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ΕΝ ΑΘΗΝΑΙΣ

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MICHAEL PSELLOS' THEORY OF SCIENCE*

I

There are good reasons why the Byzantine philosopher, statesman, historian and professor of the Trivium and the Quadrivium Michael Psellos (A.D. 1018 - c. 1078) should have developed an interesting theory of science. His knowledge of logic, mathematics, physics and metaphysics, i.e. the work of Plato, Aristotle, Euclid, the Stoics, the Neoplatonists and the Christian Fathers was considerable. He also knew and practised[1] medicine and he does not seem to have despised applied science as he took pride in doing experiments in optics and constructing some pneumatic contrivances and other automata[2] in imitation of Hero of Alexandria

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The following abbreviations are used:

Scripta Minora I and II = E. Kurtz - F. Drexl, Psellos, Scripta Minora magnam partem adhuc inedita, vol. I (Milan 1936); vol. II (1941).

Sathas I and II = C. Sathas, Μεσαιωνική Βιβλιοθήκη, vol. IV (Athens - Paris 1874) and vol. V (Venice - Paris 1876).

Boissonade = Psellos, De Operatione Daemonum, ed. Jo. Fr. Boissonade, Nürrnberg 1838.

Chronographia = Psellos, Chronographia, ed. E. Renauld, I - II, Paris 1926 - 1928 (Les Belles Lettres).

Doctrina = L. G. Westerink, Psellos, De Omnifaria Doctrina, Critical Text and Introduction, Utrecht 1948.

De Anima = Psellos, Περὶ Ψυχῆς, etc., Migne, Patrologia Graeca, vol. 122.

Accusation = Psellos, Opuscules etc., ed. J. Bidez, Brussels 1928.

Philosophical Definitions = Πόσα τὰ γένη τῶν φιλοσοφουμένων λόγων, ed. C. Sathas, Bull. Corr. Hell., 1, 1877.

1. Cf. Scripta Minora I 175. Cf. also Sathas I 38.

2. Cf. Scripta Minora I 368, where among other things he says that he gave voice to an artificial bird and movement to its bronze wings.

and Archimedes [1]. Lastly, he was by any standards an extremely intelligent and hard-working man.

Despite his eclecticism [2], Psellos' ideas about science and scientific method form an integrated and consistent theory, neatly tied up with his psychology, his theory of knowledge and his theology.

II

The basic fact about his thought is the aristotelian division of reality into three realms of being, consisting of the sensibles (αἰσθητά), the objects of mathematics (μαθηματικὰ) and the intelligibles (νοητά) [3]. Psellos accepted this division with a firm Platonic ontological commitment. In this classification the objects of mathematics occupy a middle position between the other two [4], hovering, as it were, over the bodies of the senses [5], but in an incorporeal manner, being composite but not in time (i.e. having permanence denied to the sensibles), and forming a ladder for going from the lower physical objects of sense to the higher objects of the intelligible world, which are simple and separate from bodies [6].

III

This conception of being naturally determines or is bound up with Psellos' epistemology. Following the Pre-Socratic principle that like is known by like he divides the reasoning cognitive faculties of the soul into:

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1. Psellos did not despise even the art of making cheese. He writes to someone: I shall explain (φιλοσοφήσω) to you the making of cheese, because nature behaves here in a wonderful manner. Cf. Scripta Minora II 236.

2. No systematic attempt will be made here to trace the several origins of Psellos' ideas.

3. In one passage he equates the intelligible substance with the Good. Cf. Sathas II 354.

4. It seems that this Platonic division of Aristotle's was given wide currency in the Middle Ages through Proclus. Cf. Sathas I 132.

5. Boissonade 161.

6. Philosophical Definitions 128.

(1) opinion (δόξα) for the concrete objects of sense
(2) understanding (διάνοια) for the causes of phenomena
(3) intellect (νοῦς) for the intelligibles or universals.

The polarisation of δόξα and νοῦς [1] is mitigated by the role of διάνοια which combined with νοῦς apprehends the intelligibles, whilst combined with imagination (φαντασία), it apprehends the sensibles [2]. Perception (αἴσθησις) and imagination form the unreasoning cognitive faculties of the soul [3] but they provide material for imagination and διάνοια respectively [4].

The faculties determine in their turn three kinds of knowledge [5].

(1) knowledge of νοῦς [6] (νοερά), seeing reality directly, usually called θεωρία [7], seeing things that perception cannot even hint at.
(2) knowledge of reason (λόγος) sub-divided into
(a) science (ἐπιστήμη) known by the reasoning soul and appertaining to unchanging things.
(b) opinion (δοξαστικὴ γνῶσις) by the reasoning soul but appertaining to changing things.
(3) knowledge by the unreasoning soul (i.e. perception or imagination), having to do with particulars. Perception acts through the body and its inevitable mistakes are corrected by the reasoning soul, thus giving rise to the sciences.

Psellos recognizes also a fourth kind of knowledge beyond νοῦς, supra-rational or divine knowledge.

The threefold classification or rather hierarchy of being is also reflected in the three basic sciences, i.e. physics, mathematics (μαθήματα) and metaphysics or theology. The way of knowledge is from the lower to the higher sciences. In a number of passages Psellos stresses this point: «I studied physics and through the inter-

1. De Anima 1029. Doctrina No. 31.
2. De Anima 1032.
3. De Anima 1036. Cf. also Sathas I 435.
4. De Anima 1068.
5. Cf. Doctrina No. 94.
6. The physical analogue of νοῦς was for Psellos the heavens. Cf. Scripta Minora I 31.
7. The ubiquitous Byzantine concept of θεωρία is described as an activity of the νοῦς. Cf. Sathas I 185.

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mediate entities I reached the first philosophy» [1]. Starting with nature and investigating its causes you reach the μαθήματα [2] and thence the incorporeal natures and ultimately God [3]. One cannot proceed from the physical world to the vision (θεωρία) of the realities except through the μαθήματα. Geometry occupies a middle position between divisible and indivisible objects [4].

In Aristotelian fashion Psellos posits a series of metasciences locating the principles of a lower science in a higher or subordinating one. When a science proves the principles of another science, he says, it is more exact than the latter, e.g. physiology with regard to medicine, geometry with regard to mechanics and arithmetic with regard to music [5]. He places metaphysics which he also calls 'dialectic' or 'wisdom' (σοφία) almost at the apex of this scheme because it provides the principles and interprets the axioms of the other sciences [6]. The sciences whose subject is non-material such as geometry, arithmetic and theology are more exact than the ones that relate to matter. Geometrical lines, though not existing in the ordinary sense [7] are the principles of all the physical sciences. The principles of optics, he says, lie in geometry [8]. The material lines of optics owe their logical status to the immaterial objects and principles of geometry.

IV

Psellos' classification of the sciences is in line with these general ideas. His basic dichotomy of learning is between the theoretical sciences which he subsumes under philosophy whose domain comprises the natures of beings (sensible, mathematical and intelligible beings), and the practical sciences (τέχναι) such as the art of rhe-

1. Chronographia I, 135.
2. Details on the interests of a Byzantine scientist are given by Psellos in Sathas I 54 - 55.
3. Scripta Minora I 307. *Cf.* Chronographia *I*, 136.
4. Sathas I, 132.
5. De Anima 1056.
6. Sathas I 55.
7. Sathas I 446.
8. Sathas II 394.

toric [1]. He never wearies of repeating (quite rightly) that he, himself, cultivated both philosophy and rhetoric.

Consistently with his ontology he says that as there are lower and higher parts of the body, so in philosophy the more deductive sciences (connected with νοῦς) occupy a higher position than the conjectural sciences dealing with the natural world [2], while at a lower rung of the ladder are the political sciences such as law and rhetoric which fail to reach the truth because their demonstrations do not start from principles or first causes [3].

Explaining the different functions of the scientists in a hierarchical way Psellos says that the physicist deals with perceptible or intelligible substance as far as this is inseparable from physical objects [4]. The physiologist, being a philosopher, deals with it as a separate entity, the dialectician deals with essences and their definitions as such, the mathematician abstracts them from objects and the first philosopher deals with the separate existences of the soul [5].

Like διάνοια the vital sciences called μαθήματα which include mainly arithmetic and geometry as subordinating sciences and music and astronomy as subordinate ones, have a threefold direction and purpose. When directed to bodies they include computation, geodesy, optics and catoptrics, when treated purely as μαθήματα they consist mainly of arithmetic and geometry, but aiming still higher they achieve the vision of the intelligibles [6].

V

Although Psellos places physics in a comparatively low position he feels the highest respect for this science [7] and thinks that the ascent to higher things should start from the study of physics and the

1. Cf. Chronographia I 137.
2. Scripta Minora I 430.
3. Scripta Minora I 430.
4. Boissonade 161.
5. Doctrina No. 44.
6. Boissonade 160, 162.
7. For a lyrical praise of physics and nature in general see Scripta Minora I 353.

hidden ways of nature [1]. This is part of his conception of scientific method which he derived mainly from the Posterior Analytics and the Ars Medica [2]. He insists that there are two ways to knowledge or truth [3], two kinds of demonstration (which he calls the organon of science) [4]; demonstration by induction which he variously calls ἀνάλυσις from composites apprehended by the senses to simples [5], ἀναγωγή to accepted principles, reasoning from the posterior and synthetic objects to the prior, according to nature though not according to our senses, the process upwards from the divisible tensibles or from effects to causes [6]. As an example of such a method of reasoning he cites the theory (invented by Herodotus) that geometry arose pragmatically in Egypt out of the problems created by the floods of the Nile [7].

The second way is demonstration from above by deduction from primitive terms and principles intuited by the νοῦς [8], going from the prior to the posterior according to nature though not according to us, descending axiomatically [9] to the sensibles, from causes or known principles to effects [10].

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1. Boissonade 163. It is significant in this connexion that Psellos praises Aristotle for his knowledge of metaphysics, for the fact that he defined the methods of science, most of logic and demonstration and for having studied physics and natural phenomena. Cf. Sathas II 396 - 397.

2. For methodological ideas of Galen see Ars Medica, C. 1, De Sectis CC. 7 - 9 and De Methodo Medendi, i. 3 - 4, ii. 7, iii, 1, 2, 7 in Opera Omnia, ed. G. G. Kühn. Cf. A. C. Crombie, Robert Grosseteste, 1953, p. 27.

3. Psellos distinguished three kinds of syllogism: (1) true or demonstrative, (2) dialectical and (3) sophistical. Cf. Sathas I 195.

4. Sathas I 255.

5. Cf. Chronographia II, 120, I, 135.

6. Cf. Aristotle, Posterior Analytics, i. 2, 71b 9 ff; cf. Physics i. 1, 184a 16ff, and Metaphysics, A. 1, 981a 2 - 6.

7. See Scripta Minora II 69 where it is also stated that arithmetic owes its origin to the computations of the Phoenicians, astronomy to nautical observations and music to the sounds of cauldrons. Cf. also Boissonade 167.

8. Sathas I 54. Cf. Aristotle, Posterior Analytics, ii. 19, 100b 5ff.; also Plato, Republic, vi. 510.

9. Axioms, he says, are the beginnings of deduction but demonstrated theorems can also be used as axioms for the deduction of further theorems. Cf. Sathas II 395.

10. This method corresponds to the Western compositio, whilst the former corresponds to resolutio.

Psellos stresses that reasoning can proceed both ways but that the method of deduction is more vigorous and exact and should be preferred [1]. He associates this method with the demonstrations practised by geometers (which some called ἀνάγκαι [2], though he admits that he takes pleasure in both deduction and induction [3]. In one passage he resorts to a physical analogy in order to describe this twofold apodeictic, considering induction as reaching the sun from the rays and deduction as following the rays from the sun [4].

He realizes that if we do not accept primitive terms in deduction we shall arrive at no conclusion, while from a physical point of view, we shall abolish concrete universals [5]. He also realizes that we have to start from accepted first principles if we are to avoid an infinite regress [6] and that we should accept the consequences of deduction even when they seem paradoxical, as in the case of the non-commensurability of the diagonal of a square [7].

Even in theological matters Psellos wanted to use the deductive method of proof. «I shall expound my subject», he says, «scientifically and clearly. Like the geometers I shall assume certain common notions and certain axioms of piety so that you may check the heresies against them» [8]. In another passage he chides someone for positing as a common notion something disputed by the Fathers [9].

On the other hand it seems that induction was also dear to Psellos for a theological reason. Induction leads naturally to a first cause or principle of all and he characteristically says that

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1. Scripta Minora II 69.
2. Chronographia I 136.
3. Sathas 3 55.
4. Scripta Minora I 95.
5. Sathas I 446. The passage is obscure but 'concrete universal' for ὁλότης has the Aristotelian precedent τὰ καθόλου.
6. Scripta Minora I 434. The passage relates to the physical level where one avoids infinite regress by positing God as the first principle, «ἵνα μὴ ἀρχῶν ἀρχὰς ζητῶμεν ἐπ' ἄπειρον».
7. Sathas I 473.
8. Scripta Minora I 234. A little later Anselm of Canterbury was going to advocate and brilliantly execute a similar programme.
9. Sathas I 195. In general, Psellos defended logic against some religious diehards. He writes to one of them: «Logic, my dear brother, is not a dogma alien to the church..... but a mere instrument of truth.» Sathas I 447.

Moses achieved an ἀναγωγὴ to God [1]. He also commends astronomy (as distinct from astrology which he condemns) [2] in that it leads up to (ἀνάγει) the architect of all [3].

In spite of his general rationalism [4] and his idea that pagan wisdom should be used as a collaborator of the Christian faith [5] we can detect certain cracks in his rational edifice. «In problems of faith», he declares, «even if the pagans seem to be proving by demonstration or even if they prove with the things themselves, (i.e. more unquestionably than by words), we shall still close our eyes» [6].

This irrational attitude is certainly derived from what Psellos might consider as a supra-rational element, «a wisdom», as he says, «lying beyond demonstration and known only by the ἐνθουσιάζων νοῦς» [7]. Beyond νοῦς, he says, there is ἔλλαμψις in which we are not even conscious that we think [8]. He associates Pythagoras and even Plato in his un-Greek or Egyptianizing moments with thinkers who claim that not all knowledge is by demonstration. At the same time he commends Aristotle who followed the more human practice of deriving everything by demonstration [9]. On the other hand he attacks the Stoics for believing that there was nothing beyond demonstration [10].

VI

What about the application of the inductive-deductive method to science? We have seen that Psellos accepts Aristotle's idea that

1. Philosophical Definitions 128.
2. Though he accepts that stars exert some general influence. He says, for example, that Venus has a propitious influence in matters of love. Cf. Sathas I 478.
3. Scripta Minora II 69.
4. Some of one's highest possessions, says Psellos, are first theorems, syllogisms and demonstrations. Cf. Accusation 78.
5. Scripta Minora II 312. Note that he does not say 'handmaid'.
6. Scripta Minora I 237.
7. Chronographia I 136.
8. Sathas I 449.
9. Philosophical Definitions 128.
10. Sathas I 445.

what is prior to us is posterior to nature and vice versa. For example a composite object such as a table is prior to us in perception but the material of which it is made, the purposes into which it can be put, etc. is prior to nature. So Psellos repeated the Aristotelian injunction that knowledge should start from the sensible objects of the physical world and proceed to principles, as every art and science is known when its principles are known [1]. Psellos interpreted and practised this inductive method in a fruitful manner. Avoiding much of the sterile preoccupation of medieval scholars with substances, categories and accidents he concentrated on finding the causes of physical events, interpreting Aristotle's middle term as the cause of phenomena, following of course Aristotle himself, but with a particular emphasis of his own [2].

He believed that no phenomenon of nature was uncaused even though the finding of some causes may elude man [3]. He himself tried to find the cause of a number of phenomena which others considered uncaused or miraculous [4]. «I explained the causes of the movements of the heavens», he says, «which others considered haphazard» [5]. He gives a physical explanation of the changes of the colour of a polypous according to its environment in the Empedoclean terms of the symmetric emanations of the pores of its skin and those of the objects around [6]. He also gave physical reasons in terms of the reactions of the hot and the cold for the fact that the tears of bears are sweet while those of deer are salty [7]. He explained physically the wondrous and, to others, uncaused power of sea-urchins to foresee an imminent north or south wind [8]. He also mentions that many of his contemporaries wondered at the

1. Accusation 212.

2. Cf. Sathas I 151. He repeats, though, that «in this world of ours truth is a matter of consistency of propositions.» Cf. Doctrina No. 102.

3. Sathas I 326, 475, but especially 477.

4. Sathas I 478, 510.

5. Scripta Minora I 368. It is difficult to substantiate this claim but Psellos would conceive such explanation in terms of reduction to Ptolemaic geometrical principles.

6. Doctrina No. 181.

7. Doctrina No. 189.

8. Sathas I 478.

Echoing Room of Nicomedia thinking that it was a wonder without cause. But having seen it once he did not marvel at it and did not consider it uncaused. In fact he gives a physical explanation of it on the basis of the most general principles of physical interactions [1]. He also explained that contrary to general belief the falling stars were not really stars [2]. A considerable part of his De Omnifaria Doctrina deals with the causes, the *why*, of phenomena [3].

It seems that Psellos had an additional theological reason for combating acausality and trying to reduce the miraculous to its absolute minimum. He could see that the lack of causality might easily lead to polytheism, while the reduction of causes to a first cause leads naturally to monotheism. It is significant in this connexion that he refers to the Egyptians who worshipped magnets because they attract iron in an almost miraculous manner [4]. In another passage he says specifically that one should not feel wonder at the strange and admittedly secret ways of nature. One should think of magnets and realize that there are mysterious forces in nature, forces beyond ordinary human explanation; but that there is a supreme explanation either in νοῦς or beyond [5]. Echoing the Stoics he says that things are in sympathy with each other [6], that they act in σύμπνοια [7] and that they are all under the first cause [8].

It can be claimed that far from being irreligious Psellos, in his search for natural causes, defends Christianity, or at least monotheism, from a superior standpoint to that of some of his detractors like Tzetzes who took exception to Psellos' naturalistic explanation of the eclipse of the sun [9].

Whilst God or the Greek Demiourge is the most distant cause [10],

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1. Boissonade 58.
2. Scripta Minora II 222.
3. Cf. Nos. 166 ff. He was also conscious of the plurality of causes. Cf. Doctrina No. 169.
4. Philosophical Definitions 130.
5. Sathas I 326.
6. Sathas I 477.
7. Doctrina No. 200.
8. Sathas I 326.
9. Cf. Bull. Corr. Hell., 1, 1877, p. 122.
10. In a similar vein he calls the emperor the πρωταίτιος of all. Cf. Scripta Minora I 293, Chronographia II 66.

Psellos insists that there are a number of intermediate natural causes [1]. He chides someone for blaming earthquakes on the god of earthquakes and philosophizing only up to this point, leaving nature out of account [2]. Of course God is the first principle of all. But nature lies between Creator and Creation like the hand of the first cause [3]. In another passage he says that earthquakes are made by God like everything else. But their proximate cause is the πνεῦμα emanating from the earth [4]. Many people, he says, do not causally connect rain and clouds but then why does it not rain when there are no clouds in the sky? Far from being pious, he declares, such haphazard explanations deprive God of wisdom and ascribe to him erratic behaviour [5]. Though God is the ultimate cause of every substance and the proximate cause of incorporeal substances, the proximate causes of bodies are bodies [6]. This clear-cut principle represents a great advance in the thinking of the previous centuries throughout Europe.

VII

In an important passage Psellos goes as far as to express scepticism about certain experimental falsifications of some verbal (i.e. theoretical) explanations. Many are not satisfied he says with verbal explanations. They demand experimental verification; but this may not be forthcoming because the theory may be correct but the applied science, the τέχνη [7], may fail. The experimenter may ignore some factor contributing to a phenomenon such as the use of proper materials, proper dimensions etc. He cites the example of Archimedes whose lenses were not always effective [8]. The

1. Sathas I 479 - 480.
2. Boissonade 150.
3. Ibid.
4. Doctrina No. 164.
5. Boissonade 150.
6. Sathas I 518. Cf. also Sathas II 385. Similar ideas were expressed in the beginning of the twelfth century by Adelard of Bath. Cf. A. C. Crombie, op. cit. p. 12.
7. An important passage for the meaning of the word is to be found in Boissonade 167.
8. Boissonade 61.

kind of resignation exhibited here by Psellos may be inimical to the progress of science but bearing in mind the state of applied science in his time we can sympathise with his position. What is perhaps more important is that he was conscious of problems of experimental falsification and verification [1].

Psellos had no illusions that man could arrive at certain knowledge of the causes of nature. The explanation of natural phenomena, he says, is most difficult and one cannot hope to account for them fully but must settle for probable explanations [2], or as he put it, one must not chase after certain causes [3].

Having been bred on both Aristotle and the Aristotelian commentators Psellos did not ignore final causes although he did not give prominence to such causes. And this is another aspect of the originality of his emphasis. He believed of course in the providential teleology of nature as when he pointed out that milk comes to the female of the species not at conception but at bearing [4]. Nature, he says, gave stings or horns to bugs and cuttle-fish in the form of their obnoxious smell and dark ink, respectively [5].

At a different level of explanation Psellos was aware in a rather mystical manner of the prophetic but at the time sterile Pythagorean and Platonic conception that there is a deeper level of physical reality in the arithmetical and geometrical relations of the material substratum. He even says that the physicist must establish a harmony (or in modern idiom a correspondence) between physical numbers and physical causes [6].

He had an idealistic attachment to science in for the end of the twelfth century and the beginning of the thirteenth for such advanced and wide-ranging ideas on science.

It seems that the Westerns were conscious of the scientific activity in Byzantium in the eleventh century. Early in the twelfth century an English pioneer of modern science, Adelard of Bath,

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1. On the other hand this attitude may also be considered as just as aspect of medieval self-abasement.
2. Doctrina Nos. 187, 189.
3. Ibid.
4. Scripta Minora II 236.
5. Boissonade 91.
6. Cf. Rev. Études Grecques, 5, 1892, p. 344.

took pride in the fact that he discussed with a certain Greek philosopher «both the art of medicine and the nature of things» [1]. Bearing in mind the work not only of Psellos but also of John Italos, Theodoros Smyrnaeos, Symeon Seth and Eustratius of Nicaea, Adelard's pride was indeed justified.

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1. Cf. B. Lawn, The Salernitan Questions, Oxford 1963, p. 20.