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Experience and Demonstration

The Sciences of Nature
in the 13th and 14th Centuries

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Albert the Great on the Epistemology of Natural Science

In the eleventh and twelfth centuries, before the re-discovery of the works of Aristotle, the predominant approach to nature might be called the Timaeian model, because it was so greatly influenced by Chalcidius' translation of Plato's *Timaeus*.¹ Rediscovering Aristotle offered the Latin West the issue of nature as a system of causes that could be rationally investigated. Moreover, Peripatetic philosophy furnished conceptual tools fit to start a systematic and coherent study of natural reality. Albert was among the first schoolmen to have a complete knowledge of Aristotle's works. Remarkable is the amazing number of times Albert rejected the "errors of Plato" or, more commonly of the Stoics, under which pejorative label he included Plato, Socrates, Pythagoras, Avicenna, sometimes Augustine and their followers on certain points.² As it is well-known, Albert was basically an Aristotelian insisting (i) on the autonomy of the natural sciences in their own field, and (ii) on the impossibility of discovering the "real causes" of natural things qua natural via mathematics.

In his monumental *History of Magic and Experimental Science* Lynn Thorndike qualified Albert's treatises on natural science as his more original works and called attention to the fact that Albert, although heavily leaning on his predecessors, added chapters of his own, and that he drew in large measure from his own observation, experience and classification.³ His was a genuine scientific spirit, as is shown by his *De causis et proprietatibus elementorum et planetarum*, where he defended natural research against possible theological objections.⁴ Furthermore, against Aristotle he argued for the distinction between philosophy and several branches of natural science, because philosophy cannot deal with particulars.⁵ Accordingly, his works on plants and animals contain many passages in which he recognized experience as a criterion of truth or gives the results of his personal observation. Thorndike also offered some examples where Albert questioned Aristotle's views because inspired to credulity or contradicting his own observations. However, so Thorndike observed, reliance upon experience proved to be no sure guarantee against incorrect notions, credulity and unquestioned trust in authority, as proved Albert's *Mineralogy*.

Thorndike's remarks suggest some clues for an analysis of Albert's views on science and methodology, more specifically as to his sources (featuring Aristotle), the relation with other

1 Benedict M. Ashley, "St. Albert and the Nature of Natural Science", in: James A. Weisheipl (ed.), *Albert the Great and the Sciences. Commemorative Essays 1980*, Toronto 1980, pp. 74f.

2 Attacks are most frequent in *Physica*, *De natura et origine animae*, *Metaphysica*, and *Liber de causis*. See James A. Weisheipl, "Life and Works of St. Albert", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 13-51, on p. 32.

3 See Lynn Thorndike, *A History of Magic and Experimental Science*, 2 vols., New York 1923, here vol. II, pp. 517-592.

4 See Albertus Magnus, *De causis et proprietatibus elementorum et planetarum* I, tr. 2, c. 9 (*Opera omnia* V/2), ed. Paul Hossfeld, Monasterii 1980, pp. 76-79.

5 Thorndike referred to *De animalibus* XXII.

disciplines (such as, theology, philosophy, and mathematics), and the role of experience and observation. Some disclaimers are due. First, astrological and alchemical works attributed to Albert are not considered here.⁶ Second, a thorough study of Albert's views on the epistemology of natural science largely surpasses the limits of this paper.⁷ Therefore, here I merely aim at clarifying some central issues of Albert's methodology in scientific research.⁸ Section 1 presents Albert's encompassing view of natural reality in a nutshell. In section 2 his program for natural science is briefly outlined. The subsequent section is devoted to an analysis of the empiricist strand of his scientific investigations. The final section illustrates the methodology of Albert's research on the basis of two *exempla*, focussing on some of his basic views on the overall structure of the two disciplines that study the extremes of natural reality, namely mineralogy and psychology.

1. *Opus naturae est opus intelligentiae*

Albert drew a clear line of distinction between science and philosophy, on the one hand, and theology, on the other. This guaranteed a remarkable autonomy and freedom to scientific research. As a rule, first came the study of the laws of nature with a scientific and rational method, and then the check whether it could be conciled with theology.⁹ Yet, his scientific research was shaped by basically Neoplatonic, Christian views.

For Albert, research into natural reality was an investigation of causes, more precisely of nature's inherent productive principles. Albert identified the latter with the inner ideal structure of every single being, the substantial form which determines its powers, capabilities and shape. All substantial forms originate in the first intellect: "nulla omnino forma inducitur in

⁶ For discussion of Albert's astrology, see Thorndike, *A History of Magic*, *op. cit.*, pp. 577-592; Dorothy Wyckoff, "Introduction" to Albertus Magnus, *Book of Minerals*, translated by Dorothy Wyckoff, Oxford 1967, pp. XXIX-XXX. Cf. *Speculum astronomiae*, ed. Paola Zambelli *et al.*, Firenze 1973; and *The Speculum Astronomiae and its Enigma*, ed. Paola Zambelli, Dordrecht 1992. The paternity of this work has recently been challenged by Agostino Paravicini Bagliani, *Le 'Speculum astronomiae': une énigme? Enquete sur les manuscrits*, Turnhout 2001. For Albert's relation with alchemy, see Pearl Kibre, "Albertus Magnus on Alchemy", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 187-202; George C. Anawati, "Albert le Grand et l'alchimie", in: Albert Zimmermann (ed.), *Albert der Große. Seine Zeit, sein Werk, seine Wirkung*, Berlin/N.Y. 1981, pp. 126-133; Robert Halleux, "Albert le Grand et l'alchimie", in: *Revue des sciences philosophiques et théologiques* 66 (1982), pp. 57-80.

⁷ For a survey of recent studies on Albert's natural science and philosophy of nature, see Claus Wagner, "Alberts Naturphilosophie im Licht der neueren Forschung (1979-1983)", in: *Freiburger Zeitschrift für Philosophie und Theologie* 32 (1985), pp. 65-104.

⁸ Methodological issues are also tackled in the essays by Theodor W. Köhler and Pietro B. Rossi in this volume.

⁹ The relation of science with theology is discussed in Lawrence Moonan, "Albert the Great and some Limits of Scientific Inquiry", in: Burkhard Mojsisch / Olaf Pluta (eds.), *Historia philosophiae aevi. Studien zur Geschichte der Philosophie des Mittelalters*, 2 vols., Amsterdam/Philadelphia 1991, vol. II, pp. 695-710. See also Luca Bianchi, "Loquens ut naturalis", in: Luca Bianchi / Eugenio Randi (eds.), *Le verità dissonanti. Aristotele alla fine del Medioevo*, Roma/Bari 1990, pp. 33-56, on pp. 37-38; Loris Sturlese, "Il razionalismo filosofico e scientifico di Alberto il Grande", in: *Documenti e studi sulla tradizione filosofica medievale* 1 (1990), pp. 373-426 (reprint in Loris Sturlese, *Storia della filosofia tedesca nel Medioevo. Il secolo XIII*, Firenze 1996, cap. 3), on pp. 384-386, 390-391.

materiam, quae non sit in lumine intelligentiae.”¹⁰ Thus, in Albert’s view nature is a product of intelligence, more precisely, of the divine or first intellect. This total dependence applies to the entire created reality, ranging from stones to human souls. The former owe their powers (*virtus lapidis*) to their substantial form which in turn depends upon the celestial bodies¹¹ and thus on the first intellect, while the latter are produced directly by the first intellect according to its image and similitude:

[...] the first intellect, origin of the whole nature, is the only principle of things that come to be; to the similitude of its light the rational soul is generated in being.¹²

Albert’s view of nature as a work of ‘intelligence’¹³ has significant consequences for the investigation of natural reality. First, the dependence of the sublunar reality on the celestial bodies and thus on the first intellect entails the existence of natural laws, and thus the world’s full intelligibility.¹⁴ Second, although form prevails over matter,¹⁵ the latter possesses all forms “per inchoationem”¹⁶ and in varying degrees the “splendor primi intellectus.”¹⁷ Third, the substantial form specifies a natural being as a *whole*. For example, human flesh and bones are specifically different from those of the animals, because man has a rational soul.¹⁸ Fourth, the ubiquity of the first intellect and its all-pervasive activity allow the

¹⁰ Albertus Magnus, *De natura et origine animae* tr. I, c. 1 (Opera omnia XII), ed. Bernhard Geyer, Monasterii 1955, p. 4.

¹¹ Albertus Magnus, *Physica* II, tr. 2. c. 19 (Opera omnia IV/1), ed. Paul Hossfeld, Monasterii 1987, p. 128.

¹² Albertus Magnus, *Liber de animalibus* XX, tr. 1, c. 1, ed. Hermann Stadler, in: *Beiträge zur Geschichte der Philosophie des Mittelalters* (BGPhMA)16, Münster 1920; in: *De natura et origine animae, op. cit.*, p. 2: “[...] intellectus primus, cuius totius est opus naturae, est unum principium generantium, ad cuius lucis similitudinem in esse producitur anima rationalis.” Cf. section 4 (*infra*).

¹³ See, *inter alia*, also Albertus Magnus, *De animalibus* XVI, tr. 1, c.7, n. 43, *op. cit.*, p. 1082, ll. 14-28. Albert derived this view from the *Liber de causis*. For discussion, see James A. Weisheipl, “The Axiom ‘opus naturae est opus intelligentiae’ and its Origins”, in: Gerbert Meyer / Albert Zimmermann / Paul-Bernd Lüttringhaus (eds.), *Albertus Magnus Doctor Universalis 1280/1980*, Mainz 1980, pp. 441-463; Ludwig Hödl, “*Opus naturae est opus intelligentiae*. Ein neuplatonisches Axiom im aristotelischen Verständnis des Albertus Magnus”, in: Friedrich Niewöhner / Loris Sturlese (eds.), *Averroismus im Mittelalter und in der Renaissance*, Zürich 1994, pp. 132-148.

¹⁴ For the general structure of Albert’s thought as characterized by *exitus-perfectio-reductio*, see Henryk Anzulewicz, “Die Denkstruktur des Albertus Magnus. Ihre Dekodierung und ihre Relevanz für die Begrifflichkeit und Terminologie”, in: Jacqueline Hamesse / Carlos Steel (eds.), *L’élaboration du vocabulaire philosophique au Moyen Âge*, Turnhout 2000, pp. 369-396.

¹⁵ See, for example, the role of the “*virtus mineralis*” in the generation of stones, in Albertus Magnus, *Mineralia* I, tr. 1, c. 4-5 (Opera omnia 5) ed. Auguste Borgnet, pp. 5-8.

¹⁶ Albertus Magnus, *De natura et origine animae* tr. I, c. 2, *op. cit.*, p. 5: “Aristoteles probat, quod omnes formae naturales sint ab intellectu conferente virtutem formativam, qua ad formam formativam educantur de materia, eo quod in ipsa sint omnes per inchoationem”. Cf. *Physica* tr. I, c. 17 (Opera omnia IV/1), *op. cit.*, pp. 73-75 on “de appetitu materiae et rationibus privationis et nominibus formae”. For discussion, see Bruno Nardi, “La dottrina d’Alberto Magno sull’ ‘inchoatio formae’”, in: *id.*, *Studi di filosofia medievale*, Roma 1979, pp. 69-101.

¹⁷ Albertus Magnus, *De natura et origine animae* tr. I, c. 3, *op. cit.*, p. 6.

¹⁸ *Ibid.*, c. 5, p. 13, ll. 69-76.

individuation of numerous structural cosmological analogies. Thus, for example, the embryogenesis 'reproduces' in the female womb the formation of the world.¹⁹

2. The Program of Natural Science

According to Albert natural science²⁰ studies *corpus mobile*, i.e. "body subject to change", which is known to us by intelligent reflection on sense experience. In his view it is rooted in a single set of principles and hence forms a single discipline.²¹ Thus, the first task of such a science is to establish its basic principles by arriving, through an analysis of sense experience, at a definition of this subject "changeable body". Then this model can be used in analyzing every kind of natural body.²² However, Albert was by no means content with only general reflections on the nature of natural science and its most general abstract principles. For him the value of such principles was in their application to detailed scientific researches on the actual species of things in which these universals were exemplified:

In investigations of nature, however, it is necessary not only to consider the changeable understood universally according to its common features, but it is necessary to get down to details so that the primary agent in each individual case may be ascertained, especially in sensible, animate things, because in investigations of nature we must discover the universal principles through singulars, since in such investigations the particulars are better known than the universals. It is through the singulars that we come to believe that it is convenient and necessary for universals and their principles to exist, since it is only those universals which are exemplified in particulars that we accept, while those which are not exemplified in particulars, we reject.²³

That natural science regards singulars puts precise limits to the role of philosophy, logic and mathematics in the scrutiny of nature. For Albert neither the metaphysician nor the logician or the mathematician has a privileged insight in nature. The world of nature will yield its secrets only to the person who studies it carefully through observation and empirical reasoning.

¹⁹ Albertus Magnus, *De animalibus* IX, tr. 2, c. 4, ed. Hermann Stadler, in: BGPhMA 15, Münster 1916, p. 721, ll. 16-21.

²⁰ Note that in Albert "natural science" cannot be distinguished clearly from what today might be called "philosophy of science" or "natural philosophy".

²¹ Albertus Magnus, *Physica* I, tr. 1, c. 3 (Opera omnia IV/1), *op. cit.*, p. 5: "Omnis enim scientia est alicuius generis subiecti, de quo probantur passiones et cuius considerat partes et differentias. Hoc autem in omni scientia naturali absque dubio est corpus mobile, prout motui subicitur. Voco autem corpus subiectum physicae in communi et non hoc corpus vel illud. In communi autem accipio non simpliciter, sed quod motui subicitur."

²² For extensive discussion, see Ashley, "St. Albert and the Nature of Natural Science", *op. cit.*, pp. 73-102, on pp. 80f.

²³ Albertus Magnus, *De principiis motus processivi* tr. 1, c. 1 (Opera omnia XII), ed. Hermann Stadler, Monasterii 1955, p. 49, ll. 21-31 (transl.: Ashley, "St. Albert and the Nature of Natural Science", *op. cit.*, p. 87).

In *De vegetalibus*, Albert recognized the distinction between a philosophical, generalized study of plants and the approach of the herbalists and the compilers of *receptaria*.²⁴ And in *De animalibus*, Albert argued that the logician, armed with his syllogisms only, is out of his depth in sciences that bear on nature. Only experience, one's own or that of others – laboriously discovered – holds the key to scientific research.²⁵ The reason for this resistance to syllogisms in natural science is easily understood: “In natures so particular a syllogism cannot be had.”²⁶ Syllogistic science is necessarily expressed in universal propositions, whereas the investigator in a particular science must deal with instances that, by definition, fail of universality.²⁷

It is well known that Aristotelians regarded mathematics as the least of the theoretical sciences.²⁸ Mathematics is remarkable for its certitude and clarity, but deficient as regards its subject matter which is merely the quantity of physical objects considered in idealizing abstraction.²⁹ The role of mathematical-physical sciences, such as optics and astronomy, is that of a *mixed* science in which physical subject matter is open to scientific investigation and demonstration only in restricted terms which usually yield only conjectural (dialectical) solutions. This is why Albert is convinced that many of the mathematical theories of the astronomers are only hypothetical.³⁰ With hindsight it is tempting to say that Albert's influence was inimical to the growth of mathematical physics. More positively we may see that Albert was warning against the dangers of fitting the variety of nature into an ill-fitting mathematical strait-jacket.³¹

In the past Albert's dependence on Aristotle has been widely discussed. Albert 'rewrote' the whole of Aristotelian philosophy in the Latin language, restating, expounding, correcting, expanding, and even adding whole areas of scientific thought. Albert's reworking of all Aristotelian and pseudo-Aristotelian books, probably written between 1250 and 1270,³²

24 Albertus Magnus, *De vegetabilibus* VI, tr. 2, c. 1 (Opera omnia 10), ed. Auguste Borgnet, pp. 217-219. For discussion, see Jerry Stannard, “The Botany of St. Albert the Great”, in: Meyer / Zimmermann (eds.), *Albertus Magnus Doctor Universalis, op. cit.*, pp. 345-372, on p. 346 and note 7.

25 Cf. Albertus Magnus, *De vegetabilibus* VI, tr. 1, c. 1, *op. cit.*, pp. 159b and 160a; cf. Albertus Magnus, *Metaphysica* I, tr. 1, c. 2 (Opera omnia XVI/1), ed. Bernhard Geyer, Monasterii 1960, p. 5: “Sed ego tales logicas convenientias in scientiis de rebus abhorreo, eo quo ad multos deducunt errores.”

26 Albertus Magnus, *De vegetabilibus* VI, tr. 1, c. 1, *op. cit.*, p. 160a.

27 Cf. *De animalibus* XI, tr. 1, c. 1, *op. cit.*, p. 761: “Neque dicitur hic scientia, quae est effectus demonstrationis, quoniam illam habere non possumus de naturis particularibus animalium, sed opinionem ex probabiliibus possumus concipere.” Nonetheless, throughout his works on natural science Albert exhibits the same concern for logical method as in his logical commentaries, especially that on the *Posterior Analytics*.

28 For the relation between metaphysics, physics and mathematics in Albert, see: *Physica* I, tr. 1, c. 1-6 (Opera omnia IV/1), *op. cit.*, pp. 1-13; Ashley, “St. Albert and the Nature of Natural Science”, *op. cit.*, p. 95; A. George Molland, “Mathematics in the Thought of Albertus Magnus”, in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 463-478, on pp. 466-467.

29 Albertus Magnus, *Metaphysica* I, tr. 1, c. 1, *op. cit.*, pp. 1-3.

30 Albertus Magnus, *Physica* II, tr. 1, c. 8 (Opera omnia IV/1), *op. cit.*, pp. 88-91. On the role of mathematics in Albert, see Robert Ineichen, “Zur Mathematik in den Werken von Albertus Magnus”, in: *Freiburger Zeitschrift für Philosophie und Theologie* 40 (1993), pp. 55-87 (with bibliographical references to relevant studies); Paul M.J.E. Tummies, “The Commentary of Albert on Euclid's Elements of Geometry”, in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 479-499.

31 Molland, “Mathematics in the Thought of Albertus Magnus”, *op. cit.*

32 Weisheipl, “Life and Works of St. Albert”, *op. cit.*, on p. 27. For a chronology, see pp. 30-31.

makes up almost half of his entire writings.³³ Yet, Albert did not think Aristotle “nature’s best effort” and a “canon of truth” as did many Peripatetics.³⁴ Albert defended his own independence:

Perhaps some will say that we have not understood Aristotle and that on this account we have not agreed with what he said or that (from their certain knowledge) we contradict him in point of truth on some matter. To him we say that whoever believes that Aristotle was a god ought to believe that he never erred; if, however, one believes him to be but a man, then without doubt he could err just as we do.³⁵

At the very outset of his *Physica*, Albert explained that his procedure would be to follow the order and opinion of Aristotle, presenting whatever seemed necessary to explain and demonstrate his views, making digressions, clarifying difficulties and supplementing whatever might be wanting in the view of Aristotle. Nevertheless, Albert disclaimed final responsibility for the opinions he expounded.³⁶ Indeed, in his paraphrases, Albert did not present an original or independent natural philosophy, but usually explained the text and opinions of Aristotle, his followers, and other authors, adopting the opinions of one or another.³⁷ However, Albert went so far as to expend considerable effort in filling what he conceived to be gaps in the Aristotelian corpus.³⁸ And he recognized that “the aim of natural science is not simply to accept the statements of others, but to investigate the causes that are at work in nature.”³⁹

Albert sketched out a vast program for the collection, synthesis, and completion of what was known about nature. The individual treatises are not independent, they are all parts of one coherent natural history, because the different areas of research use similar methods

33 For discussion of Albert’s sources and way of commenting, see Paul Hossfeld, “Die Arbeitsweise des Albertus Magnus in seinen naturphilosophischen Schriften”, in: Meyer / Zimmerman, *Albertus Magnus Doctor universalis*, *op. cit.*, pp. 195-204; *id.*, “Seneca’s *Naturales Quaestiones* als Quelle der *Meteora* des Albertus Magnus”, in: *Archivum Fratrum Praedicatorum* 50 (1980), pp. 63-84; *id.*, *Albertus Magnus als Naturphilosoph und Naturwissenschaftler*, Bonn 1983, pp. 15-18; *id.*, “Die Physik des Albertus Magnus (Teil I, Bücher 1-4). Quellen und Charakter”, in: *Archivum Fratrum Praedicatorum* 55 (1985), pp. 49-65; and *id.*, “Zur Physik des Albertus Magnus: I. Quellen und Charakter”, in: *Philosophia naturalis* 23 (1986), pp. 113-122.

34 However, not even the Peripatetic school functioned without a certain freedom of interpretation. See Albertus Magnus, *De anima* III, tr. 2, c. 3 (*Opera omnia* VII/1), ed. Clemens Stroick, Monasterii 1968, p. 182, ll. 8-14.

35 Albertus Magnus, *Physica* VIII, tr. 1, c. 14 (*Opera omnia* IV/2), ed. Paul Hossfeld, Monasterii 1993, pp. 577-579; cf. *Meteora* I, tr. 1, c. 1 and III, tr. 4, c. 11 (*Opera omnia* VI), ed. Paul Hossfeld, Monasterii 2003. For discussion of the role of Aristotle in the science of nature, see Albert Zimmermann, “Albert le Grand et l’étude scientifique de la nature”, in: *Archives de Philosophie* 43 (1980), pp. 695-711.

36 Albertus Magnus, *Politica* VIII, c. 6 (*Opera omnia* 8), ed. Auguste Borgnet, pp. 803f.; *Physica* VIII, tr. 4, c. 7 (*Opera omnia* IV/2), *op. cit.*, pp. 650-651. Cf. Ashley, “St. Albert and the Nature of Natural Science”, *op. cit.*, p. 79, note 32.

37 See, in particular, the nineteen texts from *De caelo et mundo*, *De generatione et corruptione*, and *Physica*, presented and extensively discussed by Hossfeld, *Albertus Magnus als Naturphilosoph*, *op. cit.*, pp. 18-76.

38 In *Physica* I, tr. 1, c. 1 (*Opera omnia* IV/1), *op. cit.*, p. 1, he explained: “And we shall also add, in certain places, parts of unfinished books, and in other books passed over or omitted, ones which Aristotle did not produce or, if perhaps he did produce them, they have not reached us.”

39 Albertus Magnus, *Mineralia* II, tr. 2, c. 1, *op. cit.*, p. 30a.

both to collect data and to analyze them. He considered his works on natural science as a closely related series, and linked them all together, rather elaborately classified in a logical order, near the beginnings of his *Physica*.⁴⁰ The first part of natural science treats of what is common to all bodies: local motion (*Physica, De coelo*), and other kinds of change (*De generatione et corruptione*). The second part (*Meteora*) deals with the elements in the process of mixture and combination to form compound bodies. The third part treats of compound bodies of various kinds, both inanimate (*De mineralibus*) and animate (*De anima, De intellectu et intelligibili, De natura et origine animae, Parva naturalia*). Finally, Albert came to what he considered the real goal of natural science: the study of specific kinds of living things, applying the general chemical and physiological model to plants (*De vegetalibus*, a commentary on the ps-Aristotelian *De plantis*)⁴¹ and animals (*De animalibus*).

Albert's treatises on natural science are more original than the term 'commentary' or 'paraphrase' might suggest. If there was a basic text, it was paraphrased and interwoven with his own contributions – sometimes exposition or refutation of the opinions of earlier commentators, sometimes new illustrations, drawn from his own wide reading and experience. If there was no basic text, as for *Mineralia*, the selection and arrangement of materials offered even more scope for the development of his own ideas.

3. Experience and Observation

In a short paper published in 1932, Thomas Greenwood stated that Albert's encyclopedic teaching was completely based on the writings of Aristotle. However, he admitted that Albert in his biological works, although closely following Aristotle, introduced an amount of personal observation and that he was a naturalist of great ability. He thus referred to the opinion of Singer that Albert's *De vegetabilibus et plantis* was the best book on natural history produced during the Middle Ages.⁴² In the article dedicated to Albert in the *Dictionary of Scientific Biography*,⁴³ William Wallace highlighted Albert's empiricist methodology, that is, his remarkably accurate observation of nature and the fact that his works abound in description of phenomena. Wallace argued that according to Albert evidence based on sense perception is the most secure and is superior to reasoning without experimentation.⁴⁴ Albert's zoology, botanics and embryology are cases in point.⁴⁵

⁴⁰ See *Physica* I, tr. 1, c. 4 (Opera omnia IV/1), *op. cit.*, pp. 6-8; cf. *Meteora* tr. 1, c. 1, *op. cit.*, pp. 1-4. For discussion of the background and motivations of Albert's project, see Loris Sturlese, "Il razionalismo filosofico e scientifico di Alberto il Grande", *op. cit.*, pp. 379-388.

⁴¹ The book on plants is now usually attributed to the first century-C.E.-Greek philosopher Nicholas Damascenus. See Sybil D. Wingate, *The Mediaeval Latin Versions of the Aristotelian Scientific Corpus, with Special Reference to the Biological Books*, London 1931, pp. 55-56; cf. Bernard G. Dod, "Aristoteles Latinus", in: Norman Kretzmann / Anthony Kenny / Jan Pinborg (eds.), *The Cambridge History of Later Medieval Philosophy*, Cambridge 1982, p. 47.

⁴² Thomas Greenwood, "Albertus Magnus: His Scientific Views", in: *Nature* 129 (1932), pp. 266-268.

⁴³ *Dictionary of Scientific Biography*, 18 vols., ed. Charles Coulston Gillispie, New York 1970-1990, vol. I, pp. 99-103.

⁴⁴ Elsewhere, Wallace has attempted to demonstrate that Albert had anticipated the technique of *ex suppositione* reasoning later explained by Thomas Aquinas, and that this method might even have influenced Galilei's view of hypothetical reasoning in physics. See William A. Wallace, "Albertus Magnus on Suppositional Necessity in the Natural Sciences", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 103-128. Albert's

In Albert's view, a conclusion in physical science that contradicts sensation is at least suspect and "a principle" discovered to be out of harmony with experiential knowledge can only be a pseudo-principle:

Anything that is taken on the evidence of the senses is superior to that which is opposed to sense observation; a conclusion that is inconsistent with the evidence of the senses is not to be believed; and a principle that does not accord with the experimental knowledge of the senses is not a principle but rather its opposite.⁴⁶

There is more than a hint that Albert's 'experience' shaded from brute observation toward a methodical, systematic 'experimentation'.⁴⁷ Naturally, he could not oversee everything for himself and part of the difficulty of the scientist, as Albert saw it, was to check and to evaluate the reliability of witnesses.⁴⁸

Traditionally, the judgment on Albert as a natural scientist largely, not to say decisively, depends on the observations of which his works are full. However, it is now clear that Albert took a good deal of his material from earlier sources. For example, recently John Friedman has shown that Albert in his natural history recycled material from Thomas of Cantimpré and earlier sources through a variety of rhetorical stratagems to make it his own. Friedman argued that Albert's reputation as the first important medieval direct observer of nature can be seen to be based as much on his rhetorical skills as on the breadth and acuity of his actual experience of the animal world.⁴⁹ This raises the issue of the precise nature and status of the observations reported in Albert's work. In other words, which scientific experiences did Albert have and how did they develop? An essay published by Paul Hossfeld in 1983 on Albert's own observations is certainly of some help.⁵⁰

Some works, such as the paraphrasis of *De caelo*, contain no personal observations but only those that are derived from the Arabic-Latin translation, or else are generally shared

method in zoology seems to confirm this interpretation (cf. pp. 120-125), but, as Wallace is forced to admit, there is no textual evidence as to its application in physics in a more strict sense; cf. p. 113: "Albert does not explicitly use the expression *ex suppositione* or enters into details of the demonstrative process in a natural science, although his answer to the first Heraclitean objection [in *Physica*, I, tr.1, c. 2 (Opera omnia IV/1), *op. cit.*, pp. 3-5] may be seen as implicitly involving this doctrine." See also *id.*, "The Scientific Methodology of St. Albert the Great", in: Meyer / Zimmermann (eds.), *Albertus Magnus Doctor Universalis*, *op. cit.*, pp. 385-407.

⁴⁵ *Dictionary of Scientific Biography*, *op. cit.*, I, pp. 101f.

⁴⁶ See Albertus Magnus, *Physica* VIII, tr. 2, c. 2 (Opera omnia IV/2), *op. cit.*, p. 587, ll. 40-45: "Omnis enim acceptio, quae firmatur sensu, melior est quam illa quae sensui contradicit, et conclusio, quae sensui contradicit, est incredibilis, principium autem, quod experimentali cognitioni in sensu non concordat, non est principium, sed potius contrarium principio."

⁴⁷ Albertus Magnus, *Ethica* VI, tr. 2, c. 25 (Opera omnia 7), ed. Auguste Borgnet, p. 443a: "Oportet enim experimentum non in uno modo, sed secundum omnes circumstantias probare, ut certe et recte principium sit operis." Cf. Wyckoff, *Book of Minerals*, *op. cit.*, pp. 128-129.

⁴⁸ *De animalibus* XXV, c. 29, *op. cit.*, p. 1567, ll. 21-27.

⁴⁹ John B. Friedman, "Albert the Great's Topoi of Direct Observation and his Debt to Thomas of Cantimpré", in: Peter Binkley (ed.), *Pre-Modern Encyclopaedic Texts. Proceedings of the Second Comers Congress*, Groningen, 1-4 July 1996, Leiden 1997, pp. 379-392.

⁵⁰ Paul Hossfeld, "Die eigenen Beobachtungen des Albertus Magnus", in: *Archivum Fratrum Praedicatorum* 53 (1983), pp. 147-174; also reproduced in Hossfeld, *Albertus Magnus als Naturphilosoph und Naturwissenschaftler*, *op. cit.*, pp. 76-96.

observational statements, as they are usually introduced by “nos”.⁵¹ Other works, such as *De causis proprietatibus elementorum*, *Meteora*, *De somno et vigilia*, and *De vegetabilibus* contain ‘personal’ observations by Albert,⁵² as well as ‘experiments’ and some (rare) parapsychological experience.⁵³ Crucial works for the issue under scrutiny are *Mineralia* and *De animalibus*, where Hossfeld counted twenty-five, and, respectively, some seventy ‘real’ observations. These observations need to be qualified, however.

The observations in the *Mineralia* can be subdivided in four classes. There are eight cases where Albert’s phantasy and magical imagination prevail (especially in the individuation of figures or images in stones), there is one possibly common experience, one observation is probably the result of some sort of experiment,⁵⁴ while the other fifteen can be viewed as experiences of an open and interested observer. Also the observations in *De animalibus* are of different kinds: nine are reported, seven are connected to some sort of experiment,⁵⁵ while among the remaining fifty-four observations two are of inferior quality, four are due to mere credulity, and five are the result of observation in an extended sense.⁵⁶

On the whole, of the one hundred eleven observations reported by Hossfeld ten are not observations in a strict sense, fifteen are intertwined with tall stories (qualified as “Jägerlatein” by Hossfeld) or the result of common credulity, while seven to nine are connected to some sort of experiment. As a rule Albert’s observations are purely qualitative, that is, they lack any statistical or quantitative elaboration.⁵⁷ Furthermore, Albert was a ‘bookish’ scientist, who systemized the materials that he took from the works of other authors. And it is surely not by pure accident that personal observations abound in works that lacked an Aristotelian basis, such as, *Mineralia*, or where, as in *De animalibus*, Albert extensively drew upon his memories of a country life and did not apply the comparative anatomical method of the Stagirite.

Most probably, commenting upon the whole corpus of Aristotelian works, Albert – as Hossfeld suggests – simply did not have the time for extensive observations or comparative research. His intensive commenting activity largely explains his ‘literary’ and generally theoretical approach in research of nature.

51 See Hossfeld, “Die eigenen Beobachtungen”, *op. cit.*, pp. 148-150.

52 *Ibid.*, pp. 150-153, 157-159.

53 See, for example, the experiment in *Meteora* IV, tr. 4, c. 2 (Opera omnia VI), *op. cit.*, on the difference between most and wine. For a parapsychological experience, see *De somno et vigilia* III, tr. 1, c. 10 (Opera omnia 9), ed. August Borgnet, pp. 190-193.

54 Alchemical gold or silver dissolves after repeated heating; cf. Albertus Magnus, *Mineralia* III, tr. 1, c. 9, *op. cit.*

55 Among which, those concerning the eyes of the mole (Albertus Magnus, *De animalibus* I, tr. 2, c. 3, n. 140, *op. cit.*, p. 51), an unnamed fish (*ibid.*, IV, tr. 1, c. 8, n. 74, *op. cit.*, p. 391), the anatomy of the bees (*ibid.*, IV, tr. 1, c. 7, n. 71, *op. cit.*, p. 390), the heating of salamanders and spiders (*ibid.*, XXV, c. 2, n. 36, *op. cit.*, p. 1571), and types of ants (*ibid.*, XXVI, n. 16, *op. cit.*, p. 1587).

56 Hossfeld, “Die eigenen Beobachtungen”, *op. cit.*, pp. 153-57, 159-170.

57 Hossfeld carries out a contrastive analysis with the work of contemporary scientist Peter of Maricourt (Petrus Peregrinus), the author of an important treatise on the loadstone; cf. *De magnete*, ed. Gustav Helman, in: *Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus*, vol. X, Berlin 1898. For discussion, cf. Edward J. Dijksterhuis, *De mechanisering van het wereldbeeld*, Amsterdam 1985 (first edition: 1950), II, §§ 58, 79, 80; III, §§ 3, 62, 64.

4. Albert at Work: Minerals to Human Soul

Albert's research resulted in significant contributions to practically all of the sciences known in his days. Animal history,⁵⁸ botanics,⁵⁹ and physiology⁶⁰ are significant cases in point. A summary view of the structure of his mineralogy and psychology, the two disciplines that study the 'extremes' of natural reality, may illustrate the basic lines of his thought on the methodology of natural science.

According to Albert, nature is made up of elements, *mixta* (cf. *Meteora*), and substantial forms. Beings endowed with a substantial form can be divided into minerals, plants and animals, the latter including man. The two extremes of natural, created reality, that is, stones and human souls, are both subject of natural science. Mineralogy lacked an Aristotelian basis text and was put together by Albert. His psychology leaned heavily upon Aristotle, and the majority of his psychological works were Aristotle commentaries. Yet, his *De natura et origine animae* and *De intellectu et intelligibili* can be viewed as largely original treatises.

4.1. Minerals

The Aristotelian *corpus* contains almost nothing on mineralogy. Albert was therefore forced to draw up his own plan for dealing with minerals.⁶¹ The result shows us not only the contemporary state of mineralogy, but also Albert's idea of what a science of mineralogy should be. Like every scholastic treatise, Albert's *Mineralia* tried to mould the research problems to the dominant philosophical model, and thus analysed data in order to arrive at general prin-

⁵⁸ Christian Hünemörder, "Die Zoologie des Albertus Magnus", in: Meyer / Zimmermann, *Albertus Magnus Doctor universalis, op. cit.*, pp. 235-48, lucidly explains that Albert had a double aim: classify differences and distinction, and explain these. Four main problems can be individuated: i. about the way of live of many animals almost nothing is known; ii. some are so small that their anatomy is uncertain; iii. the plurality of differences cannot be explained always by common principles; iv. the confusion about animals in sources. A nice example is Albert's discussion of falcons and hawks, an original work which may have been based on first-hand observation; see Robin S. Oggins, "Albertus Magnus on Falcons and Hawks", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 441-462. For Albert's dependence upon Thomas of Cantimpré, see Pauline Aiken, "The Animal History of Albertus Magnus and Thomas of Cantimpré", in: *Speculum* 22 (1947), pp. 205-25; Friedman, "Albert the Great's Topoi", *op. cit.*

⁵⁹ Stannard, "The Botany of St. Albert the Great", *op. cit.*, pp. 345-372, stresses the enormous range of knowledge that he was able to assemble, organize and explain; not only commenting, because in his text are different strata: 1. ps-Aristotelian *De plantis*; 2. adoption of Aristotelian principles; 3. range of extra-Aristotelian materials; 4. examples from empirical evidence, observations. See, in particular, pp. 348-349, and p. 361.

⁶⁰ See, for example, Joan Cadden, "Albertus Magnus' Universal Physiology: the Example of Nutrition", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 321-339; James Rochester Shaw, "Scientific Empiricism in the Middle Ages: Albertus Magnus on Sexual Anatomy and Physiology", in: *Clio medica* 10 (1975), pp. 53-64 (slightly elaborated in: "Albertus Magnus and the Rise of an Empirical Approach in Medieval Philosophy and Science", in: David Lyle Jeffrey (ed.), *By Things Seen. Reference and Recognition in Medieval Thought*, Ottawa 1979, pp. 175-185). See also: Nancy G. Siriasi, "The Medical Learning of Albertus Magnus", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 379-404; Luke Demaitre / Anthony A. Travill, "Human Embryology and Development in the Works of Albertus Magnus", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 405-462; Tommaso Vinaty, "Sant' Alberto Magno, embriologo e ginecologo", in: *Angelicum* 58 (1981), pp. 151-180.

⁶¹ For a general discussion, see Wyckoff, "Introduction", *op. cit.*; John M. Riddle / James A. Mulholland, "Albert on Stones and Minerals", in: Weisheipl (ed.), *Albert the Great, op. cit.*, pp. 203-234.

principles, to make things understandable by explaining their causes: material, efficient, formal and final. The Aristotelian theory of elements is the basis of Albert's general classification of minerals into three groups: stones (mixtures of earth and water), metals which are made up of quicksilver (earth and water) and sulphur (containing something of all four elements), and finally 'intermediates' which are neither stones nor metals.⁶² In explaining the efficient cause Albert referred to the exhalation theory of *Meteorology*, where Aristotle set forth a theory that there are two underground 'exhalations': one of these, a dry 'smoke', produces earths and stones, the other, a 'watery vapour', produces metals.⁶³ According to Albert the exhalations are converted into minerals by the action of heat and cold, which in turn are merely the instruments of the real efficient cause, which is the 'mineralizing power', due to the influence of the heavenly bodies. Accordingly, the formal cause or formative power descends from the heavens, and this is what determines the particular kind of mineral. Last, the final cause is rarely mentioned because inanimate things can hardly be said to have an 'end'. Having dealt with the essential parts of stones and metals, Albert considered their 'accidental' properties.⁶⁴

Albert took the 'chemistry' from Aristotle, but its application to stones derived from Avicenna. Albert's treatise makes vivid the difficulties that hindered the development of modern chemistry and mineralogy. Although Albert used information from alchemical works and reported many observations of his own, he tried to fit everything into an Aristotelian plan.⁶⁵ The Peripatetic doctrine of forms, elements and qualities was quite inadequate for developing any sort of chemical classification of minerals. Form was the essential being or identity of a thing. Stones are inanimate, but they do have a form: that which makes a stone distinctively what it is and able to do whatever it does. As a consequence, Albert's developed a typical 'biological' explanation of the origin of stones: the female aspect supplies the matter, while the male (the 'mineralizing power') supplies the form. An excellent example is the 'power' of magnetism, essential to our identification or definition of the mineral magnetite. And medieval lapidaries ascribed many other 'powers' that Albert considered to be inherent in their forms and imparted to them by the formal cause, the formative power of the heavens. This theme is further developed in the tractate on sigils, images or markings found in certain stones.⁶⁶

As Wyckoff stated at the end of her Introduction to the English translation of Albert's treatise, the *Book of Minerals* is an impressive attempt to organize a science of mineralogy. Despite its outdated approach, its many errors of fact or of interpretations of fact, there is something here that we recognize: the introductory exposition of general principles (the origin, physical and chemical properties of minerals), followed by descriptions of individual minerals (appearance, mode and place of occurrence, uses, etc.) with the help of a lot of

62 The sulphur-quicksilver theory derived from Avicenna and other alchemists. See Wyckoff, "Introduction", *op. cit.*, pp. XXXI-XXXII.

63 Albertus Magnus, *Meteora* III, *op. cit.*

64 As to stones: texture, colour, hardness, fissility, cleavage, density, structure and fossils. As metals are concerned: fusibility, malleability, colour and lustre, taste and colour, and various chemical reactions.

65 See the reconciliation of Aristotle and the Sulphur-Quicksilver theory in Book I. Albert criticized and rejected alchemical theories that could not be reconciled with the Aristotelian teachings.

66 Wyckoff, "Introduction", *op. cit.*, pp. XXXIV-XXXV. See *Mineralia* II, 3, *op. cit.*

knowledge about the field where the research questions arose.⁶⁷ In this sense, Albert probably had in mind Aristotle's remarks at the outset of the *Topics*.⁶⁸

The presence of magical views in Albert's mineralogy should not be rejected as unscientific *tout court*. Albert was particularly interested in the efficacy of stones and metals, which in his days was unchallenged. The power of stones (*virtus lapidis*) was based upon their substantial form,⁶⁹ which depended upon the heavens and the activity of the first intellect. The description of specific minerals and the explanation of its powers were thus integrated in an all-encompassing cosmology. Recently, Udo Reinhold Jeck has convincingly argued that Albert's main contribution in mineralogy was a substantial "Entmystifizierung" of magical phenomena, because his invoking of suitable metaphysical principles led to an integration of magical effects into the rational and conceptual framework of natural philosophy.⁷⁰

4.2. Human Soul

At the outset of his treatise *De intellectu et intelligibili* Albert pointed out that the "scientia de anima" is not fully treated in Aristotle's *De anima*.⁷¹ This motivated Albert to analyze several psychological issues in separate treatises. To be sure, also the latter were deeply influenced by Aristotle. Yet, devoted to issues not explicitly tackled by Aristotle, they contain significant clues for a reconstruction of the conceptual frame of Albert's psychology. Here I concentrate on *De intellectu et intelligibili* and *De natura et origine animae*.

Albert followed Aristotle in viewing psychology as a part of natural philosophy or science.⁷² Accordingly, the place of the soul in natural reality determines its scrutiny, because every scientific discipline is linked to a determinate object and thus characterized by its ontological qualities. Psychology investigates living beings, that is beings endowed with a vital principle: plants, animals and men. Albert's essentially Neoplatonic worldview, cen-

67 Wyckoff, "Introduction", *op. cit.*, pp. XXXV.

68 Aristoteles, *Topica*, 100a21-22: "Our treatise proposes to find a line of inquiry whereby we shall be able to reason from reputable opinions about any subject presented to us, and also shall ourselves, when putting forward an argument, avoid saying anything contrary to it." Cf. 101a34-101b4: "For the study of the philosophical sciences it is useful, because the ability to puzzle on both sides of a subject will make us detect more easily the truth and error about the several points that arise. It has a further use in relation to the principles used in the several sciences. For it is impossible to discuss them at all from the principles proper to the particular science in hand, seeing that the principles are primitive in relation to everything else: it is through reputable opinions about them that these have to be discussed, and this task belongs properly, or most appropriately, to dialectic; for dialectic is a process of criticism wherein lies the path to the principles of all inquiries." (trans. in *The Complete Works of Aristotle. The Revised Oxford Translation*, ed. by Jonathan Barnes, 2 vols., Princeton 1984)

69 Udo Reinhold Jeck, "Materia, forma substantialis, transmutatio. Frühe Bemerkungen Alberts des Großen zur Naturphilosophie und Alchemie", in: *Documenti e studi sulla tradizione filosofica medievale* 5 (1994), pp. 205-240.

70 Udo Reinhold Jeck, "Virtus lapidum. -- Zur philosophischen Begründung der magischen Wirksamkeit und der physikalischen Beschaffenheit kostbarer Mineralien in der Naturphilosophie Alberts des Grossen", in: *Early Science and Medicine* 5 (2000), pp. 33- 46.

71 See Albertus Magnus, *De intelligibili et intellectu* I, tr. 1, c. 1 (Opera omnia 9), ed. Auguste Borgnet.

72 For recent views on Aristotle's psychology, see Martha C. Nussbaum / Amélie Oksenberg Rorty (eds.), *Essays on Aristotle's 'De anima'*, Oxford 1992.

tered upon the activity of the first intellect and the “incohatio formarum”, entails several important novelties, however. Unlike Aristotle, Albert held that the human soul, like all other natural beings, is produced by the first intellect. Its closeness to the latter, being ‘immediately’ generated, distinguishes the rational soul from the vegetative and sensitive soul. The vegetative and the sensitive soul are brought about from matter and its inner virtues. Only the rational soul is produced “ad imaginem et similitudinem intellecti primi” and therefore it cannot be seen as “forma corporis”, “actus corporis” or “virtus operans in corpore”.⁷³ Nonetheless, the direct production⁷⁴ of the rational soul by the first intellect is not a supernatural event:

On the basis of what has been said it becomes manifest what we said in *On animals* book XVI, namely that the nature of rational soul enters the foetus from without, not in the sense that the first intellect causes the soul beyond nature, but because it brings forth soul from its light and not from any of the material principles.⁷⁵

The first intellect, which is defined as “auctor naturae” is not an extrinsic agent, rather it is distinguished from natural beings “per esse”, not “per situm et locum”.⁷⁶

Man does not possess three distinct souls: the vegetative, sensitive and intellectual souls have a organical and dynamical relationship, because “incohatio rationalis est in sensitivo.”⁷⁷ Furthermore, the rational soul cannot be separated from the vegetative and the sensitive souls, “sed illae separantur ab ipsa.”⁷⁸ Thus, rational soul dominates not only the inferior capacities, but it also determinates the outer shape of man.⁷⁹ Albert, in effect, held that human bones and flesh, featuring man’s hand and tongue, differed from those of other animals because man has a rational soul.⁸⁰ This is a quite remarkable example of the fact that,

⁷³ *De natura et origine animae* I, c. 5, *op. cit.*, pp. 12-13. For the soul as “imago Dei”, see *De intellectu et intelligibili* I, tr. 1, c. 6, *op. cit.*, p. 486a.

⁷⁴ Note that Albert in *De natura et origine animae* and *De intellectu et intelligibili* avoided the traditional terms of creation or infusion, and prefers *influerre* and derivatives.

⁷⁵ *De natura et origine animae* I, c. 5, *op. cit.*, p. 13: “Ex dictis autem elucescit, quod in sexto decimo scientiae DE ANIMALIBUS libro diximus, quod intellectus in animae rationalis natura ingreditur in conceptum ab extrinseco non ita, quod intellectus primus causet ipsum extra naturae opus, sed quia educit eum de luce sua et non de aliquo materialium principiorum.” For other references, see Sturlese, “Il razionalismo filosofico e scientifico di Alberto il Grande”, *op. cit.*, pp. 406f.

⁷⁶ *De natura et origine animae* I, c. 5, *op. cit.*, p. 14.

⁷⁷ *Ibid.*, p. 13.

⁷⁸ *Ibid.*, c. 6, p. 14. See also tr. II, c. 3, p. 23: “Et si quaerat quis, quomodo hoc sit, quod in anima rationali manent post corpus vegetativum et sensitivum et non in animabus aliorum animatorum, plana est responsio per antedicta, quod videlicet hoc contingit propter duas causas. Quarum una est, quia non solae materiales causae educunt in homine vegetativum et sensitivum, sed potius primum agens est intellectus, et ab illo informatae agunt omnes qualitates, quae sunt in materia. Secunda autem causa est, quia agentes causae in materia hominis non terminant actionem suam nisi in formam et esse intellectualis naturae, et hoc in ullo contingit nisi in homine, in quo calor digerens et spiritus formans in semine magis movent et formant secundum virtutem caelestem et secundum virtutem animae et secundum virtutem intellectus, quam secundum qualitatem elementi vel secundum qualitatem materiae.”

⁷⁹ *Ibid.*, c. 7, p. 15: “Sola enim ultima forma dat esse speciei et formae, et antecedentes omnes sunt potentiae essentialis determinatae per ultimam formam, sicut iam saepius dictum est.”

⁸⁰ See *ibid.*, c. 5, p. 13: “et ideo loco anteriorum pedum in quadrupedibus formantur homini manus, quae sunt organa intellectus, sicut in libro DE ANIMALIBUS ostensum est; et sicut dixi de manu, ita est de aliis, sicut lingua, quae in homini congruit interpretationi, quae non est nisi actus rationis, et auris, quae est auditus

also in Albert's case, every observation is theory-laden. Albert's overall frame for natural research in general and that in psychology in particular, is dominated by a hierarchical view of natural reality, according to which the superior layers of reality contain and determine the inferior ones. Thus, his experience and most noticeably the interpretation of his observations were strongly 'colored' by theoretical assumptions.⁸¹

In *De intellectu et intelligibili* Albert discussed more at length the issue of the origin and cause of the difference between vegetative, sensitive and intellectual soul.⁸² If the first cause produces souls in virtue of its light how does it come that not all souls are equal? Albert rejects several explanations, among which the generation of soul by intermediary agents (the intelligences), the view that all souls are intellectual (attributed to Pythagoras), and the individuation of soul by the body. His rejection of the latter theory is of paramount importance: the qualities of a body depend upon the form it receives and thus cannot determine, preliminarily, the reception of the form. By contrast, Albert endorsed an essentially Neoplatonic view: all forms are produced by the first cause and their difference is merely due to their distance from the source, and thus to the "gradus dissimilitudinis in descensu."⁸³ The original unity of life, being and cognition remains unimpaired unless it is obscured by the distance of the dissimilitude:

The essence that emanates from the first cause has a full power of life, knowledge and motion because it emanates from what is the source of life, knowledge and motion; and it essentially preserves this power unless it is overshadowed by the distance of dissimilitude from the first cause, when the first cause that gives being to rational and intellectual beings vanishes in a very far dissimilitude. In this sense, it will be the principle of life, knowledge and motion in all.⁸⁴

At this point it does not come as a surprise that Albert summarizes his views on the origin and diversity of souls with a quote from Dionysius Areopagita:

disciplinalis, quod non competit nisi intellectui, et sic facile est considerare in omnibus aliis organis sensuum. Propter quod etiam in figura organa hominis ab omnibus differunt animalium organis, eo quod sensitiva in homine coniuncta rationi multo maioris virtutis, quam sit in aliis animalibus."

81 A similar case is Albert's interpretation of Platonic teaching about the human soul which led him to reject the Galenic description of the role of the three major organs in physiology. For Albert, writing in an age when natural science was indeed natural philosophy, it must have seemed entirely proper to choose between rival physiological systems on philosophical (or theological) grounds. Nor indeed were alternative means of choice readily available. For discussion, see Siriasi, "The Medical Learning of Albertus Magnus", *op. cit.*, p. 402.

82 For discussion, see Alain de Libera, *Albert le Grand et la philosophie*, Paris 1990, pp. 216f.; Sturlese, "Il razionalismo filosofico e scientifico di Alberto il Grande", *op. cit.*, pp. 404-417.

83 *De intellectu et intelligibili* I, tr. I. c. 5, *op. cit.*, p. 484

84 *Ibid.*, c. 6, p. 487a: "Essentia emanans a prima causa, plenam habet virtutem vitae et cognitionis et motus per hoc quod emanat ex ipsa quae est fons vitae et cognitionis et motus: et hoc essentialiter retinet nisi obumbretur per distantiam dissimilitudinis a causa prima, cum essentia prima quae dat esse rationalibus et intellectualibus, non abierit in dissimilitudine longissima: ideo erit vitae et cognitionis principium et motus in omnibus."

Every nature that proceeds from the first cause is so much more simple and noble and powerful, as it has been nearer to the first cause in similitude; and in turn, as far as it has been distant through dissimilitude, it is so much more material and obscure, and less powerful.⁸⁵

5. Conclusion

The medieval period actually prepared the way to modern science, not because it anticipated the new approach to nature or provided new concepts or techniques, but because it created the institutional and mental conditions that made the later scientific revolution possible. The reception and discussion of Aristotle, the development of a positive attitude toward natural philosophy even among theologians, the autonomy of scientific research, the organization of the universities as permanent institutions for teaching and research: all these conditions contributed to the generation of the new science, however different it might be in its method from its medieval predecessors.⁸⁶

In writing about natural science, one of Albert's goals was to articulate the general, all-encompassing principles of the subject. Although most of his conclusions were arrived at through interpreting Aristotle and his main commentators, Albert was critical of a strictly 'philosophical' approach in natural science and claimed that all science should be based upon experience and observation. We have seen, however, that Albert did not become an autonomous observer and *experimentator*. He did not subject to experiment the sayings of the ancients, many of his own observations are merely "Ansätze", and as a child of his time he endorsed many views now seen as based upon credulity. As a rule, in his works, conceptual assumptions often prevail over observed and recorded facts.⁸⁷ In this sense Albert's works confirm the modern view that observation as a rule is not encapsulated.

Albert endorsed the view of a law-governed universe made up of several layers. In his view, the order of nature was grounded in the formal determination of all created being, astral influx, and "incohatio formarum". Although this worldview had a strong Christian and Neoplatonic flavour, the impact of the latter did not block or frustrate research into natural reality. By contrast, the bounds of his overall view of the world as an "opus intelligentiae" guaranteed an open and thorough investigation of nature, because sensible reality as a creation of the first intellect was intelligible at all levels. Thus, surprisingly, Albert's Christian Neoplatonism favoured relatively autonomous research.

⁸⁵ *Ibid.*, c. 8, p. 489a: "Omnis natura procedens a causa prima tanto simplicior est et nobilior et in potestate multiplicior, quanto fuerit illi intimior per indistantiam similitudinis: et e regione e contra e quanto fuerit distantior per dissimilitudinem, tanto est materialior et ignobilior et paucioris potestatis."

⁸⁶ Edward Grant, *The Foundations of Modern Science in the Middle Ages: Their Religious, Institutional and Intellectual Contexts*, Cambridge 1996; Carlos Steel, "Nature as Object of Science; on the Medieval Contribution to a Science of Nature," in: ed. Chumaru Koyama, *Nature in Medieval Thought. Some Approaches East and West*, ed. Chumaru Koyama, Leiden 2000, pp. 125-152, on p. 148.

⁸⁷ A example is in Vinaty, "Sant'Alberto, embriologo e ginecologo", *op. cit.*, p. 166: the formative virtue of animals lies in the masculine sperm and not in the womb; thus, the same virtue that forms the umbilical cord, also forms the cotyledon veins.