ALBERT THE GREAT AS A SCIENTIST

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In the paper the author provides a brief sketch of Albert the Great as a scientist. By quoting passages from his works he shows that Albert the Great had a well-elaborated understanding of science. It is argued that in some aspects Albert was not too far from modern criteria that science and its methodology should meet. Accepting Aristotelian model of science, Albert stressed the need for experience and repeated observation in scientific research. While valuing authority, he examined carefully what it was stating and was not afraid to criticize even such an important authority as Aristotle, if his claims contradicted Albert's observations. Although science was in close relation with theology, it wasn't limited in its research and on the methodological level Albert was well aware of the need for their mutual independence. He was not afraid of providing science with freedom of inquiry, because he knew that in principle science and theology, if both sound, couldn't contradict itself, because there is just one truth known from their different perspectives. The article also introduces Albert's understading of and major contributions to mineralogy, astronomy, astrology, alchemy and other disciplines that were considered scientific in his time.

1. Introduction

Albert the Great is undoubtedly a very famous figure in the history of philosophy. But the fact that he is well known does not mean that he is also known accurately. And in fact, the common knowledge about Albert the Great is very often limited to the information that he was an important mediaeval bishop, politician, theologian, philosopher, scientist, etc., but in the first place that he was the teacher of Thomas Aquinas. It seems that Albert the Great, so to speak, stays in the shadow of his giant pupil. One of the aims I would like to achieve in this essay is to show that Albert the Great was and still is important not only because he was the teacher Aquinas. I would like to provide a brief sketch of Albert the Great as a scientist. My aim is to describe his understanding of science, scientific methodology, and scientific research. My textual analysis should provide some support for the thesis that Albert wasn't too far from meeting even some of the basic modern scientific criteria. I hope to show that he really deserves the title "Magnus" that was used even during his life and that the statements of his contemporaries as for example that he was "so godlike in every branch of knowledge that he can pro-

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perly be called the wonder and marvel of our age" (Cf. [14], 1), and the like, are not just ungrounded exaggerations, but accurate characterizations of the historical Albert.

Before going to the characterization of Albert the Great, I would like to mention a very important process that started in the early Middle Ages in the Latin West. This process is connected with the reappearance or rediscovery of the lost or unused works of Aristotle. It is appropriate to mention this process, because the work of Albert the Great is very closely connected with Aristotelian Corpus. Albert not only made Aristotle's works known and intelligible to the Latins, but these works also served as the basis and at the same time a precondition for his own works. Moreover, it is the rediscovery of Aristotle's works, translated either from Greek or from Arabic, that enabled further development of the sciences in the Scholastic period.

2. Aristotelianism in the Middle Ages

Before describing the fate of Aristotle's works in the Middle Ages, it is important to make several introductory notes and remarks. First of all, Aristotelianism is not a term of Antiquity or of mediaeval times. It has been coined and popularized in 18th century[1]. This term suggests the existence of some unified doctrine or unhistorical set of propositions. It also suggests that the fate, interactions, and impacts of this doctrine can be traced down and examined in the individual historical periods. (Cf. [6]) But this is clearly not the case. Aristotle's doctrine was in fact transmitted during the centuries through controversies, and quarrels about what is the actual Aristotelian corpus and how is it to be explained and interpreted. The fate of Aristotelianism in the Middle Ages can be seen in the process of translations, reception, and commentaries on the reappearing works.

2.1 Early Middle Ages

Aristotle wrote in Greek. Very few educated people from 500 to 1450 AD were able to either write or read in this language. This fact explains the very rare use of Greek works in the late Antiquity and Early Middle Ages. Boethius (480 – 524 AD) was the first, who attempted to translate

[1] On the contrary to the information indicated by Jordan (Cf. [6]), Prof. Christoph Meinel form the Department of the History of Science at Regensburg University, Germany suggested to me that the term „Aristotelianism" was coined earlier, viz. alerady in the 16th century.

Aristotle's works into Latin. However, he ended up translating only Aristotle's logical works (*Categories*, *De interpretatione*, *Prior* and *Posterior Analytics*, *Topics*, and *Sophistical Refutations*) i.e. the logical works of the *Organon*. It is also important to note that translation is not the same as reception. The works probably existed and circulated in translations, but were not utilized for speculative use. The reception of Aristotle before the Middle Ages did not take place because of several potential reasons, e.g. the small number of copies, difficulty of the texts, or the focus on other areas of study. (Cf. [6])

2.2 High Middle Ages (the 12th and 13th centuries)

The first stage of the recovery of Aristotle consisted in finding and using the translations of Aristotle's logical works made by Boethius (except for *Categories* and *De interpretatione*). These works weren't lost or unavailable before, but they weren't read. The renewed interest in logic made them relevant again, which can be seen in 1120s. (Cf. [6]) After this first impulse, translators from northern Italy (Pisa and Venice) again begun working on new translations from original Greek versions (1130s). They were able to work with Greek texts, because they had connections with Greek-speaking Byzantium. James of Venice was one of the most important translators from this group (*Sophistical Refutations, Posterior Analytics, Physics, On the Soul,* five of *Parva naturalia* - smaller natural works, and *Metaphysics* 1-4.4) However, all the translations made by Boethius, James, and his colleagues covered only less than one third of Aristotelian corpus. (Cf. [6])

Another source of Aristotle's works was found in Arabic philosophy with its centers in Spain. The prominent Islamic authors were Aristotle's commentators Averroes and Avicenna. Despite the fact that the Arabic versions were rather commentaries and interpretations of Aristotle than actual texts, they became more important than those translated directly from Greek. This is even more interesting when we consider that the translations from Greek were more fluent and accurate. Preferring the translations from Arabic in the Latin West is understandable from the viewpoint that textbooks of Aristotle's philosophy were needed more than the texts themselves. (Cf. [6]) However, a problem is rooted in the fact that Arabic versions were commentaries on Aristotle's texts. It was difficult to discern, which views are Aristotle's and which that of the translator or commentator. Also, several works were translated that were considered to be written by Aristotle, but in fact were from different

authors. One of the most important books incorporated into the Aristotelian corpus, which was not written by Aristotle, was the book *Liber de causis* (*Book of Causes*) that was translated by Gerard of Cremona. Even more complicated was the process of translating the books on physics. At the end of the 12th century approximately one half of Aristotle's writing was available in Latin. (Cf. [6])

At the beginning of the 13th century many theologians were concerned with the rapidly growing interest in Aristotle's works. They were afraid that especially his works on nature could contradict or replace the explanations of the Bible. Several condemnations were issued, but they had a little impact on the study of Aristotle's works. By 1240s the study of Aristotle was not only permitted, but also required in arts faculties. (Cf. [6]) Albert attempted to make Aristotle understandable by systematizing him with available bodies of knowledge. He decided to write paraphrases on the whole Aristotelian corpus and fill in the gaps in the corpus with what he thought would be Aristotle's teaching on the missing points. This project took him about 20 years form 1250 to 1270.

3. Models of Science

Before the rediscovery of Aristotle's works, Platonism was the predominant philosophy in the Latin West. This Platonism, however, was adjusted to the needs of Christianity, thus we could speak of a kind of Christian Platonism. Besides other areas, Platonism influenced also the understanding of science. There were two basic platonic scientific models.

3.1 Augustinian (Timaean[2]) model of science

Within this model of science nature and natural changeable, individual, and contingent things are seen only as the images of universal ideas that are present in the divine mind. Nature presents divine ideas and is understood only as a manifestation of true reality. It is thus inferior or less perfect than divine ideas. In itself, nature is of only little intrinsic interest. It is understandable only through divine illumination and is interpreted in allegorical way. It is, moreover, not open to rational investigation, but only to contemplation.

[2] Named after Plato's dialogue Timaeus.

3.2 Pythagorean model of science

This model is focused more on the regularities of nature, and thereby opens the possibility for the science of nature. However, science understood within this model should seek for the mathematical basis of reality. This model accepts pragmatic approach and is thus interested in research, experimentation and technological application of the knowledge of nature. But also in this model of science nature has only instrumental value.

3.3 Aristotelian model of science

First with Aristotle and the development of his concept of science nature becomes to be interesting because of itself. For Aristotle, the forms or intelligible content of our knowledge is immanent in the material objects themselves. We are thus not compelled any more to rely upon the knowledge God in order to gain the knowledge of things. The order of nature is to be found in nature itself. With Aristotelian concept of science nature receives its own voice and can speak for itself. Natural philosophy and sciences are autonomous from mathematic or metaphysics. Science for Aristotle is the "highest form of human knowledge, true and certain, because arrived at through apodictic demonstrations, and thus yielding conclusions about a subject matter that cannot be otherwise" ([12], 103). Aristotelian science aims at describing the reality in terms of the ultimate causes.

4. Albert the Great

After indicating the situation in philosophy and natural sciences at the beginning of the Middle Ages, we can focus on the main subject of this paper. Even though Albert's main interest during his whole life was in theology, Albert is no less important for philosophy and the development of mediaeval science. It will be attempted here to introduce Albert the Great as a scientist. I will try to show Albert's understanding of science by quoting passages from his texts. When we consider Albert's main concern was theology, it is even more amazing to see how much he did achieve in the sciences. He was the first scholastic interpreter of Aristotle's works, who managed to comment on the whole of what was then known as Aristotelian corpus. His method of exposition was that of paraphrasing rather than literal commentary[3]. The sources for Albert's

[3] Literal commentary was an approach used for example by Averroes.

works were both the Arabic translations and commentaries and the Greek and Byzantine texts. His aim, as already mentioned, was to make Aristotle intelligible to his Latin contemporaries and to harmonize the teaching of Aristotle with that of Christianity and Platonism.

Although it might seem at the first sight irrelevant, his membership in the Dominican order was very important for his work. The very impulse for his commenting on Aristotle came from within the Dominicans. It was upon the request of his fellow Dominicans that Albert undertook the task of presenting the Aristotelian works in a coherent and intelligible manner. But there are yet more aspects of Dominican lifestyle that had impact on his work and will be shortly mentioned later.

4.1 Works

Albert the Great was an enormously prolific author. There are more than 470 distinct works attributed to him[4]. In total there are about seventy treatises important for philosophy, theology and science that consist of 20,000 pages in manuscript. ([14], 18) There are authors, (e.g. Van Steenberghen) which state that Albert was the most prolific author of the whole Middle Ages. ([14], 18) Approximately 20 major works are directly aiming at the study of nature[5].

4.2 Albert the Great and the necessity in natural science

On the contrary to the "Oxford Platonists" (e.g. Roger Bacon) and their arguing for the mathematical necessity in science, Albert emphasizes the value of suppositional necessity in scientific reasoning. In mathematical demonstration one finds double necessity: a) the premises are necessary; their necessity dictates b) the necessity of the conclusions. In natural sciences, however, we can observe very often only the *effects* without seeing their *causes*. But if nature is to be intelligible, we have to assume that there are causal relations. And although we cannot argue from cause to effect (we first don't know the cause) we know that every effect has to have a cause. So we can argue from the effect to the cause. Then we can postulate as a hypothesis the cause of the regularly observed effect. This postulated cause stands in the place of necessary mathematical premise. But it possesses only conditional or hypothetical necessity. (Cf. [14], 28)

[4] Many of these were sermons and homilies.

[5] For a complete list see: Weisheipl, J. (ed.): *Albertus Magnus and the Sciences*. Pontifical Institute of Mediaeval Studies, Toronto 1980, 565-575

"Although it is not possible to argue with certainty from the presence of the cause to the necessary appearance of the effect – let us say from an olive seed to an olive tree one can move in the other direction. From the presence of the olive tree, one *can* stipulate the *necessary existence* of the cause, the olive seed." ([14], 29) Let us now look at Albert's text. How should the science proceed? In *De vegetabilibus et plantis* Albert writes:

> The task of philosophy is to search for a certain evident and true cause of known effect, and to show its proof, and show what is impossible to be otherwise.[6] ([4], 11)

In this passage we can see more aspects of Albert's understanding of science. First, we see here Aristotelian concept of science that is looking for the causes of things and aims at knowledge that cannot be otherwise. Albert's preference for the suppositional necessity in science can also be supported by the above quote. The goal of natural science, the text suggests, is to determine the unknown cause (certam et manifestam et veram causam) for the known effect (effectus cogniti). This is exactly how scientific reasoning based on the concept of suppositional necessity proceeds.

4.3 Science vs. Theology

It is often believed that science in the Middle Ages was very strongly limited by theological dogmas. Some may attempt to discredit mediaeval science because of its dependence on theology. But in Albert's works we read:

> In natural science we should not investigate how God the Creator according to his absolutelly free will governs his creatures through the miracles, nor how he affirms his might. But we should rather investigate what can naturally come about in natural things on the basis of given causes of nature.[7] ([4], 7)
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> If however somebody said that God by his will could at any time bring all the creation into non-being, just as at some time it did not exist and then begun: I

[6] My translation from Latin into English. (In original draft of this paper I have quoted some passages from Albert's works from German translation (Cf. [4]). For the purposes of publishing the paper I have translated these passages form Latin into English. In order to minimize possible inaccuracy of translation I recommend the reader to consult my translation with Latin text in the foot notes.) "Philosophari enim est, effectus iam cogniti certam et manifestam et veram causam investigare, et ostendere, quomodo illius causa est, et quod impossibile est aliter se habere." *De vegetabilibus et plantis l.2 tr.2 c.1*

[7] My translation from Latin into English. "Nec nos in naturalibus habemus inquirere, qualiter Deus opifex secundum suam liberimam voluntatem creatis ab ipso utatur ad miraculum, quo declaret potentiam suam, sed potius quid in rebus naturalibus secundum causas naturae insitas naturaliter fieri possit." *De caelo et mundo (Ed.Col. t.5,1)*

> reply that when I am examining natural things, God's miracles do not interest me at all.[8] ([4], 7)

Both passages indicate that Albert was well aware of the need for distinguishing between the research of natural science and theology. Thus we have to avoid two mistaken positions. First position would state that mediaeval science was, so to speak, only a slave of theology. The other position is inclined to argue that mediaeval science and theology were independent in the modern sense. Either of the views is inappropriate. Theology did not dictate what the science should discover, but neither would these two disciplines meet the modern criteria for their mutual independence. When judging the relation between mediaeval science and theology, one has to keep in mind that one must not apply modern criteria for the distinction between these disciplines. We may say that on methodological level, as it is clear from the quoted texts, Albert respected and argued for the distinction between theology and science. But, because there was no institutional division between individual fields of study, we cannot speak about two independent and isolated study programs at mediaeval university. Scientific and philosophical research was conducted with the aim to help doing better theology. This does, however, not mean that theology was deciding what the science could or should discover or say.

4.4 Place of Aristotle and Plato in philosophy

Some might believe that Albert the Great was a strict Aristotelian, valuing and relying only on his philosophy. This is, however, not the case and the error probably stems from insufficient study. To the distinction between the two philosophical systems, Albert has to say the following:

> This, according to my opinion, was the whole reason of the controversy between Plato and Aristotle that the former wanted to follow the general forms of things, from which he wanted to understand the first principles of things. But Aristotle, on the other hand, wanted to find the first principles of things in their nature.[9] ([4], 13-15)

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[8] My translation from Latin into English. "Si autem quis dicat, quod voluntate dei cessabit aliquando generatio, sicut aliquando non fuit et post hoc incepit: dico, quod nihil ad me de Dei miraculis, cum ego de naturalibus disseram." *De generatione et corruptione l.1 tr.1 c.22* (My translation into English.)

[9] My translation from Latin into English. "Hoc enim, meo iudicio, omnis causa fuit controversiae inter Platonem et Aristotelem, quod iste rationes universalium sequi voluit et ex illis rerumprincipia quaesivit. Aristoteles autem non sic, sed ex naturis trerum quaesivit principia rei." *II Sent. d.1 a.4*

He is also very clear on the importance of both philosophical traditions of Antiquity. He states that it is important to study both:

> You must know that a man cannot be a philosopher unless he knows both, the philosophy of Aristotle and that of Plato.[10] ([4], 13)

We could say that had the concept of *philosophia peraennis* been elaborated in his time, Albert would be one of its strong proponents. But, even without explicitly saying so, as the passages indicate, Albert believed that there is only one true philosophy, one truth if you will, that the philosophers and philosophical schools should keep trying to arrive at.

4.5 Methodology of Natural Science

One of surprisingly well-elaborated aspects of Albert's understanding of science is visible in methodology he follows and recommends. In some points his methodology is rather close to some features of modern scientific methodology. I will try to demonstrate this, again, by quoting several texts.

In the first place, Albert, in order to arrive at the true solution of a problem, consults all to him available sources.

> Here we inted to investigate carefully these difficult things, therefore according to our abilities we first want to explain all the views of Aristotle, then introduce the opinions of other Peripatetics, after that to look at Plato's views, and then in the end to state our own opinion...[11] ([4], 5)

This passage clearly shows that Albert is not primarily trying to support his thesis, but to find the truth. He consults what Aristotle and his followers had written on the dealt-with topic. Then he proceeds to the analysis of Plato's opinions. It is not the easier way for Albert. Following this method he will have to deal with doctrines that he can expect will be difficult to reconcile. Then, first after analyzing and considering what had been written, Albert provided his solution. Despite the difficulties, he chooses to follow the more difficult procedure. In order to arrive at true knowledge of the subject Albert takes pains to wage and inquire all

[10] My translation from Latin into English. "Et scias, quod non perficitur homo in philosophia nisi ex scientia duarum philosophia Aristotelis et Platonis." *Metaphysica (Ed. Col. t.16)*

[11] My translation from Latin into English. "Et quia res difficillimas hic perscrutari intendimus, ideo volumus primo totam Aristotelis sententiam pro viribus nostris explanare, et tunc inducete aliorum Peripateticorum opiniones, et post hoc videre de opinionibus Platonis, et tunc demum nostram ponere opinionem…" *De anima (Ed. Col. t.7, 1 p.177)* (My translation into English.)

relevant body of knowledge. This method is, however, also more likely to avoid errors.

4.6 Role of experience in natural sciences

Scientific work before Albert, more often than not, consisted in compiling available sources without sufficient critical examination of the content. Nature was studied from books. Albert is the first important figure of the Middle Ages who is stressing the importance of experience in the study of nature. There are many passages in his works where he sounds this requirement very explicitly. I have chosen just a few of them:

> True curiosity urges on to make experiments.[12] ([4], 7)
> And this agrees with our exeperience and with all that has been proven and with reasoning[13] ([4], 5)
> Experience is indeed the best instructress in such things [in the study of nature][14] ([4], 5)

In *De Animalibus* we find further evidence for Albert's ascribing great value to experience and observation. He concludes his description of various species of hard-shelled animals by a sentence that could be seen as a motto of his scientific work:

> They can be studied better by viewing than by reading. *De Animalibus IV.38*

Albert not only values experience, but he also stresses the need for repeated observation:

> A lot of time is required in order to prove an observation in a way that all mistakes are excluded. Whence Hippocrates said in his *Medicine*: "Life is short, art [of medicine] is long, experience is deceptive, and judgment is difficult." It is therefore important that the experiment is not conducted in one way only, but that it is tested according to all circumstances, so that it can be reliably and rightly used as a principle [...] Some are scattered in sensible things and need much examination and coparison to one. It needs much time and examination before we can accept them to be without any doubt.[15] ([4], 7-9)

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[12] My translation from Latin into English. "Curiositas enim experiendi incitatementum facit." *Super Dan. 14,15*

[13] My translation from Latin into English. "[…] Et hoc concordat cum experientia quam nos […] experti sumus et cum ratione." *De Animalibus l.4 tr.1 c.7*

[14] My translation from Latin into English. "Experientia enim optima est in talibus magistra." *De Animalibus l.23 c.19*

[15] My translation from Latin into English. "Multitudo enim temporis requiritur ad hoc, ut experimentum probetur, ita quod in nullo fallat. Unde Hippocrates in "Medicinalibus"

When we consider that in the early Middle Ages the study of nature was almost exclusively limited to compiling of previously written sources, it is amazing that Albert was so clear on the importance of experience in the study of nature. Albert's orientation on experience may be explained by several factors. One of them might be the fact that Albert was a member of the recently founded mendicant Dominican Order. As a Dominican, Albert had to travel a lot, but he was not allowed to use any travel vehicles – horseback including. Feet were the only vehicle that Dominicans were allowed to use on their journeys. And so, Albert, on his journeys as a friar, but also as a Prior Dominican and a bishop, had many opportunities to see the discrepancy between what the books say and the nature itself. It is obvious in all Albert's works that he had taken advantage of these journeys and that he used them for careful observation of nature that makes his works so valuable.

4.7 Authority and Tradition vs. Experiment; Originality

As a mediaeval scholar and a member of a religious order Albert undoubtedly valued authority. However, this did not prevent him from correcting the authorities (even Aristotle himself) if, according to Albert's knowledge or experience, these authorities were mistaken. There is sufficient evidence that he did not adjusted his research conclusions to what the authorities were saying. When it was necessary, he was ready to be very straightforward in correcting even the greatest scientific authority of that time, i.e. Aristotle:

> 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 he however believes that Aristotle was but a man, then without doubt he could err just as we can too.[16]

loquens, hoc ipsum innuit, dicens: "Vita brevis, ars longa, experimentum fallax, iudicum difficile." Oportet enim experimentum non uno modo, sed secundum omnes circumstantias probare, ut certe et recte principium sit operis […] (f.158ra) Quae autem in sensibilibus sparsa sunt, et multa indigent collatione et proportione ad unum, tempore indigent et multa examinatione, antequam certe credantur." *Ethica l.6 tr.2 c.25*

[16] "Dicet autem fortasse aliquis nos Aristotelem non intellexisse, et ideo non consentire verbis eius, vel quod forte ex certa scientia contradicamus ei quantum ad rei veritatem. Et ad illum dicimus quod qui credit Aristotelem fiusse Deum, ille debet credere quod numquam erravit, si autem credit ipsum esse hominem, tunc procul dubio errare potuit sicut et nos." *Physica VII,I,14*

Or elsewhere, while accepting Augustine as theological authority, he rejects him as an authority in medicine:

> Augustine is to be preferred rather than the philosophers in case of disagreement in matters of faith. But if the discussion concerns medicine, I would rather believe Galen or Hippocrates, and if it concerns things of nature, Aristotle or anyone else experienced in natural things.[17] ([15], 382)

And in *De Animalibus* Albert openly rejects traditional account of the generation of a Basilisk:

> Some say that a decrepit cock generates an egg on its own and places this in excrement. They say that the egg lacks a shell but has a strong enough skin to stand up to the strongest blows and that this egg is fertilized by the heat of the dung to form a basilisk. This is a serpent like a cock in all respects except for having a long serpent's tail. Now I do not think this is true, but it was said by Hermes and has been accepted by many on the authority of the one saying it. (*De Animalibus XXIII, 116*)

These are just few examples that are, however, I think sufficient to demonstrate that Albert, as a prominent representative of the mediaeval science, was – despite honoring and valuing authority – rather critical in his scientific work. This of course must not be interpreted as if Albert conducted scientific research according to modern criteria for the role of authority in science.

Yet another interesting problem is connected with the role of authority in mediaeval science. It is the problem of originality of scientific works. It has to be made very clearly that the mediaeval concept of originality was very different form the modern one. In the Middle Ages originality consisted in new and enriching combination or compilation of knowledge. It was not necessary to come up with some completely new information or data. So in this respect Albert was indeed very original mediaeval author.

4.8 The Goal of Science

The next two Albert's texts can throw some light on his understanding of the goal of natural sciences. It will be shown that beside instrumental value science had for theology, it also had its own intrinsic value as a source of speculative and practical knowledge:

[17] "Unde sciendum, quod Augustino in his quae de fide moribus plus quam philosophis credendum est, si dissentiunt, sed si de medicina loqueretur, plus ergo gredem Galeno vel hippocrati; et si de naturis rerum loquatur, credo Aristoteli plus vel alii esperto in rerum naturis." *II Sent. d.13 a.2*

> To know this is not delightful only to those that aim at the mastery of natural things, but in fact it is also useful for life and the well-being of community.[18] ([4], 9)
> And so astrology and geometry and other sciences lead to prudence, but not through understanding them, but through exercising them.[19] ([4], 9)

4.9 Individual Sciences

Albert was very prolific and original author. There can be no doubt that he was original in the mediaeval understanding of originality as discussed above. A look at some of the individual sciences he contributed to can support the claim that to a certain degree, Albert was original also in the modern sense of originality. In several areas, Albert contributed to and enriched the body of knowledge with new and original (in modern sense) data. I would like to mention only some interesting aspects of three disciplines Albert dealt with in order to provide the reader with a closer look at his work.

4.9.1 Mineralogy

Albert made a great contribution to this branch science. (We might probably even say that he was the founder of mineralogy as an independent research area.) Before Albert, mineralogy was studied only within other sciences (astrology, medicine, etc.) It was not perceived as independent scientific discipline. He was aware of the fact that he was doing a pioneering work, because he could not find any works and authorities to rely on[20]. The task before him was very difficult. He knew that he would not be able to exhaust the subject so he intended that "on the basis what has been said [in his work], anything else [relating to minerals] that has not been mentioned here can also be readily understood." (*De min. V, 1,9*; [9], 201-202) That he was aware of the fact he was founding a new science can be seen also from this reference: "[…] et complebimus in eius totam istius scientiae de mineralibus intentionem." (*De min. III, 1,*1; Cf.

[18] My translation from Latin into English. "Hoc enim scire non solum delectabile est studenti naturam rerum cognoscere, quinimmo est utile ad vitam et civitatum permanentiam." *De vegetabilibus et plantis l.7 tr.1 c.1*

[19] My translation from Latin into English. "Et sic astrologia et geometria et aliae scientiae proficiunt ad prudentiam, non quidem per ipsum scibile, sed per exercitum in ipso." *De bono* (*Ed. Col. t.28 p225 1-4*)

[20] However, Albert did not work without any sources. He probably used Avicenna's treatment of minerals and possibly other sources, but all of them seemed to him insufficient. (Cf. [9], 203)

[9], 204, footnote 3) In the first book he explains that minerals aren't alive, have no souls, and are composed of earth or water. The efficient cause of stone formation is a mineralizing power that is a natural process produced by heavenly powers. This process is difficult to explain by other means than by analogy. In *De Mineralibus* Albert is also describing the characteristics and features of to-him-known stones. However he is listing them in alphabetical order and doesn't develop a systematic classification. (Cf. [9]) He believes that stones are influencing their environments and some have healing effects. This can be explained not only by superstition as some might attempt to. There are references to "healing stones" that are true, because some stones really contain chemical compounds with healing effects. Positive healing effect of other stones can be ascribed to what modern medicine would call placebo effect.

Beside stones, in *De mineralibus* Albert deals with metals. Here we can also see several features of his scientific work, viz. consulting all available sources, critical examination of the opinions of the authorities, accepting what proved to be true, and adding the data from own observation and research:

> In [writing] this as well as the preceding books, I have not seen the treatise of Aristotle, save for some excerpts for which I have inquired assiduously in different parts of the world. Therefore I shall state, in a manner, which can be supported by reasoning, either what has been handled down by philosophers or what I have found out by my own observations. For at one time I became a wanderer, making long journeys to mining districts, so that I could learn by observation the nature of metals. And for the same reason I have inquired into the transmutation of metals in alchemy, so as to learn from this, too, something of their nature and accidental properties. For this is the best and surest method of investigation, because then each thing is understood with reference to its own particular case, and there is very little doubt about its accidental properties. (*De min. III,1,1*; [9], 215)

In his teaching on minerals Albert was successful in uniting the Arabic concepts of metal formation from sulfur and quicksilver (alchemy) and Peripatetic concepts of matter consisting of four elements, i.e. earth, water, fire, and air. In this work Albert, we could say, came close to the present-day requirements for scientific work and wiring, i.e. hypothesis, observation, and interdisciplinary authority.

3.9.2 Astronomy and Astrology

Many might think that astronomy and astrology were not distinguished in the Middle Ages. And in fact, Albert himself uses these two terms inter-

changeably. But this does not mean that the distinction between these two disciplines was unknown to the mediaeval scholar and scientist. The distinction on theoretical and methodological level was clear. It was not so clear on practical level. Both these sciences have the same subject matter, i.e. heavens and celestial bodies. Albert characterizes the distinction as follows:

> It ought be stated that there are two parts of astronomy (*astronomiae*), as Ptolemy says: one is about the location of superior [heavenly] bodies, their quantities and their individual phenomena (*passionibus*); and arrives at the knowledge of this part through demonstration (*demonstrationem*). The other is about the effects of the stars on inferior [terrestrial] things, which effects are impermanently assumed by the mutable thing; and therefore one arrives at the knowledge of this part only by conjecture, and it is necessary that the astronomy of the latter kind exists according to something physical, and that it be conjectured by physical signs. (*De fato, a.4*; [10], 156)

4.9.3 Alchemy

Albert considered also Alchemy to be a legitimate field of scientific inquiry. He understands it as a science studying the transmutations of metals. He argues against the view that the pure metal is gold and the other kinds metals are just formed when gold gets a "disease". In alchemy, Albert again relies to a great degree on his own observations. However, Albert is not too positive about Alchemy:

> I have examined many alchemical books, and I have found them lacking in [evidence] and proof." They merely rely "on authorities" and conceal "their meaning in metaphorical language, which has never been the custom in philosophy. Avicenna is the only one who seems to approach a rational [attempt], though a meager one, towards the solution of the above question, enlightening us a little. (*De min. III,1,7*; [7], 190)

5. Conclusion

In this paper I have attempted to provide a brief sketch of Albert the Great as a scientist. By quoting passages from his works it was shown that he had a well-elaborated understanding of science. I have argued that in some aspects Albert was not too far from modern requirements for sound science and methodology. Accepting Aristotelian model of science, Albert argued for the suppositional necessity in scientific reasoning, stressed the need for experience and repeated observation in scientific research. While valuing authority, he examined carefully what it was stating and was not afraid to criticize even Aristotle, if he contra-

dicted his observations. Although science was in close relation with theology, it wasn't limited in its research and on the methodological level Albert was well aware of the need for their mutual independence. He was not afraid of providing science with freedom of inquiry, because he knew that in principle science and theology, if both sound, couldn't contradict itself, because there is just one truth known from their different perspectives. I hope that I have succeeded in indicating Albert's huge contribution to the development of science. And it seems to me that even before and without considering his theology, Albert, already for his achievements and contribution to the development of science, really deserves to be called "the Great".

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