, not the substance.'[3] 'The nature of all metals is one in the unity of species; for quicksilver is always of one species, and there are not found diverse species of sulphurs.'[4] 'It may reasonably be concluded that the diversity of natures and of metallic species does not come from diversity of matter, which is always one and the same, but from diversity of depuration and digestion.'[5]

In common with all alchemists, Roger Bacon regarded gold as the most perfect metal, and taught that gold is formed by the interaction of the proper proportion of the purest forms of quicksilver and sulphur.[6] If all metals are made of the same two things—quicksilver and sulphur—then all that is needed to get gold from other metals is to remove the infirmities, to cure the sicknesses, of the other metals. This seems to have been Roger Bacon's view, at least when he wrote *De Arte Chymiae*.[7] Some of the other

[1] See, for instance, *Art. Chym.*, p. 217.
[2] *Art. Chym.*, pp. 98–102.
[3] Ibid., p. 104.
[4] Ibid., p. 105.
[5] Ibid., p. 122.
[6] See, for instance, *Opus Minus*, pp. 375–83 (Brewer's edition).
[7] See *Art. Chym.*, pp. 138–42, where he talks, somewhat vaguely, of making gold.

metals are too humid, some are too dry, in some coldness is too predominant, in some there is too much hotness. In *De Arte Chymiae*, he regards silver as a kind of lead burdened by imperfections. The directions (entitled *De preparatione Lunae ad Sulphur*) for making silver from lead are not very unlike the modern method for obtaining pure silver from argentiferous lead, by cupellation.[1]

It is not easy to put an exact and definite meaning on Bacon's remarks about the transmutations of material things. He deals with transmutation more fully in *De Arte Chymiae* than in his other writings. Take this passage, for instance :

' Let all workers in alchemy know that true species cannot be transmuted. For they say, and it is said also here, that lead is always lead, even granted that its impurities are purged away so that silver may be seen ; thus they deceive men not understanding the words of Aristotle on solution. To whom it may be answered that it is not for us to be labouring about the transmutation of bodies in order to make some sort of being from non-being (*ut faciamus aliquod ens de non ente*), and to make something from this mineral that is not of this mineral. But that we may reduce a corrupted mineral to an incorrupted mineral . . . Since lead is a species of silver, the sicknesses of which mineral—to wit, softness, blackness, and foulness—have invaded it, when these are put aside, there is silver true and good ; and so it is reduced to its true mineral, and in accordance with its first primary origin (*secundum primam radicem*) it is not translated nor transmuted from its own mineral. Similarly iron is silver, but it is corrupted . . . by the power of its impure sulphur and of its impure quicksilver. From which source hurtful things enter it, to wit, blackness, hardness, dryness ; which being removed, there is good silver. In like manner copper is the soul and sister of silver, in all its dispositions, to wit, in softness, in hardness, in fusibility and malleability, but it is red ; we take away from it its redness, and then there is genuine silver. Similarly tin has softness, the grating sound of teeth, and blackness, which being removed it is reduced to silver. In like manner silver is gold save in its colour, because the colour of gold was taken away from it, in its mineral state,

[1] Ibid., pp. 181–3. But on p. 103 he says, ' Lead will remain lead even if it looks like silver.'

by the power of its quicksilver. But we give colour to it, and then there is good gold. This is in keeping with what is said by Aristotle. If the quicksilver be pure and bright, and the sulphur be clean and red, and a temperate heat be used, mineral gold is made from these, in nature, after a long time. Similarly if the quicksilver be impure, and the sulphur be not clean, some other mineral body is made from these, in accordance with the inward disposition of that body. What nature does in a thousand years, we are able to accomplish artificially in a short time, perhaps in one day, or in some hours, with the proper medicine, that takes a long time to prepare, by the use of which bodies suffering from mineral corruptions are reduced to uncorrupted mineral substances.' [1]

There is an interesting passage on p. 342 of *De Arte Chymiae* :

' Some speak of transmutation. Some speak of improving (*de correctione*) . . . Some say it is necessary to transmute, they say that form gives the essence of a thing (*dicunt quod forma dat esse rei*), but that the essence of gold is different from the essence of lead : therefore there is here made a transmutation of form. They who speak of improving say that when a sick man is cured of his sickness he is not transmuted from one species into another. Either reasoning is good. But one of them is better. . . . Read what Avicenna says, and read again, and find wisdom.'

Roger Bacon taught that, in reasoning about natural events, we have to pay heed to matter as that which may become any particular thing, and form as that which differentiates and specifies each particular thing. Matter, he said, has a potentiality of becoming this or that thing ; form is the act of becoming a special thing. He would have observers of nature study all the conditions of existence of each object of sense, all the conditions by which each is distinguished from other objects. He was never tired of insisting on activity, effort, change ; he tried to get at general rules

[1] *Art. Chym.*, pp. 389–95. On pp. 217–28 directions are given for preparing the Elixir. These directions are untranslatable into definite words ; but they often mention particular substances and are more practical than most alchemical receipts for making the Elixir.

expressive of the activities of natural agents, such as heat, cold, humidity, dryness. The action of an agent he held to be limited ; an agent acts for a limited time on a particular object ; but one action may be followed by another, so that change may continue as long as there is any matter to be acted on.[1]

On the whole it seems to me that while Bacon recognized the possibility of effecting many unlooked-for changes in material things, he also recognized that there are limits to the changes which can be effected. Again and again he asserts that one species of things cannot be transmuted into another species. The ordinary alchemical doctrine was that species can be transmuted. This doctrine rested on the conception of one primary matter, underlying, and present in, all things. To change one species of things into another could be done, it was commonly taught, because it was possible to get at the primary matter common to different species. Arnald de Villanova said : ' Species can be transmuted only by the reduction of their matter to the generic First Matter.' [2]

Roger Bacon's mental picture of material changes was constructed without the help of the elusive notion of a common substance, without the will-o'-the-wisp conception of an invisible, intangible basis of properties which remains unchanged when properties change, is independent of properties, and cannot be got hold of by observing and comparing properties of different things. Bacon condemned the notion of a universal primary matter ; if this notion were true, he said that everything in nature would be essentially the same as everything else.[3] There are, it is true, sentences in his writings which, taken alone, might be read as if he favoured the notion of a common matter ; but considering how

[1] Cf. Schneider, loc. cit.

[2] Waite's translation of *The New Pearl of Great Price*, p. 315.

[3] Cf. *Opus Tertium*, xxxviii. 121 (Brewer's edition).

definitely he speaks against the notion of one primary matter, I do not think stress can be laid on a few detached remarks.[1]

Considering the differences between the language used by Roger Bacon and that used by chemists now, it is not unfair to say that the general aspects of the picture which he formed of material changes resemble those of the picture drawn by modern chemistry. Ceaseless change is the mark of both conceptions of natural events. Chemists represent the changes of material things as combinations of distinct kinds of matter, which they call elements because none of them has been separated into unlike portions ; as decompositions of compounds, and as re-combinations of the unlike parts of these compounds. In all these never-ceasing mutations they trace the activity of something which they call energy, and they recognize different kinds or forms of energy. Roger Bacon came nearer to this conception of chemical changes than any of his predecessors, than most of his successors till Lavoisier gave definite form to the science of chemistry towards the end of the eighteenth century.

Before summarizing those aspects of Roger Bacon's conception of alchemy which have been dealt with in the preceding pages, I ask the reader to notice the place which Bacon gave to alchemy in his arrangement of the sciences. He had a passion for tracing connexions between the special sciences which he placed under the guidance of the great science *Communia Naturalium*, and for arranging the special sciences in order of dignity and importance. He placed

[1] One of these passages occurs in *Opus Tertium*, A. G. Little's edition, pp. 86–7 : ' The hidden spirit . . . is one of the humours, namely that which is blood in animals ; but it has not the name of blood in all [things] ; and therefore when reduced to the matter common to animate and inanimate things it loses the name of blood, and is called the humour of warm and humid complexion, which becomes blood in animals, and into which blood corrupts when it is transformed from its own heat and is reduced to the original nature of that humour which is found in all things.'

alchemy fourth of the special sciences. In the *Communia Naturalium*, he says : [1]

'Of natural philosophy there are many separate sciences . . . for besides the *Communia Naturalium* (i. e. conditions of being common to all the material world, as motion, place, vacuum, time, &c.) there are special divisions of the physical sciences : (1) optics ; (2) astronomy, judicial and operative ; (3) gravity (*scientia ponderum de gravibus et levibus*) ; (4) alchemy ; (5) agriculture ; (6) medicine ; (7) experimental science.'

'The study of wisdom', Bacon said, 'has two parts, one speculative, and the other practical and operative.' Some sciences, he said, are essentially speculative ; some are concerned with practical operations. Alchemy he declared to be partly speculative and partly practical. The following is Bacon's description of the scope of speculative alchemy : [2]

'There is another science which treats of the generation of things from the elements, and of all inanimate bodies ; such as the elements, and simple and compound liquids (*humoribus*) ; common stones, precious stones, marbles ; gold and other metals ; sulphurs, salts and inks ; blue, vermilion and other colours ; oils and combustible bitumens, and an infinity of other matters of which Aristotle has not spoken, of which the natural philosophers know nothing. . . . Ignorance of these matters involves ignorance of everything about natural things. . . . The generation of man, and beasts, and vegetables is from elements and humours (*ex humoribus*) and corresponds with (*communicat cum*) the generation of inanimate things. . . . This science is speculative alchemy, which reasons about all inanimate things, and the whole generation of things from elements.'

It is instructive to compare Bacon's description of the business of speculative alchemy with what Paracelsus said of the aim of alchemy. Paracelsus lived about three centuries

[1] I quote from Brewer's translation in the preface to his edition of *Opera inedita*, p. li.

[2] *Opus Tertium*, xii. 39 (Brewer).

after Roger Bacon; he, too, was a student of nature, and a rebel against authority. His conception of alchemy was much hazier, much less scientific, than Bacon's. He said: 'To grasp the invisible elements, to attract them by their material correspondences, to control, purify, and transform them by the power of the Spirit—this is true Alchemy.'

I have already quoted from *Opus Tertium* what Bacon says of practical alchemy (p. 302). It teaches how to make 'noble metals and colours, and many other things, better and more copiously by art than nature. . . . It provides money for a state. . . . It teaches the means of prolonging life.'

From what Bacon says about speculative alchemy, it is evident that he did not regard that science as purely introspective. He founded it on observation and experiment. Its business is to reason on the data of experience, so as to come at just general conclusions regarding 'the generation of all things'. Practical alchemy takes some of the results of the reasoning of speculative alchemy, and applies them to certain specific practical purposes.

Let me now bring together what I have said about Roger Bacon's attitude toward alchemy and chemistry.

I. Roger Bacon laid stress on the usefulness of alchemical knowledge. He said that the importance of a branch of knowledge is largely dependent on the utility of it. He therefore sought to base his reasoning about 'the generation of things'—which study he took to be the business of alchemy—on facts gained by observation and experiment. He was not altogether happy in his treatment of what we now call chemical changes. He does not appear to have studied these events much at first-hand. He followed the footsteps of others. At the same time he insists on the necessity to the alchemist of a practical acquaintance with the methods of distilling, calcining, separating, and the like. He recognized and unhesitatingly recommended the only way to accurate and fruitful knowledge of the changes of

material things. In some branches of nature-knowledge he showed wise judgement in selecting the kind of facts which ought to be studied if real advance was to be made.

II. When one remembers that Roger Bacon lived before the ferment of the Renaissance had become fully active, and that he was a Franciscan monk, trained in scholastic ways of thinking, and vowed to obedience, one cannot but be admiringly astonished at his boldness in pleading for freedom of reasoning on the results of experience. It is true that he told the ' unlearned crew ' that they must follow authority, and that he professed intellectual obedience to the Church ; nevertheless, his writings are singularly outspoken and bold.

III. That he might form an intellectual picture of how natural changes proceed, Roger Bacon used the instrument that his predecessors used, namely, the four elements—earth, fire, air, water ; dryness, hotness, coldness, wetness. But he used this mechanism in a manner different from, and more suggestive than, that wherein it was used by other alchemists.

IV. Roger Bacon protested against, and completely discarded, the central conception of alchemy. He would have nothing to do with the universal primary matter, which was the chief stock-in-trade of his predecessors and of most of those alchemists who came after him.

V. Having abolished the primary matter, the ' soul of bodies ', Roger Bacon recognized the existence of distinct material things, each characterized and distinguished from all others by its own particular properties.

VI. Roger Bacon realized, more fully than most of the alchemists, that effort, activity, change, are the marks of physical things. He seems to have been feeling his way toward a universal activity, a conception not wholly unlike the modern notion of energy.

By his abandonment of the conception of a primary matter, by his insistence on dealing with particular objects of sense and their interactions, by his recognition of the importance

of the actions of natural agents on particular substances whereby other substances are produced, and by the breadth and scientific character of his conception of the objects and range of speculative alchemy, Roger Bacon stands out from the crowd of ordinary alchemists, and is worthy of being placed among the chemists. The justness of classing him as a chemist, rather than as an alchemist, is supported by his avoidance of many of the purely speculative questions which were the life and soul of the scholastic philosophy wherein he was born and bred.

XII

ROGER BACON AND GUNPOWDER

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The exact date of Roger Bacon's *Epistola de Secretis Operibus Artis et Naturae et de Nullitate Magiae* is uncertain; but it is quite certain that the work was written many years before the *Opus Majus* and the *Opus Tertium*, both of which lie within the period 1265–8. In the latter works Bacon says that certain play-toys, 'crackers,' were well known in many places, and in the *Opus Tertium* he explains to the Pope that the explosive contained in them was a mixture of saltpetre, charcoal, and sulphur.[1] On the other hand, in the *De Secretis* he took extraordinary care to conceal, by cryptic methods and anagrams, the names and proportions of the ingredients which formed the explosive. Circumstances had totally changed in the lapse of years; the composition of gunpowder, which must have been known all along to his laboratory assistants, had been divulged, and the first use made of the deadly mixture was for the amusement of children.[2] We shall not be far wrong in dating the *De Secretis* at 1248; a date which would receive considerable support from the dedication of the tract to William, Bishop of Paris, who died in 1249, if the dedication should prove to be authentic.

Bacon attacks Magic in this book on the ground that

[1] *Un Fragment inédit de l'Opus Tertium de Roger Bacon*, ed. by Prof. P. Duhem, 1909, p. 154.

[2] 'Experimentum hujus rei capimus ex hoc ludicro puerili,' *Opus Majus*, 1733, p. 474.

science and art can exhibit far greater wonders than the alleged wonders of the Black Art, and to prove his point he enumerates, in the first eight chapters, a number of wonders which (he believed) art could produce and magic could not. Everything is sufficiently clear until we reach the ninth, tenth, and eleventh chapters, and these are unintelligible as they stand. Now, it is past belief that a man of commanding genius should have deliberately stooped to write page after page of nonsense. The three chapters, therefore, must have *some* meaning, hidden from us though it be.[1]

There is nothing extraordinary in lighting upon cryptic writing of the thirteenth century. During that period, and for long afterwards, 'superior knowledge excited only terror and suspicion. If it was shown in speculation, it was called heresy. If it was shown in the study of nature, it was called magic.'[2] Alchemy was considered a diabolical art, and was condemned by the Pope in 1307,[3] a few years after Bacon's death. The alchemists therefore were forced in self-defence to hide their dangerous lore as best they might, and seven of the methods they employed are mentioned by Bacon in a moment of suspicious candour :

(1) *Characteres et carmina ;*
(2) Enigmatic and figurative words ;
(3) Consonants only, without vowels ;
(4) Letters from different alphabets ;
(5) Specially devised letters ;[4]

[1] 'Quand le sens littéral est absurde, incohérent ou obscur . . . on doit présumer un sens détourné.' Langlois et Seignobos, *Introd. aux Études Historiques*, p. 127.

[2] Lecky's *Rise, &c., of Rationalism in Europe*, i. 275.

[3] Prof. J. B. Bury, *History of Freedom of Thought*, 1913, p. 65. A century after Bacon, Langland wrote :

> Ac astronomye is an hard thyng, and yvel for to knowe ;
> Geometrie and geomesie, so gynful of speche, &c.
>
> *Vision of Piers the Plowman*, Passus x.

[4] 'Lines, circles, scenes, letters, and characters.' Marlowe, *Doctor Faustus*, Sc. i.

(6) Prearranged geometric figures ;

(7) *Ars notatoria*, a system of abbreviations.

Bacon has occasionally availed himself in chaps. ix, x, and xi of some of these methods, which apply chiefly to words and phrases ; but he has not dropped a hint to indicate the general method which underlies the whole of chaps. ix and x. Some of the early cryptic methods were too tedious and some were too complicated to be used throughout the whole of these two chapters ; and the method he adopted (as the result will show) was that clearly described long afterwards by G. B. della Porta,[1] and called in England ' the Argyle cipher '.[2] Thackeray has given a capital example of this cipher in *Esmond* :

' [*The King will take*] medicine on Thursday. His Majesty is better than he hath been of late . . . Madame Maintenon continues well . . . [*the Viscount Castlewood's passports*] were refused to him, 'twas said ; his lordship being sued by a jeweller for Vaisselle plate . . . 'Tis a pity such news should get abroad [*and travel to England*] about our young nobility here. Mademoiselle Meruel has been sent to Fort l'Evesque ; they say she ordered not only plate, but furniture, and a carriage and horses [*under that lord's name*], of which extravagance his unfortunate Viscountess knows nothing,' &c.

The essential words are within brackets ; and it is evident, even from this much abridged version of Colonel Esmond's letter, that the cipher is one which it is almost impossible to solve without the key, unless the matter in question is known beforehand—the subject of the cryptic statement. Here, then, we should have found ourselves left in utter darkness were it not for a ray of light afforded by chap. xi. There we are told that *something*, in connexion with saltpetre

[1] *De Occultis Literarum Notis*, 1606, p. 140. On p. 143 Porta gives a plate showing the key to the cipher, which is simply a blank sheet of paper exactly the same size as the paper on which the cryptic statement is written. Rectangular slits are cut in the key in such a way that when it is laid on the statement only the essential words are visible.

[2] *Penny Encyclopaedia*, art. ' Cipher.'

and sulphur, produces an explosion,[1] and we know that this something is charcoal. Since chap. xi is concerned with the composition and effects of this mixture, what more probable than that chaps. ix and x should deal with its ingredients separately—or at least with saltpetre and charcoal, for sulphur was so simple and common a drug that Bacon was not likely to dwell upon it? Now, towards the end of chap. x Bacon speaks without disguise of charcoal under the name of the wood from which it is made,[2] and mentions the two trees, hazel and willow, which give the best. He significantly adds that when charcoal is added to proper proportions of certain other substances, something noteworthy happens.[3] Since, then, charcoal is one of the subjects of these two chapters, it becomes all the more probable that saltpetre forms another. Bacon was writing but a few years after its discovery, and nothing could be more natural than that the great alchemist should bestow his attention upon the preparation of the new salt. This hypothesis explains simply and completely the most remarkable feature of chaps. ix and x—the series of common and well-known alchemical terms and phrases, referring undoubtedly to the preparation of either saltpetre or gold, which are scattered and hidden among incoherent maunderings about chalk and cheese, philosophic eggs and Tagus sand. But how could the preparation of gold lead up to the recipe for an explosive with which chap. xi ends? There is no connexion whatever between gold and gunpowder, while the connexion between saltpetre and gunpowder is of the closest possible kind. Before giving a recipe for gunpowder it was absolutely necessary for Bacon to describe the method of refining the

[1] 'Tonitruum et coruscationem.'

[2] Aeneas Tacticus adopts the same mode of expression, *Poliorketikon*, xxxv. 79.

[3] Si vero partes virgulti coryli aut salicis multarum justâ rerum serie apte ordinaveris, unionem naturalem servabunt: et hoc non tradas oblivioni, quia valet ad multa.

lately discovered saltpetre, without which his recipe would have been worthless; and he took advantage of the close similarity between the alchemical preparation of gold and the refining of saltpetre to conceal the real import of his tract. By the title of the last three chapters—'On the Method of Making the Philosopher's Stone'—and by constantly harping on gold, he endeavoured to distract and deceive his ordinary readers, leading them to believe that he was writing about gold when he was really treating on saltpetre.

The unnamed substance saltpetre, then, is the principal subject of chaps. ix and x, and our course is clear. We must treat these chapters as we should treat Colonel Esmond's letter were the brackets omitted [1]—we must make shift to insert them. We must bracket together the phrases and sentences relating to the real subject of these chapters, the familiar alchemical expressions relating to saltpetre. On doing so we shall find a connected and rational method of refining the salt.

In the following reproduction of chaps. ix and x I have used the Esmond brackets, but I have not thought it necessary to reprint *all* the padding which connects them. All omissions, however, are shown by dots. No word of the bracketed phrases has been changed, altered, added, or suppressed, nor has the order of the words been altered. Nothing has been done but to indicate by brackets the misleading interpolations.

Cap. IX

De modo faciendi ovum philosophorum.

Dico igitur tibi quod volo ordinari [2] quae superius narravi exponere, et ideo volo ovum philosophorum et partes philosophici ovi investigare, nam hoc est initium ad alia.

[1] That is, supposing we knew the subject of his letter.

[2] Another reading is 'ordinate'.

[*Calcem*[1] *igitur diligenter*] aquis alkali et aliis aquis acutis [*purifica*], et variis contritionibus cum salibus confrica[2] et pluribus assationibus concrema, [*ut fiat terra pura penitus liberata ab aliis elementis*[3]], quam tibi pro meae longitudinis statura dignam duco. Intellige si potes, quia proculdubio erit compositum ex elementis, et ideo est pars lapidis qui non est lapis,[4] et est in quolibet homine et in quolibet loco hominis. . . . Deinde oleum ad modum crocei casei et viscosi accipias,[5] primo ictu insecabile, cujus tota virtus ignea dividatur et separetur per distillationem; [*dissolvatur*[6] *autem in aqua*] acuta temporatae acuitatis [*cum igne levi,*[7] *ut decoquatur quatenus separetur pinguedo sua*[8]], sicut pinguedo in carnibus. . . . Melius est tamen ut decoquatur in aquis temporatis in acuitate [*donec purgetur et dealbetur*].

[1] To lull suspicion he calls natural saltpetre chalk, a *verbum figurativum*. Other manuscripts read 'sal'.

[2] 'Tere ipsum fortiter cum aqua salis communis. . . . Ablue in aceto acerrimo.' The section 'Nitri Separatio' of 'Aristoteles, de Perfecto Magisterio', in the *Theatrum Chemicum*, ed. by Zetzner; a collection of alchemical tracts of the Middle Ages, iii. 68.

Almost literally translated by Whitehorne: 'clarified and from earthe and grosse matter diligently purged.' *Certain Waies for the ordering of Souldiers in Battelray*, London, 1560.

[4] i.e. the lapis Assius = saltpetre. We have here unmistakably a *verbum aenigmaticum*. The efflorescence of the stone of Assos, which was unknown to the crowd, was of course 'not a stone', although called so. The philosopher's stone, which was well known by name to the crowd, was likewise 'not a stone', although called so:

> . . . 'tis a stone
> And not a stone; a spirit, a soul, and a body.
> Jonson's *Alchemist*.

Bacon avails himself of the ambiguity of the phrase, 'stone which is not a stone,' to support the delusion created by the title of the chapter, and confirm the unwary in the belief that the philosopher's stone is under discussion, instead of saltpetre.

[5] He passes suddenly from chalk to cheese—yellow cheese, laughing openly in his reader's face.

[6] i.e. the cleansed natural saltpetre.

[7] 'Put the jar on a gentle fire.' Hassan-er-Rammah (1275–95) in Reinaud and Favé's *Du Feu Grégeois*, Paris, 1875, p. 20.

[8] 'The mother liquid is boiled until the scum ceases to rise.' Waltham Abbey process, in the official *Handbook of the Manufacture of Gunpowder*, by Capt. F. M. Smith, R.A., 1871.

Aquae vero salutaris exaltatio fit ex igne sicco vel humido ; et [*iteretur distillatio*] ut effectum bonitatis recipiat sufficienter [*donec rectificetur : rectificationis novissima signa sunt candor et crystallina serenitas* [1]] ; et cum caetera [2] nigrescunt ab igne hoc albescit, mundatur, serenitate nitescit et splendore mirabili. [*Ex hac aqua*] et terra sua argentum vivum generatur, quod est sicut argentum vivum in mineralibus, et quando incandidit hoc modo [*materia congelatur. Lapis vero Aristotelis, qui non est lapis, ponitur in pyramide in loco calido* [3].]

Cap. X

De eodem, sed alio modo.[4]

Transactis annis Arabum sexcentis et duobus, rogasti me de quibusdam secretis. [*Accipe igitur lapidem* [5] *et calcina ipsum*] assatione leni et contritione forti sive cum rebus acutis. [*Sed in fine parum commisce de aqua dulci ; et medicinam laxativam* [6] *compone de*] septem rebus . . . vel de quot vis ; sed quiescit animus meus in [*duabus rebus quarum proportio melior est in sesquialtera proportione* [7]] vel circiter, sicut te potest docere experientia. [*Resolve* [8]] tamen aurum [9] [*ad ignem et mollius calefac*]. Sed si mihi credas,

[1] ' Clear and fair and of an azure colour.' Whitehorne.

[2] i. e. the scum and impurities.

[3] i. e. ' to drie throughly.' Whitehorne.

[4] This repetition corresponds with Whitehorne's second process.

[5] i. e. the crystals just obtained.

[6] A powder to purge, or to purify and clarify. ' Prenez de la chaulx vive et de l'eau de pluye . . . et les brouïllez bien ensemble, et puis le laissez reposer . . . et se fera forte lexive . . . Prenez de la lexive dessus dicte, et mettez vostre salpetre dedans,' &c. ' Livre de Canonnerie,' &c., which although not published until 1561, appears to belong to the end of the fifteenth century. In Reinaud and Favé, pp. 146–7.

[7] Bacon does not name the two substances he alludes to, but Whitehorne names two and prescribes the same proportions : ' Two parts of unslacked lime and three of oke asshes.'

[8] Treating ostensibly on gold, Bacon is obliged to use *resolve* for *dissolve*.

[9] The alchemical preparation of gold had much in common with the refining of saltpetre. In the ' Nitri Preparatio ' of Bernard and Penoti's *Theatrum Chemicum*, iii. 78, we read : ' Fac postmodum

accipias unam rem, hoc est secretum secretorum, et naturae potens miraculum. [*Mixto*[1] *igitur ex*] duobus, aut ex pluribus, aut [*Phoenice*[2]], quod est animal singulare, [*adjunge, et incorpora per fortem motum ; cui si liquor calidus adhibeatur,*[3] *habebis propositum ultimum*[4]]. Sed postea coelestis natura debilitatur si aquam infundis ter vel quater. Divide igitur debile a forti in vasis diversis,[5] si mihi credas. [*Evacuato*[6] *igitur quod bonum est.*] Iterum adhibe pulverem, et aquam quae remansit diligenter exprime, nam pro certo partes pulveris deducet non incorporatas. Et ideo illam aquam per se collige, quia pulvis exsiccatus ab ea habet incorporari medicinae laxativae . . . [*Regyra cum pistillo,*[7] *et congrega materiam ut potes, et aquam separa paulatim*] et redibit ad statum. Quam aquam exsiccabis, nam continet pulverem[8] et aquam medicinae, quae sunt incorporanda sicut pulvis principalis.

When the bracketed words and phrases in the foregoing pages are read or written consecutively,[9] it will be found

de eo per omnia ut dicam in preparatione auri, id est, destilla per alambicum et congela,' &c.

[1] i. e. to the laxative.

[2] A *verbum aenigmaticum*. The Phoenix is a singular animal, as Bacon justly observes, inasmuch as it springs from its own *ashes*. Its name, therefore, may be figuratively used with perfect propriety to denote *animal charcoal*, an efficacious agent in clarifying solutions of impure saltpetre. Bloxam's *Chemistry*, 8th ed., p. 488.

[3] Bacon appears to have poured the hot solution upon the laxative, precisely as Clarke directs in his *Natural History of Nitre*, London, 1670, p. 42 : ' Pour the hot liquid on ashes . . . 'tis no matter how soon you let it run off the ashes again.'

[4] i. e. the removal of the insoluble impurities.

[5] ' Then pour it into the other jar.' Hassan, in Reinaud and Favé's *Du Feu Grégeois*, p. 21.

[6] i.e. into a crystallizing jar.

[7] ' The solution is kept in constant agitation by poles while cooling.' Waltham Abbey Regs.

[8] ' The mother liquid, from which the saltpetre flour has been deposited, is boiled down and crystallized.' Bloxam's *Chemistry*, 8th ed., p. 488.

[9] They will be found collected and translated in *Gunpowder and Ammunition*, by the present writer, Longmans, 1904, chap. ii ; where the Waltham Abbey method is given also, to admit of comparison, in Table I.

that the method of refining saltpetre devised about 1248 by a persecuted monk falls little short of the modern method pursued at Waltham Abbey, though founded on the experience of centuries and supported by all the help a Government could give.

It would be presumptuous to suggest that the foregoing solution of Bacon's steganogram is free from error; but whatever errors may be found, there can at least be little doubt that the occult meaning of the two chapters is the refining of saltpetre. One sentence, two sentences, or even more, might be selected from the description of almost any long chemical process which would apply with equal propriety to some other process; but it is incredible that a long, varied, and connected process, such as the refining of saltpetre, could be extracted by any method from documents professedly devoted to the philosopher's stone, unless this process had been designedly inserted there, piecemeal or whole, by the author himself. For the figurative interpretation given of two or three words and phrases, we have Bacon's own warrant. He threatened to employ *verba aenigmatica* and *verba figurativa*, and he has been taken at his word; with the result that a rational chemical process has been extracted from what was previously unintelligible.

Having said all he had to say about the ingredients, Bacon proceeds to deal with their mixture in chap. xi, in which he employs a different cryptic method.

Cap. XI

De eodem, tamen alio modo.

Annis Arabum 630 transactis, petitioni tuae respondeo in hunc modum . . . Item pondus totum 30. Sed tamen salis petre LURU VOPO VIR CAN UTRIET sulphuris; et sic facies tonitruum et coruscationem, si scias artificium. Videas tamen utrum loquor enigmate aut secundum veritatem.

Omitting the anagram, the translation is : ' In this 630th year of the Hijra I comply with your request as follows. . . . Let the total weight (of the ingredients) be 30. However, of saltpetre . . . of sulphur ; and with such a mixture you will produce a bright flash and a thundering noise, if you know "the trick". You may find (by actual experiment) whether I am writing riddles to you or the plain truth.'

The mention of a flash and a loud noise indicates plainly that we have here to do with an explosion. But a mixture of saltpetre and sulphur will not explode. Therefore the name of some third substance which will render the mixture explosive must be concealed in the anagram, *luru vopo vir can utriet.* The construction of the second clause of the second sentence, *et sic facies*, &c., shows that the anagram must contain some verb, such as *take* or *mix*, in the imperative mood. We may expect the name of some unit of weight, or the word *partes* (parts), and the numbers of the weights or parts. Now, so much information could not be conveyed to us by the twenty letters of the anagram. Therefore Bacon must have had recourse to the seventh and last of the methods of concealing secrets enumerated in the eighth chapter of the *De Secretis*, the *ars notatoria* or shorthand, of which he thought highly.[1]

Rearranging the letters of the anagram, we get :

RVIIPARTVNOUCORULVET

and combining these letters into groups :

R. VII. PART. V. NOV. CORUL. V. ET

The second sentence of the above passage therefore reads : ' sed tamen salis petre recipe vii partes, v novelle coruli,[2] v

[1] Majus artificium occultandi . . . que est ars notandi et scribendi ea brevitate qua volumus et ea velocitate qua desideramus ; cap. viii.

[2] In chap. x he says ' willow or hazlewood ' ; having discovered

et sulphuris,' that is, ' but take 7 parts of saltpetre, 5 of young hazelwood (charcoal), and 5 of sulphur ' ; and the recipe for the explosive is :

Saltpetre	41·2	parts
Charcoal	29·4	,,
Sulphur	29·4	,,
	100·0	

This mixture will explode ' if you know the trick ' ;—if you use pure saltpetre, incorporate the ingredients thoroughly, keep the powder dry, and avoid subjecting it to undue pressure.

It is clear that, though invariably attached to *utri*, the word *et* does not belong to the anagram, which thus consists of eighteen letters. Now, the solution of these eighteen letters yields thirty letters, a fact which probably explains the first short sentence, *item pondus totum 30*. Bacon wished thereby to make known to his correspondent the number of letters in the solution.

Such is the solution of Bacon's first anagram. The second anagram, which is contained in the same chapter, remains unsolved.

It is not to be supposed that Bacon's claim to the possession of gunpowder rests solely upon the foregoing solution of his first anagram ; for it can be proved quite independently that he possessed an explosive when the *De Secretis* was written.

The igneous bodies of which Bacon speaks fall into two classes. The first class are incendiaries. ' Incendiaries ', he tells us, ' may be made from saltpetre, or petroleum, or

experimentally that ' light woods (should be) selected for the preparation of charcoal for gunpowder, because they yield a lighter and more easily combustible charcoal.' Bloxam's *Chemistry*, 8th ed., 1895, p. 490.

maltha,[1] or naphtha, mixed with other substances. . . . To these are allied Greek fire and many other incendiaries.'[2]

But side by side with these passages we find descriptions of igneous compositions of a totally different kind. 'There are other natural wonders. We can produce in the air sounds loud as thunder and flashes bright as lightning—nay, even surpassing the powers of nature. A small quantity of (a certain) composition, no bigger than one's thumb, will give forth (on ignition) a deafening noise and a vivid flash.'[3] We have, too, the passage, already quoted, in the eleventh chapter, where he says that saltpetre and sulphur and *something else* give forth (on ignition) 'a thundering noise and a vivid flash'.[4]

The consequences of igniting these two classes of composition are described so clearly as to preclude all possible misunderstanding: the incendiary *burns* fiercely, while the other mixture gives forth *a bright flash and a loud noise.* In the latter case, Bacon was describing an explosion, and, as he has elsewhere spoken of saltpetre, charcoal, and sulphur, the reasonable conclusion is that the explosive was gunpowder.

It has been said that the first of the foregoing passages—'there are other natural wonders,' &c.—describes a rocket. As everybody knows, a rocket in its flight makes a whizzing noise and is followed by a trail of heated gas and sparks.

[1] 'Malta, quae est genus bituminis.' *Opus Majus*, London, 1733, p. 474 (ed. Bridges, ii. 217).

[2] 'Possumus artificialiter componere ignem comburentem, scilicet, ex sale petrae . . . ex oleo petroleo . . . ex maltha et naphta et consimilibus . . . His vicinus est ignis graecus et multa comburentia.' *De Secretis*, cap. vi.

[3] 'Sunt alia stupenda naturae. Nam soni velut tonitrua et coruscationes fieri possunt in aere; immo majori horrore quam illa quae fiunt per naturam. Nam modica materia adaptata, scilicet ad quantitatem unius pollicis, sonum facit horribilem et coruscationem ostendit vehementem.' *De Secretis*, cap. vi.

[4] See p. 156.

The whizzing noise can only be compared to thunder by a total disregard of fact, for no sound resembles thunder less. The fiery trail can only be called a flash by an equal disregard of fact : it gives a continuous light. But if the rocket carries a bursting charge which explodes in mid-air, the explosion may, with venial exaggeration, be said to produce a flash like lightning and a noise like thunder. Bacon was alluding to a bursting charge consisting of an explosive, and that explosive was gunpowder.

Had Bacon considered the possibility of controlling and utilizing the explosive force of gunpowder ; of projecting by its means a heavy body from a strong tube through a certain distance in a certain direction ?

There is nothing in his works (so far as I am acquainted with them) which suggests that he had. He knew that gunpowder exploded, and he believed that an army might be either actually blown up by it, or put to flight by the terror inspired by its explosion ;[1] but he seems to have gone no further. He experimented, probably, with very small quantities of it ; and the behaviour of gunpowder when fired in large quantities under pressure is so unlike its behaviour when fired in small quantities in the open air, that its projective force could neither have been predicted by abstract reasoning nor realized by even his powerful imagination.

The famous Greek fire was not an explosive, but an incendiary mixture. The claims to the invention of gunpowder which have been made for the Arabs and Hindus collapse when critically examined. The invention has always been disavowed on the part of their countrymen by sober Chinese historians, though in despite of them a claim was raised in the eighteenth century by some Jesuit missionaries who

[1] This is M. Berthelot's view : *Sur la Force des Matières Explosives*, Paris, 1883, ii. 358 ; and it is probably the right one.

unwittingly confounded explosive and incendiary mixtures.[1] By whom, then, was gunpowder invented?

If gunpowder had been invented by another and if Bacon was induced by love of science to write about it, there is no apparent reason why he should have done more than describe it fully in the metaphorical language of the alchemists. But not content with the free use of figurative terms, he buried the facts in the laborious cipher of chaps. ix and x and in the two anagrams of chap. xi, one of which still defies the ingenuity of man. It was a strong motive, surely, that moved him to act in this way, and there is but one rational explanation of his behaviour; namely, that he himself was the inventor of gunpowder, and that he was driven to employ cryptic methods by fear of the Inquisition, which had been founded by Pope Gregory IX about the year 1233. The Church, he well knew, would exact a dreadful retribution from the man who discovered and recorded the composition of a substance believed to possess magical properties, and who broadly hinted at its possible utility in warfare.[2] No precautions could be too ample or too minute to shelter such a man from the wrath of the Holy Office. Unhappily his elaborate devices mystified friend and foe alike: they enabled him to evade the grasp of the Inquisition, but they deprived him for centuries of the honour of his discovery.

In all probability gunpowder was not invented, but discovered accidentally by Bacon;[3] just as the structure of crystals was discovered accidentally by Haüy, the polarization of light by Malus, galvanism by Galvani, and the decomposition of water by Nicholson. Whilst he was

[1] On the subject of this paragraph see *Gunpowder and Ammunition*, by the present writer, Longmans, 1904.

[2] *De Secretis*, cap. vi.

[3] Hallam (*Middle Ages*, 12th ed., i. 479) suggested that gunpowder was discovered accidentally; but he added, 'perhaps in some remote age and distant region,' not having been aware that saltpetre was unknown before the period A.D. 1225–50.

experimenting with some incendiary composition containing saltpetre, charcoal, and sulphur, the mixture suddenly exploded, shattering the glass and scattering the brazen apparatus that lay around. Traces of such a mischance may perhaps be detected in the explosion which followed the fall of the brazen head in 'The Famous Historie of frier Bacon': [1] 'therewith (the Brazen Head) fell downe, and presently followed a terrible noyse, with strange flashes of fire.[2] At this noyse the two Fryers awaked, and wondered to see the whole room so full of smoake.' Thus Bacon became accidentally possessed of a dangerous secret; and if his passion for science impelled him to record it in writing, common prudence obliged him to do so in a manner that would shield him from persecution.[3]

Enough has been said to show that until new and unexpected facts are brought to light in favour of another, we are justified in holding that gunpowder was discovered by Roger Bacon.

[1] Thoms' *Early Prose Romances*.

[2] Almost the words of the *De Secretis*: 'modica materia adaptata . . . sonum facit horribilem et coruscationem ostendit vehementem,' cap. vi.

[3] 'Insanus est qui aliquod secretum scribit nisi ut a vulgo celetur, et ut vix a studiosissimis et sapientibus possit intelligi,' cap. viii.

XIII

ROGER BACON AND MEDICINE

By E. WITHINGTON

The Medicine of the Thirteenth Century

Richer, monk of Rheims, in his valuable *History of his own Times*, relates a curious contest between an ecclesiastical and a lay physician, which may form an appropriate preface to some estimate of Friar Bacon's attitude towards the practitioners of his age and a brief account of the state of medicine in the thirteenth century.

'In A. D. 946 died Derold, Bishop of Amiens, an honourable courtier, beloved of the king and very skilled in medicine. The story is told that, when he served the king, he had a contest in cunning with a certain Salernitan. Both were excellent physicians, but while Derold was in greater favour with the king, the queen considered the Salernitan more skilful. So the king contrived a way to test their respective ability without their knowing it. He invited both to dinner, and put questions to them on medical matters. They answered as best they could: Derold, being a man of learning, gave satisfactory definitions; while the Salernitan, though without any literary knowledge, possessed great talent and practical experience. By royal command they came to dinner every day, and sat next to one another. Now, they were disputing one day over the dynamidiae (potencies) of drugs, and the respective provinces of pharmaceutics, botanics, and chirurgics. The Salernitan had never heard those strange names, so he blushed and was silent. Thenceforth he became so jealous that he plotted to poison his rival, while pretending special friendship for him. Having prepared a poison, he anointed the nail of his middle finger therewith, and put it in the pepper water (*liquorem piperis*) in which they both dipped their food. Derold, carelessly tasting thereof, soon began to feel unwell; so he was led out by his friends and cured himself in three days with theriac. On his return he concealed his knowledge of the trick, and when the Salernitan inquired after his health

said he had had a slight catarrh, treating him with great courtesy so as to put him off his guard. Then he (Derold) strewed some poison, which he held between his little and ring fingers, on his neighbour's meat, which being absorbed drove out the vital heat, and the sick Salernitan was led away by his friends. He tries to expel the poison, but in vain. Now he praises Derold as the best of physicians and entreats his aid. Derold, at the king's command, gave him antidotes, but purposely left the cure incomplete ; for the theriac drove the poison down into his left foot, where it caused a swelling and afterwards an open wound, so that, finally, his foot was miserably amputated by the surgeons.' [1]

The worthy monk is thought sometimes to have put edification before accuracy, and some details of this story may be doubted, but it represents, in part, Bacon's attitude in the most interesting of his medical treatises, the *De erroribus*.

He is there exposing the defects of the inheritors of the Salernitan tradition, the *Latino-barbari* as they were afterwards called, men who knew no Greek and had read but little even of the Latin versions of Avicenna, Rhazes, and the other Moslem physicians. These were contrasted with the *Latini elegantes et docti*, who knew Aristotle and the Arabs, and with whom the *Doctor mirabilis* would doubtless have classed himself, though the elegance of his Latin would scarcely have satisfied Linacre. In the tract *De erroribus* Bacon deals with these *Latino-barbari*, the *vulgus medicorum*, much in the style in which the Bishop of Amiens probably addressed the Salernitan. But the *dynamidiae* and pharmaceutics have been raised to a higher plane by aid of the mathematics of Alkindi, botanics has become *agricultura philosophica*, and two fresh sciences, alchemy and astrology, have been introduced under Greek and Arabic authority, not to mention Bacon's own *scientia experimentalis*. Well might the *Latino-barbari* blush and be silent! Bacon, however, though he seems to have suffered much from

[1] Pertz, *Monumenta Germaniae*, iii. 600.

a Salernitan purgative, is more merciful than the bishop. Errors become defects, defects impediments, and many of these natural and excusable in the circumstances.

To return to the Salernitan. His practical knowledge and deficient general culture characterized the school of which he is one of the earliest known members, through its whole course. When Rudolf the monk (Raoul Leclerc) went to Salerno about 1040, the 'Hippocratic city' was rising to the height of its fame, yet we are told he could find none who could meet him in argument save a certain learned matron.[1] But he gained much practical knowledge there, and on entering the abbey of St. Martin, taught the healing art with a success shown by the number of his pupils, who were scattered through the monasteries of Anjou and Touraine and obtained much wealth for their communities by medical services to neighbouring nobles.[2]

This development of monastic medicine, the most important of which we have any record, was suppressed in the twelfth century by repeated decrees of Church councils (Clermont, 1130; Rheims, 1131; Lateran, 1139; Montpellier, 1162), which denounced it not only as leading to love of lucre and a vagabond life, but also as necessarily dealing with matters *de quibus loqui erubuit honestas*, and which therefore *non debet Religio pertractare*.

Meanwhile the practical Salernitans made little progress. They collected the popular and proverbial medicine of the age in their famous *Regimen Sanitatis*, and they handed down the old forms of treatment in medical families and in therapeutic Compendia. Though they claimed the heritage of the classical tradition, they possessed, according to Constantine, no Latin version of 'Galen' when he came

[1] Ord. Vitalis, *Hist. Eccl.*, II. iii. 11.

[2] 'La médecine en Touraine au XI[e] siècle,' Dubreuil-Chambardel; 'Les médecins angevins au moyen âge,' C. Ballu, *La France Médicale*, 1911 (11 and 22).

to Salerno about 1060, and they paid little attention to the translations from the Arabic which that remarkable man, *Orientis et Occidentis magister, novusque effulgens Hippocrates*, issued as his own compositions from the monastery of Monte Cassino. In the next century they produced little more than books on drugs, and when one of their most learned 'masters', Gilles of Corbeil, attempted at the close of that epoch to give lectures at Montpellier, he was howled down by the students [1] as a teacher entirely out of date. For the great revival had begun which marks the thirteenth century, and which, among other things, saved medicine from degenerating into the hands of *rustici* and *Latino-barbari*.

From east, west, and south; from Constantinople, taken by the Crusaders in 1204, from Toledo, long lost to Islam but still retaining many relics of the *studia Saracenorum*, from the Sicilian court of the Emperor Frederick, *stupor mundi*, the writings of Aristotle and the Arabs poured like a flood over the schools of western Europe.

The triumphal progress of Aristotle is one of the marvels of man's mental history. The *Physica* and *Metaphysica* of the pagan philosopher, who taught the eternity of the universe, the mortality of the soul, and the non-intervention of the Deity in the fate of the world or the affairs of men, were promptly and naturally condemned by the Church in 1209, 1215, and later. Yet, in less than a century, the greatest of Catholic theologians had converted them into a bulwark of orthodoxy, and the greatest of Catholic poets had given their author the immortal title, 'Master of those who know.'

The influence of Aristotle on medicine was diverse. Indirectly he contributed to the unfortunate dominance of Avicenna, whose Canon became the rule of European

[1] 'Postquam eum fortiter verberaverunt, clamabant post ipsum ac si esset rusticus vel calcifex.' Quoted by Pansier, *Janus*, September 1904.

practice for three centuries, mainly because it was thought to harmonize Aristotle with Galen, just as St. Thomas harmonized him with Catholic truth. The harmony was far from complete, as, indeed, Bacon points out, but was sufficient to impress the mediaeval physician, who held that where Galen and Aristotle differed none could decide, and where they agreed none could dissent.

But, on the other hand, the study of 'the Philosopher' gave a new freedom to thought and the investigation of Nature—hitherto largely looked upon as a ruin, beset with pitfalls and haunted by demons, into whose clutches the rash explorer of its mysteries was certain to fall, if he had not made an unholy compact with their master, the Prince of this world. This was now replaced, in part, by the Greek view of the universe as a harmonious whole, 'the diapason closing full in man,' who is himself a little universe or microcosm.

Bacon's attitude towards Aristotle differs somewhat from that of contemporary physicians such as Peter of Abano, the great Conciliator, who attempted to complete the work of Avicenna. He speaks with disparagement of such treatises as the *Topics* and *Sophistici Elenchi* as leading only to vain disputations, and pays more honour to the *Secretum Secretorum* and other spurious productions in which the pseudo-Aristotle hints at marvellous remedies, praises the virtue of viper's flesh, and recommends Alexander the Great to take rhubarb. This pleased Bacon's practical mind, especially as rhubarb was the favourite medicine which he took himself. But Aristotle was an Asclepiad, the member of a medical family, as well as disciple of Plato, and, in the genuine works, the Asclepiad sometimes overcomes the speculative philosopher. There is a famous passage, quoted by practitioners contemporary with Bacon, and twice noticed by him in the *De erroribus*, which gives so clear a view of what he probably meant by *scientia experimentalis*

that it may be repeated in full in the language of Professor Gomperz.

At the end of the *Posterior Analytics* ' a fine image and one of great significance presents itself. As, when the tide of battle turns, first one stout-hearted warrior holds his ground, then a second, a third, and continually more and more ; so in the mind the first sense-impression of which a copy remains is joined by a second, then a third and others in increasing numbers, till from the summation of retained perceptions there rises the completed structure of an experience. For out of perception there is first produced memory, while experience is the result of repeated memories. Out of experience, in its turn, or out of all the " Universal that being a one as well as many, has become firm rooted in the mind " there proceed art and science, where by " science " pure theory is meant, and by " art " theory applied to practice. In this context it is stated with express emphasis that it is " sense perception " that generates universal notions, and that we necessarily obtain all our " first principles " by " induction ".' (*Greek Thinkers*, iv. 55.)

This, with special emphasis on tangible knowledge and the verification of truth in sense, seems to be Bacon's *scientia experimentalis*. (This passage, together with the other referred to by Bacon as *in principio Metaphysice*, is quoted by his younger contemporary Henry of Mondeville, *Cyrurgia* ii. 8 ' *Philosophus dicit in fine II*^{i} *posteriorum* " *Ex multis sensibilibus fit una memoria, et ex multis memoriis unum experimentum ; ex multis experimentis fit unum universale, quod est principium artis et scientiae . . .*" *Similiter quod ratio sit debilis, non juncto sibi experimento, patet auctoritate Philosophi in prohoemio metaphysicae* " *expertos magis proficere videmus, scilicet sine ratione* " *quam, supple, ratione utentes sine experimento.*')

Next to *experientia* Bacon ranks mathematics : ' If in other sciences we would reach certitude free from doubt,

and truth without error, we must set the foundations of cognition in mathematics' (*Opus Majus*, i. 106). Now, according to the beliefs of the age, medicine required mathematics directly for the proper compounding of drugs according to their *dynamidiae* and indirectly through astrology.

In the first centuries of our era astrology was the *mathesis*, and astrologers the '*mathematici*' *par excellence*. Even the mind of Ptolemy, the last great astronomer and mathematician of the ancient world, was seduced by its influence. It was, however, opposed with vigour and success by Christianity. The signs of the Zodiac might appear in the stones of her churches, the embroidery of her vestments, and even on the chair of St. Peter, but the intrusion of that fatalistic and heretical science into theology was prevented, and St. Leo [1] speaks with contempt and abhorrence of its most characteristic medical doctrine, the supposed influence of the zodiacal signs on the various parts of the human body. But at the end of the twelfth century it returned with the translations of Ptolemy, Aristotle, and the Arabs. Even the authority of Hippocrates was invoked. The Father of Medicine had declared that there is τι θεῖον in disease. We still hardly know what he meant, but the first Latin translators rendered θεῖον, not by *divinum* but by *coeleste*, so mediaeval physicians understood at once that he referred to the influence of the heavenly bodies. The doctrine of the microcosm, of man whose every element corresponds to some part of the universe, of a general solidarity and sympathy between all things, and, for men like Bacon, the exactness of mathematical calculation which could be

[1] *Epistola* xv. John of Salisbury has a chapter which might have warned Bacon, 'Quod mathesis via damnationis est' (*Policraticus*, ii. 26). 'Hanc vanitatem (says the bishop) Catholica et universalis Ecclesia detestatur, et eos qui eam ulterius exercere presumpserint legitimis poenis mulctat. . . . Plurimos audivi, novi multos, sed neminem in hoc errore diutius fuisse recolo, in quo manus Domini condignam non exercuerit ultionem.'

brought in, helped towards this second triumph of astrology which was no longer so strongly opposed by theologians. Those who went too far, or were otherwise heretical, like Peter of Abano, might incur the severest censures of the Church, but a Dante might, without rebuke, put almost on a level with Divine providence the '*opra delle rote magne, che drizzan ciascun seme ad alcun fine, secondo che le stelle son compagne*'.[1]

Practical men, however, who had to earn their livings, were not yet carried away by the current, and Mondeville treats the matter with his usual humour, good sense, and eye for the fee. He knows that Hippocrates had said in the *Prognostics*, '*Est etiam quoddam coeleste*,' in disease, which means that a surgeon must keep his eye on the moon (p. 120), that Ptolemy had written *in centilogio propositione* 20ª '*Secari membra ferro, luna exeunte in signo signante super ipsa, horribile est*' (p. 342), and that physicians recognized the absurdity of giving a 'laxative downwards' when the moon is in the ram, bull, or he-goat, for they are ruminant animals, and everything then naturally tends to return to the mouth. But, for the practitioner, his patients' needs (and his own) are supreme. There are 'times of election', indicated, doubtless, in part by the stars, but there are also times of necessity. We must often operate without troubling about the moon and the zodiac, or the patient

[1] *Purgatorio*, xxx. 109. The importance attributed to astrology even in the most enlightened circles is well seen in the following extract from a contemporary account of the marriage of the Emperor Frederick II with Isabella of England, 1235. 'Nocte, vero, qua concubuit imperator cum ea, noluit eam carnaliter cognoscere donec competens hora ab *Astrologis* ei nunciaretur. Consummata autem carnali commixtione summo mane, deputavit eam quasi pregnantem diligenti custodiae dicens ei, "Custodi te diligenter, quia habes in utero masculum:"' Matthew Paris, *Chronica Majora*, ad annum 1235 (iii. 324). The emperor reported all this to Henry III, by the Bishop of Exeter and J. de Sancto Egidio, O.P. The prophecy was correct, but the boy died in infancy.

may die (p. 343); while if he hesitates, and seems likely to call in some other practitioner, the prudent surgeon may point out that the celestial aspects are just now at their very best, or, similarly, postpone operation till he has assurance of payment, if he is doubtful of getting it afterwards (p. 350). How far Bacon's practical mind would have led him in the same direction in similar circumstances we can only conjecture, but we are still far from the time when these theories were carried to greater lengths, when, in the full blaze of the Renaissance, the most learned of the reformers, Melanchthon, published a new edition of Ptolemy's *Tetrabiblos et centilogium*, and when decrees of town councils forbade men to be bled or shaved on days marked 'dangerous' in astrological almanacs.

The higher criticism has played havoc among mediaeval alchemists. The mysterious Geber, *magister magistrorum*, as Bacon called him, has almost vanished, most treatises on alchemy attributed to Albertus Magnus, Raimon Lull, and Arnald of Villanova are declared spurious, and the last great figure, the 'pious Spagyrist', Basil Valentine, is pronounced to be the shadow of an imposing name made to cover comparatively modern productions. There is little doubt, however, that the best influence of the Arabic writers on medicine was the importance they attributed to alchemy for the discovery of new drugs, and the proper synthesis and 'fermentation' of compound remedies. Leo Africanus, at a later period, describes a chemical society at Fez as 'a most stupid set of men (*stupidissimi homines*) who contaminate themselves with sulphur and other horrible stinks. They are wont to meet in the evening at the principal mosque, and there dispute over their vain imaginations'.[1] Doubtless there were similar associations in the golden age of 'Saracenic studies', and many 'Arabists' of the thirteenth century were eager to continue their labours.

[1] *Descriptio totius Africae*, lib. 3. s.v. 'Alchymistae.'

Of the two great medical schools which replaced Salerno, Padua represented Aristotelianism and astrology in Peter of Abano, while Montpellier claimed as pupil the chief exponent of the alchemy of the period, Arnald of Villanova. It is interesting to compare Bacon with Arnald. Both believe in the possibility of transmuting metals, and Arnald is alleged by a contemporary to have made gold.[1] But a science which teaches (as Bacon says) how to resolve *quodlibet ex quolibet*, and to analyse the *mundus inferior* into its elements, may accomplish greater things than this. Curiously enough, the older man seems ignorant of Arnald's favourite alcohol, the *aqua vini* or *vitae* of the Arabs, to which he attributes wonderful powers of extracting the active principles of drugs and of restoring youth to the aged, matters which attracted Bacon's special attention. Yet, of the two, Bacon seems to have greater faith in drugs as distinguished from the dietetics and hygiene of the old Salernitans. At present, he says, there are men and nations with few or no drugs or doctors, who are stronger, bolder, more beautiful, and longer lived than those who have them; when, however, medicines discovered or improved by alchemy have been combined by aid of that science and mathematics into proper compounds, and are administered by physicians who, being perfect astronomers, know the right times and influences, this state of things will naturally and necessarily be reversed (*De erroribus*).

Bacon's Medical Treatises

Two prominent peculiarities may be noticed in Roger Bacon's medical treatises: first, they are the production of a man of singularly practical mind who was not in practice, and had, as he complains, few opportunities of getting 'certitude by experience' as to the matters of which he

[1] J. Andreas in Durandus, 'Speculum Juris,' cap. '*De Crimine falsi.*'

speaks; secondly, the writer, though by nature a rebel against authority, '*nullius addictus jurare in verba magistri*,' nevertheless accepts without question a theory of medicine eminently based on authority, the system of Galen, as further formularized and stereotyped by Avicenna and the Arabs.

Bacon's energetic and sanguine temperament, unsobered by the experiences of the general practitioner, is shown by his confidence in the power of drugs, known or discoverable. He proclaims, as did Francis Bacon after him, the vast potentialities of natural things, and the mastery which he believes may be obtained over them by methodic and diligent investigation. The contemporary medicine, indeed, abounds in errors: there are 'thirty-six great and radical defects with infinite ramifications' in one department alone. We expect a root and branch demolition in Paracelsic style, but, after describing seven of these defects, he passes over the other twenty-nine with an almost ludicrously pathetic *non sufficio*, an utterance which has more than its immediate implication. Roger did not think himself 'sufficient'—as did Paracelsus and Van Helmont—'to overthrow the entire philosophy of the ancients and establish a new science of nature.' On the contrary, he believes that these ancients, the *antiqui*, had a sort of primitive medical revelation, which, after passing through Chaldeans and Greeks, still shines in the writings of the Arabs, though dimmed by the errors and defects of the *Latini rustici*. To expose these errors, to reveal with caution certain *secreta* of the ancients, thus adding something to the tradition of the wise as represented by Rhazes, Avicenna, and the Halys, and to show that the path of progress lies through the study of astrology, alchemy, and *scientia experimentalis* are the ends of his ambition.

Gilbert the Englishman, Roger's contemporary, declared that were it not for the singularity of the thing, he would rather follow Hippocrates than the Arabs, and wrote

an *Expositio* of the Aphorisms. But Bacon is an Arabist on principle, the principle being that capable men who follow the path above mentioned are bound to make progress. Even in the case of Aristotle, greatest of the Greeks, it was only in his old age, when he began to pay serious attention to astrology and alchemy, that he could produce the *Secretum Secretorum*, the most valuable of his works in Bacon's opinion.

The Arabs had made further progress in the same direction. Rhazes, as Bacon probably knew, was called 'the Experimentator'; Avicenna, as he points out, had, 'through the experience of alchemy,' corrected Galen's erroneous opinions concerning the humours and other matters, while Haly of the 'Super Tegni' had been a greater astrologer than either Galen or Hippocrates, and even earned his living by the art, good evidence of its practical value.

Bacon's familiarity with the Greek medical authors appears slight. He knows the Aphorisms of Hippocrates, but pays less attention to them than to those of Damascenus, and his acquaintance with the bulk of the *Corpus Hippocraticum* seems indirect. Thus, its most famous saying (next to 'Life is short but the Art long'), 'Do good, or at least do no harm', is quoted '*testante Haly super Tegni*', and he follows Avicenna in attributing to Hippocrates a remark on the evils of purgation which occurs in Galen's commentary.[1] The references to Galen are scanty and often indirect '*testante Isaac*', '*testante Avicenna*', while some of those he appears to quote at first hand are from spurious mediaeval treatises, the *dynamidiae* and *secreta*. For example, Galen tells four interesting stories of the cure of 'leprosy' which were condensed into one by Arabic and mediaeval writers.[2] Roger might have read this version in

[1] He also quotes it in an incorrect form derived from the Arabic or old Latin version. This is given in Burton's *Anatomy of Melancholy*, ii. 4. 1. A reference to the original, *In Hipp. Vict. Acut.*, ii. 12 (Kühn's *Galen*, xv. 540), will show how the mistranslation arose.

[2] *De Simp. Med.*, xi. 1.

his youth in William of Canterbury's account of the miracles of St. Thomas,[1] but he gives it '*testante Isaac*'. Similarly two-thirds of the references to Aristotle are to the *Secretum*, while Dioscorides is quoted twice '*testante Haly super Tegni*'.

A striking instance of this ignoring or ignorance of the classical writers, as compared with the Arabs, is seen in the story of the poisonous Persian tree, which though told by Dioscorides, Pliny (who declares it false), Galen (three times), Plutarch, Columella, and the pseudo-Aristotle (*De Plantis*) is quoted by Bacon '*testante Avicenna*'.

Passing to Arabic writers we find a great contrast. He knows them well and quotes them (as a rule) honestly and accurately, more so than did many contemporary physicians and surgeons who use *Avicenna* and *Albucasis* much more frequently than they name them.

First, in what may be called density of quotation, come two of the great little books of mediaeval medicine, the *Aphorisms* of Damascenus and the *Commentary* of Haly ben Rodwân.[2] John of Damascus is doubtfully identified with the elder Serapion, and certainly belonged to one of those ninth-century Syrian medical families who translated Greek works into Syriac or Arabic. The 160 short aphorisms, afterwards printed as a preface to Serapion's *Practica*, were probably learnt by heart by most mediaeval medical students, and are largely quoted by all professional writers of the age. They are dedicated to the writer's 'son', who is translating Galen's *Megategni* (the *De Methodo medendi*), 'I return thanks to God that I have found thee such a translator.'

[1] 'Nunquam, inquit Galenus, vidi in vita mea hominem a lepra plenarie sanatum nisi qui vinum biberit ubi tyria inciderit, et ibidem computruerit. Hunc enim vidi excorticari et cute expoliari cum vinum illum biberit.' This is clearer, but not more correct than Bacon's version.

[2] The other two were the *Isagoge* of Joannitius, and the *Nonus Almansoris* of Rhazes.

We know more about the commentator on the *Microtegni*. Haly ben Rodwân (about 980–1060), the son of a poor Egyptian baker, earned a living at first by astrology, which indicated correctly that he would become a famous physician, but failed to warn him of the imprudence of adopting a young girl left orphan by a plague, who, on reaching years of discretion, collected all his portable property, amounting to 20,000 dinars or ducats, and disappeared, doubtless with some local Lorenzo, thus reducing the aged physician to his primitive poverty.[1] But he was an irascible man, troubled by an excess of that *cholera* of which he speaks so much, and which, if a reference in the *Super Tegni* applies, as is probable, to himself, was shown by a ' lupinosity ' of temper which he may not have controlled so well as he says he did. His best known works are an astrological commentary on Ptolemy's *Tetrabiblos et Centilogium*, quoted elsewhere by Bacon, and the famous *Exposition* of Galen's *Ars medica*, which gave him almost a title, Haly super Tegni.

Accounts of the three greater Moslem physicians, Rhazes, Haly Abbas (Regalis, of the Royal Book), and Avicenna, may be readily found elsewhere, while of Isaac ben Solomon it need only be said that he lived a century (about 850–950), was of Solomonic temperament (except that he remained unmarried), and that his two great works on diet and fevers respectively are considered the best Arabic productions on those subjects. But half of the references to *Isaac* are from the works of his pupil, Ahmed ben al Gezzar, a highly practical man and physician to Saracen Corsairs, who wrote the *Viaticum* and the *De Gradibus* books which Constantine translated and attributed to himself.[2]

Bacon's medical writings are based upon these authorities,

[1] Leclerc, *Histoire de la médecine arabe*, i. 523. See also Brockelmann, *Geschichte der arabischen Literatur*, and *Super Tegni*, ii. 2. 13.

[2] Steinschneider, *Constantinus Africanus und seine arabischen Quellen*, in *Virchow's Archiv*, 37.

and though he sees the weak points of Avicenna, he calls him elsewhere '*dux et princeps philosophorum*' and makes him his chief guide in medical matters, quoting him as frequently as all other authors combined. But we may note that the references include the two most interesting and practical passages in that huge *methodica inanitas* (as Haller too severely calls it), the Canon, viz. the accounts of the cure of a consumptive lady by unlimited sugar-eating, and of how Galen obtained sleep in his old age.[1]

The bulk of the treatises deal with the retardation of old age and the conservation of youth, and Bacon's usual honesty of quotation helps us to conclude both that they form the most complete compilation on the subject then known, and that they are essentially a compilation, in spite of the author's reiterated claim to originality, or, rather, to be the revealer of 'secrets' long forgotten or concealed. These secrets, with one exception, are well-known substances often named openly by Roger's predecessors, viz. gold, pearls, ambergris, viper's flesh, bone of stag's heart, rosemary and lign-aloes. The exception is the *minera nobilis animalis* or *fumus juventutis*, terms referring to the contagiousness of health by the close application of the body of a healthy adolescent, preferably with crisp yellow hair (the Galenic mark of a good temperament) to the sick or aged. Though this forms his most novel contribution to the medicine of the age, he is unusually anxious to disclaim

[1] Roger's frequent repetitions and occasional unacknowledgements interfere with the accuracy of quotation statistics, but, roughly speaking, Avicenna (who includes *Aboaly* and *filius principis*) may claim 100 references; 'Aristotle' 36 (but 25 of them to the *Secretum*); Rhazes and the two Halys have about 15 each; Isaac and Ahmed 12 between them, and J. Damascenus 9. No other writer comes up to the last of these 'Arabs'. Practically the whole chapter *De regimine senum*, by Haly Abbas (II. i. 24), is quoted by Roger in his treatises on the subject, usually with, but sometimes without acknowledgement, and the same may be said of the corresponding section of the other Haly's *Super Tegni* (iii. 123).

originality, bringing in Solomon (apparently Eccles. iv. 11), as well as Damascenus and Galen, to his support. But, as he admits, they mention the subject obscurely, and the next plain and emphatic reference to the restorative value of balsamic exhalations *a sano et athletico corpore* seems to be that by our English Hippocrates, Sydenham, whose language closely resembles Bacon's, except that he fears ridicule rather than scandal (*Obs. Med.*, i. 4. 40).

We may briefly notice the relation of the *Epistola* and its companion treatises to the current theory of old age, and to two later works on the same subject, the authors of which probably knew some of them, and held opposite opinions as to their value.

According to the humoral physiology, the fiery and watery elements of the body, innate heat and radical moisture, are relatively greatest at birth, and after full growth begin to diminish, while the cold and dry earthy constituent increases.[1] This is the natural cause of old age and death. But the Greeks, from Heraclitus and Hippocrates downwards, laid stress on heat as the principle of life. 'According to Hippocrates (says his editor, Littré), the human body is pervaded by a heat which he calls innate (ἔμφυτον). Its amount is at the maximum in infancy, and continually exhausts itself by the processes of life till it arrives at a minimum in old age. This change, corresponding to the yearly variation of the sun's heat, gave rise to an analogy of ages and diseases with the seasons.'[2] Galen, with unusual brevity, defines death as the extinction (σβέσις) and old age as the wasting (μαρασμός) of the innate heat (*De Temp.*, ii. 2). The Galenic, or pseudo-Galenic *History of Philosophy* concludes with the statements that 'the Stoics and all physicians declare with one voice that old age is due to a decrease of the innate heat', and

[1] See especially Galen's commentary on the 14th Aphorism, quoted by Roger (Kühn, 17 b, 405).

[2] *Œuvres d'Hippocrate*, i. 443.

'Asclepiades pointed out that the natives of Britain whose bodies are made dense by their climate, retain their innate heat for an immense period, and only grow old at 120 years'.[1] Finally, the pseudo-Aristotle, as Bacon points out, urges Alexander by all means to keep up his caloric.

Arabic writers, influenced, perhaps, by their climate and neighbouring deserts, accentuate the other factor, moisture. Rhazes puts it clearly and succinctly, '*Homo a nativitate usque ad senium desiccari non cessat, donec nihil fiat. Senium namque non est aliud nisi magnum in corpore siccitatis dominium.*'[2] This exaggerates Galen's statement, while the heat element is comparatively ignored. Both factors, and their combination in the burning lamp metaphor, were, of course, generally recognized, but the reader may notice the dominance of one or the other according as Bacon is quoting from Greek or Arabic sources.

Within twenty years of Roger's death, Arnald of Villanova dedicated to Robert the Wise of Naples and Jerusalem his *De Conservatione juventutis et Retardatione senectutis*, the best known mediaeval treatise on the subject. Any one who reads this after the Baconian treatises will be struck by its close resemblance in matter and style to the one entitled *De juvene a senectute tardando, et sene ad juventutem reducendo Liber*. Whole passages are verbally alike. Some of these are quotations from the Latin versions of Arabic writers, but the similarity in transitions, and the introduction of extraneous subjects such as the use of white hellebore for wounds (Roger says it is his own experience, Arnald has '*Est homo qui vidit*'), seem to prove that Arnald saw and used his predecessor's work.

The peculiarities of the later treatise are the hints or 'tips' characteristic of the man 'in practice', and the first clear and emphatic notice of distilled spirits of wine. Thus, Arnald says that the Rosemary elixir, highly praised by

[1] Kühn's *Galen*, 19. 344. [2] Almansoris, 2. 15.

Roger, is greatly improved if taken '*in aqua vini cum scientia et sapientia facta*', which he afterwards explains is *aqua vini distillata*, while the clyster *de succo foliorum* (praised by Bacon) is more effective with the addition of half an ounce of hiera-picra: '*quod est secretum magnum.*' Black hellebore, doubtless, 'changes a bad "complexion" into a good one,' as Avicenna (and Bacon) says, but is too violent a drug for '*corporibus delicatis et nobilis complexionis*', and the advantages of potable gold may cheaply and conveniently be got by 'extinguishing' hot gold coins in your wine. But Arnald's potable gold was brandy. '*Ex vino fit aqua vitae, multum diversa a vino in colore, substantia et operatione.*' This is a '*res magna, faciens operationes super omnem estimationem*'. It is particularly good for the old, since it opposes putrefaction '*propter ejus sinceritatem et puritatem*'. On account of its 'simplicity', it readily extracts the flavours and virtues of other drugs, '*faciens eis acquirere in eorum operationibus additamentum.*' Its only defect is that it is a little over 'temper' as regards heat, and it should therefore be taken in small doses and with other things.[1]

If the *Epistola de sanguine humano* be genuine, Arnald had equal faith in Bacon's '*lapis nobilis animalis*', the '*lapis qui non est lapis, et est in quolibet homine et in quolibet loco hominis*'. His elixirs of life, in short, were blood and brandy.

Francis Bacon declared that part of medicine which relates to the prolongation of life to be the most noble of all,[2] and wrote a special treatise on the subject, *History Natural and Experimental of Life and Death, or of the Prolongation of Life.* That he had seen Roger's *Epistola* (printed at Oxford, 1590)

[1] He says his immediate predecessors knew more about the *aqua vini* than they chose to tell, concealing it under the name *aurum.* As he quotes Roger's whole account of potable gold (except the directions), and applies it to his own spiced brandy, he perhaps had Bacon specially in mind.

[2] *De Augmentis scientiarum*, iv. 2.

is highly probable, and by no means contra-indicated by his sweeping condemnation of all writers on the subject since Aristotle as having 'handled it so idly and superstitiously, that by reason of their vanity the argument itself has come to be reputed vain and senseless. For they tell us that death consists in the destitution of warmth and moisture; and therefore that the natural warmth should be comforted, and the radical moisture cherished. Just as if this could be done by broths, or lettuces, or mallows, or starch, or jujubes, or spices, or generous wine, or even spirits of wine and chemical oils; all of which are rather injurious than beneficial'. His own theory is that old age and death are due to 'two depredations', that of the native spirit and that of the surrounding air, 'the spirits like a gentle flame continually preying upon our bodies, conspiring with the outward air.' But 'both those things which vulgar physicians talk of, Radical Moisture and Natural Heat, are but mere Fictions'.[1] All this evidently applies to Roger and Arnald, though he mentions neither, and the following may be particularly directed at the former. 'When I hear discourses touching medicines made of Gold, because Gold is not subject to corruption, and that a certain man when he had found an ointment hidden under the ground, and had anointed himself therewith from head to foot (excepting only the soles of his feet), did by his anointing live three hundred years without any disease save only some tumours on the soles of his feet—(a story Roger tells at least twice)—and such-like fabulous and superstitious vanities, I wonder exceedingly that men should so much dote as to suffer themselves to be deluded with these things.'[2]

But, in spite of his contemptuous references to 'the unprofitable rabble of cordials', and to 'the credulity of thinking that the course of Nature can be delayed or turned back by a morning draught, or the use of some precious

[1] *History*, Preface. [2] *History*, 'The Intentions.'

drug, by potable gold, or essence of pearls, or such like toys', the chancellor has almost as great faith as the friar in certain substances.[1] His favourite was nitre, 'which cools and condenses the spirits making them less eager. . . . Therefore, as strong wines and spices do burn the spirits and shorten life, nitre doth compose and refresh them and is of prime force to long life.'[2] He took a morning draught containing three grains of it every day for thirty years.[3] He values saffron even more highly than does Roger: 'Our ancestors, who were longer lived than we, did use saffron much in their cakes, broths and the like. The Irish, especially the wild Irish, even at this day live very long . . . and use to wear saffroned linen and shirts, which, though it were at first devised to prevent vermin, yet howsoever I take to be very useful for the lengthening of life.'[4]

It is strange that none of these writers mentions what seems to us the most important premature 'accident' of age, and one which the progress of science has done most to remedy, partly by aid of gold—dental deficiency.

Roger's scientific genius is less prominent in the treatises on old age than in the fragment *De Graduacione medicinarum*. According to Gomperz,[5] we are first confronted by the conception of an exact science in the Hippocratic writings, where the author of the *De Prisca medicina* says, 'One must aim at a standard, but a standard, weight or number, which shall serve thee as a sure guide thou shalt not find, seeing there is no other than the sensibility of the body.'[6] Later writers, e.g. Plato in the *Philebus*,[7] accentuate the same point. Galen makes an attempt to get a fixed starting-point for measuring the hot-cold, moist-dry. Mix, he says, equal volumes of boiling water and ice, also equal volumes

[1] *De Augmentis*, iv. 2.
[2] *History*, ii. 1.
[3] Rawley's *Life*, end.
[4] *History*, ii. 2.
[5] *Greek Thinkers*, i. 299.
[6] Littré, i. 588.
[7] Arithmetic, mensuration, and weighing being taken from any art, the rest will be only conjecture; p. 55 E.

of dry earth and water, and you get the exact 'means' between these respective qualities.[1] Fix them in your memory by feeling them (he thinks they represent the exact normal temperature and consistency of the palm of the human hand), and it will not be difficult to use them as 'canons and criteria' for the degrees of deviation. This is a very imperfect escape from conjecture and bodily sensation, and Bacon, returning to the Hippocratic ideal, points out the necessity both for a *certus terminus* and an exact uniform scale. With better opportunity and material he might have gone further, but the world had to wait three centuries for Galileo's thermometer.

Perhaps the most interesting, original, and typically Baconian of the treatises is the *De Erroribus*.[2] There is, of course, nothing original in finding fault with physicians, but Roger, as we have seen, does it in an unusually moderate fashion, and adds much valuable advice culminating in his most characteristic aphorism that, of the three ways in which men think they acquire a knowledge of things, authority, reasoning, and experience, only the last is effective and able to bring final peace to the intellect; a startling utterance for that age, and well calculated to disturb the minds of his brethren. It is expressed more briefly in a phrase of Hobbes, which, according to a modern writer,[3] 'ought to be inscribed in golden letters over the head of every talking philosopher—*No discourse whatsoever can end*

[1] *De Temp.*, i. 9.

[2] *De Erroribus Medicorum.* He begins to describe 36 'defects' as regards drugs, but after the seventh passes to 'external defects', lack of proper books—translations of *Aristotle* criticized—waste of time in verbal disputes to the neglect of astrology, alchemy, and *agricultura philosophica.* Much of this is repeated under the heading 'Causes of their defects'. The treatise concludes with an emphasis of 'experience', and has an appendix of notes on drugs, prescriptions for cordials, and methods of extracting the 'virtue' of rhubarb, and their essential oils from herbs.

[3] Santayana, *The Life of Reason*, iii. 198.

in absolute knowledge of fact. Absolute knowledge of fact is immediate; it is experiential.' So understood, it seems a valuable, time-saving truth, in no way opposed to religious faith; but if Bacon went about trying to fix this novel halo over the heads of the talking theologians of his time, as, judging from his combative temper and love of repetition, he probably did, we can understand, and perhaps even sympathize with, some of the motives for his temporary seclusion.

The fragment of an *Antidotarius* compares favourably in clearness and directness of language with the corresponding work of Arabic and other mediaeval writers, and it is, perhaps, in these *disjecta membra* rather than in the *Epistle* that we find sufficient evidence of greatness to justify the conclusion *gigantis.*

XIV

ROGER BACON IN ENGLISH LITERATURE

By Sir JOHN EDWIN SANDYS

In English literature the reputation of Roger Bacon has rested mainly on his magical powers and his imaginary mechanical inventions. In the *Palice of Honour*, written early in the sixteenth century by the Scottish poet Gavin Douglas, he is named as one of three noted necromancers :

> The nigromancie thair saw I eik anone
> Of Benytas, Bongo, and Frier Bacone,
> With mony subtill point of juglary.[1]

Before the end of the century only three of the works ascribed to Roger Bacon had been printed : (1) the *Speculum Alchemiae*, of uncertain authorship, printed at Nürnberg in 1541, and translated into English in 1597 ;[2] (2) the treatise *De mirabili potestate artis et naturae*, Paris, 1542 ; Oxford, 1594, also translated in the same volume as the *Speculum* above mentioned ;[3] and (3) the *Libellus de retardandis senectutis accidentibus*, Oxford, 1590.[4] Towards the close of the century some of the legendary traditions respecting Roger Bacon's inventions were collected in a popular work published in London, of which more anon. Conspicuous among the inventions there mentioned was his wonderful ' Perspective Glass ' and his ' Brazen Head '. For the latter there is no authority in any of his extant works. But magical inventions of this kind had already

[1] Vol. i, p. 65, ed. Small, 1874.

[2] Cf. A. G. Little, *Appendix de Operibus Rogeri Bacon*, in Franciscan Studies, iii. (1911) 104. [3] Ibid., 91. [4] Ibid., 93.

been ascribed to other persons of intellectual eminence. Thus among the legends associated with the name of Virgil, mention is made of 'a mirror in which one could see everything that happened at a distance';[1] and in the *Image du Monde* the poet is said to have constructed a 'talking head', which he, from time to time, consulted as to future events.[2] The same story is told of Gerbert of Aurillac, who, in 999, was raised to the papacy as Silvester II, while in the thirteenth century Albertus Magnus is said to have made a 'talking head', which was destroyed by his distinguished pupil, Thomas Aquinas.[3] Roger Bacon's eminent friend, Robert Grosseteste, bishop of Lincoln, is described by Gower in the *Confessio Amantis* (1393) as having constructed a brazen head that could speak:

> For of the grete Clerc Grossteste
> I rede how besy that he was
> Upon clergie a Hed of bras
> To forge, and make it forto telle
> Of suche thinges as befelle.[4]

Similar inventions were ascribed to Roger Bacon in 'The famous historie of Fryer Bacon, containing the wonderful things that he did in his life, also the manner of his death, with the lives and deaths of the two conjurers, Bungye and Vandermast'. One of the earliest of the many editions was that 'printed at London for Francis Grove by E. A.', that is Elizabeth Alde, late in the sixteenth century,[5] or more probably early in the seventeenth. It was also printed in 1627 (for Francis Grove) and in 1630.

[1] Comparetti, *Virgilio nel medio evo*, ii. 74, ed. 1872 (p. 303, E.T.).

[2] Ibid., 80 (p. 307, E.T.); *L'Image du Monde de Maître Gossouin*, p. 185, ed. O. H. Prior, Lausanne, 1913.

[3] Ibid., p. 80, n. 4.

[4] Liber iv, 234 f., ed. G. C. Macaulay, 1900.

[5] W. J. Thoms, *Early English Prose Romances*, ed. 1858, i. 179–250. An edition of Greene's play on Friar Bacon was printed for Elizabeth Alde in 1630, with the Brazen Head forming part of a scene represented on the title-page.

It is here stated that Roger was 'borne in the west part of England, and was sonne to a wealthy farmer, who put him to schoole to the parson of the town where hee was borne. . . . Young Bacon tooke his learning so fast, that the priest could not teach him any more, which made him desire his master that he would speake to his father to put him to Oxford'. The father refused, whereupon 'young Bacon . . . gave his father the slip, and went to a cloyster some twenty miles off, where he was entertained, and so continued his learning, and in small time came to be so famous, that he was sent for to the University of Oxford, where he long time studied, and grew so excellent in the secrets of art and nature, that not England onely, but all Christendome admired him.' . . .

The king, being at a nobleman's house in Oxfordshire, on hearing of Friar Bacon's fame, sent for him. Bacon modestly said to the king, that 'fame had belide him, and given him that report that his poor studies had never deserved'. Asked to show the king and queen 'some of his skill',

'he waved his wand, and presently was heard such excellent musicke that they were all amazed'. . . . 'Waving his wand againe, there was lowder musicke heard, and presently five dancers entered. . . . These did divers excellent changes . . ., and having done their dances, they all vanished away. . . . Then waved he his wand againe, and there was another kind of musicke heard, and whilst it was playing, there was sodainly before them a table richly covered with all sorts of delicates. . . . Then waved he his wand againe, and sodainly there was such a smell, as if all the rich perfumes of the whole world had bin there prepared in the best manner that art could set them out. . . . He waved his wand againe, and there came divers nations in sundry habits . . ., all bringing sundry kinds of furres.' . . .

'Fryer Bacon reading one day of the many conquests of England, bethought himselfe how he might keepe it hereafter from the like conquests, and so make himselfe famous hereafter to all posterities. This (after great study) hee found could be no way so well done as one; which was

to make a head of brasse, and if he could make this head to speake (and heare it when it speakes) then might hee be able to wall all England about with brasse. To this purpose hee got one Fryer Bungey to assist him, who was a great scholler and a magician (but not to bee compared to Fryer Bacon); these two with great study and paines so framed a head of brasse, that in the inward parts thereof there was all things like as in a naturall mans head.' . . .

They 'went one evening to a wood thereby', where, in answer to their 'words of conjuration', the devil appeared and told them that 'with the continual flame of the six hotest simples it would have motion, and in one month space speak.' . . . After watching for three weeks himself, with Fryer Bungey, he set his man Miles to watch the head. At last, 'after some noyse the head spake these two words, TIME IS'; and again, after an interval, 'TIME WAS; and again, TIME IS PAST; and therewith fell downe, and presently followed a terrible noyse, with strange flashes of fire, so that Miles was half dead with feare; at this noyse the two Fryers awaked. . . . Out on thee villaine (said Fryer Bacon) thou hast undone us both, hadst thou but called us when it did speake, all England had been walled round about with brasse, to its glory, and our eternal fames.' . . .

'In those times, when Fryer Bacon did all his strange trickes, the Kings of England had a great part of France. . . . The King of England . . . did beseige a strong towne and lay before it full three months', and offered a reward to any one that would 'deliver this towne into his hand'. . . .

'Fryer Bacon hearing of it, went into France,' and informed the king 'that art oftentimes doth those things that are impossible to armes' . . . 'I will speak onely of things performed by art and nature, wherein shall be nothing magical: and first, by the figuration of art, there may be made instruments of navigation without men to rowe in them, as great ships to brooke the sea, only with one man to steere them, and they shall sayle far more swiftly than if they were full of men: also chariots that shall move with an unspeakable force, without any living creature to

stirre them. Likewise, an instrument may be made to fly withall, if one sit in the midst of the instrument, and doe turne an engine, by which the wings being artificially composed, may beat the ayre after the manner of a flying bird.' [1] . . .

'But physicall figurations are farre more strange: for by that may be framed perspects and looking-glasses, that one thing shall appeare to be many, as one man shall appeare to be a whole army, and one sunne or moone shall seem divers. Also perspects may be so framed, that things farre off shall seem most nigh unto us: with one of these did Iulius Caesar from the sea coasts in France marke and observe the situation of the castles in England.' [2] . . .

'It appertaineth to a higher power of figuration, that beams should be brought and assembled by divers flexions and reflexions in any distance that we will, to burne any thing that is opposite unto it, as is witnessed by those perspects or glasses that burne before and behinde; but the greatest and the chiefest of all figurations and things figured, is to describe the heavenly bodies, according to their length and breadth in a corporall figure, wherein they may corporally move with a daily motion. These things are worth a kingdom to a wise man.' [3] . . .

In two days the king's 'pioniers' had raised a mound 'rather higher than the wall'. . . . 'In the morning Fryer Bacon went up to the mound and set his glasses, and other instruments up . . . Ere nine of the clocke he had burnt the state-house of the towne, with other houses, only by his mathematicall glasses.' . . .

We also learn 'how Fryer Bacon overcame the German conjurer Vandermast, and made a spirit of his owne carry him into Germany'; . . . and also 'how two young Gentlemen that came to Fryer Bacon, to know how their fathers

[1] This is taken from the English translation of cap. iv of *De mirabili potestate artis et naturae*, p. 533 of *Opera Inedita*, ed. Brewer; and similarly in the case of the next two passages.

[2] Ibid., cap. v, p. 534.

[3] Ibid., p. 535. In the *Opus Tertium*, p. 18, ed. Little (1912), he speaks briefly of burning-glasses, flying machines, sailing machines, and scythed chariots moving without animals to draw them.

did, killed one another; and how Fryer Bacon for griefe did breake his rare Glasse, wherein he could see any thing that was done within fifty miles about him'; and, lastly, 'how Fryer Bacon burnt his books of Magick, and gave himselfe to the study of Divinity only.'

'And that all the world should know how truly he did repent his wicked life, he caused to be made a great fire; and sending for many of his friends, schollers, and others, he spake to them after this manner: My good friends and fellow students, it is not unknowne unto you, how that through my art I have attained to that credit, that few men living ever had: of the wonders that I have done, all England can speak, both king and commons; I have unlocked the secret of art and nature, and let the world see those things, that have layen hid since the death of Hermes, that rare and profound philosopher: my studies have found the secrets of the starres; the bookes that I have made of them, doe serve for presidents (*sic*) to our greatest doctors, so excellent hath my judgment beene therein. I likewise have found out the secrets of trees, plants and stones, with their several uses; yet all this knowledge of mine I esteeme so lightly, that I wish that I were ignorant, and knew nothing: for the knowledge of these things, (as I have truly found) serveth not to better a man in goodnesse, but onely to make him proud and thinke too well of himselfe. What hath all my knowledge of natures secrets gained me? Onely this, the losse of a better knowledge, the losse of divine studies, which makes the immortall part of man (his soule) blessed. I have found, that my knowledge has been a heavy burden, and has kept downe my good thoughts: but I will remove the cause, which are these bookes; which I do purpose here before you all to burne. They all intreated him to spare his bookes, because in them there were those things that after ages might receive great benefit by. He would not hearken unto them, but threw them all into the fire, and in that flame burnt the greatest learning in the world.'

Friar Bacon's 'Brazen Head' is repeatedly mentioned by the Elizabethan dramatists. In Ben Jonson's *Every Man in his Humour* (1598), Cob says: 'Oh, an' my house were the Brazen-head now! faith it would e'en speak *Moe*

fools yet' (Act II, Sc. iii); and in Robert Greene's *Tu Quoque* (printed 1614) we find: 'Look to yourself, sir; the brazen head has spoke, and I must leave you.' Far more important than these passing allusions is Robert Greene's *Honourable History of Frier Bacon and Frier Bongay*, first printed in 1594, but performed as early as February 1592 and probably earlier.

It has been assumed by the learned editor of this play[1] that 'the story of Friar Bacon and Friar Bungay was taken by Greene from a popular story-book', namely the 'Famous Historie' already quoted.[2] An examination of the printed text of this 'Historie' proves, however, that parts of it are taken, word for word, from chapters iv and v of the translation of Roger Bacon's treatise 'on the marvellous power of nature and art'. This translation was not printed until 1597, five years after the death of Greene in 1592, and more than that time after the first recorded performance of the play. Hence, in accepting the 'Historie' as the source of the play, we must assume that the translation had already been in existence in a manuscript form, and that the manuscript of the 'Historie', partly derived therefrom, was accessible to the author of the play at least five years before the translation was printed. The ultimate printing of the 'Historie' may have been prompted by the interest excited by the play. Both were printed by the same person, Elizabeth Alde.

In the first scene of this play the king's fool says: 'Weel ride to *Oxford* to Frier *Bacon*; oh, he is a brave scholar, sirra; they say he is a brave nigromancer' (i. 96).[3]

[1] A. W. Ward, *Old English Drama, Select Plays*, in 'Clarendon Press Series', 1878, Introduction to Greene's *Friar Bacon and Friar Bungay*, pp. xcvi ff.

[2] p. 360, *supra*.

[3] I have mainly followed Churton Collins's edition (Oxford, 1905); but I have added the references to the scenes and lines of the 'Clarendon Press Series', ed. A. W. Ward.

The second scene is 'Friar Bacon's cell at Brasenose', where the Friar asks the Oxford doctors:

> Why flocke you thus to *Bacons* secret Cell,
> A frier newly stalde in *Brazennose*?

One of the doctors replies:

> *Bacon*, we hear, that long we have suspect,
> That thou art read in Magicks mysterie;
> In Piromancie to divine by flames;
> To tell by Hadromaticke,[1] ebbs and tides;
> By Aeromancie to discover doubts,
> To plaine out questions, as *Apollo* did (ii. 10–18). . . .
> I tell thee, *Bacon*, *Oxford* makes report,
> Nay, *England* and the court of *Henrie* saies,
> Thart making of a brazen head by art,
> Which shall unfold strange doubts and Aphorismes,
> And read a lecture on Philosophie;
> And, by the helpe of divels and ghastly fiends,
> Thou meanst, ere many yeares or daies be past,
> To compasse *England* with a wall of brasse (23–30).

Bacon admits that he had 'contrivd and framde a head of brasse' (55), and speaks as follows of Friar Burden:

> As the colledge called Brazennose
> Is under him, and he the Maister there,[2]
> So surely shall this head of brasse be framde,
> And yeeld forth strange and uncouth Aphorismes (172–5).

In the fourth scene King Henry III, at Hampton House, says to the German sorcerer Vandermast:

> In *Oxford* shalt thou find a iollie frier,
> Cald Frier *Bacon*, *Englands* only flower (iv. 59 f.).

In the rest of this play the scene is laid sometimes at Oxford, sometimes in Suffolk, but the difference is immaterial, for Friar Bacon's 'glass prospective' enables him to show at Oxford 'what 's done this day in merry Fressingfield' (vi. 111).

[1] Hydromancy, Ward.

[2] Friar Burden is, by an anachronism, described as 'Master' (instead of Principal) of Brasenose, which was not founded until 1509.

In the ninth scene King Henry is thus addressed by the Emperor :

> Trust me, Plantaget, those *Oxford* schooles
> Are richly seated neare the river-side : . . .
> The towne gorgeous with high-built colledges,
> And schollers seemely in their grave attire,
> Learnèd in searching principles of art.—
> What is thy iudgment, *Jaquis Vandermast* ?

Vandermast replies :

> That lordly are the buildings of the towne,
> Spatious the romes and full of pleasant walkes ;
> But for the doctors, how that they be learnèd,
> It may be meanly, for aught I can heere.

Whereupon Friar Bungay retorts :

> I tell thee, Germane, *Hapsburg* holds none such,
> None red so deepe as *Oxenford* containes (ix. 1–14).

Vandermast and Bungay have a contest in conjuring, in which Vandermast is victorious, when Bacon comes on the scene, and is thus addressed by Vandermast :

> Lordly thou lookest, as if that thou wert learned ;
> Thy countenance, as if science held her seate
> Betweene the circled arches of thy browes (123–5).

Vandermast, in turn, is vanquished by Bacon, who is thus congratulated by the king :

> *Bacon*, thou hast honoured *England* with thy skill,
> And made faire *Oxford* famous by thine art (168 f.).

The king dines with Bacon, who promises His Majesty and the Emperor a right royal entertainment, with delicate viands from distant Egypt and Candy and Persia and Spain and Judaea (255–76).

In the eleventh scene Friar Bacon is discovered lying on a bed, with a white wand in one hand and a magic book in the other. The scene also discloses the Brazen Head and Bacon's servant, Miles. Bacon, in the course of his

speech, refers to his 'nigromanticke charmes' (xi. 17), and to the 'monstrous head of brasse',

> That, by the inchaunting forces of the Devil,
> Shall tell out strange and uncoth Aphorismes,
> And girt faire *England* with a wall of brasse (20 f.).

In the hearing of the servant Miles, three times, after three long pauses, the Brazen Head makes a great noise, and, after each noise, utters the words TIME IS, TIME WAS, TIME IS PAST. 'A lightning flasheth forth, and a hand appeares that breaketh down the Head with a hammer.' As the voice had not been heard by Bacon himself, all was in vain; and the Friar soliloquizes on TIME IS PAST:

> 'Tis past indeed. Ah, villaine! time is past:
> My life, my fame, my glorie, all are past.—
> *Bacon*,
> The turrets of thy hope are ruin'd downe,
> Thy seven yeares study lieth in the dust:
> Thy Brazen Head lies broken (xi. 96–101).

In the thirteenth scene he complains to Friar Bungay:

> Ah, *Bungay*, my Brazen Head is spoild,
> My glorie gone, my seven yeares studie lost!
> The fame of *Bacon*, bruted through the world,
> Shall end and perish with this deepe disgrace.

But Bungay reassures him:

> *Bacon* hath built foundation of his fame
> So surely on the wings of true report,
> With acting strange and uncoth miracles,
> As this cannot infringe what he deserves (xiii. 4–11).

In the same scene the 'glass prospective' enables two scholars of Oxford to see their fathers slay one another in Suffolk, and Bacon sorrowfully admits:

> This glasse prospective worketh manie woes; . . .
> End all thy magicke and thine art at once . . .
> So fade the glasse, and end with it the showes
> That Nigromancie did infuse the christall with (77–84).

He breaks the glass, and tells Bungay that he repents

> That ever *Bacon* meddled in this art.
> The houres I have spent in piromanticke spels,
> The fearfull tossing in the latest night
> Of papers full of Nigromanticke charmes (87–90).

In the fifteenth scene, laid for the last time in Friar Bacon's cell, the stage direction runs, '*Enter a Devill*' (almost the last appearance of any devil on the English stage), and the Devil explains his presence thus :

> *Bacon* hath raisd me from the darkest deepe,
> To search about the world for *Miles* his man,
> For *Miles*, and to torment his lasie bones
> For careles watching of his Brasen Head (xv. 6–9).

In the sixteenth and last scene, Bacon appears in silence at Court, at the marriage of Prince Edward to Elinor of Castile, and the king asks :

> But why stands Fryer *Bacon* here so mute ?

and Bacon confesses himself

> Repentant for the follies of my youth,
> That Magicks secret mysteries misled (xvi. 35–37).

We cannot part from this play without recalling the fact that its author, a member of St. John's College, Cambridge (incorporated at Oxford in 1588), actually anticipated the proposal to set up a statue in honour of Roger Bacon at Oxford, a proposal now happily in course of fulfilment.

In the cell at Brasenose one of the Doctors of Oxford thus addresses the Friar :

> *Bacon*, we come not greeving at thy skill,
> But ioying that our Académie yeelds
> A man supposde the woonder of the world ;
> For if thy cunning worke these myracles,
> *England* and *Europe* shall admire thy fame,
> And *Oxford* shall in characters of brasse,
> And Statues, such as were built up in *Rome*,
> Eternize Frier *Bacon* for his art (ii. 36–43).

Miles Windsore, in the Elizabethan age, connects the story of the Brazen Head with the 'brazen nose' in the face over Brasenose College gate, and reports that a likeness, either of Bacon or of the Head, was kept in the secret recesses of the Hall of Philosophy, which occupied part of the site of Brasenose.[1] In the title of the Elizabethan translation of 'the admirable force and efficacie of Art and Nature', the author is described as 'sometime fellow of Merton Colledge, and afterwards of Brasen-nose Colledge', whereas Brasenose was not founded until 1509, although Merton had been founded in 1264–74, during the lifetime of Roger Bacon.

In the seventeenth century, 'Bacon's Study', on the south side of Oxford, was reverently visited by the Danish scholar and votary of chemistry, Olaus Borrichius; and it was used as a point of observation when Oxford was besieged by the Parliamentary forces in 1644.

In *Hearne's Diary* for September 23, 1724, we read that 'the Place known now by the name of Bacon's Study (the lower Part whereof is certainly very old) was used by him chiefly for his Astronomical Studies, and here, I believe, he penn'd many of his writings that any thing related to that Subject, whilst what he did in Chymistry was carried on by him in places more private, sometimes in the Suburbs . . . in which there was also a fine Grove of trees, now a bare Meadow, and sometimes at Sunningwell, then much more retired than even at this time, abundance of woods having been destroyed thereabouts. . . . At Sunningwell they have the tradition of Fryer Bacon's studying there to this day, where (according to the same tradition) he had an Observatory, and that, too, upon the Tower of the Church. Other Scholars of Oxford had, in those times, likewise their retiring Places, in imitation of Fryer Bacon, whose Example was much followed, he being, indeed, a Prodigy of Learning,

[1] *Hearne's Diary*, cxxxii. 73 f. (A. W. Ward's Introduction to Greene's *Friar Bacon*, p. xxi).

which made him so much taken notice of by all sorts of people that he was prosecuted as a magician, tho' he writ against that practice '.[1]

The Oxford Almanack of 1780 has a view of 'Folly Bridge' and the curious gateway and chamber called 'Bacon's Study', and a drawing of the latter is preserved in the Bodleian.[2] Both of these are reproduced opposite pages 43 and 48 of the 'Book of Words' of the Oxford Pageant of 1907.

In the 'Apology concerning the Earl of Essex' (1604), the Friar's great namesake, Francis Bacon, makes a pointed reference to the Brazen Head in the advice which he offers to Queen Elizabeth:—'Madam, if you will have me to speak to you in this argument, I must speak to you as Friar Bacon's head spake, that said First, *Time is*, and then *Time was*, and *Time would never be*'.[3] At the end of the 'New Atlantis' (1627), Bacon mentions 'your monk that was the inventor of ordnance and of gunpowder'. Sir Thomas Browne, in his *History of Vulgar Errors* (1646), says that 'every ear is filled with the story of Friar Bacon, that made a Brazen Head to speak these words, *Time is*', for which story Sir Thomas devises an ingenious alchemistic explanation.[4] Butler, in the second part of *Hudibras* (1664), refers to Friar Bacon's 'noddle' of brass, and aptly couples together 'Old Hodge Bacon and Bob Grosted'.[5] Pope, in line 104 of the third book of *The Dunciad* (1728), speaks of 'Bacon trembling for his brazen head'. Johnson, in 'The Vanity of Human Wishes' (1749), referring to the tradition that Friar Bacon's Study would fall, when a man greater than Bacon passed under it, applies to 'the young

[1] *Hearne's Diary*, viii. 271, Oxford Hist. Soc., 1907.

[2] There is also an engraving in Skelton's *Oxonia Antiqua*, ii. 9 (1823), and on the title-page of *Oxoniana*, vol. i, and in Alden's *Oxford Guide*, ed. 1882, p. 108.

[3] Spedding's *Life and Letters of Bacon*, iii. 152 (A. W. Ward's Introduction, lib. cit., p. xxvi n.).

[4] Book VII, c. xvii, § 7.

[5] Cantos i and ii.

enthusiast', burning for a scholar's fame, the memorable couplet:

> O'er Bodley's dome his future labours spread,
> And Bacon's mansion trembles o'er his head.

Lastly, we find Lord Byron, in *Don Juan* (1818), using the phrase:

> Now, like Friar Bacon's brazen head, I've spoken.[1]
> *Time was, Time is, Time's past.*

The references to Roger Bacon in English literature, as set forth in this paper, show little, if any, appreciation of the value of his real discoveries. Even in the science of Optics, to which he devoted ten years of study, one of his most important discoveries has been ignored by a German of world-wide reputation. Humboldt, in his *Cosmos*,[2] has attributed to Francis Bacon, in the second book of the *Novum Organum*,[3] the discovery that light must have an appreciable velocity. But this discovery was really due to the earlier Bacon. In the *Opus Majus* of Roger Bacon we read that all the authors, including Aristotle, hold that the propagation of light is instantaneous; but the truth is that its propagation is effected in a very short but appreciable interval of time.[4] A former Master of Trinity, in the supplementary volume to his History of the Inductive Sciences, resting his opinion on the *Opus Majus* alone, describes that work as 'the Encyclopaedia and the Novum Organum of the thirteenth century'.[5] The present Master of Trinity has assured me, on the authority of his brother, Mr. Spencer Perceval Butler, that one of the eminent editors of the works of Francis Bacon, Mr. Robert Leslie Ellis, once said to Dr. Whewell: 'I have lately been reading some of Roger Bacon's writings, and I am inclined to think that he may have been even a greater man than our Francis.'

[1] Canto i, 217. [2] iii. 90, ed. 1850. [3] ii. 46.
[4] pp. 298, 300 (ii. 67, 71, Bridges); Charles, p. 295.
[5] Whewell, *On the Philosophy of Discovery* (ed. 1860), p. 65.

APPENDIX

ROGER BACON'S WORKS

WITH REFERENCES TO THE MSS. AND PRINTED EDITIONS

ANY one who has attempted to compile a bibliography of Roger Bacon will be inclined to echo Leland's saying, that 'it is easier to collect the leaves of the Sibyl than the titles of the works written by Roger Bacon'. The difficulty is partly due to Bacon's habit of re-writing his treatises 'four or five times' before he could get a satisfactory version, and to his using the same material over and over again in different connexions. The same works recur with different titles and different *incipits*, and different works with the same title; and the number of fragments and unfinished works is enormous. Many spurious writings are attributed to Bacon, and some genuine ones are hidden under other names.

The following bibliography is a revised edition of that printed in vol. iii of the British Society of Franciscan Studies (1911), which in turn was based on the account of Bacon's works given in *The Grey Friars in Oxford*, pp. 195–211 (1892). My appeal in 1911 for 'additions and corrections' has met with a ready response, and I desire to record my indebtedness to Dr. M. R. James, Mr. Robert Steele, Rev. H. M. Bannister, Rev. Father Delorme, Cardinal Gasquet, Monsieur J. A. Col, Mr. Gilson, Mr. Madan, Mr. Craster, and, above all, to the Rev. Father Michael Bihl, who generously placed at my disposal the results of his researches in Italian libraries. Further additions and corrections would still be welcome, and many points remain obscure. Perhaps some one will be moved to bring order into the chaos of

the alchemical works attributed to Bacon: and I would specially draw the attention of Aristotelians to the Amiens MS. (Nos. 1–3, 40); of mathematicians to Nos. 17, 44, 45; of philologists to the 'Summa Grammaticae' in No. 34, and to the very interesting MS. Toulouse 402 mentioned in the note to No. 33.

The discovery in the Vatican Library of what appears to be a complete copy of Bacon's *Metaphysica*, news of which reached me as these pages were in the press, raises hopes of still further finds.

A. G. LITTLE.

RISBOROUGH,
SEVENOAKS.

I. GENUINE

1*a*. Quaestiones super libros i–v Physicorum Aristotelis.

Inc. tabula: 'Incipiunt questiones naturales et primo questiones libri Phisicorum Aristotelis.' *Inc. lib.* i: 'Questiones primi Phisicorum Rogeri Bachun. Quoniam quidem intelligere, etc. Hic primo queritur utrum de corpore mobili.'

MSS.: Amiens 406, ff. 6–28 [ends imperf.] (sec. xiii ex.).

Described by Victor Cousin in *Journal des Savants*, 1848, pp. 459–72.

1*b*. Quaestiones super libros i–vi Physicorum Aristotelis.[1]

'Incipiunt questiones supra librum Phisicorum, a magistro dicto Bacuun. Quoniam intelligere et scire circa omnes scientias accidit, etc. Iste liber, cujus sub-

[1] Digby MS. 150 (sec. xiii ex.) contains two treatises ascribed in later hands to Roger Bacon. The first is the *Summa philosophiae naturalis* or *Philosophia pauperum* often attributed to Albertus Magnus, *inc.* 'Phylosophia dividitur in tres partes, videlicet in logicam ethicam et phisicam. . . .' *expl.* 'Hanc summam composuit fr. Rogerus Bagount.' The second ('scriptum Bakon super libros phisicorum') is an analysis of the eight books of the Physics of Aristotle (*inc.* 'Naturalis philosophie principales partes sunt viii'), ascribed to Bacon in two hands of the fifteenth and sixteenth centuries. The latter treatise appears to be contained in MS. Amplon. F. 297 (sec. xiv), where it is attributed to Walter Burley (*fl.* 1275–1345), but the date of the Digby MS. makes this ascription improbable if not impossible. The work seems to have been written by a religious; e.g. Digby MS. f. 100: 'Hec igitur dicta de libro phisicorum breviter sufficiant que quandoque repetendo hunc librum quibusdam nostris fratribus hec modica extraximus.'

stantivum est corpus mobile. Queritur primo utrum de naturalibus possit esse scientia.' [1]

MS. : Amiens 406, ff. 29–56, 63^{v}–74^{r} (sec. xiii ex.).

Described by V. Cousin.

2. **Quaestiones super librum de Plantis** (or **Vegetabilibus**).

'Incipiunt questiones supra librum de plantis, a magistro Rogero Baccon. Tria ut ait Empedocles in tota rerum varietate principia, etc. Supposito quod hec scientia de corpore mobili, animato, composito.'

MS. : Amiens 406, ff. 57–63 (sec. xiii ex.).

Described by V. Cousin (cf. Charles, *Roger Bacon*, p. 284).

3. **Quaestiones in Aristotelis Metaphysica.**

'Incipiunt questiones supra primum Metaphysice, a magistro Rogero Bacco. Omnes homines natura scire desiderant, etc. Dubitatur de ista scientia, primo de substantivo.'

MS. : Amiens 406, ff. 78–113^{v}, 74, 166–76 (sec. xiii ex.).

Described by V. Cousin.

Another series of questions on books i, ii, and iv of the Metaphysics is contained in the same MS., f. 176^{v} seq. : 'Hic incipiunt questiones supra primum Metaphisice Aristotelis. Omnes homines . . . Queritur hic primo utrum hec propositio.' It is not clear whether these are by Bacon.

4. **'Summa M. Rogeri Bacon de sophismatibus et distinctionibus.'**

Inc. : 'Potest queri de difficultatibus accidentibus.'

MS. : Bodl. Digby 67, ff. 117–24^{v} (sec. xiii) : fragment.

5. **'Questiones naturales mathematice astronomice, etc.,'** or **'reprobationes Rogeri Bacon.'**

MS. : Paris : Bibl. Nat. 16089, ff. 91^{v}–7^{r} (secc. xiii–xiv).

These *quaestiones* relate to rapidity of movement, circles, weights and measures, astronomy, rubrics, dominical letters, solar year. The passage expressly attributed to Bacon is that on weights and measures. *Inc.* f. 91^{v}: 'Mensura ut dicitur est quidquid ponderis capacitate, longitudine, altitudine comprehenditur;' f. 93^{v}: 'Expliciunt reprobationes Rogeri Baconis.' This is immediately followed by: 'Rogerus. Nunc iuvandum [? mirandum] est quod in diversis scientiis multa tractantur eadem;' fragments on astronomy, rubrics, dominical letters, solar year, ending on f. 97^{r} with the words: 'ut anni dividantur per 60 ut fiant hore et resultant 8 hore' (from information kindly supplied by Monsieur J. A. Col).

6. **Tractatus ad declaranda quaedam obscure dicta in libro Secreti Secretorum Aristotelis.** *Inc.* : 'Propter multa in hoc libro

[1] Cf. Worcester Cathedral MS. Q. 13, ff. 2–4^{v}, 79–116.

contenta qui liber dicitur Secretum Secretorum Aristotelis sive liber de regimine principum.'

MSS.: Oxford: Bodl. Tanner **116**, ff. 1–6^{r} (sec. xiii ex.); the same MS., ff. 13^{v}–65^{v}, contains the *Secretum Secretorum* attributed to Aristotle 'cum quibusdam declarationibus fratris Rogeri Bacon'.—Corpus Chr. Coll. **149** (sec. xv).

Cambridge: Trin. Coll. **1036** (sec. xv ex.), ff. 1–20^{v}; ff. 25–130, 'expl. liber secreti secretorum Arist. . . . qui liber intitulatur liber decem scienciarum cum quibusdam declaracionibus Fr. Rogeri Bacun de ord. minorum.'—Fitzwilliam Museum, McClean **153** (sec. xv). (These three MSS. appear to be copies of Tanner 116.)

(Cf. Bridges, i, 10 n., 258 n., 403 n., ii. 64.)

EDITION by Mr. Steele is in the press.

7. **Computus Naturalium,** a treatise on the calendar, in three parts, containing respectively 21, 20, and 8 chapters, written A.D. 1263. *Inc.* '*Omnia tempus habent*, etc., ut Salomon testatur. Igitur omnia sive sint producta.' *Expl.* 'ut simplices instructionem et sapientes pluris investigationis capiant occasionem.'

MSS. British Museum: Royal **7 F. viii**, ff. 99–163 (sec. xiii ex.).[1]

Oxford: Bodl. Selden supra **79**, f. 150 (excerpta).—Univ. College **48** (sec. xvii).

Douai **691**, § 2 (sec. xvii).

Cf. Erfurt: Amplon. **F. 394**, ff. 145–7 (sec. xiv in.): 'Liber Bachonis de compoto.' *Inc.* 'Si locatis aliquibus volueris scire in circulo': *expl.* 'latitudinem australem multam a via solis.'

Summary printed by E. Charles, *Roger Bacon*, pp. 335–8.

This is perhaps the work mentioned in the Catalogue of the Austin Friars' Library, York, No. 196, as 'tractatus Rogeri bacon de tempore' (ed. M. R. James, in the *Fasciculus Joanni Willis Clark dicatus*).

8. **De termino Paschali,** an earlier work, to which Bacon refers in the *Computus naturalium* (Charles, p. 78: 'In praecedenti opere ubi de termino Paschali inquisivimus,' *Computus*, cap. iii), does not seem to be extant.

[1] The following article in this MS., ff. 164–91, is a 'Calendar beginning with September, showing lunar conjunctions, etc., for four cycles of nineteen years, beginning 1254. The canon below is very incorrectly transcribed, but fixes the date as 1268. Among the very few saints inserted are SS. Francis, Denys and Germain' (Mr. Gilson's Catalogue). Cf. Vienna, Bibl. Palat. MS. 2510, calendar compiled 'circa 1254'.

9. **De cometis.**
Inc. 'Occasione cuiusdam comete que nuper apparuit.'
MS. Florence: Riccardi **885**, ff. 113–14.
(Cf. Bridges, i. 385.)

Cf. a passage on the comet of 1264 inserted in Royal 7 F. vii, f. 109^{v}, and re-copied in Royal 7 F. viii, f. 11, intended for insertion at the end of Part I, cap. ii, of the *De Multiplicatione Specierum*. *Inc.* 'Deinde queritur an aliquod agens': *expl.* 'spirituali et corporali' (not printed by Bridges, ii. 431).

10. **Opus Majus**: written A.D. 1266–8: 7 parts. *Inc.* 'Sapientiae perfecta consideratio consistit in duobus.'

(*A*) MSS. and editions of the whole work or of several parts:

British Museum: Cotton **Jul. D. v**, ff. 71–151^{v} (sec. xiii ex.), injured by fire, contains Parts I, II (f. 83), III (f. 91^{v}), and a large portion of Part IV (f. 108^{v}); ends 'et ideo philosophi (universaliter dampnant)', Bridges, i. 241. —Add. **35253**: a photographic copy of Vatican MS. (see below).

Oxford: Bodl. Digby **235** (secc. xv et xiv), containing *Opus Majus*, Parts I–V, *Tractatus de Multiplicatione Specierum*, *Opus Majus*, Parts VI, VII.

Winchester College **39** (sec. xv), ff. 85–180, containing *Opus Majus*, Parts I–IV, ending abruptly in the middle of the word 'Cili[ciam]', Bridges, i. 150; 'ciam' forming the catchword of the next (lost) quire.

Dublin: Trinity College **381** (sec. xvi ex.), copied from Digby MS.

Cambridge: Trinity College **1294** (sec. xvii), copied from Dublin MS.

Rome: Vatican **4086**, ff. 1–74 (sec. xiv in.), containing Parts I, II, III, and IV (except the astrological treatise beginning 'Post locorum descriptionem', Bridges, i. 376–403). It ends 'principalem scripturam', Bridges, i. 376. This closely resembles Cott. Jul. D. v, but is not a copy of it.

Paris: Bibl. Nat.: Nouv. Acq. Lat. **1715** (sec. xv), a copy of Vatican MS. (?)—Bibl. Mazarine **3488** (sec. xviii).

PRINTED: Parts I–VI, ed. S. Jebb, London, 1733: reprinted Venice, 1750. Parts I–VII, ed. J. H. Bridges, 2 vols., Oxford, 1897, with a (3rd) supplementary vol., London, 1900.

(*B*) MSS. and editions of separate parts :

I. *On the four general causes of human ignorance. Inc. cap.* i, ' Sapientiae perfecta consideratio.'

MS. Brit. Museum : Cott. **Jul. F. vii**, ff. 186–200 (sec. xv).[1] The leaves have been misplaced in binding ; the work ends with the words ' facilius adimplere ' on f. 196^{v} (Bridges, i. 32, iii. 35). Fol. 197^{r} begins ' manifestis. Quemadmodum ' (Bridges, p. 6) ; f. 200 ends with the words ' sicut ipsemet confitetur et ' (Bridges, p. 15).

II. *On the connexion of philosophy with theology. Inc. cap.* i, ' Relegatis igitur [in infernum] quatuor causis.'

No separate MSS.

III. *On the study of language* or *De utilitate grammaticae. Inc. cap.* i, ' Declarato igitur quod una est sapientia.'

No separate MSS.

IV. *On mathematical science,* or *De utilitate mathematicae. Inc.* ' Manifestato quod multae praeclarae radices sapientiae.'[2]

The part contains several sections : (*a*) *Utilitas mathematicae in physicis,* in 4 ' distinctiones ', Bridges, i. 97–174 ; *inc. ut supra.* (*b*) *Utilitas mathematicae in divinis,* Bridges, i. 175–238 ; *inc.* ' Postquam manifesta est necessitas.' (*c*) *Judicia astronomiae,* Bridges, i. 238–69 ; *inc.* ' Manifestato quomodo mathematica necessaria est.' (*d*) *Correctio calendarii,* Bridges, i. 269–85 ; *inc.* ' Sed haec hactenus. Nunc vero inferam secundum ' (cf. *Op. Tert.,* cap. 68, p. 274). (*e*) *Geographia,* Bridges, i. 286–376 ; *inc.* ' Postquam declaratum est quomodo mathematica.' (*f*) *Astrologia,* Bridges, i. 376–403 ; *inc.* ' Post locorum descriptionem.'[3]

MSS. Brit. Museum : Royal **7 F. vii**, ff. 2–62 (sec. xiii, ex.) : ' Pars quarta compendii studii theologie.' *Inc.* ' Manifesto (*sic*) quod multe,' &c. *Expl.* ' principalem

[1] This seems to be the MS. which Renan consulted in the library of St. Gregory *in Clivo Scauri* at Rome (*Averroès et l'Averroïsme,* p. 263 : *Archives des Missions,* &c., i. 377). Father Livarius Oliger, O.F.M., informs me that no MS. of Roger Bacon is mentioned in the catalogue of the St. Gregory MSS. which are now in the Biblioteca Nazionale at Rome ; nor is it at St. Gregory's. Like many of the St. Gregory MSS., this Paris MS. originally came from Venice. The passage quoted by Renan, *Averroès et l'Averroïsme, u.s.,* will be found in Bridges, iii. 47.

[2] In Jul. D. v, and Vat. 4086 the transition from Part III to Part IV is not clearly marked. See Bridges, iii. pp. viii, ix.

[3] This section (*f*) is not found in Vat. 4086, nor in Tib. C. v, but occurs in Digby 235 and in Escorial g. iii. 17. The substance of it agrees with what is said in *Opus Tert.* (Brewer, 96–9) of the section ' De Caelestibus ' in the *Opus Minus,* of which work it originally formed a part. Cf. Little, *Part of the 'Opus Tertium'* (1912), pp. xvii–xviii, 18. (See below, No. 12.)

scripturam.' Ibid. f. 68, 'Tractatus de corporibus celestibus' (fifteenth century title); *inc.* 'Post locorum descriptionem': *expl.* 'natura obedit cogitationibus,' Bridges, i. 376–402 (i.e. Art. (*f*) above).

Cotton **Tib. C. v**, ff. 49–119 (sec. xv): 'Incipit 4ta pars maioris operis fratris Rogeri Bacon in qua ostenditur potestas mathematice in scientiis et rebus mundi.' *Inc.* 'Manifesto (*sic*) quod multe.' *Expl.* 'principalem scripturam,' Bridges, p. 376.

Cotton **Otho D. i**, ff. 209–21 (injured by fire), the section 'Geographia', Bridges, i. 286–376, ending 'de locis et gentibus totius habitabilis'.

Cotton **Jul. F. vii**, ff. 178–82 (sec. xv): 'Declaratio effectus vere mathematice in 4ta parte majoris operis fratris Rogeri Bacon distinctione 5ta inter alia sic declarat. Veri mathematici considerans (?) scitus et loca planetarum' (not identified): 'De moribus hominum secundum complexiones causatas a constellationibus supracelestibus prout allegat doctor Rogerus Bacon in quarta parte majoris operis . . . ut in fine capituli 4ti et in principio cap. 5ti. . . . Complexiones locorum—maxime a juventute,' Bridges, i. 137–9, 'et nunc ponam unum exemplum . . . tam sanis quam infirmis,' Bridges, i. 139–43.

Add. **8786** (sec. xiv), ff. 12v–13v, containing cap. xv, and part of cap. xvi, of Dist. iv, Bridges, i. 167–72.

Sloane **2629**, ff. 17–53 (sec. xvii): 'Incipit tractatus fratris Rogeri Bacon de utilitate astronomie,' 'Superius quidem dictum est . . . plura conscribere,' Bridges, i. 377–403.[1]

Lambeth Palace, **200**, ff. 2–37v (sec. xv): 'De commendatione artis mathematice': *inc.* 'Manifesto quod'; *expl.* 'principalem scripturam. Explicit liber Iohannis (*sic*) Bacon de commendatione artis mathematice,' Bridges, i. 97–376, omitting the section 'Correctio Calendarii', and perhaps other passages.

Oxford: Bodl.: Digby **183**, f. 49 (sec. xiv, ex.), fragm. beginning 'et virtutis a loco', and ending 'plane vel concave non', Bridges, i. 111–56.—E. Musaeo **155**, p. 185 (sec. xv, in.): 'Pars quarta in qua ostendit potestatem mathematicae,' &c., *expl.* 'principalem scripturam.'—Laud. Misc. **674**, f. 7 (sec. xv): 'Nota de correctione Calendarii ex Rogeri Baconis libro ad

[1] Cf. Bale, *Index Brit. Script.*, p. 396: '*Introd. in Astrologiam.*' *Inc.* 'Fusius quidem,' &c. ('fusius' is a mistake for 'superius').

Clementem papam ' (one page only).—Seld. supra **79**, pp. 42–84 (sec. xvii), excerpts.—Univ. Coll. **49** (sec. xvii), ff. 105–50, 164–76.

Cambridge : Corpus Christi Coll. **426, ii** (sec. xv) : Tract. fratris Rogeri Bacon in quinta parte mathematicae de situ orbis. ' Postquam declaratum est . . . tocius habitabilis,' Bridges, i. 286–376.—Peterhouse **277** (sec. xv), f. 185^{v} : ' De utilitate arismetrice per Rogerum Bacon. De utilitate arismetrice potest sumi per infra scripta ' (!) . . . ' 10° luna 11° mercurius. Et sic est finis huius operis Magistri Rogerii bakonis ut patet in sua summa ad Clementem,' Bridges, i. 224–36.

Paris : Bibl. Nationale **7455, A.** (sec. xv) : ' De utilitatibus scientiae mathematicae verae.'

Wolfenbüttel : Herzogl. Bibl. **4125** (41 Weiss.), ff. 91–120 (sec. xv), ' Rogeri Baconis de regionibus ad papam Clementem.' *Inc.* ' Sed hoc hactenus. Nunc vero inferam.' *Expl.* ' principalem scripturam,' &c. (i.e. *Correctio Calendarii* and *Geographia*, Bridges, i. 269–376).

Escorial, **g. iii. 17** (sec. xiii), f. 1, ' Pars quarta in qua ostenditur potestas mathematice in scienciis et rebus et occupationibus huius mundi.' *Inc.* ' Manifesto quod multe' (includes also *Geographia*, f. 50^{v}, and *Astrologia*, f. 72).

PRINTED by Combach, Frankfurt, 1614, under the title : *Specula mathematica in quibus de specierum multiplicatione . . . agitur*, &c., as far as Bridges, p. 174 (i.e. § *a, Mathematicae in Physicis Utilitas*).

V. *Optics*, or *De Scientia Perspectiva*. *Inc. cap.* i, ' Propositis radicibus sapientiae.'

(In some MSS., and in the edition of 1614, this part begins : ' Cupiens te et alios,' a preface perhaps to a later copy of the *Perspectiva*, addressed to some person unknown, not to the Pope. See Bridges, ii. 1, n.)

Divided into three parts : (1) explains the general principles of vision, and has ten *distinctiones* : *inc.* ' Propositis radicibus ' ; (2) deals with direct vision, and has three *distinctiones* : *inc. cap.* i, ' Et quoniam eadem est scientia oppositorum ; ' (3) deals with reflected and refracted vision, and has three *distinctiones* : *inc. cap.* i, ' Habito de visu facto secundum lineas rectas.'

MSS. : Brit. Museum [1] : Royal **7 F. viii** (sec. xiii), ff. 47–98^{r} : ' Tractatus perspective habens tres partes prima est

[1] The treatise ' de visu et speculis ' in Royal 7 F. vii, f. 64 (*inc.* ' De speculorum miraculis . . . Nichil ab oculo ') is not by Bacon, but probably by Henry of Southwark. (Assisi MS. 673, *Pars Perspective, inc.* ' Prima pars perspective que est de radio directo ', seems to be by Pecham.)

de communibus.' *Inc.* 'Hic aliqua dicenda sunt de perspectiva. Autores quidem multi tractant' (i.e. in the preface beginning elsewhere, 'Cupiens te et alios'); *expl.* 'non posset sustinere,' Bridges, ii. 1–166.

Cotton Fragments **iv**, ff. 23–6 (sec. xiv). *Inc.* 'Sciendum vero quod visio': *expl.* 'speculo' (i.e. Bridges, ii. 148–63).

Sloane **2156**, ff. 1–41^{v} (A.D. 1428): 'Hic incipit tractatus perspective . . . Hic aliqua dicenda sunt.' *Expl.* 'non posset sustinere. Ecce finis perspective summe bonitatis illius mirabiliter nobilis et nobiliter mirabilis Rogeri Bachon Anno Christi 1428.'

Sloane **2542**, ff. 1–54 (sec. xv), imperfect, beginning illegible: *expl.* 'non posset sustinere. Explicit, etc.'[1]

Harl. **80**, ff. 1–33^{r} (sec. xv): 'Tractatus perspective habens tres partes . . . Propositis radicibus.' *Expl.* 'non posset sustinere.'

Add. **8786**, ff. 84–107: 'Incipit tractatus de modo videndi. Quoniam precipua delectatio' (i.e. Bridges, ii. 2, l. 4). *Expl.* 'non posset sustinere.'

Oxford: Bodl.: Bodley **874**, pp. 1–71 (sec. xv): *Inc.* 'Cupiens te et alios'; *expl.* 'aliqualiter sustinere.'—Digby **77**, ff. 1–56^{v} (sec. xiv): *Inc.* 'Cupiens te et alios.'—Digby **91** (sec. xvi).—Corpus Chr. Coll., **223**, f. 3 (sec. xv).

Cambridge: Magdalene College, Pepysian Library, **1207** (sec. xv).[2]—Trinity College **1418**, f. 66 (sec. xv): *Inc.* 'Prepositis iudicibus (!) sapiencie'; *expl.* f. 96^{v}, 'multum (!) nativitatis sue in speculo, etc.' (Bridges, ii. 163).

Paris: Bibl. Nat. **2598**, ff. 57–86 (sec. xv).—Nouv. Fonds Lat. **10260** (sec. xvi).

[1] This is followed in Sloane 2542, ff. 54^{v}–55^{r} by two paragraphs: (1) 'Quod autem candela appareat maior . . . sicud fumus habetur, etc. Explicit perspectiva fr. Rogeri Bakun' (cf. Bridges, ii. 158); (2) 'Auctores autem perspective asseruerunt . . . quare peius videant qui habent oculos proeminentes', &c. (cf. Bridges, ii. 83).

[2] I am indebted to Mr. S. Gaselee, Pepysian Librarian, for the following notes on this MS., which is very badly written. It was obtained by Dr. Dee at Oxford in 1559, and was perhaps intended as a working copy for the Oxford schools. *Title*: 'Tractatus perspective habens tres partes: prima est de communibus ad ceteras 2as: secunda pars descendit in speciali ad visionem rectam principaliter: 3^{a} ad reflexam visionem.' [*Inc. prol.*] 'Nunc igitur ad instanciam tuam quedam medullaria' [i.e. in the letter elsewhere beginning 'Cupiens te'.] [*Inc. Opus*] 'Quoniam precipua delectacio nostra est in visu' [i.e. Bridges, ii, p. 2, l. 4]. *Expl.* 'languide conspicientibus rem visum. Possunt etc. sicut (?) superius habetur [cf. Bridges, ii, p. 159, l. 1]. *Explicit perspectiva fratris Rogeri Bakun.*'

Erfurt : Amplon. **F. 393**, ff. 1–22 (sec. xiv ex.) : *Inc.* ' Cupiens te.'

Prag : Bibl. Publ. et Univ. **1552** (sec. xiv) : *Inc.* ' Propositis radicibus.'—**1601** (sec. xiv), ' Tractatus perspective habens tres partes.'

Florence : Riccardi **885**, ff. 144–98 (sec. xiv). *Inc.* ' Cupiens te et alios.' *Expl.* ' aliqualiter sustinere.' (Cf. *Arch. Franc. Hist.* iii. 554, where reference is made to a fifteenth-century copy of this work at Toledo, mentioned in *Revista de Archivos, Bibliotecas y Museos*, An. III,n. 6, ser. i.)

Milan : Ambrosiana **R. 47 sup.**, f. 61 (sec. xiii) : *Inc.* ' Propositis radicibus.'

Rome : Vatican Palat. **828**, f. 49 (A.D. 1349). *Inc.* ' Propositis radicibus sapientie.'—Vat. Lat. **3102** (sec. xiv), ff. 1–27 : *Inc.* ' Hic aliqua sunt dicenda.' —Cf. Vat. Lat. **2975** (sec. xvi), Tract. perspect. a fr. Rog. Baco : *Inc.* ' Quoniam inter gradus sapientiae.'

Venice : S. Marco, Lat. **vi, 133** (Vol. IV, Cl. xi, Cod. 10) (sec. xiv) : *Inc.* ' Cupiens te et alios.' [1]

PRINTED by Combach, Frankfurt, 1614, under the title : *Rogerii Baconis Angli . . . Perspectiva. Inc.* ' Cupiens te et alios.'

VI. *Experimental Science. Inc. cap.* i, ' Positis radicibus sapientiae Latinorum.'

MSS. Brit. Museum : Sloane **2629** (sec. xvii), ff. 2–16 : ' Tractatus fratris Rogeri Bacon extractus de VI^a. parte compendii studii theologie quem librum fecit ad instanciam Clementis et est tractatus de materia prius tractata et extrahitur de capitulo quod intitulatur de scientia experimentali : et si quis velit pleniorem habere doctrinam et responsionem ad difficultates que possunt in contrarium, querat scripta principalia, viz. librum vi scientiarum et librum quem intitulatur compendium studii theologie et inveniet,' &c. *Inc.* ' Corpora vero Ade et Eve post peccatum ' (*Opus Minus*, p. 373) : *expl.* ' et alibi multis modis ', &c. (*Opus Majus*, ii. 204–13).

Oxford : Bodl. : Can. Misc. **334**, f. 53, ' Alius tractatus ejusdem Fratris Rogeri extractus de sexta parte compendii studii theologiae ' : *inc.* ' Corpora vero . . .

[1] The same MS. contains (ff. 50–72) *Tractatus de velocitate motuum ; inc.* ' Omnis racionabilis opinio de velocitate ', two treatises—(1) algorismus proportionum, (2) de quibusdam subtilibus inferioribus ex praedictis. Is this by Bacon ? or William de Heytesbury ? (Cf. Bruges MS. 497.)

multis modis' (*ut supra*). Bodl. **438**, ff. 29ᵛ–31ᵛ (sec. xv); Selden supra **94**, f. 256ᵛ (sec. xiv): E Musaeo **155**, p. 689 (secc. xiv–xv), and Arch. Seld. **B. 35**, f. 39ᵛ (sec. xiv), the same extract.—University College **49**, f. 151 (sec. xvii).

Cambridge: Trinity College **1389** (sec. xv), f. 39ᵛ: 'Alius tractatus eiusdem fr. Rogeri Bakon extractus de sexta parte,' &c. 'Corpora vero . . . | multis modis' (*ut supra*). (Ibid. **922**, f. 56ᵛ (sec. xv), contains an English translation of the same passage.) Ibid. **1119**, f. 56ᵛ (secc. xvi, xvii): 'Here followeth the first part of the great work namely the experimental science of Roger Bacon written to Clemens ye Pope.' 'Now that I have set forth ye rotes of the science of knowledge of the Latines in respect of toungs.' Ends unfinished, f. 68ᵛ.

Manchester: Chetham Library **A. 5. 24** (sec. xv), f. 61ᵛ: 'Corpora vero', *ut supra*.

Douai **691**, § 3 (sec. xvii).

Rome: Vatican **4091** (sec. xvi), ff. 49–61, contains cap. i–vii (cf. Bridges, iii, pp. xii, 182). *Inc.* 'Positis radicibus'.[1]

VII. *Moral Philosophy*. *Inc.* 'Manifestavi in praecedentibus quod cognitio linguarum.' Six parts: (1) duty to God, to neighbour, and to self: (2) 'Secunda pars descendit ad leges et statuta hominum inter se': (3) 'De regimine hominis in comparatione ad se ipsum': (4) 'consistit in persuasione sectae fidelis credendae et amandae et operibus comprobandae quam debet humanum genus recipere,' or the grounds for accepting the Christian religion: [(5) 'Quinta pars est de sectae jam persuasae et probatae exhortatione ad implendum in opere et ad nihil faciendum in contrarium, et hic exigitur modus praedicationis: (6) Sexta vero pars moralis philosophiae est de causis ventilandis coram judice inter partes ut fiat justitia: sed hanc solum tango propter causas quas assigno.'] Parts (5) and (6) are unknown; the description of them is taken from *Opus Tert.*, cap. xiv: cf. also ibid., pp. 266, 304–8. A brief summary of them is contained in Professor Duhem's

[1] This MS. Vat. Pal. 4091, ff. 49–88, copied in a late sixteenth-century hand 'ex oper. perg.' presents a curious combination. It contains 'Rogeri Bachonis Tractatus in quo fit sermo de experientia in communi habens 4 distinctiones et 1ª habet 7 capita', Part VI of *Opus Majus*, capp. 1–7 (the seventh, on haloes, differs from Bridges, cap. vii). The four distinctions are: f. 49, *de experientia in communi*: f. 62, *de potestate artis et naturae* (=No. 18): f. 71, *de retardanda senectute* (=No. 23): f. 88, *de mirabili artificio quod fit per lapidem magnetem* (=No. 70).

Op. Tert., and Little, *Op. Tert.* (see below). The last part (6) was never written: 'excusavi me ab expositione istius partis': Duhem, p. 179.

MS. Brit. Museum: Royal 8 F. ii (sec. xv), f. 167. *Inc.* 'Manifestavi (etc.) . . . eius quod est post se' (Bridges, ii. 223–75); it includes Parts (1) and (2), and capp. i–v of Part (3).

This part, omitted by Jebb, was first printed by Bridges, ii. 223–403. (It was not printed at Dublin in 1860, but described by Dr. Ingram in a paper printed in vol. viii of the *Proceedings of the Royal Irish Academy*.)

11. **Tractatus de Multiplicatione Specierum.**

A treatise on this subject was sent to the Pope in 1267–8 apparently in two versions: e.g. *Op. Tert.*, p. 227, 'tractatus de radiis quem vobis misi separatim ab Opere Majori;' ibid. 230, 'in tractatu de radiis quem Johannes extra principalia opera deportavit;' ibid. 38, 'sed completiorem tractatum mitto vobis de hac multiplicatione;' ibid. 99, 'Tractatus de speciebus et virtutibus agentium quem dupliciter misi vobis, et tertio modo incepi sed non potui consummare.' Either at this time or later it formed part of a larger work. At the beginning of the treatise, as printed by Jebb (p. 358) and Bridges (ii. 408), are the words: 'Recolendum est igitur quod in tertia parte hujus operis tactum est, quod essentia, substantia, natura, potestas, potentia, virtus, vis significant eandem rem, sed differunt sola comparatione.' There is nothing about this in the third part of the *Opus Majus*, but it is found in the *Communia Naturalium* (Lib. I, pars ii, p. 80, in Steele's edition), to which Bacon refers elsewhere in the same treatise (Bridges, ii. 424, 'ut prius in Communibus Naturalium demonstratum est'), while in the *Communia Naturalium* he frequently refers to the *De Mult. Specierum* (e.g. Steele, pp. 38, 203, 272, &c.). The treatise was therefore included in a work of which the *Communia Naturalium* formed the third (or a portion of the third) part. This was the *Scriptum Principale* or *Compendium Philosophiae* (see No. 35 below).

The versions of the *De Mult. Spec.* differ considerably, and the treatise is divided sometimes into six, sometimes into ten parts. Two distinct recensions are extant, marked in this list (*A*) and (*B*).

(*A*) *Inc. prol.*: 'Postquam habitum est de principiis rerum naturalium.' *Inc. opus*: 'Primum igitur capitulum circa influentiam agentis habet tres veritates.'

MSS.: British Museum: Royal 7 F. viii (sec. xiii ex.), ff. 13–46^{v}. *Inc.* 'Primum igitur capitulum;' *expl.* 'receperit.' This is followed by a passage marked *vacat*, which Bridges prints at the end of the treatise (pp. 551–2), and which is inserted in MS. Royal 7 F. vii, f. 109;

inc. 'Sed hoc est intelligendum.' On the same leaf, 109^{v}, is a passage for insertion in Royal **7 F. viii**, f. 16, at the end of cap. ii of the *De Mult. Spec.*, and recopied in **7 F. viii**, f. 11 (not printed in Bridges, p. 431); *inc.* 'Deinde queritur an aliquod agens': *expl.* 'spirituali et corporali.'—Add. **8786**, ff. 21^{v}–45^{v} (sec. xiv): *inc.* 'Postquam,' &c.—Sloane **2156**, ff. 42–71 (A.D. 1428): *inc.* 'Primum igitur,' &c.: *expl.*, cap. 31, 'Sed an in aere . . . postquam receperit' (Bridges, ii. 551).

Oxford: Bodl. Digby **235**, f. 153 (sec. xv): *inc.* 'Primum igitur,' &c.: inserted in *Opus Majus*: *expl.* 'postquam receperit' (Bridges, ii. 551).

Cambridge: Trin. Coll. **1294** (sec. xvii).—Magdalene Coll., Pepysian Lib. **1207** (sec. xv): *inc.* 'Species multiplicata in medio aliunde vocatur similitudo agentis et ymago.' (Cf. Bridges, ii. 409, l. 7.)

Winchester College **39** (sec. xv), ff. 45–84: *inc.* 'Primum igitur capitulum.'

Dublin: Trin. Coll. **381** (sec. xvi ex.), in *Opus Majus*.

Paris: Bibl. Nat. **2598**, ff. 21–56 (sec. xv): *inc.* 'Postquam,' &c.—Mazarin **3488**, p. 239 (sec. xvii).

Bruges **490** (sec. xiii), called *Philosophia Baconis*; *inc.* 'Primum igitur.'

Douai **691**, § 4 (sec. xvii).

Florence: Laurenz. Ashburnham **957** (sec. xv, humanistic writing), ff. 1–70: no title. *Inc.* 'Primum igitur': *expl.* 'propter rationes contrarias ut in luna,' Bridges, ii. 550.—Bibl. Naz., Conventi Soppressi I, IV, 29 (sec. xv), ff. 2–47 (from San Marco), contains same as Ashburnham MS.

Milan: Ambros. **R. 47 sup.** (sec. xiii), f. 1: *De generatione (et corruptione) specierum*: *inc.* 'Postquam,' &c.

Venice: S. Marco, Lat. **vi. 133** [Vol. IV, Cl. xi, Cod. 10], (sec. xiv): *inc.* 'Primum igitur.'

Vienna: Bibl. Palat. **5311** (secc. xiv, xv), ff. 101–6 (excerpts), followed by Roger Bacon, *De multiplicatione lucis*, ff. 108^{r}–13^{v}.

PRINTED by Jebb, between Part V and Part VI of *Opus Majus* (pp. 358–445): and by Bridges, at the end of *Opus Majus*, ii. 407–552. Extracts from the prologue in Bridges, ii. 183–5.

(*B*) The beginning of another recension exists in two versions; these differ somewhat from each other, but still more from the printed edition.

MSS. : Brit. Museum, Royal **7 F. viii**, ff. 2–12 (sec. xiii), an amplified version of the earlier part of the *De Mult. Specierum*. *Inc.* ' Dato prologo istius quinte partis huius voluminis quod voco compendium studii theologie, in quo quidem comprehendo in summa intentionem totius operis, extra partem ejus signans omnia impedimenta totius studii et remedia, nunc accedo ad tractatum exponens ea que necessaria sunt theologie de perspectiva et de visu ' : it includes Dist. I, capp. 1–5, Dist. II, capp. 1–2, with references to the remaining parts of the treatise.

Rome : Bibl. Angelica **1017** (sec. xv),[1] ff. 76–92. *Inc.* ' [C]onpletis 4^{or} partibus 3^{ii} libri de compendio studii theologie sequitur 4^{ta} (*sic*) pars istius libri que est de perspectiva que fundatur in actionibus agentium et virtutibus eorum quas influunt in materiam mundi et in contrarium in sensum et intellectum humanum et angelicum '—ending apparently with cap. iv of Pars (or Dist.) II : Bridges, ii. 478.

12. **Opus Minus**, written in 1267, was both an introduction and a supplement to the *Opus Majus*. It seems to have consisted of the following parts :

i. Introduction or dedicatory letter. Bacon describes this in the *Opus Tert.*, p. 7 : ' Primo igitur in Opere Secundo, secundum formam epistolae Marci Tullii post exilium revocati, . . . recolens me jam a decem annis exulantem quantum ad famam studii quam retroactis temporibus obtinui, . . . vestramque sapientiam admirans . . . ; secundo assurgens vestrae clementiae, exordium sermonis capiens, post pedum oscula beatorum, stylum altius elevando, propter vestram celsitudinem, sub his verbis incepi perorare : " Cum tantae reverentiae dignitas sapientiae scaturiens plenitudine," ' &c. The introduction therefore began with some autobiographical reminiscences. This appears to be lost ; but perhaps to it is to be referred the passage quoted by Anthony Wood from the *Opus Minus* : ' Praelati enim et fratres me jejuniis macerantes tuto custodiebant, nec aliquem ad me venire voluerunt, veriti ne scripta mea aliis quam summo pontifici et sibi ipsis divulgarentur.' [2] The second part of the introduction began with the words ' Cum tantae reverentiae ', &c., and is quoted in the *Opus Tertium*. The fragment dis-

[1] This appears to be in an English hand and may be the MS. which Bale refers to as being at Peterhouse, Cambridge : *Leges multiplicationum* ; *inc.* ' Expletis quatuor partibus libri ' : *Index Brit. Script.*, p. 394. I am indebted to Cardinal Gasquet for a rotograph of the Angelica MS.

[2] Wood, *Antiq. Univ. Oxon.*, ed. 1674, p. 138. Browne, *The Cure of Old Age*, 1683, quotes the passage, with the alteration of one word, evidently from Wood, on whom his ' Life of Roger Bacon ', prefixed to *The Cure of Old Age*, is based. The passage is probably to be found somewhere in the MSS. of Brian Twyne, where, however, I have searched for it in vain.

covered by Cardinal Gasquet[1] in Vatican MS. 4086, and printed in the *Eng. Hist. Rev.* xii, represents probably a revised and partially expurgated edition of this part. The earlier portion of it is almost identical with *Op. Tert.*, pp. 7–12. The latter portion is occupied by a brief summary of the *Opus Majus*, the sciences being treated in inverted order or according to their dignity, moral philosophy first.

ii. An addition *de notitia caelestium* was made to the section on Mathematics. This, there seems no doubt, was identical with the treatise on astrology printed by Bridges, i. 376–403, at the end of *Opus Majus*, Part IV, beginning 'Post locorum descriptionem' (see above). That treatise is found in the Escorial MS. (sec. xiii) of the *Opus Majus*, and in the Digby MS. (sec. xv) and those copied from it: not in the Vatican MS. nor in the Cotton (Tib. C. v), Bodl. E Musaeo, Lambeth and Wolfenbüttel MSS. of Part IV, while in MS. Royal 7 F. vii it is separated from the rest of the mathematics by two treatises occupying four leaves. And in the *Opus Tert.* ed. Little, p. 18, Bacon says that the *geographia* (*de locis tantum*) was included in the *Opus Majus*, the *Astrologia* (*de alterationibus locorum et rerum per celestia*, &c.) was included in the *Opus Minus*. It should be noted that the Digby MS. at the end of the preceding section (*Geographia*) has 'Finitur quarta pars majoris operis', though it goes on directly to the *Astrologia*.

iii. Practical alchemy, 'in enigmatibus.'

iv. Notes on the chief points in *Opus Majus* to which Bacon wished to call the Pope's special attention, beginning with moral philosophy.

v. Treatise on the seven sins in theological study.

vi. Speculative alchemy or *De rerum generatione ex elementis*,[2] inserted in the sixth *peccatum*.

vii. *Remedia studii*.

The fragment edited by Brewer, *Op. Ined.*, pp. 311–90, from Digby MS. 218, includes a few pages of Part iii, all of iv, most of v, and part of vi.

The omission in Part vi (Brewer, p. 375) on the prolongation of human life may be partly filled in from *Opus Majus*, Part VI, Exemplum ii (Bridges, ii. 205), where the passage 'Est autem . . . curabit et' occurs word for word. How much of *Opus Majus* was here inserted is doubtful; probably to the end of Exemplum ii: 'et alibi multis modis' (Bridges, ii. 213). Several MSS. quote the passage beginning 'Corpora vero Adae et Evae' (*Op. Min.* p. 373), and ending 'et alibi multis modis' (*Op. Majus*, ii. 213).[3] The substance of some of the lost part of the *De rerum gen.* is contained in *Libellus de retardandis accidentibus senectutis*. Cf. also the *Breve breviarium* below.

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[1] Gasquet considers this fragment to be a complete introduction to the *Opus Majus*, distinct from the *Opus Minus*. This may be so, but I incline to think it is part of the *Opus Minus*. No further light is thrown on this point by the parts of the *Opus Tertium* edited by Professor Duhem and myself (see No. 13 below).

[2] Beginning 'Hic autem volens ponere radicalem generationem.' Brewer, *Op. Ined.*, p. 359.

[3] See above No. 10 (B), v.

MSS. Rome: Vatican **4086**, ff. 75–82 (sec. xiv); Part i; *inc.* 'Sanctissimo patri Domino Clementi . . . Cum tante reverentie dignitas.'

Paris: Bibl. Nat., Nouv. Acq. Lat. **1715** contains the same letter as the Vatican MS.

Oxford: Bodl. Digby **218** (sec. xiv), f. 57, imperfect: contains most of the work: the sixth part, on speculative alchemy, begins on f. 65: title in later hand, 'De rerum generationibus:' *inc.* 'Hic autem volens ponere radicalem generationem rerum.'—Corpus Chr. Coll. **255** (secc. xvi–xvii), 'De rerum generationibus.'[1]

(For MSS. of Part ii, *De Caelestibus*, see No. 10, *Opus Majus*, Part IV.)

PRINTED: Part i, in *Eng. Hist. Rev.*, xii. 494. Part ii, in Bridges, *Opus Majus*, i. 376–403. Parts iii–vi (incomplete), in Brewer, *Rog. Bacon Opera inedita*, pp. 313–89.

Cf. Hody, *De Bibliorum Textibus*, Oxon., 1705, pp. 419–28 (extracts).

Summary in Duhem, *Opus Tert.*, pp. 179–81. Little, *Opus Tert.*, pp. 77–9.[2]

13. **Opus Tertium**, written in 1267–8, was, like the *Opus Minus*, both an introduction and a supplement to the *Opus Majus*.

As edited by Brewer it contains 75 chapters (but the divisions of chapters are given in the MSS. in a modern hand). Chapters 1–21 deal with Bacon's gratitude to the Pope, his difficulties, the relative importance of sciences and their relations to each other, with special reference to the *Opus Minus*. With chapter 22 begins the commentary on the *Opus Majus*, which includes a long digression on vacuum, motion and space, capp. xlii–lii. The remainder of the work deals with the utility of mathematics in relation to secular and sacred subjects, as treated in Part IV of *Opus Majus*.

Here the treatise as edited by Brewer ends.[3] Professor Duhem recently discovered most of the remainder of the work in a MS. at Paris (Bibl. Nat., Lat. 10264, sec. xv), under the name of Alpetragius or Al Bitrogi: *Liber tertius Alpetragii. In quo*

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[1] This MS. (transcripts of Brian Twyne) also contains 'excerpta ex libro ad Clem. IV de peccatis theologorum,' i.e. from *Opus Minus*.

[2] Trin. Coll., Cambridge, MS. 1363, ff. 1–3^{v} (sec. xv), formerly belonging to Dr. Dee, contains a passage which I have failed to find; it may belong to *Opus Minus*. 'Bacon in Epistola ad Clementem papam cap. i.' *Inc.* 'Secundum quod sunt 4^{or} elementa sic sunt quatuor corpora quorum quodlibet componitur ex elementis sed ex uno per dominium.' *Expl.* 'Et quanto magis iste ordo iteretur tanto magis augmentatur sua claritas et virtus. *Expl. tres medicine lapidis.*' (But cf. note to *Tract. de erroribus medicorum*, No. 28, below.)

[3] There is no analysis of the later sections of *Op. Maj.* part iv, i.e. of the sections on geography and astrology, nor of parts v, vi, vii.

tractat de perspectiva : De comparatione scientie ad sapientiam. De motibus corporum celestium secundum ptolomeum. De opinione Alpetragii contra opinionem ptolomei et aliorum. De scientia experimentorum naturalium. De scientia morali. De articulis fidei. De Alkimia. This fragment contains (1) summary of *Op. Majus*, part v : (2) excursus *de motibus corporum celestium* (*inc.* 'Hic in fine perspectivarum volo advertere aliqua de motibus celestibus') with a comparison of the systems of Ptolemy and Al Bitrogi ; (3) summary of *Op. Maj.* part vi, with a chapter *De scientia quinte essentie* ; (4) summary of *Op. Maj.* part vii ; (5) summary of *Opus Minus.* (6) *De Alchemia* [see below, No. 14]. (7) *Magnus Tractatus et nobilis, De rerum naturalium generatione*, &c., fragment, beginning : 'Hiis habitis volo descendere,' i.e. *Communia Natural.* Lib. i, pars ii, Dist. 2 (Steele, pp. 65–8). Professor Duhem argues that this last treatise formed part of the *Opus Tertium*, and that it was followed by a treatise *De peccatis et remediis studii theologiae*, which he identifies with the *Metaphysica* in *Comp. Phil.*, vol. iv (see No. 35 below).

A gap still remained to be filled between the end of Brewer's fragment and the beginning of Duhem's. The missing section has now been discovered in MSS. Winchester College 39 and Tanner 116 and edited by the present writer.

Inc. 'Sanctissimo patri ac domino Clementi . . . Vestrae [sapientiae] magnitudini duo transmisi.'

MSS. Brit. Museum : Cott. **Tib. C. v** (sec. xv), ff. 2–45, containing capp. 1–75 in Brewer's ed.—**Jul. F. vii** (sec. xv), ff. 183–5, containing cap. 59 and part of 60.—Royal **7 F. vii**, ff. 106–108^{v}, contains a passage for insertion at the end of Part III of the *Communia Nat.*, which corresponds almost verbatim with *Opus Tert.*, capp. 46–9 (Brewer, pp. 168–84).—Add. **8786**, ff. 14–19 (sec. xiv), capp. 41–51 (Brewer, pp. 142–98), with variants.

Lambeth Palace **200**, ff. 38–59 (sec. xv), containing capp. 1–45 of Brewer's edition, entitled *Epistola Rogeri Bacon ad Clementem papam*,[1] beginning 'Sanctissimo domino patri' and ending 'uti dictum est. Capitulum 53 de mobilitate substantie separate' [Occasione vero (catchword)].

Oxford : Bodl. E Musaeo **155** (sec. xv. in.), (Brewer's (edition).—Tanner **116** (sec. xiii, ex.) : (*a*) ff. 6–8, 'Item

[1] Mr. Claude Jenkins, Lambeth Librarian, has kindly pointed out to me that on f. 37^{v} the *explicit* of the Mathematics, *Opus Majus* iv, is followed (original hand) by : 'Ex consequenti sequitur alius liber eiusdem de laude scripture sancte. Ad Clementem papam liber sequitur et prout brevis epistola ad eundem' (and in a slightly different hand) 'vocaturque totus liber epistola ad Clementem' : with catchword 'Hucusque'. But the next leaf f. 38^{r} begins 'Incipit epistola, . . . Sanctissimo domino patri.' It looks, therefore, as if the *De laude scripture sancte*, beginning 'Hucusque' were lost. It is, however, not clear whether a new quire begins with fol. 38.

capitulum extractum de quodam opere quod fecit idem fr. Rogerus Bacun de ord. minorum ad mandatum pape et valet ad expositionem dictorum et dicendorum in textu. Sequitur de scientia experimentali . . . | sicut aves inviscatas' (Duhem, pp. 137–8, 148–57; Little, pp. 43–54): (*b*) f. 8^{r}, 'Deinde cogitavi opus . . . | et sic terminatur intentio operis utriusque et sic explicit' (Duhem, pp. 179–81; Little, pp. 77–9): (*c*) ff. 8^{r}–9^{r}, 'Item aliud cap. eiusdem fr. Rogeri Bacun de ord. min. de potestate verbi . . . extractum de prima parte maioris operis (*sic*). Deinde comparo linguarum utilitatem . . . divine operationis' (Brewer, *Op. Tert.*, cap. xxvi, pp. 95–100): (*d*) ff. 11^{r}–13^{v}, 'Post hec sequitur operatio mathematice . . . | veniunt Christiani' (Little, pp. 1–19). —Corpus Chr. Coll. **149** (sec. xv) appears to contain the same as Tanner **116** (?).—Univ. Coll. **49** (sec. xvii),[1] a copy of Bodl. E Musaeo.

Cambridge: Univ. Libr. **Ff. iv, 12** (A.D. 1528–9), f. 318 et seq.: 'Determinata quarta parte . . . convincere fraudulentum' (Duhem, pp. 178–90; Little, pp. 75–89).—Trin. Coll. **1036**, ff. 21–4^{v} (sec. xv), contains most of the first section (*a*) in Tanner **116**, beginning 'Item capitulum extractum', ending incomplete, 'consistit in duobus' (Duhem, pp. 137–8, 148–52; Little, pp. 43–8).—Ibid. **1294** (sec. xvii), transcript of **Tib. C. v.**—Fitzwilliam Museum, McClean **153** (sec. xv) contains the same extracts as Tanner **116**, from which it is apparently copied.

Winchester College **39** (sec. xv), ff. 183–98: *inc.* 'Post hec sequitur operatio mathematice' (Little's edition of *Opus Tert.*, but called in the MS. 'secundum opus fratris Rogeri Bacon'): ff. 199–206, *Opus Tert.*, a fragment beginning 'Sanctissimo' and ending 'de his radicibus', corresponding to Brewer, pp. 3–38.

Douai **691** (sec. xvii), Brewer, wanting capp. 38–52: this MS. has been described by Victor Cousin, *Journal des Savants* for 1848 (five articles).

Paris: Bibl. Nat., Lat. **10264** (sec. xv), ff. 186–226, *Inc.* 'Postquam manifestavi mathematice potestatem aspiravi' (=Duhem).—Ibid. **2598** (sec. xv), ff. 48^{v}–56^{v} (capp. xli–li, pp. 142–98, of Brewer's edition), *inc.* 'Quoniam circa tempus et evum.'

Escorial, **g. III, 17** (sec. xiii), ff. 80–97, seems to contain Brewer, pp. 74–9, 120–35, 295 (?)–310.

[1] Cf. Corp. Chr. Coll., Oxford, 260 (Bryan Twyne), p. 101, 'Excerpta ex preambulo Rogeri Bacon ad opus suum majus et minus ad Clem. IV.'

PRINTED, capp. 1–75 in *Opera Inedita* (R.S.), ed. Brewer, pp. 3–310. The latter part in *Un fragment inédit de l'Opus Tertium de Roger Bacon précédé d'une étude sur ce fragment par Pierre Duhem* (Quaracchi, 1909), and in *Part of the Opus Tertium of Roger Bacon*, by A. G. Little (Brit. Soc. Franciscan Studies, iv, 1912).

14. **Tractatus expositorius enigmatum alchemiae.**

Bacon sent to Clement IV four treatises on this subject: two were inserted in the *Opus Minus*, a third was sent separately by the hand of John, and is unknown. The fourth was first discovered by Professor Duhem appended to the *Opus Tertium*. It consists of three chapters: *De enigmatibus Alkimie, De expositione enigmatum Alkimie, De clavibus alkimie.*

MSS. Paris: Bibl. Nat. **10264**, f. 222 (sec. XV): *inc.* 'Quoniam vero non expressi'—*expl.* 'convincere fraudulentum'.

Cambridge: Univ. Libr. **Ff. iv, 12**, f. 310 (A.D. 1528–9), *inc.* 'Determinata quarta parte philosophie moralis addidi de quinta'—*expl.* 'convincere fraudulentum' (Duhem, pp. 178–90; Little, pp. 75–89).

Winchester College **39**, f. 196 (sec. XV).

PRINTED in Duhem's *Op. Tert.*, pp. 181–90: Little, *Op. Tert.*, pp. 79–89.

15. **Treatise on Astrological Judgements.**

A separate treatise on this subject was sent to the Pope. 'Et si vultis copiosius videre, jubeatis Johanni ut faciat scribi de bona litera tractatum pleniorem quem habet pro vobis;' *Op. Tert.* (Brewer), p. 270; cf. *Op. Majus* (Bridges), i. 393. This does not appear to be extant; a passage belonging to it may be preserved in the *De laudibus Mathematicae* (see below, No. 16).

Compare also '*Processus fratris Rogeri Bacon . . . de invencione cogitacionis*' (astrological fragment). *Inc.* 'Notandum quod in omni judicio quatuor sunt inquirenda, scil. natura planete.' MS. Bodl.: Digby **72** ff. 49^{v}, 50 (secc. xiv–xv). Probably an extract from one of Bacon's larger works.

16. **De laudibus mathematicae.** A different recension of matter which occurs, for the most part word for word, in *Opus Majus*, Part IV.

MSS. Brit. Museum: Royal **7 F. vii**, ff. 72–7 (sec. xiii ex.). The contents are: (i) Preface, *inc.* 'Post hanc scientiam experimentalem;' (ii) Bridges, p. 175, 'Et cum multis modis;' to p. 180, 'qualitatibus applicari;' (iii) After a short connecting link, Bridges, p. 239, 'ideo volo in praesenti;' to p. 245, 'certificare in omnibus;' (iv) A passage on the uncertainty of astrological judgements, beginning f. 73^{v} i, 'et si[c]

astrologi promittunt se certificare non est eis credendum,' ending f. 76[v] ii, 'quas videmus in sompnis ex illa contingunt,' not found in *Opus Majus*, but possibly connected with the separate work mentioned in *Opus Tert.*, Brewer, p. 270, and in *Opus Majus*, Bridges, i. 393; (v) Bridges, p. 246, 'His igitur et huiusmodi;' to p. 253, 'veritati contradicit;' (vi) After a short connecting link, Bridges, pp. 180–1, 'una est notitia caelestium . . . sciunt astronomi quod tota terra.' Ends incompletely. It is not clear to what scheme this work belongs. In the *Grey Friars in Oxford*, p. 203, it was suggested that it may have been meant as a preface to vol. ii of the *Compendium Philosophiae*; but in that scheme physics follow mathematics, and not vice versa. (See Mr. Gilson's catalogue of the Royal MSS.)

Oxford: Bodl.: Digby **218**, ff. 98–103[r] (sec. xiii ex.–xiv). *Inc.* 'Post hanc scientiam': *expl.* 'quod tota terra'.

17*a*. **De speculis comburentibus.** *Inc.* 'Ex concavis speculis ad solem positis ignis accenditur': *expl.* 'de distantia combustionis nihil certum scio ad praesens'.

MSS. Brit. Museum: Add. **8786**, ff. 49–61 (sec. xiv).

Oxford: Bodl. **874**, pp. 71–95 (sec. xv).—Ashmole **440** (sec. xvi).

Florence: Riccardi **885**, f. 200 (sec. xiv).

PRINTED at Frankfurt, 1614, in Combach's *Specula Mathematica*, pp. 168–204.

There is some connexion between the **De speculis comburentibus** and two other works, **Liber de visu** and **Liber de speculis**, sometimes ascribed to Bacon.

MSS. Milan: Ambrosiana **R. 47** (sec. xiii), f. 133, *Liber de visu Baconis*, ten chapters: *inc.* 'Supponatur ab oculo eductas lineas rectas': *expl.* 'videbitur illud non latum retrorsum ferri'.

Milan: Ambrosiana **R. 47** (sec. xiii), f. 150, *Liber de speculis*, thirty-four chapters: *inc.* 'Visu[m] rectum esse': *expl.* 'ex concavis speculis ad solem positis ignis accenditur. Explicit liber Euclidis de speculis'.

Rome: Vatican **3102** (sec. xiv ex.), ff. 35[v]–48 [*Perspectiva Vitalonis*]: *inc.* 'Suponatur ab oculo eductas lineas rectas.' | 'Explicit perspectiva Vitalonis'.

Rome: Vatican **3102** (sec. xiv ex.), ff. 48–51, *Tractatus de speculis Bachonii*. *Inc.* 'Visum rectum est cuius media': followed by f. 52, 'In planis speculis rei vise' (anon.).

Florence: Bibl. Naz., Conventi Soppressi, **I. IV. 29**,

ff. 48r–72v (sec. xv) : no title : anon. *Inc.* 'Ponatur ab oculo rectas eductas lineas . . . | ex concavis speculis ad solem positis ignis accenditur. Esto concavum speculum *a b* . . . quare in eis stupa posita accenditur.' (This seems to contain both the *Liber de visu* and the *Liber de speculis*. It is closely allied to the Vatican MS. Both contain the *Perspectiva* of Bacon, and a treatise beginning 'Geometria assecutiva', anon. in Florentine MS., ascribed (rightly) to Thomas Bradwardine in the Vatican MS.)

Erfurt : Amplon. **F. 37** (sec. xiii ex.), ff. 60–3. *Liber de naturis speculorum Jordani. Inc.* 'Visum rectum est.' | 'ex concavis . . . accendere. Esto concavum . . . stupa posita accendetur.' Cf. Nos. 44, 45 below.

17*b*. **Notulae de speculis** (anon.). *Inc.* '[Notandum quod] quia omnes axes . . . | et sic de omnibus aliis intellige.'

MS. Oxford : Bodl. **874** (sec. xv), p. 95, where title and first two words are inserted in hand of sixteenth century, the rest being in same hand as the *De speculis comburentibus*.

PRINTED by Combach, *ut supra*, pp. 205–7.

18. **Epistola fratris Rogerii Baconis de secretis operibus naturae et de nullitate magiae,** or **De mirabili potestate artis et naturae.**[1] *Inc. cap.* i, 'Vestrae petitioni respondeo diligenter. Nam licet.'

The work consists of ten or eleven chapters, the last five of which Charles considered doubtful,[2] addressed perhaps to William of Auvergne (died 1248)[3] or to John of London, whom Charles identifies with John of Basingstoke (died 1252).

MSS. Brit. Museum : Sloane **2156** (sec. xv), ff. 111–16.

Oxford : Bodl. : Digby **164**, ff. 8–12v, containing capp. i–ix (sec. xv).—Tanner **116** (sec. xiii ex.), ff. 9r–11r, containing capp. i–v and beginning of cap. vi.—Cf. Merton Coll. **230**, f. 51 (sec. xiv).

Leyden : Bibl. Univ. **Q. 27**. Chim. Voss. **64** (sec. xvi).

Quaracchi : MS., sec. xiv, ten leaves, no title : *inc.* 'Vestre petitioni . . . | nullus aperiet. Explicit Bacon de potestate artis et nature.'

[1] Florence, Bibl. Naz., Pal. 887 (secc. xv, xvi) has *Roger Bacon de secretis naturae. Inc.* 'Obsequiis mihi possibilibus ergo terra aqua et natura frigida et humida' (probably spurious).

[2] Apparently merely because they are 'enigmatic'. But see the ingenious explanation by Lieut.-Col. Hime, *Gunpowder and Ammunition* (1904), pp. 141–62.

[3] The Hamburg edition of 1618 based on a MS. of John Dee has after the Explicit : [ad Gulielmum Parisiensem conscripta]. I have not found this in any MS.

Rome : Vatican **4091**, f. 62 (extracts).

Cf. Vienna : Bibl. Pal. **11314** (sec. xvi), f. 75, ' Tractatus Rogerii Bachonis de secretissimis naturae misteriis supercoelestis ' (?).

PRINTED at Paris, 1542 ; Oxford, 1594 ; Hamburg, 1618 ; in Zetzner's *Theatrum Chemicum*, 1659 ; Manget's *Thesaurus* (1702), i. 616, and by Brewer in *Rog. Bacon Opera Ined.*, App. I. French translations, 1557, 1629 ; English translations, 1597, 1659.

19. **Excerpta de libro Avicennae De anima per fratrem Rogerum Bacon.** *Inc.* ' In illius nomine qui major est.'

MS. Bodl. : Ashmole **1467**, ff. 1–30 (sec. xvi).

PRINTED at Frankfurt, 1603, under the title *Sanioris medicinae magistri D. Rogeri Baconis angli de arte chymiae scripta*, &c., pp. 17–86 : reprinted, 1620, under the title *Thesaurus Chemicus*, &c.

Cf. Glasgow : Hunterian Museum, MS. **253** (sec. xiii ex.), f. 1, *Avicenna De anima* : *inc.* ' Explanabo tibi ' : f. 28^{r}–42^{r}, *Liber expositorius precedentis libri Avicenne Inspector dictus Rogeri Bacon* (title in much later hand) : *inc. prol.* ' In nomine Domini dixit inspector in hoc libro propter magnum studium legendi quod habui in hoc libro cogitavi quod reducerem difficiliora ad memoriam et acuerem sensum meum.' *Inc. opus*, f. 28^{v} : ' In nomine Domini hec est prima clavis que tractat de calce que fit post primam ablutionem.' *Expl.*, f. 42^{r}, ' plumbo alcofoli et plumbo alcali et magnum.' This MS. formerly belonged to St. Augustine's, Canterbury (No. 1544 in James's Catalogue) and to John Dee (from information kindly supplied by Mr. J. L. Galbraith, Keeper of Hunterian Books).

20. **Breve breviarium**, or **De naturis metallorum in ratione alkimica et artificiali transformatione**, or **Caelestis alchymia**, or **De naturis metallorum et ipsorum transmutatione**, or **Breviloquium alkimiae.**[1] (Addressed to Raymund Gaufredi(?).) *Inc.* ' Breve breviarium breviter abbreviatum sufficit intelligenti.'

MSS. Brit. Museum : Sloane **276**, f. 4 (sec. xv). / [*Inc.* ' Ars alkimie duo principaliter considerat ' (two parts, *de mineralibus, de vegetabilibus et sensibilibus*).

[1] It seems to consist of two principal and two subsidiary parts : (1) Introductory—speculative : *inc. De compositione metallorum.* ' Incipiamus ergo generationem metallorum ostendere.' (2) Practical : *Incipit liber secundus de Practica.* ' Non quidem necessarium. . . .' *De consideratione Alchymiae et auri proprietate.* ' Ars ergo Alchemiae duo principaliter considerat. . . .' This deals with metals. (3) *Tractatus de vegetabilibus et sensibilibus* : ' Executo breviter tractatu de spiritibus mineralibus.' (4) *Incipit de Salibus* : ' Executis igitur duabus principalibus partibus.' *Expl.* ' moribus et studiis liberalibus ad plenum eruditi.' Cf. the treatises on alchemy in *Opus Minus*.

Oxford : Bodl. **607**, f. 63 (sec. xv in.), anon. : E Musaeo **155** (sec. xv), p. 513 : Digby **119**, ff. 64–77 (sec. xiv).
Cambridge : Univ. Library **Kk. vi 30**, ff. 87–103 (secc. xv, xvi).—Gonville and Caius Coll. **181**, pp. 189–208 (sec. xv).
Paris : Bibl. Nat. **14007** (sec. xv), f. 1 : *inc.* 'Ars alkimica.'
Wolfenbüttel **3076** (sec. xv), ff. 125–47.
Florence : Bibl. Naz., MSS. Strozzi *or* Magliabecchi, **Cl. xvi** (11), no. **77** (sec. xvi). *Inc.* 'Ars alchimie' (32 capp.).—Ibid. **xv** (8), **68** (sec. xvi) seems to contain extracts.—Riccardi **847**, Liber de Alchimia : *inc.* 'Ars principaliter duo continet.'
Rome : [1] Minerva **A.V. 9**, ff. 89–113 (anon.).

PRINTED, 1603, in *Sanioris Medicinae*, &c., pp. 95–263.

21. **Verbum abbreviatum de Leone viridi** (on minerals, the composition of the stone, and preparation of mercury : a summary by Raymund Gaufredi). *Inc.* 'Verbum abbreviatum verissimum et approbatum de occultis.'

MSS. Brit. Museum : Sloane **692**, ff. 46–51^{v} (sec. xv) : 'In nomine Domini nostri Jesu Christi incipit tractatus fratris Raymundi ord. fr. min. et eorum ministri generalis primo compilatus ab egregio doctore Rogero Bacon. Verbum abbreviatum. . . . Istud vero verbum abbreviatum ab egregio doctore nostro Rogero Bacon, cujus anime propitietur Deus, primo est declaratum, deinde ego fr. Raymundus Gaufredi ord. fr. min. ministri generalis . . . verbum . . . brevius explanare filiis philosophie curavi. In Christi igitur nomine Recipe acetum fortissimum.' Followed on f. 102 by **finalis conclusio Rogeri Bacun.** *Inc.* 'Sume argentum vivum.'—Sloane **288**, f. 167 (sec. xvi) : Sloane **1842**, ff. 32–6 (sec. xvii) : Stowe **1070**, f. 22^{v} (sec. xvi).
Oxford : Bodl. Digby **119**, f. 77^{v} (sec. xiv in.), 'Ab egregio doctore nostro R. Bacon primo declaratum.' Ashmole **1450**, ff. 28–32 (sec. xv).—Cf. Corp. Chr. Coll. **277** (sec. xv).[2]
Paris : Bibl. Nat. **19070**, f. 49 (sec. xvi).
Wolfenbüttel : Herzogl. Bibl. **468** (sec. xv), ff. 214–16^{v} : **3076** (sec. xv), ff. 147–9.

[1] Vatican Pal. Lat. 4092, 'Liber fratris Rogerii de naturis metallorum' seems to be the *Libellus* (or *Semita recta*) *Alchemiae* ascribed to Alb. Magnus : *inc.* 'Omnis sapientia.' (Cf. MS. Corp. Chr. Coll., Oxford, 185, f. 48.)

[2] Contains alchemical receipts, f. 16, Recepta ex Raymundo et Ricardo Furnivalle desumpta : 'Istud verbum habuit predictus Raymundus a fr. Rogero Bacoun anglice ;' f. 20, 'Baconus comedit Martyn,' with later note : 'Quidam volunt haec esse fratris Helie.'

Florence : Riccardi **847** (sec. xv), ff. 31ᵛ–4ʳ.
Rome : Minerva **A.V. 9**, ff. 89–113 (anon.).
PRINTED in *Sanioris Medicinae*, &c., 1603, pp. 264–85.

The printed edition and most of the MSS. (e.g. the early Digby 119) have the following note: 'Explicit verbum abbreviatum maioris operis fr. Reymundi Gaufredi, ministri ord. fr. minorum, quod quidem verbum habuit a fratre Rogero Bacon anglico, qui fuit de ordine fratrum minorum. Et ipse Rogerus propter istud opus ex praecepto dicti Reymundi a fratribus eiusdem ordinis erat captus et imprisonatus. Sed Reymundus exsolvit Rogerum a carcere quia docuit eum istud opus. Et ipse Rogerus erat discipulus fratris Alberti.' A French translation of this note occurs at the end of a treatise entitled '*Le Testament des nobles philozophes*' (*inc.* 'La distinction des secrés des sages philozophes sur la trés excellente pierre des philozophes') in MS. Bibl. de l'Arsenal, Paris, 2872, ff. 401–15 (sec. xiv).[1]

22. **Tractatus trium verborum**, or **Epistolae tres ad Johannem Parisiensem**: namely, (i) 'De separatione ignis ab oleo'; (ii) 'De modo miscendi'; (iii) 'De ponderibus.' *Inc.* i, 'Cum ego Rogerus rogatus a pluribus.' *Inc.* ii, 'Cum promisi tibi mittere duas cedulas.' *Inc.* iii, 'Cum de ponderibus utilis sit distinctio.'

MSS. Brit. Museum : Cott. **Jul. D. v** (secc. xiii, ex.–xiv, in.), ff. 152–8, 160–4).[2] Harl. **3528**, f. 81ᵛ. Sloane **1754**, ff. 62–74 (sec. xiv), 'Mendacium primum, secundum et tertium.' Sloane **2327** (sec. xv), ff. 25–6 (Epp. i, ii), f. 35 (Ep. iii, fragment).

Oxford : Bodl. : Digby **119**, f. 82 (sec. xiv, in.). Ashmole **1416**, ff. 42–51 (sec. xv), **1433**, pp. 1–72 (sec. xvi), **1448**, pp. 1–25 (sec. xv).—Corp. Chr. Coll. **125**, f. 84ᵛ (Ep. i only).

Cambridge : Univ. Lib., **Ff. iv. 12**, ff. 270–94 (sec. xvi).

Bologna : Bibl. Univ. **270** (secc. xv, xvi), p. 81 : Rogerii Bakonis Opus. *Inc.* 'Cum ego Rogerius | auxilio unius diei.' Ibid. **1062** (sec. xiv), ff. 21–33, Rogerii Baconis tract. ad Johannem Parisionum. 'Cum ego Rogerius | sapientia mundi.'—Cf. ibid. **303** (sec. xv), ff. 285ᵛ–90ᵛ :

[1] Hunterian Mus. MS. 253, ff. 89–90, contains *Liber distinctionum sapientum*; anon : *inc.* 'Distinctiones secretorum sapientum,' perhaps the original of this French treatise.

[2] Jul. D. v. ff. 166ʳ–7ᵛ has anon. letter : 'Quesivisti, fili karissime, de incantacione et adiuracione colli suspensione si quid possent prodesse, et sicut inveni in libris grecorum hec qualiter indorum etiam libris invenirem, tue peticioni compendiose in hac epistola cogor respondere. Omnes inquam antiqui in hoc videntur esse concordati . . . altitudinem. Explicit.' Probably the letter of Constantinus Africanus to which Bacon refers in *De mirabili potestate, cap.* ii.

'Liber trium verborum qui dicitur liber Trinitatis | thesaurum habet.'

Cf. Florence: Bibl. Naz.: Strozzi (Magliabecchi) **xvi** (11) **77** (sec. xvi), 'Liber trium verborum dicitur liber divinitatis et trinitatis et hec tria verba sunt de lapide pretioso | fovearum paludum, etc.' (7 leaves, anon.). (These two last entries seem to relate to a different work.)

PRINTED, 1603, as above (pp. 292–387). A new edition is being prepared by M. J. A. Col.

23. **Libellus** or **Epistola Rogerii Bacon . . . de retardandis senectutis accidentibus et de sensibus conservandis** (11 or 12 chapters).[1] This work is assigned by Charles to the year 1276, but it is referred to in *Opus Majus* (Bridges ii. 209), and hence written before 1267. According to the Paris MS. (see below) it was sent to Innocent IV. *Inc. Prol.* 'Domine mundi qui ex nobilissima (*al.* ex nobili bina) stirpe originem assumpsistis . . . Cogito et cogitavi.' *Inc. cap.* i (De causis senectutis) 'Senescente mundo senescunt homines.'

MSS. Brit. Museum: Sloane **2320** (sec. xv ex.), ff. 56–64 (fragment: ends in cap. ii).[2]

Oxford: Bodl. **211** (sec. xv); Bodl. **438**, ff. 1–12^{v} (sec. xv); E Musaeo **155**, pp. 591–637 (secc. xiv–xv); Canonic. Misc. **334**, ff. 1–18 (sec. xv), and **480**, f. 1 (sec. xv); Selden supra **94**, f. 1 (sec. xiv); Arch. Seld. B. **35**, f. 1 (sec. xiv). Cf. Digby **202**, f. 87 (sec. xvi).

Cambridge: Univ. Lib. **Dd. v. 53**, p. 72; Trin. Coll. **922**, f. 1 (sec. xv), in English; and **1389**, f. 106 (sec. xv).

Manchester: Chetham Library, **A. 5. 24** (11366), ff. 1–32 (sec. xv, ex.).

Paris: Bibl. Nat. **6178**, ff. 22–36 (sec. xiv, in.), Epistola . . . missa ad Innocentium quartum. *Inc.* 'Domine mundi qui ex nobili bina stirpe' (anon.: apparently an early version).

Milan: Ambrosiana **I. 210 inf.** (sec. xv).

Rome: Vatican Pal. Lat. **4091**, ff. 71–88 (sec. xvi): ibid. **1180**, f. 332 (sec. xv); and Urbin. Lat. **1443**, f. 1 (sec. xv).

[1] The printed editions have 16 chapters: in the 16th are included the following treatise, No. 24.

[2] Sloane 2320, ff. 27–29^{v}, and Paris, Bibl. Nat. 6978, ff. 34^{v}–36^{v}, contain 'summaria expositio epistole fratris Rogeri Bacon de Retardatione,' &c. (called in Paris MS. 'expositio predicte epistole'): *inc.* 'Rimatus sum moderno tempore omnia fere armaria latinorum et intellexi per interpretationem quorundam grecorum arabum et caldeorum scripta plurima' . . . 'Expositio primi verbi scilicet Olei. Incipiamus igitur in nomine dei . . . verba precedentis epistole vestre sanctitati et clementie aperire . . .'

PRINTED at Oxford, 1590 (and in English, London, 1683). An edition of this work and of Nos. 24, 25, 26, 27, 28 is being prepared by E. T. Withington and A. G. Little.

24. **De universali regimine senum et seniorum.**[1] *Inc.* 'Summa regiminis senum universalis ut dicit Avicenna.'

MSS. Brit. Museum : Sloane **2629**, f. 57.

Oxford : Bodl. **438**, ff. 12^{v}–14^{v} : Can. Misc. **334**, ff. 18^{v}–21^{v} ; and **480** (*explicit*, f. 16) ; E Musaeo **155**, p. 638 ; Selden supra **94**, f. 114^{v}. Arch. Seld. B. **35**, f. 15^{v}.

Cambridge : Trin. Coll. **1389**, f. 1 (sec. xv).

Manchester : Chetham Library **A. 5. 24** (11366), ff. 32^{v}–4.

(This short treatise includes *De balneis senum et seniorum* (*inc.* 'Senes sunt balneandi') : and *De compositione quarundam medicinarum in speciali que iuvant sensum*, &c. (*inc.* 'Incipiamus in nomine domini'), and is printed in cap. xvi of the editions mentioned above.

25. **Antidotarius.** *Inc.* 'Post completum universalis sciencie medicacionis tractatum.'

MSS. Oxford : Bodl. **438**, ff. 14^{v}–21^{v} (sec. xv) ; Can. Misc. **334**, ff. 21 –5, and **480**, f. 16 : E Musaeo **155**, p. 645 ; Selden supra **94**, f. 133 ; Arch. Seld. B. **35**, f. 17^{v}. Cf. Can. Misc. **480**, ff. 38^{v}–47.

Manchester : Chetham Library **A. 5. 24** (11366), f. 37^{v}.

Milan : Ambrosiana **I. 210 inf.** (beginning only).

26. **Liber Bacon de sermone rei admirabilis, sive de retardatione senectutis.** *Inc.* 'Intendo componere sermonem rei admirabilis domino meo fratri E., cuius vitam deus prolonget.'

MSS. Oxford : Bodl. **438**, f. 17^{v} : E Musaeo **155**, pp. 655–66 ; Digby **183**, f. 45 (sec. xiv, ex.) imperf. : Can. Misc. **334**, ff. 25–31 ; Arch. Seld. B. **35**, f. 20 : Selden supra **94**, f. 156^{v}.

Manchester : Chetham Library **A. 5. 24**, f. 45^{v}.

27. **De graduatione medicinarum** (or **rerum**) **compositarum.** *Inc.* 'Omnis forma inherens.'

MSS. Oxford : Bodl. **438**, ff. 21^{v}–2^{v} : E Musaeo **155**, p. 666. Can. Misc. **334**, f. 32 ; **480**, f. 23^{v} ; Selden supra **94**, f. 187 ; Arch. Seld. B. **35**, f. 24^{v}. Cf. Ashmole **1437**, ff. 2–3 (sec. xv).—Corp. Chr. Coll. **254**, f. 178^{v} (sec. xvi).

Cambridge : Trin. Coll. **1389**, f. 20.

Manchester : Chetham Library **A. 5. 24** (11366), f. 45^{v}.

[1] Bacon refers to this or a treatise with the same title as though he were not the author : *Opus Majus*, ii. 210, 213.

28. **Tractatus de erroribus medicorum.**[1] *Inc.* 'Vulgus medicorum non cognoscit.'

MSS. Oxford: Bodl. 438, ff. 22v–8; Can. Misc. 334, f. 42; ibid. 480, f. 30; E Musaeo 155, pp. 669–89; Selden supra 94, f. 194; Arch. Seld. B. 35, f. 31.—Corp. Chr. Coll. 127 (sec. xv).
Cambridge: Trin. Coll. 1389, f. 22.
Manchester: Chetham Lib. A. 5. 24 (11366), f. 58.

29. **De diebus criticis.** *Inc.* 'Ad evidentiam dierum creticorum.'

MS. Erfurt: Amplon. Q. 215, ff. 79v–83 (sec. xiv).
EXTRACTS PRINTED in Elfferding, *Roger Bacons Schriften über die critischen Tage* (Erfurt, 1913).

30. **De crisi morborum.** 'Incipit tractatus de creticis diebus quem fecit fr. Rogerus Bacun de ordine Minorum. Omnis egritudo de qua curatur homo.'

MS. Erfurt: Amplon. Q. 215, ff. 83v–5v.
PRINTED in Elfferding, *u.s.*

31. **Canones practici de medicinis compositis componendis** (13 or 15 chapters). 'Cap. i. Extractum de libro septimo Serapionis qui est antidotarium suum et est theoricum capitulum.' *Inc.* 'Necesse esse illi qui vult componere medicinas.' 'Explicit tractatus de compositione medicinarum per fratrem rugerium bacon editus.'

MSS. Bodl. Can. Misc. 480, ff. 38v–47 (sec. xv); Arch. Seld. B. 35, f. 43 (sec. xiv).

This corresponds for the most part with the translation of the *Breviarium* of the son of Serapion, Lib. vii, capp. 1–15, ascribed to Gerard of Cremona and preserved in Brit. Museum MS. Burney 350, f. 82v et seq. (sec. xiii ex.). It probably ought to be placed among the 'Doubtful and Spurious Works'.

32. **Grammatica Graeca.**

(1) 'Oxford' Greek Grammar.

MSS. Oxford: Corp. Chr. Coll. 148, ff. 1–42 (sec. xiv): 'Primus hic liber voluminis grammatici circa linguas alias a latino qui est de grammatica graeca habet tres partes.' *Pars I, Dist. i, cap.* 1: *inc.* 'Manifestata laude et declarata utilitate cognicionis grammatice

[1] Sloane MS. 3744, f. 35 (sec. xv), contains *Errores secundum Bacon. Inc.* 'Scito enim quod omne corpus aut est elementum aut ex elementis compositum.' According to Charles (p. 71) it is the *Tract. de erroribus medicorum.* This is a mistake. It treats of alchemical errors and reads more like Arnald de Villeneuve than Bacon. The beginning and end are wanting.

quatuor linguarum, scil. grece, hebree, arabice et caldee.'—University College **47** (abbreviated copy of Corpus Christi MS.).

Brit. Mus.: Cotton **Julius F. vii**, f. 175 (a fragment of one leaf), (sec. xv).

Douai **691** (identical with Univ. Coll. MS.).

(2) 'Cambridge' Greek Grammar.

MS. Cambridge: Univ. Lib. **Ff. vi. 13**, ff. 67–9 (secc. xiii–xiv), begins with Greek alphabet.[1]

PRINTED in *The Greek Grammar of Roger Bacon and a Fragment of his Hebrew Grammar*, ed. Nolan & Hirsch, Cambridge, 1902, pp. 3–182, 183–96 (cf. *Comp. Phil.* i, No. 35 below).

33. **Grammatica Hebraica.**

MS. Cambridge: Univ. Lib. **Ff. vi. 13**, f. 66 (secc. xiii–xiv) fragment.[2]

PRINTED in Nolan and Hirsch, *u.s.*, pp. 202–8.

34. **Summa Grammaticae.** *Inc.* 'Oratio grammatica aut fit mediante verbo prime persone.'

MSS. Cambridge: Peterhouse **191**, ff. 30–50 (secc. xiii, xiv): *Expl.* f. 50^{v}: 'stabit pro die dominica. Explicit summa de grammatica magistri Rogeri Bacon.'

Worcester Cathedral, **Q. 13**, ff. 5–24 (sec. xiv), anon. (same as Peterhouse MS.).[3]

35. **Compendium Philosophiae**, or **Scriptum Principale.**

An encyclopaedic work on which Bacon seems to have been already engaged before he received the Pope's command, and

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[1] Cf. Brit. Museum: Cott. **Tib. C. v**, f. 46 (after *Opus Tert.*): 'Decem et octo preposiciones habent greci 12 dissillabas 6 monosillabas: prime sunt hec: apo, ana,' &c. Then follow explanations of words beginning with these prepositions (1 page): f. 47, 'Lincolniensis post expositionem prologi angelice Ierarchie. In Greca scriptura sunt due chie' (2 pages).

The Greco-Latin Lexicon in College of Arms MS. Arundel IX, described by M. R. James in *Mélanges offerts à M. Émile Chatelain*, is not by Bacon.

[2] The (as yet unpublished) Notes or Letters to inquirers, chiefly on Hebrew and Greek grammar, with special reference to the Bible, described by Samuel Berger in *Quam notitiam linguae Hebraicae habuerint Christiani medii aevi temporibus in Gallia*, Paris, 1893, are perhaps by Roger Bacon, more probably by William de Mara. (The author refers to his lectures on Lamentations—'cum legerem Trenos,' &c.—evidently in the Univ. of Paris.) *Inc.* 'Quoniam quedam glose mencionem faciunt de literis et vocabulis hebreis et grecis.' MSS. Toulouse **402**, f. 233 (sec. xiii). Florence: Laurent. **pl. xxv sin. 4**, ff. 179–210 (secc. xiii–xiv), 'Compilacio fratris Guillelmi de Mara . . .' Einsiedeln **28**, f. 212 (extracts) (sec. xiv).

[3] Sloane MS. **1086**, f. 5, a fragment of a table of contents, sec. xiv, has *inter alia*: 'Vtilis summa grammatice quam composuit Rogerus Bacon.'

which if completed would have formed a kind of revised and enlarged edition of the *Opus Majus*, *Opus Minus*, and *Opus Tertium*. In the *Communia Naturalium* (ed. Steele, p. 1) Bacon gives a sketch of his plan. The work was to consist of four volumes and to treat of six branches of knowledge, viz. vol. i, Grammar and Logic; vol. ii, Mathematics; vol. iii, Physics (*Naturalia*); vol. iv, Metaphysics and Morals. This *Compendium* seems also to have been known as *Liber Sex Scientiarum*. The latter title is found in the collection printed at Frankfurt, 1603, in Bodl. MSS. Bodl. 438, f. 28; Can. Misc. 334, f. 49^{v}; 480, f. 33; Selden supra 94, f. 240^{v}; Arch. Seld. B. 35, f. 37^{v}; and E Musaeo 155, p. 689 (cf. Trin. Coll. Camb. 922, f. 53). In each of these MSS. the same passage is quoted as follows: 'Dicta fratris Rogerii Bacon in libro sex scientiarum in 3° gradu sapiencie, ubi loquitur de bono corporis et de bono fortune et de bono et honestate morum. (*Inc.*) In debito regimine corporis et prolongatione vite ad ultimos terminos naturales . . . miranda potestas astronomie alkimie et perspective et scientiarum experimentalium. Sciendum igitur est pro bono corporis quod homo fuit immortalis naturaliter. . . . (*Expl.*) ut fiant sublimes operaciones et utilissime in hoc mundo,' &c. Charles identifies the *Liber Sex Scientiarum* with the *Opus Minus*; but this passage does not occur in the extant portion of the *Opus Minus* which deals with the same subject and expresses the same ideas (Brewer, p. 370 seq.). It seems probable, therefore, that the passage is an extract from the section on Alchemy in vol. iii of the *Compendium Philosophiae*.

Vol. I. *Grammar and Logic*. The fragment printed by Brewer under the title *Compendium Studii Philosophiae* may be a portion of this volume. It was written about 1272, and contains an introduction on the value of knowledge and the impediments to it, and the beginning of a treatise on grammar. *Inc.* 'Quatuor sunt consideranda circa sapientiam quae volo ad praesens in summa et sub compendio quasi introductionis modo tangere.'

MS. Brit. Museum: Cotton Tib. C. v, ff. 120–51 (sec. xv).
PRINTED: Brewer, *Op. Ined.*, pp. 393–519.

For other treatises on Grammar which may in some form or other have formed part of the *Comp. Phil.* see Nos. 32, 33, 34.

Vol. II. *Mathematics*[1]: six books: (i) *Communia Mathematicae*; (ii–vi) Special branches of mathematics. *Inc.* Liber i. 'Hic incipit volumen verae mathematicae habens sex libros. Primus est de communibus mathematicae, et habet tres partes principales.'

[1] The treatise *De laudibus mathematice* (No. 16) cannot (as suggested in *The Grey Friars in Oxford*, p. 203) have been intended as an introduction to this volume, as it begins 'Post hanc scientiam experimentalem', &c. In the *Compendium Phil.* physics follow mathematics, not vice versa.

MSS. Brit. Museum: Sloane **2156**, ff. 74–97 (sec. xv), ending in the second part of the first book.

Bodl.: Digby **76**, f. 48 (sec. xiii), containing the remainder of the first book (?), or another recension (?). *Inc.* 'Mathematica utitur tantum parte': *expl.*, f. 64^{r}, 'numerare conveniet.' F. 65^{r}: 'Expeditis hiis que exiguntur ad proportiones.' F. 69^{r} [Pars II], 'Determinato de parte mathematice prima': *des.*, f. 76^{r}, 'similia trapezeis.'

EXTRACTS printed in Charles, pp. 361–8.

An edition of the *Com. Math.* is being prepared by Mr. Steele and Professor D. Eugene Smith.

Libri ii–vi. An extant fragment of a commentary on the Elements of Euclid, probably by Bacon, may have belonged to this part.

MS. Bodl.: Digby **76**, ff. 77–8 (sec. xiii). *Inc.* 'Titulus autem istius libri secundum auctores.'

Vol. III. *Physics* (or *Natural Philosophy*), four books: (i) 'de communibus ad omnia naturalia'; (ii) 'de celestibus'; (iii) 'de elementis et mixtis inanimatis'; (iv) 'de vegetabilibus et animalibus' (Steele, *Communia Naturalium*, p. 1).

Elsewhere (ibid. pp. 5–8), Bacon enumerates the seven 'special sciences' which he includes in Physics: namely (1) Perspectiva (or Optics); (2) Astronomia judiciaria et operativa (or Astrology); (3) Scientia ponderum de gravibus et levibus; (4) Alkimia, *or* Scientia de omnibus rebus inanimatis que fiunt primo ex elementis; (5) Agricultura *or* Scientia de plantarum natura et animalium . . . scilicet de omnibus animatis preterquam de homine; (6) Medicina ('de animali rationali, scilicet de homine, et precipue de sanitate et infirmitate ejus,' &c.); (7) Scientia experimentalis. Bacon adds that he may not be able to treat of the special sciences, except Perspectiva, on which he desires to compose a compendious treatise, but hopes that others may be induced by his labours to deal with them.

It would appear, therefore, that the special sciences were not included in the four books comprising Vol. III; all these would thus be devoted to general principles.

Books i and ii are extant, and possibly a fragment of Book iii; of Book iv there seems to be no trace.

No treatises on the special sciences seem to have been written for the *Compendium Philosophiae*, except perhaps a version of the *De Multiplicatione Specierum* (see No. 11), treating of the science of Optics. The compendious treatise on Perspectiva was written for and included in *Opus Majus* (Part V), and the other sciences mentioned are treated more or less fully in various works of Bacon.

Liber i. *Communia Naturalium*, divided into four parts. *Inc.* Pars i, 'Postquam tradidi grammaticam;' Pars ii, 'Dicto de efficiente;' Pars iii, 'Postquam in prima parte hujus libri;' Pars iv, 'Nunc tempus est ut fiat descensus.'

MSS. Brit. Museum: Royal **7 F. vii**, ff. 84–112^{v} (sec. xiii ex.): 'Hoc est volumen naturalis philosophie in quo traditur sciencia rerum naturalium secundum potestatem octo scienciarum naturalium que enumerantur in secundo capitulo,' contains Parts i, ii, iii, and capp. 1–7 of Part iv. *Inc.* 'Postquam tradidi grammaticam secundum linguas diversas': *expl.* 'terminus generacionis' (Steele, p. 267).

Cotton Fragment **iv**, f. 22, contains a copy of diagrams on ff. 91^{v}, 92 of the Royal MS. (Steele, p. 87).

Sloane **2629**, f. 56^{v}, contains a few lines on moral philosophy from *Com. Nat.* (Steele, p. 2).

Oxford: Bodl.: Digby **70** (sec. xv in.). *Inc.* 'Postquam tradidi grammaticam.' Contains the same as Royal MS.

Paris: Bibl. Mazarine **3576**, ff. 1–90 (secc. xiv–xv), contains all the four parts. *Inc.* 'Postquam tradidi,' &c.

Another version[1] of parts of the same work is contained in

MSS. Brit. Museum: Royal **7 F. vii**, f. 113 (sec. xiii ex.). *Inc.* 'Ostensum est in principio cuiusdam tractatus quod necessarium est Latinis.'—Add. **8786**, ff. 2–10^{v} (sec. xiv). *Inc.* 'Ostensum quippe (?) in principio huius compendii philosophiae.' *Expl.* 'terminus generationis' (Steele, p. 267).

Oxford: Bodl.: Digby **190**, ff. 29–37^{v} (secc. xiii–xiv), Rogeri Bacon Tract. de principiis naturae. *Inc.* 'Substancia igitur alia est. . . . Item omne genus' (Steele, p. 50). *Expl.* 'terminus generationis.'

PRINTED by Robert Steele, *Opera hactenus inedita Rogeri Baconi*, Fasc. II and III (Oxon., 1909, 1911).

Extracts in Charles, pp. 369–91.

Liber ii. *Astronomy* or *De Coelestibus*, divided into five parts. *Inc.* Pars i, 'Prima igitur veritas;' Pars ii, 'Habito quod oportet ponere quinque corpora;' Pars iii, 'Quinque igitur corporibus mundi;' Pars **iv**,

[1] It is possible that this was meant to form part of the *Comp. Studii Theologie* (see No. 36). Mr. Steele, however, regards this treatise as the first part of the *Communia Metaphys.*, and holds that it was in existence before any part of the *Com. Nat.* was written. In parts it is identical with *Com. Nat.*

'Nunc investigandus est numerus celorum;' Pars v, 'Terminata parte in qua investigavimus numerum.'

MSS. Paris: Bibl. Mazarine 3576, f. 91a: 'Incipit 2us liber communium naturalium qui est de celestibus uel de celo et mundo cuius hec est pars prima.' Cap. 1, 'Prima igitur veritas.'

Oxford: Bodl.: Digby 76, ff. 1–35v (sec. xiii), *Compendium Philosophiae*. *Inc.* 'Prima igitur veritas circa corpora mundi est quod non est unum corpus continuum et unius nature.' Ibid., f. 36, 'De corporibus coelestibus, sc. de zodiaco, sole,' &c. *Inc.* 'Habito de corporibus mundi prout mundum absolute constituunt' (written in 1266, probably an early draft made before Bacon had settled on the scheme of the *Opus Majus*). —Cf. Ashmole 393, I, f. 44 (sec. xv), 'Veritates de magnitudine . . . planetarum, Tractatus extractus de libris celi et mundi nobilissimi illius philosophi et doctoris S. theol. R. B. qui omnia rectificavit a tempore primorum auctorum astronomie usque ad tempus suum.' F. 44v, 'Sequitur tractatus alius de eisdem libris celi et mundi . . . de necessariis circulis in celo ymaginatis. . . . Primo igitur sciendum quod nullus cir[culus] secundum veritatem est in celo nisi gallaxa tantum.'[1]

PRINTED by Robert Steele, *Opera hactenus inedita*, Fasc. IV (Oxon., 1913).

Liber iii. *Alchemy*, or '*De elementis et mixtis inanimatis*'. Cf. 'Excerpta ex libro sex scientiarum' in *Sanioris medicinae*, &c. (Frankfurt, 1603), pp. 7, 8. 'Quarta vero scientia non modicam habet utilitatem . . . et est Alchymia speculativa,' &c., and the following passage, pp. 9–16: 'Idem Rogerus libro praedicto probat quod ex his cum adjutorio scientiae experimentalis,' &c.

Liber iv. '*De vegetabilibus et animalibus*' ('Agriculture' and Medicine).

Vol. IV. *Metaphysics and Morals.*

A fragment of the Metaphysics only has hitherto been known. This was written in or before 1266, and much

[1] Cf. Digby 183, f. 38. *Alkindus de radiis stellarum*; 'Omnes homines qui sensibilia sensu percipiunt;' with marginal note, 'quod est extractum de libro Rogeri Bakun de celo et mundo, capitulo de numero celorum.' Cf. Brit. Mus. Add. 8786, ff. 10v–12v: no title. *Inc.* 'Numerus sperarum continentium.'

of it is included in the *Opus Majus*, Part VII (see Preface and Appendix to Steele's edition). *Inc.* 'Quoniam intentio principalis est innuere nobis [*or* vobis] vicia studii theologici.'

The discovery of the whole work is announced by Dr. Nogara, Dr. Pelzer and the Rev. H. M. Bannister of the Vatican Library as these pages are passing through the press.

MSS. Oxford: Bodl.: Digby **190**, f. 86^{v} (fragment): title: 'Metaphisica fratris Rogeri O.F.M. de viciis contractis in studio theologie.' [1]

Paris: Bibl. Nat. **7440**, ff. 38–40, 25–32.

Rome: Vatican. **2227**, ff. 48^{r}–67^{r} (sec. xiv), 'De vitiis contractis in studio theologie' (anon.); Vat. **5004** (Alb. Magnus).

PRINTED, in *Opera hactenus inedita*, ed. R. Steele, Fasc. I (fragment only).

Extracts in Charles, *Roger Bacon*, pp. 391–7.

36. **Compendium studii theologiae**, Bacon's last work, written in 1292. In three or more parts. *Inc.* 'Quoniam autem in omnibus causis autoritas.'

MSS. Brit. Museum: Royal **7 F. vii**, ff. 78–83, incomplete, containing Part I, capp. 1–2, Part II, capp. 1–6. (At the end of the article a seventeenth-century hand adds: 'quaere residuum, p. 221,' referring to the version of the *Communia Naturalium* already mentioned, beginning 'Ostensum est' (see p. 405 above).

Oxford: Univ. College, 47 (sec. xvii), copied from Royal MS.

PRINTED in *Brit. Soc. of Franciscan Studies*, vol iii (ed. Rashdall), 1911.

Extracts in Charles, pp. 410–15.

II. DOUBTFUL AND SPURIOUS

37. **Summulae dialectices**, an elementary treatise on logic, characterized by Charles, who expresses a doubt as to its authenticity, as very dry, unimportant, and intended for lecturing purposes. *Inc.* 'Introductio est brevis et apta demonstratio in aliquam artem vel scientiam.' 'Expliciunt sumule magistri Roberti Baccun' (perhaps by Robert Kilwardby (?), see No. 38: or Petrus Hispanus (?), see Quetif-Echard, *Script. Ord. Praed.*, i. 485).

MS. Bodl.: Digby **204**, f. 48 (sec. xiv in.).

[1] Duhem, *Opus Tertium*, p. 33, argues that this formed part of the *Opus Tert.*, but see Little, *Part of the 'Opus Tert.'*, &c., pp. xxviii–xxx.

38. **'Sincateg[o]reumata fratris R. Bacon'** (tit. manu secunda). *Inc.* 'Parcium orationis quedam sunt declinabiles' (probably by Robert Kilwardby).[1]
MSS. Bodl.: Digby **204**, f. 88 (sec. xiv in.).
Erfurt: Amplon. **Q. 328**, ff. 74^{r}–93^{r} (sec. xiii).

39. **Tractatus de signis logicalibus.** *Inc.* 'Signum est in predicamento relationis et dicitur essentialiter.' *Expl.* 'Dicendum est quod dupliciter intelligitur aliquid in alio.'
MS. Bodl.: Digby **55**, f. 228 (sec. xiii ex.). (The ascription of this to Roger Bacon is in a later hand.)

40. **Quaestiones super librum de Causis.**
Inc. 'Supra librum de causis. Queritur circa influentiam causarum, utrum causa (?) agat per influentiam.'
MS.: Amiens **406**, ff. 114–29^{v}. Anon. and incomplete: a quire is missing between ff. 117 and 118: and ff. 125 and 126 have nothing to do with the treatise.
Described by V. Cousin, *Journal des Savants*, 1848.

41. **De somno et vigilia** (two books).
MSS. Bodl. Digby **190**, ff. 77–86^{v} (sec. xiv in.). *Inc.* 'De somno et vigilia pertractantes Perypateticorum sentenciam potissime sequemur' (name of author added in hand of seventeenth century).
Cambridge: Univ. Libr. **Ii. vi. 5**, ff. 85^{v}–8 (sec. xiii), [*Rogerus Bacon de somno et vigilia*][2]; *Inc.* 'Sompnus ergo et vigilia describuntur multis modis. Dicitur enim quod sompnus est sensus in potentia' (7 chapters).
(*Tractatus de sompno et vigilia*, by Roger Bacon, was contained in a MS. of St. Augustine's Abbey, Canterbury, No. 843 in the catalogue ed. M. R. James.)

42. **'Bacon in Meteora'** (tit. manu sec. xvi ex.).[3] *Inc.* 'Cum ad noticiam impressionum habendam.'
MS. Bodl. Digby **190**, ff. 38–43^{r} (sec. xiv in.).

[1] See L. Baur, *Die philosophischen Werke Grossetestes*, p. 121*. Cf. Bale, *Index Brit. Script.*, p. 395, who mentions among Bacon's works: *De constructione partium* [*orationis*]: *inc.* 'Ad completam cognitionem constructionis.' In the Syon MS. A. 4, from which Bale took this entry, the treatise appears from the Catalogue (ed. Mary Bateson, p. 2) to have been anonymous but to have followed 'Summa grammaticalis fratris Rogeri Bakon.'

[2] The Catalogue attributes it to Bacon, but I failed to find anything in the MS. itself to support the statement.

[3] Mr. Steele tells me he thinks this is not by Bacon. The writer refers to Albertus Magnus.

43. [**Quaestiones de perspectiva.**]

MS. Amiens **406**, ff. 155–65, fragment of a treatise (anon.) [1] on optics in the form of *quaestiones*, beginning in cap. iv, quaest. 9: '. . . ergo natura communis per quam perspicuum inest corporibus partium expansio': and ending with cap. xii, entitled: 'De radio exeunte ab oculo et de eius natura et quomodo per ipsum contingat videre et quomodo non,' &c. This cap. xii contains ten *quaestiones*, the tenth beginning: 'X[a] est de modo secundum quem res magne rotunde et quadrate presentantur in oculo qui est corpus parvum et figure rotunde' [*des.*].

44. '**Speculi almukefi compositio secundum Rogerium Bacon**' [or **De sectione conica**]. *Inc.* 'Quia universorum [*al.* diversorum] quos de speculis ad datam distantiam comburentibus tractare perpendi seu quorum vidi tractatus in scriptis, omnes et singuli duas supposuerunt conclusiones ab Apollonio Pergeo allegatas, super quibus tota eorum intentio fundabatur' [at the end: he could say much more about specula, but fears to repeat what has been said by Apollonius, whose book he has never seen] 'quanquam exactissimam diligentiam opposuerim eum vidisse, ideo presenti opusculo cum laude Dei dicta sufficiant. Explicit feliciter.'

MSS. Bodl. Can. Misc. **480**, ff. 48–55 (sec. xv).

Florence: Bibl. Naz.: Ashburnham **957**, ff. 95–110[v] (sec. xv).

Brit. Mus.: **Tib. B. ix** (sec. xv in.), ff. 227[v]–30[r], injured by fire: beginning and end illegible: refers to Apollonius, Vitello, &c.: f. 228[r], 'In omni seccione parabola signato puncto in medio sagitte'; f. 228[v], 'In speculo concavato concavitate sectionis Mukefi omnis' (= Prop. ix of Gogava's edition), followed by 'Premissis autem conclusionibus istis novem . . .' (f. 228[v]), and by *De speculis comburentibus* (see No. 45).

PRINTED in a humanistic version by Antonius Gogava Graviensis in *Cl. Ptolomaei Pelusiensis Mathematici Operis Quadripartiti in Latinum Sermonem traductio . . . Item de sectione conica, orthogona, quae parabola dicitur; deque speculo Vstorio Libelli duo hactenus desiderati*, Lovanii, 1548.

Cf. Nos. 17*a*, 17*b*, above.

45. [**De speculo comburenti, concavitatis parabolae.**] *Inc.* 'De sublimiori quod geometre adinvenerunt et in quo antiqui soliciti fuerunt et in quo bonitas proprietatum figurarum

[1] Possibly by the author of the *Summa Philosophiae* ascribed to Grosseteste? See Baur, *Die philosophischen Werke Grossetestes*, pp. 133*, 512.

geometricarum apparet et quod ab eis accidit ex rebus naturalibus est fabricatio speculorum comburentium per conversionem radii solaris. Incesserunt (scil. philosophi) ergo inveniendo ea modis diversis.' *Expl.* 'super longitudinem quesitam. Sermo ergo iste comprehendit omnem operationem speculorum comburentium que sunt secundum hanc figuram et sunt fortioris combustionis omnibus speculis quoniam radii convertuntur ex tota superficie eorum ad punctum unum.'

MSS. Brit. Mus.: **Vesp. A. ii**, ff. 140–4, with many diagrams on ff. 146, 147 (secc. xiii ex.–xiv in.), anon. Title (secc. xiv ex.–xv in.), 'De sectione Mukefi;' inscribed in John Dee's hand: 'Joannes Dee 1555. Antiquissimus libellus de speculis comburentibus.' 'Explicit de speculis quolibetmodo comburentibus.'—**Tib. B. ix** (sec. xv in.), ff. 230^{v}–2^{r}, injured by fire; beginning and end illegible: f. 231^{r}, 'In omni seccione parabola latus erectum duplum est,' contains a few diagrams.

Oxford: Corp. Chr. Coll. **260**, p. 147 (sec. xvii in.), Twyne's copy of **Vesp. A. ii**.

(Cf. Florence: Bibl. Naz.: Ashburnham **957** (sec. xv), ff. 111^{r}–22^{r} (anon., no title, but following directly on the 'Spec. Almukefi sec. Roggerium Bacon'): 'Ut facilius fiant corpora quinque regularia de quibus tractat Euclides in ultimis suis libris': *expl.* 'Sermo ergo iste . . . ad punctum suum [cf. *supra*]. Explicit de speculis comburentibus feliciter' (this seems to contain matter not in **Vesp. A. ii**).

Cf. Bodl. Can. Misc. **480**, ff. 55^{r}–6^{v}: *inc.* 'Ut facilius fiant corpora': *expl.* 'satis liquerunt ipsa proposita Deo gratias.'

PRINTED, the earlier part only, i.e. **Vesp. A. ii**, ff. 140–3 (to 'lateris erecti, et illud est quod demonstrare volumus'), in a revised version by Gogava, *ut supra*, Louvain, 1548, under the title: *Antiqui scriptoris libellus de speculo comburenti, concavitatis parabolae. Inc.* 'Ex sublimioribus quae Geometrae': *expl.* 'lateris erecti. Atque illud est quod in errandum sumpsimus.'

Cf. Nos. 17*a*, 17*b*, above.

46. **De mutabilibus pronosticorum elementorum.** *Inc.* 'Scribo vobis qui vultis de mutabilibus pronosciorum elementorum que ab astris contingunt omni tempore seculi huius.' 'Explicit tractatus subtilissime considerationis fratris R. B. ordinis minorum qui experimentarius dicitur.'

MS. Winchester College **Y. 8** (sec. xv ex.), 13 leaves, paper. (It consists of 8 *quaestiones*; 1 de humore aeris, 2 de gelu et quando humor cadens congelatur, 3 de tonitruo, 4 de terre motu, 5 de stellis que fiunt in aere, 6 de ventis, 7 de motu oceani, 8 de pestilentia.)

47. **Speculum Astronomiae.** *Inc.* 'Occasione quorundam librorum,' generally ascribed to Albertus Magnus, and printed among his works (*Opera Omnia*, Lugd. 1621, vol. v; Paris, 1891, vol. x), is ascribed to Roger Bacon by Mandonnet, who maintains that it was written in 1277: *Revue néo-scolastique de philosophie*, xvii. 313–35 (August 1910).

MSS. Bodl. Digby **81**,[1] f. 102. 'Tractatus quem composuit Albertus fr. predicator.'—Digby **228**, f. 76 (sec. xiv), anon.—Can. Misc. **517**, f. 52^{v} (sec. xv), 'Alberti magni speculum de nominibus librorum astrologie.'

Erfurt: Amplon. **Q. 223** (sec. xiv ex.), ff. 105–16: 'Tract. de nominibus librorum astronomie cui inscribitur speculum Alberti.'

Venice: S. Marco, **Cl. xi, Cod. 71** (Z.L. 337).

Vienna: Bibl. Pal. **5508** (secc. xiv–xv), ff. 161^{v}–80^{v}.

48. **Tractatus de incarnatione sive de secretis philosophiae**, or **De probatione fidei Christianae per auctoritates paganorum**, or **De adventu Christi secundum carnem**: *inc.* 'Quoniam occasione cuiusdam sermonis quem ad clerum feceram,' generally ascribed to John of Paris, O.P. (surnamed 'Qui dort'), is ascribed to Roger Bacon by Father F. Delorme, who is preparing an edition of the work. Cf. *Archivum Franc. Hist.*, April 1911; *Archiv f. Lit. u. K.-Gesch.*, iv. 312–39.

MSS. Oxford: Bodl. Can. Eccl. **19** (sec. xiv).—Lincoln Coll. **81** (sec. xv).

Paris: Bibl. Nat., Lat. **13781**. Bibl. de l'Arsenal, **78**. Laon **275**.

Cf. Bateson, *Cat. of Syon Monastery*, O 60 (p. 148), K 18 (p. 215).

Many works on alchemy are attributed to Bacon erroneously or without probability. A few of the following may, however, be genuine.

49. **Speculum alchemiae (de transmutatione metallorum).** *Inc. praef.* 'Multifarie [Multifariam] multisque modis . . .' *Cap.* 1. 'In antiquis philosophorum libris' (7 chapters).

MSS. Brit. Museum: Addit. **8786**, f. 62; **15549**, f. 101 (with the introductory letter); Sloane **1754**, ff. 62–74

[1] This volume formerly contained 'Cosmographia R. Bacon 21. Scaccarium morale 87. Mathematices vis et usus 67.'

(sec. xiv) ; Sloane **3506**, ff. 42–6 (English) ; Sloane **692**, ff.1–19, 113–17 (sec. xv) ; Sloane **3688**, ff. 87–91.

Oxford : Bodl. : Ashmole **1416**, f. 101.—New Coll. **294** (French).

Cambridge : Univ. Libr. **Ff. iv. 12**, f. 39, called ' Rosarium Johannis.'—Trin. Coll. **915**, f. 117 ; cf. ibid. **1120, III**, f. 28^{v}, ' Bacon in Speculo alkymie ; Inter cetera que dixi.'

Paris : Bibl. Nat. (franç.) **2012** (sec. xvi), f. 34, ' Miroir d'alchimie trad. de Rog. Bacon par Girard de Tornus.'[1]

Montpellier : École de Médecine **479** (sec. xv), Speculum alchemiae Rogerii Bacconis (no *incipit* given in Catalogue).

Florence : Bibl. Naz., Strozzi (Magliabecchi), **xvi (7) 30** (sec. xvi), Doctissimi viri Rogeri Bacconis de alchimia libellus cui titulus speculum alchimie. *Inc.* ' Multifariam,' &c., cap. 1, ' In pluribus antiquorum codicibus ' (ends imperf., p. 16).

Bologna : Bibl. Univ. **270** (secc. xv–xvi), vol. xxvi. *Inc.* ' Multifarium.'—Ibid. **1062** (sec. xiv), ff. 1–6 [Spec. Alch. Rog. Baconis], ' Multiphariam.'—Ibid. **303** (sec. xv), ff. 157^{v}–63^{v} Speculum Alchimie. *Inc.* ' Multipharie '[2].

Vienna : Bibl. Pal. **5509** (sec. xv), ff. 330–1^{v}, Rogerius Bacon, Spec. Alchymiae (no *incipit* given).

PRINTED at Nürnberg, 1541 ; in Zetzner's *Theatrum Chemicum* (1659), vol. ii, pp. 377–433. Manget's *Thesaurus* (1702), i. 613, &c. French translation, 1557[3] ; English translation, 1597, and in Salmon's *Medicina Practica* (1707), p. 621.

50. **Speculum Alchemiae** (perhaps by Arnald de Villeneuve ?) *Inc.* ' Speculum alchemie quod in corde meo figuravi.'

MS. Brit. Mus. : Harl. **3528**, f. 185.

Cf. Bologna : Bibl. Univ. **270** (secc. xv–xvi), vol. x, ' Speculum Alchimie Bakonis. Incipit speculum alchimie ' : *expl.* ' ubi vult spirat.'

51. **Speculum Alchemiae,** doubtfully ascribed to Bacon by Nasmith : *inc.* ' Sciendum est quia philosophi per 4^{or} verba hoc opus compleverunt ' : *expl.* ' sufficiunt intellectum habentibus.'

MS. Cambridge : Corp. Chr. Coll. **99**, p. 189 (sec. xv), anon.

Cf. Bodl. : Ashmole **1416**, f. 37, ' Libellus alchemicus de quatuor verbis.'

[1] This Paris MS. also contains (f. 73) Livre du maître Jupiter par Roger Bacon (possibly extract from *Breve Breviarium*, No. 20).

[2] A copy of this *Spec. Alchem.* (sec. xv, anon.) *inc.* (f. 169) ' Multipharie,' was in a Phillipps MS. sold at Sotheby's, April 24, 1911, Lot 7.

[3] Reprinted 1612, 1627, under the title *Miroir de maistre Jean Mehun.*

52. **Speculum Alchemiae.** *Inc.* 'Tract. sciencie naturalis sive de lapide philosophorum . . . secundum fratrem Rogerum Bacon. Salutem [quam] tibi amice karissime et speculum.'

MSS. Brit. Mus.: Sloane **692**, ff. 115–7.

Cambridge Univ. Lib. **Ff. iv. 12**, ff. 267–71 (anon.).

Cf. Bologna: Bibl. Univ. **1062** (sec. xiv), ff. 34–6. Tractatus qui dicitur Speculum Baconis: *inc.* 'Salutem': *expl.* 'valete'.

Cf. Leyden: Bibl. Univ. **Q. 27**, Chim. Voss. 64.

53. **Speculum Secretorum**, or **Liber Secretorum de spiritu occulto.** *Inc.* 'In nomine Domini . . . ad instructionem [instantiam] multorum.'

MSS. Brit. Mus.: Sloane **513**, ff. 178^{v}–81, 'Explicit liber secretorum quem Rogerus Bakun composuit.' Sloane **1081**, ff. 178–98 (sec. xv): Sloane **1118**, ff. 50–6 (sec. xv).

Oxford: Bodl. **177**, f. 54^{v} (sec. xiv ex.), anon.: Digby **28**, f. 61; Digby **119**, f. 90^{v}; Ashmole **1467**, ff. 208^{v}–13^{v} (sec. xvi); **1485**, p. 117. Corpus Christi Coll. **125**, f. 86 (anon.).

Cambridge: Univ. Lib. **Ff. iv. 12**, f. 298^{v}, followed by '*Cedula declarativa Magistri Rogeri Bacon*': *inc.* 'Quia diximus in speculo secretorum'.[1]

Florence: Riccardi **390**, ff. 138–44, followed by *Liber claritatis Rog. Bacon*: *inc.* 'De libro claritatis totius artis alchimie' (ff. 144^{v}–50^{v}).

Cf. Florence, Bibl. Naz., Pal. **758** (sec. xv), **885** (sec. xvi), **887** (sec. xvi).

PRINTED in *Sanioris Medicinae*, &c., at Frankfurt, 1603 (pp. 387–408).

54. **Secretum secretorum naturae de laude lapidis philosophorum.**[2] *Inc.* 'Secretum secretorum naturae audiant secreti quae loquor.'

MS. Oxford: Bodl.: Digby **119**, ff. 80–1 (sec. xiv in.).

PRINTED at Frankfurt, 1603 (pp. 285–91).

Cf. Leyden: Bibl. Univ. **Q. 27**, Chim. Voss. 64. Roger Bacon, *Theoretica de lapide philosophorum.*

55. **Radix mundi**, or **Tractatus alchemicus de lapide philosophico.**[3] *Inc.* 'Omnium corpora constancium tam perfecta quam imperfecta.'

[1] Cf. Ashmole 1478, ff. 39–40 (sec. xvi), 'Cedula declarativa Baconis. Amice, in istis consistit difficultas operis nostri.'

[2] Winchester College 39 (sec. xv), ff. 33–40, has anon. treatise beginning: 'Quesivisti quis trium lapidum nobilior.'

[3] Tanner, Bibl. p. 64, mentions a MS. of Roger Bacon *De philosophorum lapide* at Pembroke College, Cambridge: it is not there now.

MSS. Oxford: St. John's College **172**, ff. 311^{v}–21 (sec. xv), anon.: 19 chapters.

Bodl. Digby **133** (sec. xvi), f. 22: English translation, 'by Robert Freelove of London, mercer, the 16 of Februarii a° 1550': 15 chapters; beginning, 'The bodies of all things being' (attributed to Roger Bacon). Ashmole **1418**, ff. 47–60 (English).

Brit. Mus., Sloane **1799** (English).

PRINTED, English translation, in Salmon's *Medicina Practica* (1707), pp. 585–620, under the title, 'Rogerii Bachonis Radix Mundi, translated out of Latin into English and claused, by William Salmon,' 15 chapters (chapters 1–13 of the translation correspond generally to capp. 1–13 of the Latin version).

56. **De subjecto transmutationis.**

MS. Paris: Bibl. Nat. **2598**, f. 138 (sec. xv): *inc.* 'Licet in questione qua queritur utrum in materia in qua generatur aliquid sit principium activum non credam te aliquatenus dubitare.' 'Explicit de subjecto transmutationis secundum Rogerum Bachonis.' (It may occur in one of his larger works.)

57. **Editio super Geberem**[1] **de tribus ordinibus medicine a Rogero Bacon.** *Inc.* 'Tres sunt ordines medicinarum secundum Geberem.' *Expl.* 'Et ista duo S. capitula sunt pars cedule speculi.'

MSS. Cambridge: Univ. Libr. **Ff. iv. 12**, ff. 294^{v}–8 (A.D. 1528–9).

Bologna: Bibl. Univ. 474 (sec. xv), ff. 73^{v}–85^{r}, 'Rogerus Bacum [*sic*] super Geberem de tribus ordinibus medicine.'

Cf. Oxford, Corp. Chr. Coll. **226**, f. 34, and Cambridge Univ. Lib. **Ff. iv. 12**, ff. 63–71, *Joh. Pauper de lapide philosophorum*, or *Breviloquium Johannis Pauperis*: *inc.* 'Testatur Gebar . . . quod tres sunt ordines.'[2]

58. **'Compendium Alkymie secundum eundem Magistrum Rog. Bacon ut estimatur.'** *Inc.* 'Amice accipe artem in brevibus.'

MS. Cambridge: Univ. Lib. **Ff. iv. 12**, ff. 306^{v}–11.

[1] i.e. Jabir ibn Haiyan. Some of his works on alchemy were printed at Venice 1475 (?) together with poems ascribed to Friar Elias; and at Berne 1545 with the 'Spec. Alchemiae R. Bachonis'. Cf. Cambridge, Corpus Chr. Coll. MS. 99, §§ 9, 10; Ashmole MS. 1445, § iv, ff. 1–5. On Geber and pseudo-Geber see Berthelot, *La Chimie au moyen âge*, i. 343, iii, 126.

[2] English version in MS. Ashmole, 1418, ff. 13^{v}–20^{v}.

59. **'Epistola de spiritu occulto' in sulphure et arsenico.**[1] *Inc.* 'Interrogationi vestre de secretis nature taliter vobis scribo. Species purgantur per sua opposita.'

MS. Camb. Univ. Lib. **Ff. iv. 12**, ff. 310–18. (Cf. MS. Oxford, Ashmole **1467**, ff. 213–15 (sec. xvi), *inc.* 'Cum ergo quesieris,' anon.)

60. **Tractatus de quibusdam aquis Alkimicis inventus in antiquo exemplari compilacionis fratris Rogeri Bacon.**[2] *Inc.* 'In principio dicamus de dissolucione fermenti. Recipe vitrioli romani.' *Expl.* 'et deveniet quoddam citrinum.'

MS. Camb. Univ. Lib. **Ff. iv. 12**, ff. 326–33.

61. **Thesaurus Spirituum**, four treatises on the influence of planets, &c. *Inc.* 'Hec est doctrina omnium experimentorum.'

MSS. Brit. Mus.: Sloane **3853**, ff. 3–40 (sec. xvii): 'Hec est tabula libri sequentis . . . a quodam viro venerabili ordinis Minorum summa composita et ordinata, et a diligencia M. Rogero (*sic*) Bakon ordinis Minorum nuper recognita,' &c. 'Explicit liber qui secundum Robertum Turconem et Rogerum Bakon fratrem minorum Thesaurus spirituum nuncupatur.' Cf. Sloane **3850**, ff. 117^{v}–29: **3885**, f. 26.

Cf. MS. Sloane **3850**, f. 129^{v}, *De nigromantia*, extracted from the above: and Sloane **3884**, f. 44^{v} (sec. xvii), *Necromantiae Rogeri Bachon, inc.* 'Debes mundare manus et pedes.'

Among alchemical works ascribed to Bacon which are certainly spurious are:

62. **De consideratione quintae essentiae**[3], 2 or 3 books. *Inc.* lib. i, 'Dixit Salomon Sap. cap. vii, Deus dedit mihi horum;' *inc.* lib. ii, 'Licet liber primus qui est de consideratione;' written by a Franciscan who entered the Order at Toulouse, probably Joh. de Rupescissa.[4] A few only of the many MSS. are noted below.

MSS. Brit. Mus.: Sloane **2320** (secc. xv–xvi), f. 73; **2322**, ff. 135–68 (sec. xv), ascribed to Roger Bacon; **75**, ff. 101–23 (sec. xv); **338**, f. 1 (sec. xv), lib. i ascribed to Joh. de Rupescissa, lib. ii. to 'Raymundus'.

[1] Cf. Cambridge Univ. Lib. Ff. vi. 50 (sec. xv), ff. 44^{v}–46^{v}: *Interrogationes Uthesie ad Mariam*, 'Cum queritur quid est spiritus occultatus in sulphure et arsenico.'

[2] Perhaps from the *Semita Recta Alchemiae*; see No. 63.

[3] Also called 'De famulatu philosophiae'; e.g. Sloane 1080, a, f. 6 (sec. xv).

[4] Cf. Charles, *Roger Bacon*, p. 76. Sbaralea, *Sup. ad Script. Ord. Min.* 459–61.

Oxford : Bodl. : Can. Misc. 334, ff. 59^{v}–94^{v}, ' secundum fr. Rog. Bacun ' : E Musaeo 155, pp. 431–507,[1] ' secundum mag. Rogerum Bacon ' : Digby 43 (anon.). St. John's Coll. 172 (sec. xv). Corp. Chr. Coll. 124 (sec. xv), anon.
Winchester College 39, f. 1 (sec. xv), ascribed to Bacon or to J. de Rupescissa.
Cambridge : Trin. Coll. 1389, f. 45^{v} (sec. xv), anon.
Paris : Bibl. Nat. 7151, &c.
Savignano di Romagna 44, f. 1 (sec. xv), anon.
PRINTED : Basel, 1561, 1597.

63. **Semita recta alchemiae** (or **Liber duodecim aquarum**), also attributed to Albertus Magnus. Several different treatises have the same title. One attributed to Albertus begins : ' Talentum mihi creditum ' (*Script. Ord. Praed.*, i. 178, from MS. Colbert 1639) ; another, ' Omnis sapientia a Domino Deo ' (Hunterian Museum, 110), cf. No. 20 n., above.
MSS. Brit. Mus. : Sloane 513, ff. 155–68 (sec. xv) : ' Explicit semita recta alkemie Alberti ' (in English) : ff. 168^{v}–78^{r}, ' Nunc videndum est quomodo fiunt fornelli . . . explicit semita recta alkemie Alberti ' : ff. 181^{v}–8^{v}, ' Libelli huiusmodi aquarum . . . explicit semita recta alkemie secundum magistrum Rogerum Bakun.' Sloane 276, f. 21 (sec. xv) (anon.) ; cf. Sloane 316 (sec. xvi) (Alb. Magnus) ; 633 (sec. xvii), in English, attributed to both Roger and Albert.
Cf. Bodl. : Ashmole 1485, pp. 173–88 (sec. xvi), ' Liber Aquarum ' : Ashmole 1490, ff. 92, 93.

64. **De oleo stibii.** *Inc.* ' Stibium secundum philosophos componitur ex nobili sulphure minerali,' ascribed to Bacon but composed by Basil Valentine.
PRINTED in *Currus triumphalis antimonii fratris Basilii Valentini* (Toulouse, 1646), pp. 116–26.

Among works on other subjects than alchemy sometimes attributed to Bacon and certainly not by him are :

65. [**Elementary Treatise on Logic.**]
' Prima petia magistri p. h.'[2] *Inc.* ' Quoniam ignoratis communibus necesse est artem ignorare.'

[1] MS. Bodl. E Musaeo 155, p. 507, has *De expulsione veneni. Inc.* 'Ista subscripta sequerentur post capitulum de hiis que expellunt venenum': not expressly ascribed to Bacon : it follows the *De Consid. quintae essentiae* in the MS., and is perhaps a part of it.

[2] In E. Coyecque's Catalogue (1893) this is wrongly given as ' Prima pecia magistri Petri Bacun .' ' p. h.' may be Petrus Hispanus or Petrus Helyas.

MS. : Amiens **406** (sec. xiii ex.), ff. 130–52.

Described by Victor Cousin as a ' traité de logique à l'usage de la jeunesse . . . sans aucun titre et sans nom d'auteur. On lit seulement en tête : Prima pecia magistri S. H.'

(Peterhouse MS. **195** (sec. xiv), at Cambridge formerly contained ' Logica fratris Rogeri Bacon '.)

66. **De intellectu et intelligentia,** and **De nutrimento,** ascribed to Bacon in the Old Catalogue of the Bodleian MSS., are by Albertus Magnus.

MSS. Digby **55,** f. 119 (anon.) ; **67,** f. 107 (anon.).

PRINTED in *Opera Alb. Magni* (ed. Paris, 1890, &c.), vol. **ix.**

67. **Philosophia Pauperum,** or **Summa philosophiae naturalis** (*inc.* ' Philosophia dividitur in tres partes '), ascribed to Bacon in Old Catalogue of Bodl. MSS., is the work usually but wrongly ascribed to Albertus Magnus, really compiled from his commentaries. Cf. No. 1*b* n., above.

MS. Digby **150.**

68. **Rogerina major** (*inc.* ' Sicut ab antiquis habemus auctoribus '), **et minor** (*inc.* ' Cum medicinalis artis ' or ' Cum artis medicinae '),[1] two medical treatises, neither by Roger Bacon ; one is by a Roger Baron.

MSS. Sloane **342,** f. 146 (sec. xiii) ; Bodley **786** ; Göttingen Bibl. Univ. Hist. Nat. **12,** ff. 49–96 ; Montpellier École de Médecine **161,** &c. For other MSS. see *Hist. Litt. de France,* xx. 527 ; xxxi. 530, &c. Cf. Charles, *Roger Bacon,* p. 75.

PRINTED : Venet. 1498.

69. **Kalendarium,** 1292 ; perhaps based on Bacon.

MSS. Brit. Mus. : **Vesp. A. ii,** ff. 2–25 (sec. xiv), ' Kalendarium sequens extractum est a tabulis tholetanis A.D. 1292, factus ad meridiem civitatis tholeti que in Hispania, scita est cuius (etc.) . . . dicta vero latitudo efficitur civitatis lincolniensis.'

Bodley **464,** ff. 58–72 (sec. xiv) : ' Canon super sequens kalendarium ad veram coniunctionem solis et lune accipiendam compositum a fratre Rogero Bacoun. Kalendarium sequens extractum est a tabulis Tholetanis A.D. 1292, factum ad meridiem civitatis Tholeti, que in Hyspania scita est. Cuius meridianus non multum distat a meridiano medii puncti Hybernie.' (The kalendar is English, not Franciscan : it is not to be

[1] Bale gives ' Humana natura ' as *incipit.*

confused with the works of Robert of Leicester; *Grey Friars in Oxford*, p. 169.)

70. **De magnete.** *Inc.* 'Amicorum intime, quandam magnetis lapidis,' by Peter de Maricourt.

In *Archiv. Franc. Hist.* v. 22–40, Fr. E. Schlund gives a list of thirty-one existing MSS., and five editions. See also Silvanus P. Thompson, in *Proceedings of the British Academy*, vol. ii.

71. **De Musica.** *Inc. in verbis*: 'Consequenter de numero aliquantulum similiter prout ad principale intentum sufficienter explicemus; et primo interpretando, secundo diffiniendo, tercio dividendo, sicut prius fecimus, procedamus.'

MS. Milan: Ambrosiana **R. 47 sup.**, f. 43 (sec. xiii).[1]

72. **De sacrae scripturae profundis misteriis authore Rogero Bacon.**

MS. London: Gray's Inn **17** (sec. xv); the title is in a later hand. The work consists of an alphabetical arrangement of certain words occurring in the Scriptures with their symbolical meanings. The first two leaves of the first quire are wanting, and the text begins: 'id est secretorum sacre scripture profunda misteria,' the word commented on being *Abissus*. The last word discussed is *Zona*. Perhaps the *expositiones vocabulorum* of Roger 'Compotista', monk of Bury St. Edmund's, or the *Distinctiones fratris Mauricii*, certainly not Bacon.

73. **Tractatus fratris R. Bacon super Psalterium.** *Inc.* 'Beatus vir qui non abiit, etc. Hoc exponitur de uno martire': possibly by Robert Bacon.

MS. Bodley **745**, f. 97 (sec. xiv). (The volume contains, *inter alia*, 'Tract. fratris B.' = the *Breviloquium* of St. Bonaventura.)

[1] The treatise is anonymous, but is in a volume containing some of Bacon's works and is attributed to him in Montfaucon's Catalogue. Mr. Steele kindly lent me his facsimile of the MS., and I agree with him that the work is not by Bacon. The author was a physicist with some knowledge of alchemy. His general philosophical position may be inferred from the following extracts: 'Iterum forma est principium individuandi et ab aliis distinguendi . . . forma est principium cognoscendi et sic originandi in anima veritatem . . . forma ultimo est principium operandi.' [The treatise *De valitudine* [*valore*] *musices* (*inc.* 'Secundum Boethium et ceteros autores musices') ascribed to Bacon by Bale, *Index Brit. Script.*, p. 395, is probably an extract from the *Opus Tert.*, ed. Brewer, p. 296.]

74. **Extracts :**

Ashmole **346**, ff. 94^{v}–6 (sec. xvi), **1426**, f. 43, **1485** (sec. xvi), **1492**, **1494**, &c.

Sloane **238**, ff. 214^{v}–16^{v} (sec. xv), *de fistula*, ' secundum Rogerum Bacon ut habetur in libro qui dicitur Thesaurus pauperum ' (a medical work attributed to Petrus Hispanus and to Arnald de Villanova).

Sloane **2629**, ff. 55–6 : ' quatuor sunt sapientie inimica maxime : primum est presumptio humani cordis . . .'

Sloane **2208**, ' the ancient work of Roger Bacon as it was used by the fryer of Glassenburie.'

Savigno de Romagna **44** (sec. xv), f. 133 et seq. : ' Inc. opus probatum in sole et luna de quatuor spiritibus et est experimentum fr. Roggerii Baconis de quo mentionem fecit in libro suo. In nomine Domini : Accipe sulfur mundum | et erit aurum optimum. Deo gratias.'

Paris : Bibl. Nat. **12335**, fragments of Roger Bacon.

Wolfenbüttel : **479** (**444** Helmst.), f. 126^{v}–126^{r} (sec. xv) : ' Tractatus christiani et rogerii baconis de quatuor elementis et eorum graduacione.' *Inc.* ' Secundum reverendi magistri rogerii baconis posicionem et omnium tradicionem philosophorum Aurum est.'

The following, ascribed to Bacon by Bale, *Index Brit. Script.*, p. 394, have not been identified :

75. **Posteriora.** *Inc.* ' Dictum est de syllogismo in universali.'

76. **De forma resultante in speculo.** *Inc.* ' Queritur de forma resultante in speculo.'

77. **De fluxu et refluxu maris Anglici.** *Inc.* ' Descriptis his figuris circa mod.' Probably by Walter Burley : cf. MS. Digby **103**.

INITIA OPERUM IN PRAECEDENTI CATALOGO CITATORUM

ADDENDA

1*a* (p. 376). MS. Boncompagni **152** (sec. xv), in Narducci's Catalogue, p. 60, now in possession of Messrs. W. Wesley & Son, entitled in a late hand *Rogeri Baconis Commentaria*, contains *Quaestiones in libros viii Physicorum* (*inc.* ' Utrum naturalis sit scientia de omnibus rebus considerans '), by Johannes Buridanus. Cf. ed. Paris, 1509.

11 (*A*) (p. 387). *Add* : Rome : Vatican, Ottob. Lat. **1870** (sec. xv), ff. 1–48, anon. : ends ' ut in luna et stellis ', Bridges, ii. 550 (this and other Vatican additions have been kindly sent by Dr. Pelzer).

17*a* (p. 394). *Add* : Rome : Vat. Ottob. **1870**, ff. 70^{v}–77^{v}, *Tractatus de speculis*, anon. *Inc.* ' Visum rectum esse ' ; *expl.* stupa ' apposita accenditur '.

20, n. 1 (p. 397). *For* ' seems to be ', &c., *read* : ' is *Breve breviarium* ' ; *inc.* ' Ars alchimie duo '.

21 (p. 397). *Add* : Arezzo : Bibl. Communale **232** (sec. xv), f. 75^{r}, *Verbum Abbreviatum* ; *inc.* ' Recipe acetum ' : ff. 77^{r}–78^{r}, *Tabula vocabulorum Rogerii Baconis* : *inc.* ' Argentum vivum congelatum '.—Cambrai, **920**, f. 115 (sec. xv).

29 (p. 401). *Add* : Oxford : Exeter Coll. **35**, f. 46^{v} (sec. xiv in.), anon.

63 (p. 416). *Add* : Rome : Vat. Lat. **4091**, f. 42 : *inc.* ' Talentum mihi creditur ' (Alb. Magnus).

76 (p. 419). *Add* : MS. Vatican, Borgh. **114**, ff. 119^{v}–120^{v} (' Albertus ').

Cf. Weiss, *Primordia novae bibliographiae B. Alberti Magni*, no. 127 (2nd ed., p. 34).

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