ON THE MOVEMENT AND PROGRESSION OF ANIMALS

Translated, with Introduction and Notes by
Anthony Preus

Aristotle, de Motu Animalium
and de Incessu Animalium

Michael, Commentaria in de Motu
et de Incessu Animalium

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INTRODUCTION

The translations of Michael of Ephesus, Commentaries on The Movement of Animals and The Progression of Animals, here presented, are the first into a modern language. These are the only surviving Greek commentaries on these treatises.

In this introductory essay, I will locate Michael of Ephesus historically and say something about the interest and importance of these commentaries; at the end of the introduction, I briefly summarize some of the technical issues concerning the text and translation.

The Historical Context

The story of the translations of the ancient philosophical and scientific texts into Arabic, by ibn al-Batriq, Hunain ibn Ishaq, and others, in the eighth and ninth centuries, has become well-known; even more famous is the great philosophical tradition of ibn Sina, al Farabi, and ibn Rusbd, and the translation of the Arabic texts into Latin with the cooperation of Jews and Christians in Spain and southern Italy. The predominance of Averroes in Aristotelian study and Avicenna in medicine was so great for so long that there is a tendency to forget that the Arabic writers were by no means the only transmitters of ancient culture and civilization to the West, nor were they the first.1

1. Several sections of this Introduction rely upon an essay entitled “Anna Comnena’s Aristotelians and the Rise of Western Scholasticism” in which Paul Merckens, now of the University of Utrecht, and I, are collaborating. Some of the research to which I here refer, and some of the phrases, are his work, though I take responsibility for errors in this version of our work. Merckens calls attention here to an essay by L. Minio-Paluello, “La tradition aristotelicienne dans l’histoire des idées,” Association Budé: Congres de Lyon 1958, Paris, 1960, pp. 166-185, especially p. 174, and the same author’s “Giacomo Veneto e l’Aristotelismo Latino,” in Venezia e l’Oriente fra tardo Medioevo e Rinascimento, Firenze, 1966, pp. 53-74. Minio-Paluello summarizes his findings thus (I paraphrase): ‘The entire Aristotelian Corpus, with the exception of the de Caelo, part of the Meteorologica, and the biological works, were introduced to the Latin scholastics from Greek before Arabic. A great deal of this material was due to the efforts of James of Venice, and much to other Greek-speaking Venetians.’ Minio-Paluello might have added that at least two of the biological works were never transmitted through the Arabic tradition at all, but came solely through the Greek-- the Movement and Progression of Animals.
They were surely not the only source of philosophical inspiration, even for the scholastics of the thirteenth century. Byzantium had a philosophical tradition of its own; the fact that Byzantine philosophers were Christians tended to make their contributions more acceptable to the Latin west, yet the Byzantines were able to draw easily upon the pagan tradition as well as the Christian, incorporating both into a unified view of life which preserved and nourished the classical tradition.

One of the most obvious ways in which some Byzantine writers promoted philosophical Hellenism was in the preservation and explication of classical texts, particularly the texts of Plato, Aristotle, and other pre-Christian writers. There was more than bibliophila involved in that effort; the Byzantine empire blended Hellenic, Roman, and Semitic peoples and beliefs, and many of the doctrinal struggles which posed as theological or philosophical were actually clashes of cultures. The preservation and continuation of ancient Greek philosophy represents the ultimate triumph of the Byzantine Hellenists against the anti-intellectualism of many representatives of the Roman tradition, and the existential individualism frequently found in the Semitic tradition.

Byzantine Philosophy before Michael of Ephesus

There is a sense in which the phrase 'Byzantine philosophy' does not refer to something quite distinct in the history of thought. The work done by Michael of Ephesus...

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is continuous with work done by Alexander of Aphrodias in the years 190-210 (approximately), so much so that when Michael quotes verbatim from Alexander (as he often does) one cannot easily distinguish what is Michael and what is Alexander. Perhaps Michael is more consciously a 'classicist' than some of his contemporaries, but even the most 'Byzantine' clearly belong to traditions already delineated in the fourth and fifth centuries A.D. Platonism, with its tendency toward an ideal synthesis, Aristotelianism, often expressed in commentaries and logical analysis, a diffuse and less conscious Stoic influence, and the Christian tradition, were constantly weaving together and separating, and certain themes tend to reappear after many years.

The attention paid to Aristotle was largely in the spheres of logic and biology, because in logic he had advanced farther than Plato and had established a system, and Plato had little of use to say about biology. Plato's work continued to inspire social and political thinkers as well as those who found his expression of religious experience closer to their own. But Byzantine philosophers looked back not so much to the fourth century B.C. as to the second, third, and fourth centuries A.D.; while they read the classics, philosophical and literary, they used handbooks and commentaries produced in the later period, and their creative work was an extension of that done by Alexander of Aphrodias, Porphyry, and Clement of Alexandria.

(Transition from Late Ancient to Byzantine Philosophy)

Alexander of Aphrodias (c. 200)

Florusinus (205-270)

Porphyry (234-305)

Iamblichus (c. 250-330)

(Alexandria)

(Athenes)

Plutarch (d. 431/2)

Theon

Hypatia (d. 415)

Syrius

Synesius

Domninus

Proclus (410-485)

Hierocles

Marinus

Isidorus

Eneas

Zenodotus

Hermias

Damascius

Ammonius

Simplicius (6th Century)

John Philoponus Olympiodorus

David, Elias

Stephanos of Alexandria (7th)

John of Damascus (674-749)

Nicephorus (8th-9th)

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If one were, per impossibile, to draw a line between “ancient” and “medieval” in the East, one might suggest any of several dates. One critical moment came when a band of fanatical Christians attacked and killed the pagan philosopher Hypatia, in Alexandria, A. D. 415. There is a certain symbolic justice in the idea that the Christians, in slaying this wise and beautiful woman, also slew the ancient wisdom of the Greek world. But Hypatia was also the teacher of Synesius of Cyrene, who managed to synthesize Christian and Neoplatonic teaching adequately enough to ensure a flourishing philosophical tradition in Alexandria through the days of John Philoponus, 100 years later, and up to the Muslim conquest in the 640's.

Another attractive date for the end of the ancient and the beginning of the medieval period in philosophy in Byzantium is 529, the traditional date of the closing of the Academy in Athens. Justinian forbade the teaching of non-Christian doctrines as part of his goal of unifying the empire; those who did not follow “the catholic and apostolic church and the orthodox faith” (i.e., heretics, Jews, pagans, etc.), could not hold any position nor be honored in any way nor “under cover of any sort of instruction bring to their errors simple souls.” More precisely, “We forbid that there be any teaching by those who are sick with the sacrilegious madness of the Hellenes.” In 529, Justinian specifically instructed the schools in Athens to cease teaching philosophy or law. Several of the leading philosophers left for Persia and the court of Chosroes, most notably Simplicius, commentator on several of Aristotle’s major works, and a source for a large proportion of the fragments of the presocratic philosophers. It would make a good story to say that Simplicius and his colleagues stayed with the


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Persian king and contributed to the eventual transmission of Greek learning to the Arabic-speaking world, but as a matter of fact, they prevailed on Chosroes to have written into a treaty, then under negotiation, that they could return to their homes and schools and henceforth be undisturbed by the emperor. Apparently the Academy was returned to its owners in 532, but Justinian did have at least one more go at silencing the ancient philosophical tradition: in 562, the “Hellenes” were arrested, marched through Constantinople in public disgrace, and their books (and images of their gods, probably including those of the classical philosophers) were burned in the Kynégion.

Of the various book-burnings, this may be the most significant, because accompanied by a general policy of the emperor, pursued over many years, to eliminate all non-conformist philosophical teachings. Yet in the same period we have the last of the great pagan commentators, Simplicius, and the first of the great Christian commentators, John Philoponus; what would it mean to say that Philoponus is a ‘Byzantine’ philosopher, but Simplicius not? Between them, perhaps they do mark the end of one sort of thing and the beginning of another, and yet to one who looks at their texts, their methods and systems of beliefs are not really so disparate.

The emperor Heraclius (610-640), a contemporary of the prophet Mohammed, re-opened the system of public instruction in Constantinople, and we can discern a renewal of the neo-platonic tradition, now become clearly Christian, in the work of Stephanos of Alexandria, who had taught both in Alexandria and in Athens. He came to Constantinople in about 612, and while there cast a horoscope for Heraclius, taught the philosophies of Plato and Aristotle, and mathematics, and commented on works of Hippocrates and Galen.

After the time of Heraclius and Stephanos, the philosophical tradition had a new sort of opposition; the struggle between iconoclasm and iconodoulia caught up the philosophers and undoubtedly made it impossible to deal with anything else for some period of time. The iconoclasts saw in the vestiges of humanistic Greek culture the seeds of heresy and infidelity to the one true God; the iconodoules believed that the truths of the Christian religion could be expressed in the symbols and language of existing culture. The outstanding example of the synthesis of philosophy and theology in this period was that of John of Damascus, 674-749; his education had clearly included

7. See Lemerle, op. cit., pp. 80 ff.
study of several of the key works of Plato and Aristotle, and like Clement of Alexandria, he makes effective use of classical philosophical arguments in his defense of orthodox Christianity.

In the following century, we find Nicephorus, defender of icons, using a thoroughly Aristotelian education to good effect, yet we do not know how Nicephorus got his education, or who taught him his Aristotle. The examples of Stephanos, John of Damascus, Nicephorus, and several others of the same sort, show that some fairly sophisticated education in classical philosophy continued in several centers of the Eastern empire throughout the period which we are pleased to call the "dark ages" in the West.

The real renaissance of humanistic studies began with the ninth century. Leon the Mathematician (born before 800, died after 869) and Photios (810-891) invented a system of clock-synchronized signals for the Empire, began an edition of Plato, and collected a good many of the mathematical and scientific texts which have come down to us (Apollonius, Ptolemy, Archimedes, Euclid, et al.). Despite a few years as bishop of Salonika, Leon seems to have been the prototype of the Hellenizing humanist. Photios, on the other hand, was a bureaucrat, with an avid hunger for the classics; he pored over many of the ancient texts, including some which are no longer extant, working out his own approaches to a number of intellectual and philosophical problems.

A member of the staff of Basil I, he had a hand in educating the emperor


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Leon VI. Arethas of Patras (c.850-925) is, for the history of philosophy, possibly the most important of this group; our finest old manuscripts of Plato stem directly from his activity. We can attribute to him an edition of Plato and some of Aristotle, and the preservation of commentaries on the philosophy of Plato, as well as texts of Marcus Aurelius and others. His activities were considerably encouraged by the development of minuscule script and professional practitioners of that art, by the development of less expensive paper, and more efficient methods of binding books.

Summarizing quickly, we find in the tenth century, during the reign of Constantine Porphyrogenitus especially, a kind of encyclopedic approach to learning, a construction of analogies, and in general an encouragement of imperial Hellenism.

In the eleventh century, Michael Psellus (1018-1096) again revived ancient learning, this time reaching directly to Plato's text, at least for the style, and through the entire neoplatonistic tradition, for a large variety of teachings. His contemporaries, John Xiphilinos and Michael Cerularios, also used ancient philosophy extensively for the development of new approaches to law and theology. Psellus, with his wide interests, had something to say about just about every branch of study, including mathematics, where he had occasion to mock John of Lombardy's efforts as typically "Latin", saying that "no child of Rome has ever been any good at geometry."

Psellus, hypatoς of the philosophers and flamboyant man of learning, aroused ambitions in many of his contemporaries and successors. His immediate student, and almost as flamboyant, was John of Italy, from Calabria. Anna Comnena has a fascinating account of him in Alexiad V; she says that he was the best interpreter of the technical treatises, and that he also lectured on Plato, Psellus, Porphyry, and lamblichos. He wrote commentaries on the Topics and On Interpretation, and wrote independent treatises on logic, as well as on theological questions. Anna says of John of Italy that despite his great philosophical talents, he was a barbarian in his manners (he was known to punch his debating opponents in the face), and that he had a funny accent in Greek. In March, 1082, he was accused of heresy and condemned on the following points:

12. Lemerle, p. 203, describes Photios' "domestic academy," a private circle of friends. Leon VI was hardly a grateful student--as soon as he became emperor, he sent his former teacher into exile (Lemerle, p. 206).
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1. Trying to explain the incarnation.
2. Reviving ancient errors about the human soul, heaven, earth, and its creatures.
3. Teaching metempsychosis, and denying immortality of the soul and future life.
4. Professing the eternity of both matter and ideas.
5. Denying the miracles of Christ, the Virgin, and the Saints, as impossible, or giving them idiosyncratic explanations.
6. Considering profane letters as sources of truth.
7. Admitting the neoplatonic idea that matter subsists by itself and is enformed by the ideas, thus denying the independence of the Creator.
8. Teaching that men will be resurrected with different bodies than they have in the present life.

In other words, he was a philosophic hero.

Eustratius, Michael of Ephesus, and Michael of Italy, all had to avoid condemnation for various heresies, some of them similar to these, and they were not always completely successful.

We might add that John of Italy had a strong sense of the centrality of Aristotle’s concept of nature, and tried to revive that concept in a way which would be more consonant with Christian teaching; in this he was a true teacher of Eustratius, Michael of Ephesus, and Anna Comnena herself.15

Anna Comnena’s Aristotelians

In the previous section, I have mainly listed names and dates, and asked you to accept on faith that these people were philosophers or had some importance for the history of philosophy. Now I turn to one moment in that history, to which I have taken you, in order to direct your attention to some ways in which the events of that moment influenced the later history of philosophy, particularly in the Latin west.

Anna Comnena (1063-1148+) was the elder daughter of Alexius I Comnenus. According to George Tornikes, in his eulogy of her (written 1154-5),16 she had more desire for knowledge than was expected of a Byzantine princess—first secretly, then with the assistance of her parents, she acquired an excellent education and close ties with the intellectual elite of Constantinople. Georgina Buckler and others17 have given accounts of her life: after an early engagement to Constantine Doukas, who died before they could marry, Anna became the wife of Nicephorus Bryennius, a plausible pretender to the throne. Anna and her mother Irene tried to persuade Alexias to name Nicephorus as successor, rather than his son and Anna’s brother John, and when that did not work, plotted again to the same end during John’s reign. Nicephorus, to his credit, seems to have stayed out of these machinations, and to have maintained good relations with John II; he distinguished himself as a military leader, and as a historian of the Comnenus family up to 1076. When he died, in 1137, Anna continued his history with her justly famous Alexiad. Prevented from ruling the empire at the side of her husband, she turned to literary pursuits, and gathered around her many of the leading intellectuals of the day.18 According to Tornikes, who knew her well, she had very definite philosophical opinions and goals. She clearly favored a Christianized Aristotelianism, mixed with a healthy dose of neoplatonism.

As Browning19 points out, it was most probably to her that Eustratius dedicated his commentary on the Nicomachean Ethics. Anna says of Eustratius20 that he was “a man wise in things divine and secular, more renowned in dialectics than those who frequented the Porch and the Academy.” She may be recalling the help which Eustratius gave to Alexias in the debates against the Manicheans of Philippopolis; that particular heresy must have been as distasteful to Eustratius as a neoplatonist as it was to him as a

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16. Jean Darrouzes, Georges et Démétrios Tornikes, Lettres et Discours, Paris CNRS, 1970. This eulogy is the source for much of the information which makes possible the thesis of the present section, that Anna Comnena gathered a scholarly group which worked together and produced materials which have proven to be influential, including the present Commentaries.
18. The group surely included her mother, Irene Doukaia, Empress (widow of Alexias, mother of John II); Anna’s husband, Nicephorus Bryennius; Eustratius of Nicaea, commentator on the Nicomachean Ethics and former bishop of Nicaea; Michael of Ephesus; George Tornikes; Michael of Italy; probably James of Venice; and surely others, possibly some of the commentators known only as “anonymous.”
The section of Tornikes’ oration which is most important for my present purpose tells of Anna’s encouragement of commentaries on Aristotle:

Evidence of her love of learning are the works which our philosophers dedicated to her; these concern the works of Aristotle which had not been commented upon before her day, but had been handed down by word of mouth in all sorts of forms, without certainty and unworthily. . . . I myself have heard the philosopher from Ephesus blame her as the cause of his blindness, because he had worked night after night, without sleep, commanded by her to write commentaries on the works of Aristotle; the use of candles had caused drying of the eyes.  

The philosopher from Ephesus to whom Tornikes refers can be no other than Michael. Eustratius was deposed from the bishopric of Nicaea in 1117, just before Anna went into relative seclusion, getting out of public life. Eustratius may well have joined Anna at that time, and perhaps he brought Michael with him. In that case, Michael could have been working in the company of Anna from 1117 or 18 to perhaps 1138, if we accept Browning’s account of the circumstances.  

The date of Michael’s activity has been a matter of some scholarly puzzlement. Praechter argued rather strongly that most of Michael’s commentaries must have been written before 1040, or in other words, nearly 100 years earlier than we believe on the basis of the Tornikes eulogy. Praechter’s strongest argument derives from an anonymous summary of logic and the quadrivium, of which the oldest manuscript is dated to 1040; this manuscript contains passages which are textually identical with Michael’s commentary on the Sophistical Refutations. Praechter argues that either ‘anonymous’ copied from Michael, or Michael copied from ‘anonymous’; but the material in ‘anonymous’ is obviously a summary of the material contained in Michael, and so (Praechter argued) Michael must have written first. There is, however, another possibility, namely that Michael and ‘anonymous’ both copied from the same source. In fact, Boethius, in his commentary on the De Interpretatione, also uses the same source. Very likely the original of all these copies is the commentary on the Sophistical Refutations by Alexander of Aphrodisias himself; Michael habitually copies large sections from Alexander.  

In fact, Michael would certainly be thought a plagiarist by modern scholarly standards, since he not only copies entire sections, but he sometimes (not always) claims that the ideas in them are his own. His commentaries are so close to the text that we can often use them for correcting the text of Alexander, for example. He may have felt some philosophical insecurity, as well he might when faced with the sophistication of Alexander of Aphrodisias. Barker has gathered several autobiographical passages in Michael’s commentaries which would be worth citing here: in a gloss on the Politics, Michael complains that tyrants are always opposed to the good because they are a double danger to their authority—a danger in thinking it a shame to be governed as if they were slaves,  

22. Browning, p. 7, argues that Michael’s commentaries belong to the period between Anna’s “retirement,” 1118, and 1138, when she turned her attention to the composition of her history. Michael could have begun work on Aristotle before joining Anna’s group, and he could have continued writing commentaries when Anna started writing her history, I believe, unless we assume that Anna was responsible both for getting Michael started on this project, and for stopping him, perhaps by insisting that her scholar-friends help her with her current project to the exclusion of all else.  
24. In perib. II, 129, 10ff. L. M. de Rijk calls attention to this parallel in his Logica Modernorum. A Contribution to the History of Early Terminal Logic. Vol. I: On the Twelfth Century Theories of Fallacy, pp. 35-39. Paul Mercken, on whose research I rely heavily in the present section, has noticed that the same passage which De Rijk cites as a parallel between Boethius and “Alexander” (ed. Wallies, 44.1-45.38) is the same one which Praechter cites as a parallel between Michael and the anonymous summary. Mercken and I explore Michael’s role in the tradition of the Sophistical Refutations in more detail in our essay, “Anna Comnena’s Aristotelians.”  
and a danger in their general spirit of loyalty and their refusal to betray one another or anybody else. "This is particularly so nowadays, my dear Aristotle, and this is the reason why I am a beggar."26 In another gloss he directly attacks the ruling monarch: "This means despotic government, such as the kingship of our own times."27 He also complains of the officials who are trying to make a profit by their office: "That this is most true is proved by the carrion crows of our own times" (ibid.). Browning points out: In so far as one can attach political labels to such things, Anna Comnena’s circle belonged to the ‘outs’. She herself was in semi-dignity to the end of her days: Tornikes’ complaint that no one but himself had thought of commemorating her death bears this out. Eustathius was a man whose career was finished; the Patriarch Cosmas II Atticus, who promoted Tornikes, ... was dismissed after just over a year in office, charged... with supporting (Manuel’s) disgruntled relatives (p. 8).

In general, Michael says very little about himself; from what he does say, we might accuse him of petulance. In his commentary on the Progression of Animals, 168,13, he recommends looking at the legs of flies, adding, "there is no shortage of them!" And of course we know that he belonged to Anna’s circle only because he complained that he had lost his eyesight as a result of her command to write commentaries on the works of Aristotle.

More generally, Browning argues that some unspecified number of other persons were also engaged in more or less philosophical pursuits with the princess, and also in providing some of the research for Nicephorus and then for Anna’s historical work. George Tornikes belonged to the group for a while (Browning, p. 2). Browning argues that Anna and her group were trying to complete the cycle of commentaries on the works of Aristotle, using as a starting point the methodology of the platonizing Aristotelians of late antiquity. They turned their attention especially to the Ethica, Politica, Rhetorica, Sophistical Refutations, and the whole series of biological works, unparalleled in the Platonic tradition but central for a true understanding of Aristotle. They also attempted commentaries on some of the works which had been commented upon in antiquity; one surviving example is the pseudo-Alexander commentary on the Metaphysics, E - N, doubtless the work of Michael.

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27. Barker, p. 140.

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Anna Comnena’s Circle and Medieval Western Philosophy

Before looking at possible influences of Michael’s commentaries on the de Motu Animalium and the de Incesso Animalium, I will summarize two other possible influences of the work of Michael and his colleagues on immediately subsequent western philosophy.

James of Venice was the first translator into Latin of Aristotle’s Physics, de Anima, Metaphysics, and parts of the Parva Naturalia; he also reworked and extended the Boethius translations of the logical works. His translation of the Posterior Analytics was to become particularly influential. James worked chiefly in or near Constantinople, precisely in the period of time when Eustathius, Michael of Ephesus, and others, were working on the Greek text of Aristotle. In fact, Michael was commenting on the Parva Naturalia and the Sophistical Refutations not long before James of Venice did his translations. A collaboration is entirely possible.28 De Rijk has found "some traces of Byzantine influences" in two twelfth century commentaries on the Sophistical Refutations,29 actually quite close parallels with Michael’s commentary.

Eustathius, Michael of Ephesus, and others, commented on various books of the Nicomachean Ethics; Robert Grosseteste, Bishop of Lincoln, with the help of Greek-speaking Italians in his ‘house’, translated Aristotle’s text together with this commentary; this translation had a good deal of influence on ethical and metaphysical thought in the thirteenth century. It’s worth remembering that the Arabic commentators on Aristotle were, after all, Muslims, and the two greatest (Ibn Sina and Ibn Rushd) were not particularly orthodox even as Muslims. Aristotle’s ethics could be distressing for Christians if seen exclusively through those eyes. Eustathius, commentator on EN I and VI, was by contrast a Christian, as well as a neoplatonist in the tradition of Dionysius the Areopagite. He put some effort into giving a Christian interpretation of Aristotle’s ethics, and also diminished the contrast between Aristotle and Plato. Even though the remainder of the commentary (including Michael’s part) is not particularly Christian, and some of it not Christian at all, the authority and evident faith of the commentator on books...

28. L. Minio-Paluello, "Iacobus Veneticus Gregus," Traditio 8 (1952) 265-304. We can date James’ activity rather precisely, because on April 3, 1136, he heard a debate between Anselm of Havelberg and Nicetas, Archbishop of Nicomedia, on the question of the procession of the Holy Ghost. That’s the year before the death of Nicephorus, possibly the terminus ad quem for Michael’s commentaries.
29. De Rijk, op. cit., ch. V, pp. 100-105, see also p. 222. Mercken and I will provide more details in the essay previously mentioned.
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I and VI made this an attractive work for those who first read the Ethics in the West. Albertus Magnus took over much of the material of Eustatius and the others in both of his commentaries on the Ethics; Thomas Aquinas learned this material through Albert, as did many others. There are at least twenty manuscripts of the Grosseteste translation still extant, distributed all over Europe; eventually the Grosseteste translation of the Ethics was copied without the commentary, but that was available to those who wanted it. 30

Michael and William of Moerbeke

Michael of Ephesos' commentaries on the biological treatises of Aristotle are by far the most complete preserved to us from the Greek tradition. William of Moerbeke, in the middle of the thirteenth century or something over 100 years after the time of Michael, translated the biological treatises from Greek into Latin. He also translated Alexander of Aphrodisias' De Fato, Plato's Parmenides with the Proclus commentary, Simplicius' commentary on the de Caelo, John Philoponus on the Generation and Corruption, Themistius on the de Anima, and several essays by Proclus. His translations of the biological works conspicuously include two which the Arabs seem not to have had, and thus not included in the Aristotelian material forwarded to the West through that source, the Movement and Progression of Animals. William of Moerbeke's choices of books to translate corresponds fairly closely with those in most use by Anna Comnena's group, including those commented upon by Michael. 31

30. Merckx develops this theme in considerable detail in his introduction to the edition of Grosseteste's translation, of course, and we have added material in our essay. Gauthier mentions several explicit references to Eustatius in particular in his Introduction to the Ethics—for bibliographic details, see Merckx, Introduction, p. 6*, n. 2. We also note a translation of the Ethics, Book I, into English, in 1745, by E. Pargiter, which includes translations of some short sections of the commentary by Eustatius. The Greek text of the commentary by Eustatius et al. was printed by the Aldine Press in 1556, and subsequently by others; C. B. Feliciano retranslated the commentary into Latin, first edition Venice 1541.


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That Moerbeke might have had some fairly direct relationship with the Commenena tradition is not surprising, since he did most of his translations of Aristotle, at least, in Nicaea, 32 which had been the home of Eustatius, of course, and had more recently been the location of Nicephorus Blemmydes, who taught philosophy there from 1224 to 1226, demonstrably relying heavily on the work of Anna Comnena's group. Nicaea was also the home of Theodore Laskaris, student of Blemmydes; when he became emperor, he used Nicaea as his capital, until 1258. The text of Aristotle available in Nicaea would almost certainly be accompanied not only by ancient commentaries, some of which William translated, but also the recent commentaries by Michael of Ephesos and the others.

The influence of the Moerbeke translation of the biological books has been significant; we can discern its effects in the work of Albertus Magnus, since Albert commented twice on Aristotle's biology. The first comments, which exist as lecture notes made by Conrad of Austria in 1258, were based upon the Michael Scot translation of the Arabic version of Aristotle's History, Parts, and Generation of Animals, known collectively as de Animalibus. The later, post-1260, comments clearly make use of the Moerbeke translation and include the de Motibus Progressivis, which comments on the Movement and Progression of Animals. 33 Albert himself tells us 34 that his earlier de Motibus Animalium had been written without benefit of Aristotle's treatise, but traveling in Campania "juxta Graeciam" he came by Aristotle's Movement of Animals, so he will pass along what he has learned from its pages. He clearly had some notion of the Progression of Animals, and I believe that he had in either written or oral form some (but not all) of the interpretation which we also find in Michael's commentary. If we pick out two or three places where Michael's interpretation of Aristotle is idiosyncratic, we might then be able to show that Albert has some similar idiosyncrasies.

The first case is in the Movement of Animals 7.701b4ff, where Aristotle provides us with two mechanical analogues meant to explain animal movement by appeal to familiar and presumably well-understood artifacts. One of these analogues is of "automata" or a kind of puppet; Michael has them nearly right, but Albert doesn't talk about the


34. Mot. Prog. 1.1, Borgnet X.923.
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automata at all, except to mix up some of the phrases from that analogy with the one he does talk about. This analogue is of a "small wagon" which Aristotle describes in these words:

When the one riding on it starts in a straight line, it moves in a circle because it has unequal wheels (the smaller acts as a center, as in the case of the cylinder) . . . in the wagons there is no alteration, since if the inner wheels became smaller and then larger it would move in the same way, in a circle.

Michael explains the passage thus:

In the case of the four-wheeled carriages the smaller, being at rest, becomes as it were a center, analogous to the resting elbow . . . for since it is big, but the back wheels are bigger, and the front ones toward the oxen are small, they must stand still in turning so that the larger may move. For since the smaller and the larger are transferred from the same place to the same place in the same and equal times, clearly the movement of the larger is more and faster, and that of the smaller is slower. But the slower is slower in virtue of the mixture of the opposite, and rest is the opposite of movement, so the smaller rests because it moves slower, even if it escapes our notice because we do not want to take the trouble to look for this sort of thing (117.27 ff).

Aristotle and Michael are talking about two completely different sorts of vehicles—Michael refers to the common ox-cart of Greece, with two large wheels centered under the weight of the load, and two smaller wheels in front. Michael has a peculiar physical theory in which motion is, apparently, discontinuous, so that any object whose motion is not ultimately rapid must frequently and regularly be at rest when it seems to us to be in motion. He has, as it were, a cinematic theory of motion, something completely alien to Aristotle's theory. In fact, Aristotle is thinking rather of a child's toy, on which a child sits and pushes; it does not go straight but turns either right or left because it has large 'inner' wheels and small 'outer' wheels; as the weight shifts, it turns toward the direction of the smaller wheels upon which it moves.

Michael thus has the example wrong in several ways; most importantly for our present purpose, he supposes that Aristotle is describing how, when an animal pulls a cart, the straight line movement of traction is turned into a circular movement of the wheels. Michael's understanding of the passage is followed by Albert, except that Albert

35. Cf. Physics IV.1, 219a10, e.g.
36. Mot. Prog. II.3, Borgnet 338.

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takes the "smaller inner wheels" to be the part of the wheels next to the axle (I paraphrase):

When someone moves in place in this way, he does this like a cart, in which the immobile part pulls forward that which revolves around it; when the hub or axle is pulled straight, it in turn pulls the wheel, which moves in a circle, and the wheel goes around on that which has unequal wheels, one in another: for the nave of the wheel which is in the center hits the hub itself, and the nave revolves; the horses which pull are like the soul and thus the small wheel is the nave.

Burley and Buridan, in their commentaries on the Movement of Animals, take the error even further, since they suppose that "the one sitting" is on the horse. I find that the notion that Aristotle is talking about an animal-drawn carriage is likely to have been suggested by some acquaintance with the Greek commentary. It surely is not the obvious reading of the text. I also find that the interpretation of the "smaller" and "larger" wheels as the outer and inner parts of the same wheels is the natural consequence of Michael's account of the smaller and larger wheels, and not the normal reading of the text of Aristotle, since Aristotle is talking about the turning path of a peculiar sort of vehicle, while both Michael and Albert are talking about the nature of the turning of any wheel of any wheeled vehicle whatever.

Another similarity between Michael's account of Aristotle's theory of animal motion and Albert's is of more historical and philosophical interest. This concerns the concept of ωστήν (hormēn), or in Latin impetus or sometimes appetitum, which I here translate "impulse.

Aristotle never uses the word ωστήν in his explanation of action in the Movement and Progression of Animals (the active form of the verb, υστημι, occurs once at 70A34). Michael, following Alexander of Aphrodisias, finds ωστήν the central explanatory idea. In fact, the passages which mention ωστήν are mostly examples of Michael's copying more or less verbatim from his illustrious predecessor. Michael refers to a treatise which he calls On Impulse and the Impulsive power as if he had written it himself; but these are all quotations from Alexander of Aphrodisias, de Anima.

38. M. Hayduck, the editor of Michael's commentaries here translated, noticed several parallels, e.g. at 123.1-6; P. L. Donini, "Il De Anima de Alessandro di Afrodisia e Michele Efesto," Rivista di Filologia e di Istruzione Classica 96 (1966) 516-525, has found a good many more, including Michael's introductory paragraph, 103.2-11.
Aristotle's analysis of the sensory-motor system of animals could be closely compared to the modern analysis of action in terms of input, information processing, and output; once information has been processed, the initiation of an action is called by Aristotle an ἐπεξήγησις (externis), translated by William of Moerbeke as appetitus and by me as "intention." Aristotle's "orektic" account of action is familiar from the last few chapters of the De Anima and several chapters in the Nicomachean Ethics, in addition to the Movement of Animals, and even if it has been obscured for English readers by the translation of ἐπεξήγησις as "desire" it should be clear that Aristotle does not develop a theory of underlying impulses or drives. The word ἐπεξήγησις is derived from the verb ἐπεξηγήσατο 'to reach or grasp for.' It is Aristotle's technical term for the capacity of agents to initiate movements, or specifically the event of initiating a movement, no more, no less; it does not refer to drives, or desires, in general.

I believe that Alexander uses the word hormē to fill in what he perceives as a gap in Aristotle's theory, that he sees that Aristotle needs a theory of underlying impulses or drives. Such a theory had been developed by the Stoics, using the word hormē for their leading concept—for them, it was almost equivalent to our word "instinct." Michael takes that over without noticing that Alexander has "improved upon" Aristotle in this respect.

Aristotle's closest approach to a theory of drives is perhaps in his account of the emotions (ἐνθύμησις = pathē). The emotions or passions are, for example, the moving causes for the virtues and vices considered in the Ethics, books III and IV. His more difficult problems arise in the development of an account of akrasia in EN VII. The appetites or passions which oppose the rational principle are indeed activities of the irrational soul, but Aristotle does not examine the complexities of non-rational motivations and passages in 119-120. Michael refers to On Impulse and the Impulsive Power as his own at 114.22-27, 116.12.13, and 117.16-17. He also refers to Alexander by name, and uses material from that philosopher's De Anima, both in these treatises and in several other commentaries, notably the Parva Naturalia, Generation of Animals, and Nicomachean Ethics IX and X. Paul Moraux (Alexandre d'Aphrodise, pp. 14-19) shows that "pseudo-Alexander" on Metaphysics E · N is actually Michael of Ephesus, busily copying from Alexander. 39. I discuss this development in more detail in my "Intention and Impulse in Aristotle and the Stoics," forthcoming in Apeiron.

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ations, the ways in which passions may either cooperate with or oppose each other. His failure to make distinctions between the various drives and motives which provide for the several ethical virtues and vices, for example, prevent him from adequately countering Socratic intellectualism. He tends to interpret the problem of akrasia almost solely in terms of desires for sensuous pleasures—food, drink and sex—and then finds that the akaratos is similar to someone "asleep, mad, or drunk" (EN VII.5, 1147a18). His model demands that reason control the emotions and desires as if without help from other emotions and desires, though the virtue is partially 'feeling the right emotion in the right way to the right degree.'

Michael, following Alexander, distinguishes between the 'critical' powers of the soul and the 'practical', distinguishes between the rational (logismon) from perception and imagination (phantasia) within the critical faculty, and between the 'hormetic and orektic' and "neuroptic" in the practical. Michael/Alexander suppose that when certain pathē are brought about through one of the critical faculties, then physiological changes take place which are "impulsive activities" of the connate pneuma and the neuron (nerves, sinews, muscles). 41 Alexander, in passages closely followed by Michael, carefully distinguishes between two ways in which the soul and the body may be interrelated; the body is not really moved by (ἐρχομένος) the soul, as something distinguishable and separate; rather, the body moves κατά (kata)—according to, in virtue of—the soul, as one moves κατά the dance, or the musician plays κατά the music. That formulation accurately catches the hylomorphism of de Anima III.1, Aristotle's central theory of the relationship between soul and body.

Orexis, in Aristotle's theory, is an event; the passions (pathē) are by definition passive; what Aristotle appears to lack in his theory of motivation is an underlying process, and this Alexander provides by borrowing the notion of hormē as a physiological process from the early Stoics and the stoicized part of the peripatetic tradition.


41. Donini, op. cit., calls attention to just these passages, Michael in MA 114 ff.
Michael of Ephesus and Western Scholasticism—Summary

Michael of Ephesus and his contemporaries contributed importantly to the development of western scholasticism, and subsequently to the Aristotelianism of the renaissance. Three pathways from Michael to the West are through James of Venice, particularly in regard to Michael’s commentaries on the logical works, through Grosseteste, through the translation of the commentary on the Ethics to which Michael contributed, and through William of Moerbeke’s translation of the biological writings of Aristotle, probably guided by Michael’s commentaries. I have only scratched the surface concerning these influences, in order to give an indication of the kinds of relationships which may be discovered by subsequent investigations.

I might speculate that the western scholastics were motivated to use the Byzantine texts, when they could read Greek, or translations made directly from those texts, if they were available, and to use the Byzantine commentators to the extent possible. They surely wanted to arrive at a true understanding of Aristotle’s text, and were often dissatisfied with the shocking heterodoxy of the Averroes commentary and other Arabic sources. Those who did read the commentaries by Michael and the others were getting a mainly Christian approach to Aristotle, combined with a neoplatonistic tendency to minimize the philosophical differences between Plato and Aristotle. The Latin West also received from Michael especially a certain attitude toward the text, a method of careful study, of line by line work, of thorough examination of the arguments. Thus Michael of Ephesus is a major contributor to these aspects of scholastic methodology.

42. Alexander de An. 73.16 ff. For relation to Stoicism, see also G. Verbeke, “Aristotelisme et Stoicism dans le de Fato d’Alexandre d’Aphrodias,” Archiv für Geschichte der Philosophie 50 (1968) 73-100; Gauthier, op. cit., pp. 244 ff: “le thème stoïcien de l’‘appétit’ (φόρμη).”
Text and Translation of Michael of Ephesus, Commentaries on MA and IA

My translation of these commentaries is based upon the text published by Michael Hayduck in the Commentaria in Aristotelis Opera Graeca (CAG) vol. XXII.2 (Berlin, 1904), pp. 101-131. He used three manuscripts in the Bibliothèque Nationale, which he labels as follows:

- Paris gr. 1921 P
- Paris gr. 1925 S
- Paris gr. 1923 R

He also used Vatican Comnenus gr. 2199 (C), and the Aldine printed text of 1527, which includes Simplicius’ commentary on the de Anima, Alexander of Aphrodisias on Sense and Sensible Objects, and Michael’s commentary on the Parva Naturalia, in which the MA and IA commentaries are to be found. Hayduck lists several other manuscripts, some with a few variant readings. Rather than return to the manuscript tradition, I have used his text, for better or worse, and accepted alternative readings only when they make considerably better sense than his text.

Nicolas Leonicus Thomaes (1456-1531), subsequently called “Leonicus”, was Professor of Greek at Padua from 1497. He had a major hand in the publication of many of the works of Aristotle, both text and translations. His translation of the Movement and Progression of Animals, together with several treatises from the Parva Naturalia, is accompanied by a commentary which he presents as his own, “antiquorum more explicata,” published in Venice, 1523. This commentary is in fact largely a paraphrase and often a direct translation of Michael’s commentary, though Leonicus gives no credit to Michael until very nearly the end of one of the treatises. I have relied upon his Latin renderings occasionally. This publication was fairly popular, since it was reprinted several times, including Florence 1527, Paris 1530 (the edition which I have used), and 1541.

Evangelista Lanugu Anianus, subsequently called “Lanugu”, was another renaissance humanist. He published a direct translation of Michael’s commentaries, Scholae Michaeleis Ephesi in Aristotelis Opuscula Aliquot Non Ante Graeco in Latinum Conversa, in Venice. I have used the 1552 edition, and its Latin renderings have been very helpful to me. This translation too was reprinted several times.

Another translation of Michael’s commentaries, and of Aristotle’s treatises, was published by Conrad Gesner, in Basel, 1541; I have not examined this translation.

I have found no translation of these commentaries into any modern language. This is hardly unexpected; very few of the commentaries on Aristotle have been translated, and some are extant only in manuscript. The few short passages of Michael’s commentaries on the Movement and Progression of Animals which one might find do little more than indicate the interest which these commentaries may have for the modern reader.

Given the character of classical commentaries on ancient works, it is extremely useful to have a simultaneous retranslation of the work commented upon; the commentator expects the reader to find the phrases commented upon by the verbal similarity between text and comment, and this can be guaranteed in translation only by an enforced conformity between translations of text and comment. In order to make the present translation of Michael as useful as possible, I have generally conformed to the vocabulary and turn of phrase in the translations of Aristotle’s treatises by A. S. L. Farquharson, in the Oxford Aristotle, Vol. V (1912), by E. S. Forster in the Loeb Aristotle (bound with A. L. Peck’s edition and translation of the Parts of Animals), 1937, and especially, for the Movement of Animals, Martha Crane Nussbaum’s text and translation, Princeton University Press, 1977. For the Progression of Animals, I have mainly followed Forster, comparing Pierre Louis in the Bude Aristote (1973). In addition to these editions and translations, we might also mention the commentary by Peter Hiley, joining, included with the Theodore of Gaza’s commentaries on the other biological books, in several sixteenth century editions; in the twentieth century, Werner Jaeger has edited these treatises, and Luigi Torraca has investigated the MA in some detail, but Nussbaum’s edition and translation are now definitive. The IA has not yet been so fortunate.

My own notes, appended to each commentary, are intended to clarify whatever my translations have left obscure, and to explain whatever earlier commentators may have left unexplained. There is much important philosophical, scientific, and historical material in Aristotle’s MA and IA, and in Michael’s commentaries on them, and I have not attempted to do much more than make the commentaries available to those who cannot read them readily in Greek.

43. Other editions and translations are included in the bibliography and notes.

44. See also her Harvard dissertation, her essay in Harvard Studies in Classical Philology 80 (1976) 111-159, as well as her book, for a full account of the tradition of the Movement of Animals. One item which I have used, and she seems not to have noted, is Harold Cherniss’ review of the Loeb edition and translation, in American Journal of Philology 60 (1939) 385 ff, reprinted in his Selected Works.
Technical Details

I have set this book with the use of an IBM Composer, using Pyramid 10-point type for my introduction and comments, as well as the bibliography and index; Universal 11-Point Type for the translation of Aristotle, and Boldoni 10-point type for Michael's commentaries. In the Michael commentaries, direct quotations from Aristotle are set in Universal, paraphrases are marked with single quotation marks (''), reserving double quotation marks (" ") for referring to words, or for the other sorts of uses, other than direct quotation, for which they are customarily used in English. Hayduck notes direct quotations by enlarging the spacing of the words, and uses single quotation marks for paraphrases. My notions of what is direct quotation and what is paraphrase often diverge from Hayduck's and I have not thought it important to note these divergences.

The pages in this volume are numbered consecutively from the first page of the Introduction; in addition, the translations of Aristotle's treaties have the chapter numbers in the left margin and the standard Bekker number in the right margin, with page numbers also at the top on the inner side of the page. The translations of Michael's commentaries have the page and line numbers of Hayduck's edition in the right margin. Each section of the commentary is introduced by a short quotation from the text commented upon; following Hayduck, the chapter, page, and line numbers of the Berlin edition are usually cited. Similarly, the page and line numbers are also inserted at many of the quotations and paraphrases in the text.

I have not inserted footnote numbers into the translations. Instead, all notes have been gathered at the end of each commentary, and they are listed in the order of the passages annotated. Notes on the translation of Aristotle have a Bekker number, and notes on the translation of Michael have a Hayduck number; notes on both have both numbers. Many of the notes are also introduced by key words in the passages commented upon.

Several of the Greek words present special difficulties to the translator. One of the more important discrepancies between the translations by Nussbaum and me, on the one hand, and most earlier translations, on the other, is in the treatment of the verb forms of kueiv, particularly translating many forms which might be either middle or passive in the middle, rather than in the passive. (See also my note to 69a5.) Aristotle is trying to explain how animals move themselves, or just move, rather than (in general) how they are moved.

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The word 'pneuma' is ambiguous between 'unmoved' and 'immovable', because the ending -rov is ambiguous. Both renderings appear, but 'unmoved' is used more often because it makes a weaker claim.

As we have noted, ἐφίλησ is translated "intention" here, and ὅρημ, which appears only in the commentary, is translated "impulse".

Pneuma is simply transliterated wherever it appears. It is defined as 'hot air' in Generation of Animals II.2, and is said to be analogous to aether, the material of the stars, in GA II.3. The MA and GA, together with a few passages in the Parva Naturalia, exhaust the places where Aristotle uses the concept of pneuma in explanation. Curiously, he does not appeal to pneuma in the de Anima.45

Δρατ is notoriously ambiguous between 'origin', 'source', 'principle', 'beginning', 'rule', and so on. I try to stick to 'origin' in the translation for consistency; it is a technical term in these treatises.

Πηνων (neuron) includes muscle, sinew, and nerve, for Aristotle, and Michael generally follows him, although sometimes he recognizes some distinctions where Aristotle does not. Several passages in which this word appears are discussed in the notes, but otherwise the word is translated 'nerve'.

Καχαρ is translated 'flex'; other translators say 'bend'. Aristotle uses the word for turning at a joint; similarly the verb form, καχαρειν, I translate 'flex' rather than 'bend', saving 'bending' for the verb ψειδναον in IA 16-17.

Other words are discussed in the notes as they appear.

Abbreviations of the titles of Aristotle's works and the works of other ancient authors conform to the list of abbreviations provided by Liddell, Scott, and Jones, A Greek-English Lexicon.

45. A summary of Aristotle's theory of pneuma may be found in Stephen Clark, Aristotle's Men, Oxford, 1975, Nussbaum 1977, pp. 145 ff; Verbeke, La Doctrine du Pneuma, and his "La doctrine du pneuma et entelechisme chez Aristote," in Lloyd and Owen. For the Stoic pneumatic tradition, see David Hahn, The Origins of Stoic Cosmology, and for Galen, see Owei Temkin, Galenism. Galen's pneumatism seems to have had no effect on the tradition of the commentators.
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Several persons have been helpful with this work. I thank Martha Nussbaum for permitting me to use a photocopy of her dissertation as it was undergoing the revision which became the book; I thank Paul Mercken for his cooperation in “Anna Comnena’s Aristotelians,” first presented at the SUNY Binghamton Center for Medieval and Early Renaissance Studies. I also thank, anonymously, several friends in Greece who suggested senses of words used by Michael when the dictionaries were no help; I also thank several students and friends who insisted upon clarity when I was prepared to leave something obscure. Mistakes and ambiguities which remain are my fault. Special thanks to Stanley Kaufman, for help with technical details in the preparation of the photo-ready copy, and to Meredith Pell, who assisted with several stages of the project. Finally, I thank my wife Nicole and my son Christian, to whom this work must seem an eccentricity.

ARISTOTLE
ON THE MOVEMENT OF ANIMALS

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1. We have investigated the details of the movement of various kinds of animals, the differences between these movements, and the causes of the characteristics which each exhibits; we must now inquire generally into the common cause of animal movement of whatever kind: some animals move by flight, some by swimming, some by walking, and others by other methods.
The origin of all the other movements is that which moves itself, the origin of this is the unmoved, and the first mover must be unmoved, as we determined when we were investigating whether eternal movement exists or not, and if so what it is. But one ought not to take this as a general account only; it should also be applied to individual cases and perceptible objects, through which we seek general accounts, and with which we think such accounts should agree.

Even in perceptible objects, movement is clearly impossible if there is nothing at rest, first of all in the animals themselves. Obviously, if one of their parts moves, another is at rest; this is why animals have joints. They use their joints as centers, and the whole member in which there is a joint becomes both one and two, straight and flexed, changing potentially and actually because of the joint. When the part is flexing and moving, one of the points in the joint moves and one remains at rest, just as would happen if AD on the diameter of the circle were to remain still while B moved, and the radius AC were formed. In geometrical figures the center is considered to be in every respect indivisible— for movement in geometrical figures is, as they say, a fiction, since in mathematical figures nothing actually moves— whereas the centers in the joints become potentially and actually sometimes one

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and sometimes divided.
In any case the relative origin *qua* origin is always at rest while the part below it is moved—the elbow when the forearm is moved, the shoulder when the whole arm is moved, the knee when the shin is moved, the hip when the whole leg is moved.

So each individual obviously must have within itself something at rest, which will be an origin of that which is moved, and supported upon which it will move both as a connected whole and part by part.

2. But any rest within the individual is entirely ineffectual if there is not something external which is simply at rest and unmoved. It is worth stopping to consider this statement, for the concept applies not only to animals, but also to the motion and progression of the universe. Just as there must be something in the individual which is unmoved if it is going to move itself, so even more there must be something unmoved outside the animal, supported upon which that moves itself moves. For if it were always giving way (as it does when mice walk in the earth and when people walk in sand), there would be no progression—there would be no walking if the earth did not remain still, no flying or swimming if the air or sea did not offer resistance.

That which offers resistance must be other than that which moves, the whole other than the whole, and that which is in this respect unmoved must be no part of that which moves; if not, it will not move. As evidence consider this problem: why can a man move a boat easily from the outside if he pushes with a pole on the mast or some other part, but if he is in the boat and tries to do this, he cannot move it even if he is Tityos, nor could Boreas move it by blowing from inside the boat, if he really blew as painters paint him; for they depict him blowing the wind from his own lips.

Whether one blows gently, or so strongly as to make the greatest gale (it is the same if something else is thrown or pushed), necessarily (1) one must be supported by one’s own member, which is at rest, when one pushes, and (2) this member or that of which it is a part must remain at rest supported by something external to it. It makes sense that the man who tries to push the boat while he is in it fails to move it; because that against which he leans must remain still.

This happens to him because that which he moves and that on which he leans are the same thing. Yet if he drags or pushes the boat from outside, he moves it, for the earth is no part of the boat.

3. One might raise a problem: if something moves the whole heaven, must this too be unmoved, no part of the heaven, nor in the heaven? If it is moved and moves the heaven, it must move by touching something unmoved, and this can be no part of the mover. If, on the other hand, the mover is unmoved from the first, it cannot be a part of that which is moved. On this point at least those are right who say that no part of a revolving sphere remains at rest: for either the whole must remain still, or its continuity be torn apart. But they are not right in thinking that the poles have some kind of power, for the poles have no magnitude—they are merely limits or points. For besides the fact that nothing like that is any sort of entity (ousia), it is impossible for a single movement to have two origins (they make the poles two). From such considerations one might conclude that there is something which is related to all nature as the earth is to the animals and the things moved by them.

Those who mythically represent Atlas having his feet on the earth would seem to have told a reasonable story, as they make him a kind of radius turning the heaven around the poles: this would be reasonable because the earth remains still. But those who tell this story must say that the earth is no part of the whole universe. The force of that which sets in motion must be equal to the force of that which remains at rest—for there must be a certain force and power by which that which remains at rest remains, just as there is a force by which the mover imparts motion; and there must be a proportion between absences of movement just as there is between opposite movements: Equal forces are unmoved by each other, but they are mastered by superior forces. Therefore Atlas (or any other such internal mover) must not exert more force than that of the stability of the earth; otherwise the earth will be moved away from the center and out of its own place. As the pusher pushes so the pushed is pushed, in proportion to the force. But that which imparts motion is first at rest so that its force must be more and greater.
rather than like and equal to that of its stability; likewise it is greater than the stability of that which is moved but does not move anything else. Thus the earth's power of stability will have to be as much as that of the whole heaven and that which moves it. But if this is impossible, it is also impossible for the heaven to be moved by any such thing within it.

4. There is a problem about the movements of the parts of the heaven which might be investigated here, as it is like what we have just been talking about. If someone were to exceed the stability of the earth with the power of movement, clearly he would move it away from the center, and obviously the force from which this power arises is not infinite, for the earth is not infinite, nor is its weight infinite. The word 'impossible' has several senses: when we say 'it is impossible for us to see a sound' and 'it is impossible for us to see men on the moon' we use different senses. The first is necessarily invisible; in the second case the objects are naturally visible but will not be seen by us. We believe that the heaven is necessarily indestructible and indissoluble, whereas according to the present account this is not necessary; for it is both natural and possible that there should be a movement greater both than that by which the earth remains at rest and than that by which the fire and the upper body are moved. Now if there were overpowering movements these bodies would be destroyed by one another; if they do not exist, but possibly exist (an infinite motion is impossible because an infinite body is impossible), it would be possible for the heaven to be destroyed. What would prevent this from happening, if it were not impossible? But it is not impossible if the contradictory is not necessary. Well, there ought to be another place to discuss this problem.

Must there, or must there not, be something unmoved and at rest outside and no part of that which is moved? Does this necessarily exist for the universe? Perhaps it would seem strange if the origin of movement were inside. Thus those who hold this position would suppose that Homer spoke well:

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You could never pull down from the heavens to earth
Zeus the highest of all, no matter how hard you tried;
Gods and goddesses all, hang on tight.

For that which is entirely unmoved cannot be moved by anything. Here we can solve that old problem whether it is possible or not for the organization of the heaven to be dissolved, if it depends upon an unmoved origin.

In the case of animals there must be not only that which is unmoved in this sense, but there must also be something unmoved in those which move in place, as many as move themselves. For there must be one part in them which moves and another at rest, supported upon which the moving moves, if, for example, it moves one of its parts; for one part supports itself on another in virtue of the latter remaining at rest.

Someone might wonder about inanimate things which move, whether they all have within themselves both a moving and a stationary element, and whether they too must support themselves on something external and at rest. Or is this impossible, as in the case of fire or earth or some other inanimate thing, and must it be looked for in those things by which these are first set in motion. For all inanimate things are moved by something else, and the origin of movement of all things thus moved is those things which move themselves. Of such origins we have already mentioned animals; they all must have in themselves that which is at rest, and something external upon which they are supported. But whether there is some higher and primary mover is unclear, and we will give a separate discussion of such an origin.

All the animals which move themselves move supported upon external things, even breathing in and out. For it doesn't matter whether they propel a great or small weight, as do those who spit, cough, breathe in and out.

5. Must something be at rest only in that which moves itself in place, or also in that which alters itself and grows? Original generation and decay is another story, for if there is, as we say, a first movement, this would be the cause of generation and decay, and perhaps of all
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the other movements too. As in the universe, so in the animal, this is the first movement, when it is completed: so that it is the cause of its own growth, if this ever happens, and alteration. But if there is not <a primary movement> then <a resting point> is not necessary. The first growth and alteration are generated by another and through other means; nothing can in any way be the cause of its own generation and destruction, for the mover must pre-exist the generated; nothing is prior to itself.

6. Whether the soul is moved or not, and if it does move, how it is moved, has been discussed in the book On the Soul. Since all animate things are moved by something else, and since we have already determined how that which moves itself first and eternally moves itself, and how the first mover moves, in the books on First Philosophy, it remains to investigate how the soul moves the body, and what the origin of movement of the animal is. For except for the movement of the universe, living things are the causes of the movement of everything else, except those things which are moved by bumping into each other. Therefore all their movements have a limit, for the movements of living things have a limit. All the animals move and are moved for the sake of something (heneka tinos), so this is the limit of all their movements, the for the sake of what (hau heneka).

We see that what moves the animal are thought, imagination, choice, will, and appetite. All of these reduce to mind and intention. Imagination and perception have the same extension as mind, for they are all critical, though they have certain differences distinguished elsewhere.

Will, temper, and appetite are all intention but choice shares in both intellect and intention. So the first mover is the object of intention and thought; but not every object of thought—only the end of action.

Therefore, it is this sort of good which is a mover, and not every value; it moves inasmuch as something else is for its sake, and inasmuch as it is an end of things which exist for the sake of something else. We must suppose that the apparent good has the same extension as the good, and so does the pleasant, for it is an apparent good.

So it is clear that the eternally moved by the eternal mover, and the individual animal, move in the same way in one respect, but in another

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THE MOVEMENT OF ANIMALS

700a respect differently, in that the former move eternally, but the movement of animals has a limit. The eternally valuable and the truly and primarily good, and not just occasionally good, is too divine and precious to have anything prior to it. The first mover, then, moves unmoved, but intention and the faculty of intention move being moved. But it is necessary that the last moving thing move anything else; thus it is clearly reasonable that progression be the last movement which occurs in generated things; for the animal moves itself and progresses by intention or choice, when some alteration has occurred in accordance with perception or imagination.

7. But how is it that which thinks sometimes acts, sometimes not, sometimes moves, sometimes not? It seems that something similar happens in the case of those who reason and syllogize about unmoved objects. But in this case a theoretical proposition is the end (for when one thinks the two premises, one has already thought and constructed the conclusion); in the present case the conclusion which results from the two premises is an action. For example, when someone thinks that all men ought to walk and that he is a man, then immediately he walks. Or if he thinks that no man ought to walk now and he is a man, then immediately he stands still. In both cases he acts if nothing prevents or compels him. ‘I ought to make a good’, ‘A house is a good’ then he immediately makes a house. ‘I need a covering’, ‘A cloak is a covering’, ‘I need a cloak’. ‘What I need I ought to make’, ‘I need a cloak’, ‘I ought to make a cloak’—and this conclusion, ‘I ought to make a cloak’, is an action. He acts from an origin. If there is going to be a cloak, then x is necessary first, but if x is necessary, then y is necessary; this he does immediately. That the action is the conclusion is now clear; but two kinds of practical premises are generated, through the good, and through the possible.

Just as happens when we ask dialectical questions, so here the intellect does not stop to look at the second premise, the obvious one. For example, if walking is good for man, it does not waste time considering that he is a man. So those things which we do without calculation, we do quickly. For when one is actually using perception,
imagination or mind to some purpose (hōu heneka), what one intends, one does; instead of questioning or thinking, the activity (energeia) of intention happens. 'I ought to drink,' says the appetite; 'This is drink,' says perception, imagination, or mind; immediately he drinks. This is how animals start to move and act; the last cause of their movement is intention (orexis), which in turn is brought about either by perception or by imagination and thought. Of those who intend (orexizein) to act, some make or act because of appetite or temper, others because of intention (orexis) or will.

Animals move themselves as the automatic puppets do after a small movement is generated; the strings are released and they strike one another; and the small wagon, which the one riding starts in a straight line, moves in a circle because it has unequal wheels (the smaller acts as a center, as in the case of the cylinders). Animals have similar organs—the nature of the sinews and bones; the latter correspond to the wooden pieces and the iron, the sinews are like the strings which cause the movement when loosened and released. In the puppets and wagons there is no alteration, since if the inner wheels become smaller and then larger it would move the same way, in a circle. But in the animal the same thing has the power to become both larger and smaller and to change its shape, the parts expand because of head and contract because of cold and thus alter. Imaginations, perceptions and thoughts bring about alterations. Perceptions are at once a kind of alteration, and imagination and thought have the power of their objects; for in a way the thought form of hot and cold, pleasant and fearsome, seems to be like the particular objects, which is why those who just think about these things shiver or are afraid. All of these passions are also alterations, and when alteration occurs in the body, some parts become larger, some smaller.

It is not hard to see that when a great change occurs in an origin it makes many and great differences farther out; for example, when the rudder is moved momentarily a great change in direction of the prow occurs. Besides, when, due to heat, cold, or some other affection, an alteration is generated in the region of the heart—even in an imperceptibly small part of it—it makes a big difference in the body, in blushing, shuddering, blanching, trembling, and their opposites.

8. So then, the origin of movement (as has been said), is the object of pursuit or avoidance in the sphere of action; heat and cold necessarily accompany the thought and imagination of these objects. The painful is avoided, the pleasant is pursued. Practically everything painful or pleasant is accompanied by some heat or chilling, but we do not notice when it happens in a small part.

This is clear from the passions. Daring, fear, sexual excitement, and other bodily pains and pleasures are accompanied by heating or cooling either in a part or in the whole body. Memories and expectations, using such things as images, are causes, sometimes more, sometimes less, of the same effects. Thus it is an example of reasonable craftmanship that the inner parts and those around the origins of the organic parts change from solid to fluid, to solid from fluid, and soft and hard from each other. But since these processes happen thus, and since, furthermore, passive and active have the sort of nature which we have often said, whenever one is active and the other is passive, and neither fails to fulfill its definition, immediately the one acts and the other is acted upon. That is why it is pretty much at the same time that one thinks that one ought to walk and one starts walking, if nothing else hinders. Affections fittingly set up the organic parts, intention (orexis) sets up the affections, and imagination sets up intention; imagination is brought about by either thought or perception. It happens simultaneously and quickly because the active and passive are naturally relative to each other.

That which first moves the animal must be in some origin (arche). We have said that the joint is the origin of one thing and the end of another: thus nature uses it sometimes as one, sometimes as two. For when there is movement from it, one of its extreme points must remain at rest, and the other must move; we said that the mover must support itself on that which is at rest. The end of the forearm moves and does not move anything, but in the elbow-joint one part moves, that which is in the whole which moves; but there must also be something which does not move. This is what we mean by saying that it is one point potentially (dynamēi), but becomes two in activity (energeia). So if the forearm were the animal, the moving origin of the soul would be somewhere in this area.
ARISTOTLE

But since it is possible for an inanimate object to bear the same relation to the hand, e.g., if one were to move a stick in the hand, clearly the soul could be in neither of the extremities—not in the extremity which is moved, nor in the other origin; for the wood has both an origin and an end in relation to the hand. So for this reason, if the moving origin from the soul is not in the stick, it is not in the hand, for the end of the hand has the same relation to the wrist, and this part to the elbow. For it makes no difference whether it is attached by growth or not—the stick becomes something like a detached member. The origin of movement cannot, then, be in any origin which is the end of something else, not even if there is something farther out than it, as for example the origin of the end of the stick is in the hand, but the origin of the head is in the wrist. If it is not in the hand because it is higher up, then the origin is not there either; for with the elbow remaining at rest, everything connected below can move.

9. Since the right and left sides of the body are similar, and the opposite sides can move simultaneously, it cannot be that the left moves in virtue of the immobility of the right, nor vice versa; the origin always has to be in something higher up—the origin of the moving soul must be in the middle, for the middle is the last term of both extremes. It stands in the same relation to the movements from above as to those from below—e.g., those from the head, and those from the spine in animals having a spine. This arrangement makes sense, for we say that the faculty of perception is also there in the middle, so that when the place around the origin is altered and changed by perception, the parts connected with it change with it, and expand and contract; in this way movement must occur in animals. The middle of the body is one part potentially, but in activity it must become more; for the limbs can move simultaneously from the origin, and one can remain at rest and another move. For example, in ABC, B is moved and A moves it. But there must be something at rest, if one thing is to be moved and other to impart movement. Then A, potentially one, will be in activity two, so that

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both the origins in A must move being moved. Then there must be something besides these which moves and is not itself moved. Otherwise, the limits and origins in A would support each other when motion takes place, just as if two men were to lean on each other's back and move their legs. But there has to be some one thing which moves both—this is the soul, and it is other than such a magnitude, but it is in it.

10. According to the explanatory definition of movement, intention (orexis) is the middle, which moves being moved. In ensouled bodies there must be such body. Now that which is moved but does not naturally cause motion can be acted upon by some other power; but a mover must have some power and force. All the animals appear to have connate pneuma and to be strong in virtue of it. (What conserves the connate pneuma has been explained elsewhere). This seems to bear the same relation to the psychic origin as the point in the joints, which moves and is moved, bears to the unmoved. Since the origin in some animals is in the heart and in others the analogue of the heart, therefore the connate pneuma too appears to be there. Whether the pneuma is always the same, or always other pneuma is generated, must be discussed elsewhere, for the same question arises about the other parts. At any rate it is obviously naturally well adapted to the motive faculty and to exerting strength. The functions of movement are pushing and pulling, so the organ must have the power both to expand and to contract. This is the nature of pneuma: for it contracts and expands without constraint, and it can push and pull for the same reason; it has weight in comparison with the fiery and lightness in comparison with the opposites. That which is going to cause movement without alteration must be like that; for the natural bodies master one another by excess—the light is conquered and brought down by the heavier, the heavy brought up by the lighter.

So we have named the part in virtue of whose movement the soul causes movement, and how. The animal must be understood as constructed like a well-governed city, for once order is established in the city, there is no need for a separate monarch which has to preside over each activity; each individual does his own ordered task, and one
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Activity follows another through custom (ethos). In animals this happens by nature; each of their parts is naturally so constructed as to do its own work, so that it is not necessary for the soul to be in each part, but as it is in some origin of the body, the other parts live by natural attachment to this and naturally do their own work.

11. We have discussed how animals move in voluntary movements, and why. But some of the parts move in certain involuntary movements—most of them are really non-voluntary. I mean by involuntary those movements, for example, of the heart and of the penis; for they often move at some appearance, and not at the bidding of the mind. I mean by non-voluntary for example sleep, waking, breathing, and the like; neither imagination nor intention is strictly responsible for these, but since the animal must undergo natural alteration, and when the parts alter, some grow and others decrease, so that at once it moves and undergoes the changes which are naturally connected to each other. The causes of the movements are heatings and coolings, some coming from without, some naturally present within. Thus non-rational movements are generated in the parts named through inter-related alteration. Thought and imagination, as has been said before, bring about that which makes these effects, for they bring about the ideas of that which makes them. These parts do this especially clearly because each of them is like a separate animal. [The reason is that each has vital moisture.] The reason why the heart does this is clear, for it has the origins of perceptions. An indication that the generative organ is similar is that the power of the seed comes out of it as if it were an animal.

It is reasonable that the movements from the parts occur in the origin, and in the parts from the origin, come together, and thus reach each other. Think of origin A. The movements from each letter of the diagram come to the origin, and from the origin as it moves and changes, since it is potentially many: the origin of B goes to B, the origin of C goes to C, the origin of both to both. From B to C it goes to A as to an origin, then from A to C as from an origin. Thinking the same thoughts, sometimes the non-
Michael of Ephesus

Commentary on Aristotle’s “Movement of Animals”

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The Movement of Animals reasonably follows On Memory: the intentional ("eretikē") and impulsive ("horēmētikē") powers of the soul are linked with each other, for intention ("eretēsis") is a kind of impulse ("hornēs") and they are the causes of local movement in animals. When one intends ("eretēsetēs") something he impels ("hornēs") to it and moves in place, or turning away avoids and flees it. Since intention and impulse follow after the soul’s power of imagination ("phantasia")... for impulse seems to have its position after assent to the images, as if impulse were the end of the soul; the impulsive and intentional powers of the soul are no longer critical, but belong to another part of the soul, the practical. The soul of animals is divided in two, the critical and the practical, and the intentional and impulsive belong to the practical. So since the intentional and impulsive are causes of local movement and follow imagination, and memory is a possession of an image or phantasm, the Movement of Animals is reasonably placed after On Memory. He investigates here the cause of animals’ moving in whatever sort of movement, showing that in the case of something moving by itself it must have something unmoved in itself, and that it must also have something external to it, which is other than itself, and also unmoved. After this he investigates what it is that moves the heavens, and refutes those who say that Atlas holds up the heaven. He investigates whether it is possible for the cosmos to be destroyed, and says why something must be unmoved, in order that the cosmos may move. Then he gives attention to inanimate mobile objects, whether they must have something unmoved both within and without. He asks whether it is necessary for something external to remain at rest only in the case of things moving in place or also in the case of things growing and
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changing in quality. He shows how the soul moves the body, what is the origin (arche) of voluntary movement in animals, and how sometimes they think but do not act. He says that the first mover of the animal is with the origin, that animals move with the self-moving presuma, and tells how animals move in both non-voluntary and voluntary movements, why it is that the heart and genitals especially move thus, and how the origin is moved by the parts, and the parts in turn by the origin. That is a sufficient preface; let us proceed to the clarification of what is said, praying to God who is guardian of arguments that he give us accurate understanding of these things.

1.698a1: . . . the details of the movement of various kinds of animals, the differences between these movements...

He has written in the *Progression of Animals* about all the sorts of movement which belong to each genus or species of animal, and about their differences; for he says there why some of them move with four points and some with more, why some have feet and some do not, and generally he writes in that book about their differences and about what animals have useful for progression. Here he investigates the common cause of movement of everything, however it moves; for some are naturally constructed to move by flying, some by creeping, and others in other ways. He has shown, furthermore, in *Physics* VIII that the origin of the self moved (autokineton) is the unmoved, and this is the soul, the origin of the other movements. The first mover he calls the first God.

1.698a11: But one ought not take this as a general account (logos) only. He says 'in logos' rather than 'universally.' Since the unmoved is the origin of all other movement, this is shown universally (as in *Physics* VIII); he says this is necessary, that is, that something unmoved is necessary, if there is going to be movement, not only as a general account and universally—not simply to begin with the general demonstration as in *Physics* VIII, but also to base the explanation on individual cases. We even seek the general explanation through the individual cases; if we find the general explanation harmonizing with the individual cases, we have confidence in it, but if not, we should get rid of it.

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That the joints in us are at rest has been said in the *Progression of Animals*; for the elbow is at rest when the forearm moves; outside us the ground or perhaps something else upon which we progress remains still. The whole limb is potentially one but actually two in flexing, but actually one and potentially two in extension. Similarly, he says, in the diameter of a circle, A and D remain still, that is to say that the line AD remains still, but B moves, i.e., the line AB moves, and the movement to AC is generated. Let the line AD be the arm from shoulder to elbow, AB the lower arm. The center seems to be always undivided in the case of the diameter of the circle, but in the case of joints, sometimes it is one, sometimes divided (698b11), i.e., sometimes it becomes two, both potentially and actually. The rest he explains clearly. In the case of the jumping animal, the whole moves together. Any point of rest within the individual (2.698b8) is such potentially, whether some part or the whole is at rest; unless there is something external which is simply (and properly) at rest there couldn't be movement at all.

2.698b10: For the concept applies not only to animals. . .

He says that the demonstration, that if there were nothing external absolutely unmoved, there would be no movement, applies not only to animals, but to the entire cosmos as well; for in this case too there must be something which is wholly unmoved, if the heaven is to move. The wholly unmoved is that which, in the *Metaphysics*, is called the 'best everlasting animal'; that's how he expands on this in A of that treatise. He goes on, 'if the earth were always giving way and yielding to the mice walking on the earth' (let 'mouse' stand for those who walk, for the sake of argument), there would be no progression.' But that which is really at rest must be other than that which moves, the whole other than the whole (698b19). For the whole of that which remains at rest must be other than the whole which moves, and that which is in this respect unmoved (i.e., that which is simply unmoved) must be no part of that which moves (698b19). This is added because he says a little later that a person in a boat, pushing the mast with a pole, is a part of the boat, and the boat does not move in this case; for a person in the boat is, in a way, part of the boat.
2.698b21: As evidence, consider this problem: why can a man move the boat from outside if he pushes with a pole on the mast... He goes on: 'why does the boat move easily, if someone from outside the boat pushes the boat by shoving on the mast with a pole?' to which he adds: 'for evidence and clear proof that something must be unmoved, if movement is to occur, consider what happens with the boat; if someone standing on the earth pushes the boat with a rod or pole, shoving and leaning the pole on the mast or some other part of the boat, e.g. the stem, it moves easily; but if he sits in the same stem and shoves the pole on the mast and tries to move it, he will not be able to do it, nor would Tityos move it, nor if Boreas were in the same boat and blew from it, would he move it. But how do the winds move boats? In no other way than by blowing from outside the boat. If they blew from the boat, they would not move it. How does it happen thus? Just as a person who stands on the beach or a rock, or, in general, on the earth, because he stands on something immobile and not part of the boat, is able to move it, because there must be something unmoved, if movement is to occur. If the boat were moved by someone in it, he would have to be both at rest and moving, which is impossible; at rest, because that which is to move something must remain against something at rest, in order to push; moving, because of the implication that the boat is moved by someone who is in it. So if neither Tityos nor Boreas would be able to move the boat while in it, clearly there must be something unmoved, if there is to be movement, and this, something external, and no part of that which moves.' This is the sense of the passage. That painters do depict the winds as men blowing the breath from their mouth is quite obvious. One must be supported by means: the pilot pushing the boat first supports the forearm on the elbow, then either the elbow itself is supported on something external, on a rock or something else, or the pilot, of whom the elbow is a part, supports himself. This happens to him because that which he moves and that on which he leans are the same (698a9-10), perhaps means that it happens to the same boat to be at the same time moved and at rest; for we must lean on something which remains at rest.

3.699a12: One may raise a problem here: if something moves the whole heaven, must this too be unmoved.

The problem is this: is that which moves the heaven unmoved? Is it part of the heaven or not? For the soul moves the animal but is unmoved, and nevertheless is part of the whole animal. Is that which moves the heaven part of the heaven, as the soul is part of the animal, or not? There are three questions: 1) does the mover of the heaven move itself? 2) is it part of the heaven? 3) is it the heaven as the pilot is in the boat, or as the soul is in the animal? Having posed the problem, he shows in the first place, that it does not move itself: 'If the first mover of the heaven moved, there would have to be something unmoved (as was shown) touching which it moved, and this, on which it supports itself, is no part of that which moves. For if it is part of it as the elbow is connected to the hand, there would have to be something else again, on which it would support itself. But it is impossible for the first mover to touch and support itself on something, for it is indivisible and incorporeal, as is shown in the last book of the Physics; thus it does not itself move.' For if the mover moves, it must support itself on something and thus move itself and other things, but neither does the first mover support itself on something in this way, nor does it move at all, but it is immobile. If it is immobile, it cannot be part of that which moves; for if it were a part of the heaven, then since it must be immobile, either the entire heaven would remain at rest, or if part moved and part remained at rest, the heaven would be torn apart. This is why he approves of those who say that no part of a revolving sphere remains at rest (699a18), which amounts to saying that that which moves it, is not a part of it. This much they say correctly, but they err when they say that the poles move the heaven. For the poles are nothing; they have only conceptual existence. Besides the fact that the poles are not entities and do not have a nature, it is impossible for one movement to come about by means of two things; for a movement numerically one is generated in something moving which is numerically one, and by a mover numerically one, as is shown in the Physics, but the poles are not one but two. How could the movement from the east be divided into two for two movers? On the basis of puzzles like these, one may come to believe that there is something immobile in relation to the whole of nature, by which the whole is moved; I think that an indication of this is the statement, From such considerations one might conclude... (699a26).
3.699a27: Those who mythically represent Atlas as having his feet on the earth... The story about Atlas is clear in every way; for they show him moving the heaven by carrying pillars and standing on the earth, being analogous to the radius of the circle extending from the center to the circumference. As the radius extends from center to circumference, so Atlas extends from the earth as a center to the heaven. Aristotle says that those who tell this story are reasonable, that there is plausibility in what they say, but it is not a true story. Nevertheless, he says, even if we believed this story, it would be evidence for our position, that if there is to be movement, there must be something unmoved. For they too suppose the earth to be at rest, since they make Atlas stand on it. But having said this, he objects to the doctrine, and shows it to be false: but those who tell this story must say that the earth is no part of the whole universe (699a32). That is, ‘If the earth were not a part of the whole, they would be telling a reasonable story, but if not, it’s pointless: for just as a person seated in the stem of the boat cannot move it, since the stem is part of the boat, so one standing on the earth cannot move it, for the earth is a part of the whole.’

3.699a32: The force of that which sets in motion must be equal to the force of that which remains at rest. This too concerns the story about Atlas. He means, as there is a certain force, according to which the mover moves, so too there is a force according to which the still remains still, these forces being necessarily proportionate. For as movement is to movement, so rest to rest, and conversely as movement to rest, so movement to rest. Equal powers or movements are unchanged by each other, but move in accordance with the excess. So if there is not the force in the earth to remain at rest, equal to that of whatever rests on it and moves, it would move from its natural place, the center.

3.699b16: But that which is first at rest imparts movement... By ‘that which is first at rest’ he means Atlas; for he, standing on the earth, moves the heaven with the pillars, the pillars moving too. And since the force of the earth must resist not only the force of Atlas, but also the force of the heaven moved by Atlas, clearly the force of the earth would have to be more than the forces of the heaven and of Atlas, separately or together. The story becomes impossible when it is supposed that the power of the earth is equal to that of the whole, and also equal to that of the whole plus Atlas.

4.699b12: There is a problem about the movements of the parts of the heaven... Having shown that it is impossible for the heaven to be moved by Atlas by showing that it is impossible for the force of the earth to be equal to that of the heaven plus that of Atlas, he continues: There is a problem about the movements of the parts of the heaven, meaning now by ‘heaven’ the entire cosmos, by parts of it, earth, fire, and the divine bodies which are borne in circles, and by ‘movements’ the removals from the natural places of each of these. The problem is this: if someone were to find a power greater than the power by which the earth remains at rest, could he move the earth or not. That it is possible to find a power greater than the power of the earth, is clear. For if the earth were infinite (indicative of this: the force from which this power arises is not infinite [699b16]), and if its heaviness, the force because of which it is not moved, were infinite, one could not find a greater force, for it would be infinite; for there is nothing greater than the infinite; but since it is finite (nothing is actually infinite, as is shown in the Physics), nothing prevents finding something greater than this finite force. So that if someone could find a force greater than this, some power greater than the power of the divine bodies which are borne in circles might also be found; for these too are finite, as is shown in the de Caelo. He goes on: ‘we think the heaven to be necessarily indestructible, as sound is invisible; but it may be destructible, because of the possibility of finding a greater power, by which it and fire move, and earth remains at rest.’ But since someone would probably say that this is unclear, ‘if some power is as a whole more than the powers of the heaven and the earth and the rest,’ he goes on, now if there were overpowering movements (699b25), i.e., if there were overpowering powers. He means, ‘if there were, among beings and having reality, some powers greater than the powers of heaven and earth, they would move tomorrow or some time, and they would destroy the cosmos’ (for the words by one another [699b27] are equivalent to ‘the earth by the force greater than its power, and the heaven by the force greater than its power’). If the greater powers do not exist, they could nevertheless be generated at some time.
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The words, cannot be infinite (699b27), might mean that the bodies are not infinite, which would make their powers infinite, or they might mean that 'nothing possible has the power to generate to infinity,' but comes sometime to actuality,' as is shown in the de Caelo. For if it is possible for water to become air, it will become air sometime. 'Now if there were not powers greater than the powers of the earth and sky, but nevertheless they could be generated, it would be possible to dissolve the heaven.' For what prevents it being destroyed, if it is not impossible, but possible, to destroy the heaven? It is not impossible, if the contrary is not necessary. For when some particular thing is necessary, then its contrary cannot occur; e.g., man is necessarily an animal, so it is impossible for him to be non-animal; animal and non-animal are contraries. When one contrary is possible or not necessary, the other is not impossible, but possible. For example, it is not necessary that Socrates be walking, so not walking is not impossible, but possible, for walking and not walking are contraries. 'So it is not necessary that the heaven not be destroyed, but possible (δεσσάρον).' That's approximately what he means. He will solve the problem a little later. What I've said fits the text, for he was investigating whether, if Atlas moves the heaven, the power of the earth alone would be greater than the power of Atlas, and greater than the power of the heaven; but if this were the case, what would prevent there being another power greater than the power of the earth?

4.699b32: Must there be something unmoved and at rest outside of that which is moved?

As he has shown that if movement is to be generated, there must be something at rest, and that this cannot be part of the moved, and as he is about to investigate whether it is possible for there to be something unmoved also in the case of the movement of the heaven, in order that the heaven may move, he takes up the argument where he left off, and having asked about animals, he goes from animals to heaven, and silences us by giving us to understand that there is something outside the heaven absolutely immobile. He continues: Perhaps it would seem strange if the origin of movement were inside (699b35). For as the boat cannot be moved by someone seated in the stern, because someone seated in the boat becomes a part of the boat, so too the heaven cannot be moved by something within it as the cause of

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the movement; this would be a part of the whole, being within it. Thus Homer seems to have spoken rightly ("You could never pull down from the heavens to earth..."), for those who understand and admit that if the heaven is to move, there must be something absolutely immobile outside the heaven. Even Homer, reckoning that there must be something immobile outside the heaven, makes Zeus say to the other gods, "all you gods and goddesses would never be able to pull me loose and lead me down from heaven to earth." For the first mover, because of which the fixed stars move, is entirely immobile, so no one may move it. So by saying, "you could never pull," he shows that it is entirely immobile, and by adding "from heaven," he intimates that it is outside the heaven. But if the first mover is unmoved, there is an immediate resolution of the previously mentioned problem, which he calls "old," the one which asks whether the heaven can be destroyed or not. For that which is moved by the immobile cause will never be destroyed as long as the mover remains. He continues, 'whence, if it depends on an unmoved principle, the aforesaid problem is resolved, whether it is possible' etc. Another manuscript puts a δ in, so it would mean: 'whence the aforesaid problem is sunk.' The sense would be, 'whence, i.e., because it is unclear whether there is something immobile outside the heaven or not, the problem about this is sunk, put in its place, and the solution discovered, whether it is possible for the heaven to be destroyed or not. But if it was clear that there is something immobile outside the heaven, such a problem would not be gotten into, begun, or located.' The section which follows is sufficiently explained. The words, by which these are set in motion (700a15) mean something like this: 'there cannot be in inanimate things something unmoved both external and within themselves, but in animals, by which the inanimate things are moved, it is possible, for the inanimate things are moved by animals.' In the passage, 'Of such origins we have already mentioned animals (700a17), he means all moving things generally, both animate and inanimate. That animals lean on something just to breathe in and out is clear to those who turn their attention to it; for sometimes we are at rest, obviously, but sometimes we walk, if walking and all change in place is generated from rest and movement, as is shown in the Parts of Animals. If one pays attention, he will recognize himself that when he breathes in and out, then leaning naturally occurs. It is also clear that we lean not only when we want to throw a large weight, but also to spit and cough.
5.700a26: Must something be at rest only in that which moves itself in place or also in that which alters itself and grows?
In the womb, beings do not change and grow by themselves; for embryos are grown and changed by the mother as a part of herself; but once outside they grow and change by themselves. ‘Alteration’ should be understood as pleasure, anger, and so on; for we are altered by the environment, and by ourselves when some movement is generated within. By ‘original generation and decay’ he means the original construction in the mother; for he now begins off investigating this. Wondering whether it is possible for something to be at rest in growing and altering things as there is in things moving in place, he continues: ‘For if there is, as we say, a first movement, this would be the cause of generation and decay (700a29), meaning by ‘first movement’, ‘change in place’, for he shows in Physics VIII that this sort is prior to the others, and that cyclical movement is the prior sort of local movement. He means: ‘now if movement in place is prior to generation and alteration, and these prior to growth, and if without movement in place there can be neither generation nor any other change, and if movement in place cannot occur unless something remains at rest, then other kinds of change will not occur unless something remains at rest.’ But if not, then it is not necessary (700a33), i.e., if change in place is not prior to the others, it is not necessary that something remain at rest for things to alter and grow. But this sort of change has been shown to be prior; thus there must be something at rest in these cases too. It has been demonstrated that change in place, which is distinguished into linear and circular movement, is first both in the universe and in animals. The most perfect animals first change in place and thus copulate; and also when they suckle their young, change in place precedes. Furthermore, first the blood moves up and down, then accretion follows, then growth. When he says that the mover is prior to the moved, one should understand that he does not mean the mover and the moved of the universe, but in particular cases. (6.700b1?) Why imagining, mind, and intention differ, is said in the de Anima. Since choice is a movement of thought and intention, the choosable would also be something thought; for it would not be everything thought. Mathematics are objects of thought, but not of choice, but in the case of an object of thought where there is a doble good, as in technique and so on, there is also a choosable end. Of all goods, it is the double end which moves

6.700b29: So it is clear that that which moves eternally moves in the same way.
‘In one respect it moves in the same way’ means, ‘the heaven is moved by the first mover and animals are moved by the object of intention in a similar way,’ for the object of intention moves the intentional and impulsive power of the soul, which moves the animal; but it is in a way otherwise (700b32), i.e., differently. It is similar because the movers of heaven and of animals move them as objects of desire (epidein), but it is not similar because the one mover always moves the heavens, but the other does not always move the animals. The eternally noble and the truly and primarily good... (700b33).
δέ instead of γάρ, which would make it, ‘for the eternally noble’; saying that the first mover always moves, he adds, For the eternally noble and the primarily and truly good, and not just occasionally good, like our goods (for these are not always goods), is too divine and precious to have anything prior to it (700b35), i.e., that it is so divine that nothing is prior in worth to it; for such a thing is more precious than anything. Our goods, because they are sometimes good and sometimes not, sometimes move us and sometimes not, but that being which is always good is always the cause of movement. By ‘last moving thing’ (701a1) he means the animal which intention moves and moves itself; intention does not move in place (for he has shown that the soul is entirely immovable) but is brought from inactivity to activity (energeia). Progression is reasonably later than intention, for first intention moves, then the animal progresses. That’s how it is.

Now the soul uses the organs to move the animal, and generally causes movement somehow without being moved itself, is explained in the treatise, On Impulsion and the Impulsive Power. Anyone who wants to learn the truth should read the whole opinion of Aristotle in that book; but we will write here a little of what we write there. He says first that there are several intentional and impulsive powers, and then that there is a difference between
same thing (for as the artist is said to be moved by the art, so he is said to move according to the art; and as fire is said to be moved by lightness, so it is said to move according to lightness), so the animal is said to be moved by the soul, and according to it; for this sort of movement occurs in it according to its being ensouled, not according to heavy or light, white or black, hot or cold. For the animal perceives, thinks, walks, according to the soul, not the soul moving all by itself, in order that it may cause movement. As the dancer moves according to the art of dancing and the artist according to the art, there are in them these causes of such movement, but the causes do not change (for neither the art nor the dance moves or changes) so too those things which have souls move according to the soul without it moving. It is the impulsive and intentional power of the soul according to which animals move; for this is for animals the cause of their proper movement. And the soul in us is not like the rower in the boat, but like some form and perfection, as is said in the On Impulse and in the discussion of the impulsive power. This selection is enough to clarify what should be said; anyone who wishes to understand more about these things should get hold of the book On Impulse. Let us go on with the text of Aristotle.

7.701a7: But how is it that which thinks sometimes acts, sometimes does not, sometimes moves, sometimes not?

Sometimes when we think, we are moved to act, but sometimes we think but do not move, and as a matter of fact one kind of thought is responsible for not moving; in explanation of our sometimes moving, sometimes not, he addsuces that when the object of thought is doable, we move, but when it is not doable but knowable, and thinking of it is only theorizing, we do not move. By 'unmoved objects' (701a9) he means 'mathematical'. In the case of unmoved objects, knowledge (gnosia) alone is the end, and that is why we do not move; for when one thinks the two premises, one arrives at the conclusion and nothing more, but in the case of doables, the conclusion becomes an action. He gives a clear example of a syllogism in which the conclusion is an action: 'for when one thinks that every man ought to walk,' etc. The words, if nothing prevents or compels (702a16) are parallel; for the preventative compels us not to do that of which it is preventative. In the other syllogism the minor premise is, I need a covering (701a18), and the major is A cloak is a covering. The words, παρατει δὲ ἀπιστάρχης (701a21) mean: 'one
makes some beginning of the action, in the case of the cloak the wool or the money, in the case of the house, the stones.' He calls the premises 'practical' which, if we make syllogisms with them, we do something. They have two forms through which they reach conclusions. When we syllogize something to be good or apparently good and also possible, immediately we do it. As he says, in questions some 'elide' the obvious premise, but display the remaining one, so too in action, one displays the premise, 'walking is good' (701a27) and checks to see if it is good, but the premise, 'I am a man,' no one displays, for it is obvious. Thus those things which we do without calculating, we do quickly, for we do not syllogize in order to kill time and generally slow ourselves down by syllogizing; when animals are actually using perceptions or mind, immediately we 'impel' to the action which we intend. That intention is last, is clear; for first the perception or the imagination moves, and then the intention. In the passage, the last cause of their movement is intention (701a34), the word 'last' has been chosen instead of the word 'principal' (πρωτότοκος); perceiving or thinking would be of no use for moving, if intention did not follow. That things done through intention are done from temper, appetite, and will, has been said. Also that which differentiates will from temper, appetite, and in general from intention, is all explained in On Impulse.

7.701b2: ... as the automata move themselves, after a small movement is generated; the strings are released... By "automata" he means those operated by magicians at weddings and so on. For when they release the starting of the strings, immediately striking the next one, it releases it, and that the next, until arriving at the wooden images the movement moves them, so that it seems to those who do not know the arrangement of the strings that they move by themselves. So too when the pneuma in the heart is moved by intention, it moves the nearest nerves, and they again the next, until the movement arrives at the organic parts, hands and feet, and the animal itself moves. In the case of the four-wheel carriages (he gives these as an example), the smaller (wheel), being at rest, becomes as it were a center, analogous to the resting elbow, as is clear to those who give the matter a bit of attention; for since it is big, but the back wheels are bigger, and the front ones toward the oxen are small, they must stand still in turning so that the larger may move. For since the smaller and the larger are transferred from the same place to the same place in the same and equal times, clearly the

movement of the larger is more and faster, and that of the smaller is slower. But the slower is slower in virtue of the mixture of the opposite, and rest is the opposite of movement, so the smaller rests because it moves slower, even if it escapes our notice because we do not want to take the trouble to look for this sort of thing. Accept for the sake of argument (for accuracy in these things is not to be sought; the example is introduced only for the sake of clarity, and not for the similarity)— assume that as the pole is to the equator or simply to any of the circles described by the stars, so too the lesser wheels to the larger. But as this is so, we should know that the example of the automata has been introduced as an analogue of our nerves, but the example of the carriage for two reasons only and not for anything else: a) that the pieces of wood are analogous to the bones, b) that as the lesser wheels become unmoved as a center (pivot), so too the joints of animals; for in the joints too, as he often says, one part moves, and the other rests. That's the sense of the passage, I think.

The sense of the passage, and the wagon, which the one riding it starts in a straight line (701b4), is approximately: 'the carriage moves the one carried by it in a straight line;' for 'the one riding' means the one carried by the carriage. Even if the wheels move in a circle, the riding and carried weight moves in a straight line. But this, if I am not mistaken, preserves no image of movement which occurs in us; the following bit, because it has unequal wheels (the smaller acts as a center). . . (701b6) is very similar to the movement which occurs in us. As in the example the smaller wheels naturally stop while the larger wheels revolve (or rather rotate, for to be precise, spheres revolve, wheels rotate), so too some things in us move when we change in place, and others stand still. They make the front wheels unequal, the ones he calls inner (701b10), in order that the back ones overtaking and the front ones being pushed ahead the movement may become fast.

He mentions as in the case of the cylinders (701b6) because, it seems, they used to make wheeled vehicles with them, as even now the four-wheeled toy wagons are made with them, the wagons which children pull when playing— pretty playthings because of the decoration lavished on them by painters. The iron (701b9) means that which is wrapped around the circumference of the wheels, being itself a circle.
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Since in the lungs around the heart and in the nerves certain contractions and expansions generally occur, and generally alterations occur, but in the carriages and automata they do not occur, he further specifies that, in the automata and wagons there is no alteration (710b10), possibly saying this because if alteration were to occur in them, the same movement could be made which now occurs without alteration.

It has already been mentioned that our nerves and other parts grow or stretch and become bigger during pleasure by the agency of the well-blended heat which is generated then, and that they contract and are 'feathered' in fear by the cooling (the cold makes them stiff). We have already talked about the next bit, so it should be clear. The words, even in an imperceptibly small part of it (701b30) mean, 'even if the alteration is generated in a very small part, imperceptible to the senses.'

8.701b34: Heat and cold necessarily follow the thought and imagination of these objects.

The sense of the passage is this: 'heat and cold necessarily accompany the thought and imagination of these objects... but practically all (of them), painful or pleasant, are accompanied by [some] cooling and heating.' The others are in between. The text would be all right if it had γάρ (for) instead of δέ (but), so it would read, 'for those which are painful and pleasant.' One does not notice that even small pains and pleasures occur with heat and cold, but with great ones it is completely obvious. When heat and cold occur in us, sometimes we see one part moving in us, as in wet dreams the sex organs sometimes move, and sometimes the limbs as well, sometimes the whole body. We may even move around from place to place. In using, as it were, images like the experiences (702a6), he means the 'types' and 'copies' which are generated in us around the primary sense organ by the pleasant and painful objects.

8.702a7: Thus it is an example of reasonable craftsmanship that the inner parts and those around the origins of the organic parts...

Origins of the organic parts means the nerves and muscles and the organic parts means the hands and feet. The nerves become stiffened and as it were 'dry,' and as he says himself, hard (702a10) during fear, but fluid soft, and loose during pleasures. So when that sort of thing is caused by heating and cooling around the origins of the organic parts, it leads to those activities and services in the impulsive power, from which it also has originated, for all such actions are actualized through the activity of the bodily parts.

8.702a10: But since these processes happen thus...

That is, these changes from soft to hard and the rest of the experiences which he has mentioned, and since, furthermore, passive and active have the sort of nature... (that) one acts and the other is acted upon, since such experiences are generated by such an intention, at the same time as the intention, movements of the pneuma must occur and through this a movement of the nerves and through these of the animal. That's what he means. And neither fails to fulfill its definition (702a14) means something like this, 'and neither lacks anything pertaining to the essence and form of each,' for just as if one lacks something belonging to the definition of man, one is no longer a man, so too if something lacked part of the definition of 'active' qua active, it would no longer be what active means; similarly the passive would not be passive.

8.702a21: That which first moves the animal must be in some origin.

Everyone agrees that that which first moves the animal must be in some origin, but since the joints are origins, as has often been said, he must show that the origin cannot be in one of the joints; that which first moves the animal must not be in the sort of origin which is the beginning of one thing and the end of another, but in the sort which is simply an origin (ἀρχή kai ἀρθρόν); that is the heart. Alexander of Aphrodisias, a most accurate author, has in On Where the Governing Part of the Soul Is Situated, a demonstration with several parts that that which first moves the animal (the intentional and impulsive power of the soul, we say again) is in the heart; this is the origin of the animal, as is shown by argument and by dissection. He shows that it is not in the joints, using the forearm as a case in point; for what is demonstrated in this case applies everywhere. He says that Aristotle has already noted that joints are the origin of one thing and the end of another; for just as the present is the end of the past and the beginning of the future, so too the wrist is the beginning of the hand, but the end of the forearm. According to the History of Animals, the hand is composed of the fingers and the palm; the entire limb, from shoulder to hand, may be used as a unit, owing to the continuity of flesh and nerves, but may be used as two,
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through moving the hand with the wrist at rest (this has already been shown); so too the forearm can move, the elbow remaining at rest. For when there is movement from it (702a24) means, ‘for when it moves from this place to that.’ That there must be something leaned upon for movement to occur, something external and at rest, and something in us, was said at the beginning (1.69a14ff).

8.702a28: ... but in the elbow-joint one part moves, that which is in the whole which moves. ...

What he means is something like this: ‘the part,’ that is to say the hand, moves with the whole forearm. For the hand is in the forearm as part to whole; part of the whole moves with the whole. When the forearm flexes, the whole forearm moves and the hand moves with it. When he says, this one moves (702a29), he should continue, ‘but that one does not; instead he goes on, but there must also be something which does not move (702a29), which has often been demonstrated. Assuming this, he shows that the first mover of the animal is not in any of the joints, saying, ‘if the forearm were an animal, the soul would be in the elbow. The forearm is to the elbow as some other lifeless thing, e.g. a stick, is to the hand, for the stick is the end of the hand holding it, but the beginning of itself; for the end of the stick which the hand holds is the end of the hand, but the beginning of the stick. Since something lifeless can have the same relation to the hand as the forearm does to the elbow, and the soul is not between hand and stick, neither would it be in the wrist nor the elbow nor the shoulder nor in anything else of which one part is the origin and the other the end (telos). If it were in this joint, and not in that, why couldn’t we find similarly in all joints both an origin and an end? I think that’s the idea. He calls the hand the last moving thing, and the stick the other origin. Necessarily, he says, it is not in any origin which is the end of something else, not even if there is something farther out than it, meaning by ‘farther out’ the part which follows. The wrist follows the forearm, and something else, and something else. The soul is not in this sort of origin, which follows on something else. For with the elbow remaining at rest, everything connected below can move (702b11) means, ‘as the forearm moves, the elbow remains at rest (the forearm is connected to the elbow), so too when the elbow remains at rest the part above it, i.e., the part between elbow and shoulder, can move; ... But if that is so, then neither the forearm nor the elbow nor any such part could be the origin.

9.702b12: Since the right and left sides of the body are similar, and the opposite sides can move simultaneously... He chooses to say “simultaneously” instead of “alternately,” for in local movement the left does not always rest and the right move or the right always rest and the left move, but alternately until we stop. So he says, Since the right and the left sides of the body are similar, i.e., the heart has a similar relation to both the right and left-- the right and left moving parts end in it-- for the movements from right and left go to it, and it would be the origin of the movement from it to them. Where the movements from right and left end as in an origin, there, one reasonably supposes, is the origin of movements outward. So too in the army: the person to whom messengers come from without is the general, and he is the origin of movements outward. The external movements arrive at the heart, as is shown by Alexander of Aphrodisias in On where the Governing Part is Situated; he collects the passages about this matter from wherever they are scattered in Aristotle, and adds other very powerful arguments of his own. So, from the heart come both impulse and intention, which are the origins of local movement. So too the organs for movement, the nerves, originate from the heart, as is shown by dissection. That which is the origin of the organs for movement must also be the location of that which gives those organs the power of moving and being moved. The nerves are moved by the soul, and they move the limbs. Now since right and left are similarly related both simultaneously and alternately (he calls right and left ‘opposite’ [702b13]), right and left do not move simultaneously but alternately, and since the origin of movement for the limbs, both right and left, is higher up and not in the joints, it must be in the middle of the chest, i.e., the heart is the origin of movement. The middle is an end, limit, and as it were, a pivot-center of the right and left limbs. And in that it is in the middle, the heart has the same relationship to up and to down, and would provide movement to them both similarly, not to the one more than the other, and so for this reason too the mover should be in the heart.

Those from the spine (702b19) means the limbs, hands, and feet; for the spine is the origin of all these bones, as he says in the Parts of Animals.
and in several other places. That perception is here, and the impulsive and intentional power, is shown in On Where to Find the Governing Part. The parts connected to the place around the origin (702b23) means the nerves. That's the general idea. The passage, it cannot be that the left moves in virtue of the immobility of the right, nor vice versa (702b13), means 'the movement is not of the right nor does the right move because the left always remains at rest, nor again does the left move because the right is at rest, but both equally are naturally constructed to rest and to move.'

9.702b25: The middle of the body is one part potentially (dynamei), but in activity (energeia) must become more. "Middle of the body" means the heart and the pneuma in it. He says that the middle of animals is potentially one, but actually two. Since the movements come from the heart, when the pneuma expands in its right part, and consequently the nerve or nerves from the heart expand, part of the heart must also expand and move. For the nerves begin from it, as do the blood vessels; so that when the nerve is expanded by the expansion of the pneuma, part of the heart must also expand, the part where the expanded nerve is rooted. But since the right parts move when the left are at rest, and the left when the right are at rest, when the right parts move and the left rest the left part of the heart and the pneuma in it must also be at rest. Even though the pneuma in the heart is a continuous whole, nothing prevents part of it from resting and part moving; we even see some of the water in a tub moving, that which the hand has moved, and some of it remaining at rest. So when the left part of the heart and the pneuma in it is at rest, clearly the nerve or nerves in this part rest too. But then it is also obvious that when the right parts of the pneuma and heart rest the left move, and when the left rest the right move, and the right parts lean, when they move, on the left parts which are at rest, and the left parts on the right; this is how it seems, as he goes on to mention people who lean on each other and move their legs. As the forearm moves by leaning on the elbow which is at rest, so too the left part of the heart and the pneuma must lean on the right as on something at rest, and this again on the left, but both are moved by the soul, which is per se unmoved. Forms and dispositions are per se unmoved, and the soul has been shown to be that sort of thing. When the right and left move, the nerves in them also move, and through

the nerves the limbs. So that the pneuma, being potentially one, in movements becomes actually two, as does the heart; for as the pneuma, so the heart, and vice versa. Since some of the heart and pneuma moves, and some rests, clearly there are two in activity, but it becomes actually one when resting.

Enough about these things; let us turn to the text. When he says that it becomes two actually or in activity, he explains concisely: for also the limbs move simultaneously from the origin (702b27); again he has 'simultaneously' instead of 'alternately.' A more precise discussion is presented in the Progression of Animals. Since one of the limbs is at rest, and one moves, necessarily too some of the pneuma and heart moves and some rests.

9.708b28: For example, in ABC, B is moved and A moves it. He also uses a diagram, as he often does, to show that which is one potentially becomes two in activity, and simultaneously to show that something must remain unmoved, if the animal is to move. Let A be taken to be the whole heart, and all the pneuma in it, B the nerve or nerves in the right part of the heart, and C similarly the nerve or nerves in the left part. When nerve B moves, in A, part of the pneuma and heart move, moved by the soul. But since, as he has shown, something must be at rest if there is to be movement, the remainder of A, i.e. of the heart and pneuma, must be at rest. Then being potentially one, AE would be actually two. He calls the resting part of the pneuma and heart E, to show by means of a different letter the variance of the pneuma and heart. He differentiates, as has often been said, the resting part of the heart and pneuma from the non-resting; in that some moves, and some rests, they are differentiated. Then AE being potentially one (702b30) amounts to, 'the whole heart and all the pneuma in it being potentially one are two in activity.' And since one part rests and the other moves, it cannot be a point (702b31).

But this is the same as 'this cannot be the soul.' For if part of moving things move and part rest, but the soul is indivisible and incorporeal (without parts or body), and of indivisible things it cannot be the case that one part moves and the other rests (for then it would not be indivisible), the soul cannot be identical with the heart or the pneuma, but must be something else, their form, and immobile. If it were to move, we could always say that some of it must move and some rest; then it would be a body, not incorporeal, not a form, but substrate and matter.
9.702b32: Again, C may move simultaneously with B.
Let us make C a nerve in one part of the heart; here again he says “simultaneously” instead of “alternately”; for it is possible that after the right part moves, the left part moves, so too the part of the heart, in which the left nerve is rooted, will move.

9.702b32: So that both origins in A must move being moved.
By ‘origins’ he means the right and left parts of the heart and the neural. It would fit better if the text were to read, ‘so both parts of A must move being moved.’ For not only the neural moves, but also the heart. So, then, there must be something besides these origins, which moves without moving itself. For as those who lean on their backs and move their legs have something else in themselves moving the legs, so too here there must be something else besides the mover which also moves itself. He makes an analogy between the backs and the left and right parts of the heart and neural, and between the legs and the nerves B and C.

10.703a4: According to the explanatory definition of movement, intention is the middle, which moves being moved.
The sense is that ‘according to the account which tells and shows the cause of movement, it appears that intention, which is unmoved, since also the whole soul is unmoved, and it happens to be a part or power of the soul, now since it is unmoved it moves that which is a moved mover.’ That’s what he’s driving at; for the neural and the heart are moved movers. Something which is a moved mover is also able to listen to intention. For even if intention does not itself move (for the forms are unmoved), it is anyway aroused by intended objects, so that he writes “moved” instead of ‘aroused and become serviceable for making the animal move.’ So the sense, through which a moved mover, is, ‘according to an account of this kind intention would seem to be both mover and moved; but it is not—there must be some body which moves and moves itself.’

10.703a6: Now that which is moved but does not naturally cause motion can be acted upon by some other power.
This too is entirely true; for everything which is only moved, but does not naturally set in motion, is acted upon according to the power of the mover and is pushed as it would push it. But that’s the sort of thing the whole animal body is, for it moves in accordance with the soul, as the dancer moves in accordance with the dance. What follows is clear.
It was appropriate to talk about the preservation of the pumice in On Nutrition. He says that the neural has the relation to the soul which the moving and moved parts in the joint have to the unmoved. But as these parts are not always the same, but in movement (for they flow in and out), so too the comate neural.

10.703a24: That which is going to cause movement without alteration must be like that.
Put a comma after “alteration,” then put in “like that.” The words “like that” point out that it has to have weight and lightness, for the heat in us is both heavy and light, like air. The sense would be, ‘that which is to cause local movement, but not alteration, must have weight and lightness. For fire changes (kevel) water, pushing it from cold to hot, but this change (peraphohu) is not in place, but in quality; but the heat in the heart causes in us both alteration and local movement. In that it is light, it holds against heavy things which push and force it down, and thus does not leave its proper place (seat), but again in that it is heavy, it holds against the heavy things which push or throw it upwards (for with heavy things bearing down it would have to be carried up); so that since it is both heavy and light, it would not go up (then it would be just light), nor down (for then it would be just heavy) but in the middle; and where the middle is, is the soul. So the soul is in the middle.” It is obvious that it is both heavy and light: it contracts and expands naturally, not by force; that which naturally expands and contracts, moves up and down; that which naturally moves both up and down is both heavy and light. That’s the sort of thing pumice is; in making it move, the soul moves the animal.

Next he compares the animal to a well-governed city. As in such a city, it is not necessary for the king to be present at each action, but each one does, of the things ordered by the king, his own work according to custom; the king himself stays in the palace; so too in animals, each part does its own work through the moving nature, the soul remaining in the heart as a king in that place; in the state it is done in a customary way (for they
11.703b4: Some of the parts have certain involuntary movements—most of these movements are really non-voluntary.

The non-voluntary is between the involuntary and the voluntary, as has been pointed out also in the Ethics called Nicomachean. Whenever a very beautiful woman or hostile person suddenly stands in front of us, without our thinking anything about it the sexual parts move because of the woman, and the heart moves because of the hostile person, this movement is involuntary. When, however, one shapes for himself in thought a woman, and works up her form and each of her parts and limbs, and then asserts her to be beautiful and pleasant for intercourse, and when as a result of this sort of thinking and constructing and the consequent ascent to it, the sexual parts are moved, we call this a voluntary movement. Examples of non-voluntary movements are sleep, waking, and the like. In that the mind does not assent to sleep, it is like an involuntary act, but in that the origin of the sleeping is, generally, in us, it resembles a voluntary act. How could one say that sleep is voluntary, when there is no appearance or thought which causes it? But it is not involuntary either, for the cause of sleep is in us, as we have learned in the previous book in which he told how sleep occurs. Neither mind nor imagination is the cause, but 'since animals must alter in some natural alteration,' because of this they happen to move at the same time as the appearance; for I think that one should understand the word 'appearance' and additionally it seems necessary to put a full stop at the words some natural alteration (for the apodosis of the sentence seems to be here), and then read as the beginning of the next sentence. When the parts alter, some grow and others decrease (703b12), thus: 'not only do the sexual parts and heart move in collective alteration, but also growth and decrease occur when parts of the animal are altered.' You could also take 'parts' to be the connate parts, the pneuma in the heart and the nerves which are moved by it; the following words would support that interpretation: the changes which are naturally connected to each other (703a13-14). Non-rational movements means the involuntary ones; for these can also occur when some things are altered, whatever they may be, and not only when something appears to perception, but also when something does not appear; suddenly when we

11.703b20: These parts do this especially clearly.

"These parts" means the sexual organs and the heart. Of all the parts, he says, these alone, the heart and the sexual organs, make perfectly clear by what movement they move. These clearly move because each of them is like an animal; as animals move, so do these parts, because they are like separate animals in themselves. How the heart 'jumps' and beats, he explains more clearly at the end of On Youth and Old Age. When he says, because each of them is like an animal (703b20), he adds, the cause of this (that they are like animals) is that they have vital moisture (703b22). The heart <is like an animal> because it has the origin of perception (the animal has the essence of animal in that it perceives, for having perception differentiates the animal from the non-animal): The sexual organ <is like an animal> because the semen comes from it like an animal, being potentially an animal; that semen is potentially an animal is shown in the Generation of Animals.

11.703b26: It is reasonable that movements from the parts occur in the origin, and in the parts from the origin.

It was noted above that when the nerves are stretched, the heart contracts, so that the parts are set in motion by the origin, and the origin by the parts. As usual, he assigns letters to the origin and the parts, saying, 'let the origin be A and the parts B, C.' He means letters on a diagram; let B be the right, C the left. The movements of right and left come to the origin, the heart (for it moves with them), and are generated from it; for when it and its pneuma move, the right and left move. And the origin of B goes to B (703b32); for the origin and cause of the movement of the right parts is distributed to the right, as that of the left to the left. For neither does that of the right arrive at the left nor is it distributed on that side; nor that of the left to the right, but each stretches out to its own part. The origin of C is "to C," the left, that of both to both (703b34), i.e., of B and C to B and C; for the right and left origins terminate at the right and left. From B to C lacks the word 'not,' so it should say, 'but not from B to C,' for the origin of B, as he said, does not distribute to C, nor that of C to B. And the movement
from B to A is to an origin, that from A to B is from an origin.

11. 703b36: Thinking the same thoughts, sometimes the non-rational movement is generated. . .

Sometimes it happens that when one thinks of a woman or an enemy, the sexual part or the heart moves, but sometimes thinking the same thoughts they do not move; the reason for this sometimes moving, sometimes not, is the matter. For either there is no matter at all, and therefore the sex does not move, or there is some, but not enough or the right sort, so as to be able to move. Thus ends the treatise On the Movement of Animals, and the commentary on it.
when he does, his clauses jut out fiercely in all directions. Normally he is just long-winded.

698a5/103.15: The verbs marked * are all in the middle voice, not in the active or passive. "The middle generally signifies that the subject performs an action on himself or for his own benefit." Goodwin and Gulick, Greek Grammar, New York, 1950, p. 97, paragraph 448; see also pp. 265-6, paragraphs 1243 and 1244: "In the middle voice the subject is represented as acting upon himself or in some manner which concerns himself . . . Often the middle expresses no more than is implied in the active." See also Nussbaum, "Note on the Translation."

698a7/103.23: ὅψις, 'beginning, source, principle, origin, rule,' etc. I stick to 'origin' in translation, even sometimes when it seems odd in English, for the sake of keeping one word.

103.25: παρειαί κυαιμινῶν might be passive rather than middle (moved pneuma).

698a8/104.16: "Unmoved:" Michael refers to Physics VIII.5, 256d4ff; in fact, that is the only place I know where the word ἀνωτερότατον appears. Compare the rest of Physics VIII, Metaphysics Gamma 8, 1012b30; Lambda 6-10, 1071a5 ff. Aristotle refers to the famous 'unmoved mover' (thus Forster and Farquharson mislead the reader by giving 'immovable'). This divinity has so captured the imagination of many writers on Aristotle that they forget that the individual human or animal soul is an unmoved mover; Michael does not forget this. See de An. III.2, 9, 10. One of the virtues of the MA and Michael's commentary is that this part of Aristotle's theory is here clarified. Contrast R. Muguier, La théorie du premier moteur et l'Évolution de la pensée aristotélicienne, Paris (Vrin) 1930), e.g., p. 119.

In this section I, like Nussbaum, follow Forster's text for the reading.

104.17: I follow ms S (Paris gr. 1925) in omitting κορίτι. Hayduck keeps the word, but I make no sense of the sentence that way. Lungus translates according to ms S.

698a11 / 104.19: Our text has both ἀνωτέρω and καθόλου, and so does the Lungus translation, without the note. Jaeger omitted καθόλου but Nussbaum shows that it is correct, ad loc.

104.21: "this is necessary" translates δὲ ἐξ ἐντὸς, which is translated "but one ought," above. I need both evocations to make sense of Michael's comments. He starts by misinterpreting the phrase, then gets the idea.
698a13 / 104.25: Aristotle (and to some extent Michael) at least recognize a basic principle of scientific investigation here. There is not much record of observation in MA; but quite a bit in IA; Michael sometimes actually has looked at something relevant to his commentary on that treatise. How Aristotle uses his methods in his biological works is a theme of my Science and Philosophy in Aristotle’s Biological Works, Hildesheim (Olms) 1975.

698a20 / 104.27: Michael refers here to IA 3 and 9. A ‘joint’ is a σκηνή or flexing place. See the Introduction for further explanation. Peck also uses this translation, at PA II.9, 654b1.

698a21 / 105.3: A is the center of the circle; D, B, and C are points on the circumference such that DAB is the diameter. Michael seems to misinterpret 698b1, if he argues that the joint as a whole is either one or two in this way, but that even in the joint there is an ultimate unmoved point, analogous to the mathematical point. See also J. Cook Wilson, “Difficulties in the text of Aristotle,” Journal of Philology 32 (1913) p. 137; Nusbaum HSCP 80, 139-140, and de an. III.10, 433b26.

698b1 / 105.12: “The relative origin...” The translation of Aristotle here follows Cherniss, AJP 60 (1939) 385 ff. Michael seems at a loss what to say (“the rest he explains clearly”), as the remainder of the chapter tends against his radical contrast of mathematical and physical turning points. “Shin” is κρύφη, the leg from the knee down; “leg” is ὀκτώπον, forearm is βραχύω.

698b6 / 105.13: “Connected whole and part by part:” Of course any movement from place to place requires that the whole organism move; Michael takes the contrast as a reference to jumping animals, as in IA, see his 158.22, for example. Lungas points out that the first chapter ends here; Michael seems to put the break four lines later.

698b9 / 105.16: “simply” unmoved in opposition to the relatively unmoved (698b1) within the animal. The parenthesis “(and properly)” in Michael is his explanation of the term. ἀριθμός needn’t mean “absolutely,” which would be difficult to defend for the air or water of flying or swimming animals.

698b13: “move itself:” the infinitive must be middle, not passive. Aristotle here uses the technical term for astronomical movement, φοίνικες.

105.23: Michael refers to Metaphysics Lambda 7; Lungas charmingly calls that work the ‘transnaturals.’

698b15 / 105.25: “when mice walk in the earth” I follow Michael’s reading of the passage for the sake of clarity. The examples have given commentators (and copyists) a good deal of trouble. Nusbaum gives the reading, οὖν τοῖς ἑκάστοις τοῖς ἐπὶ τῆς ἑκάστης τῆς ἑκάστης πορευόμενος, which includes two crucial conjectures, ἡμεῖς for μοιχή, i.e., tortoises instead of mice, and τηλέω for τῆς τῆς, mud instead of earth. Something had to be done with ‘earth’, because unqualified earth is not a shifting medium; Farquharson kept the mice, but reads ἐν τῆς τῆς ὑπὸ, in the grain’ instead of ‘in the earth.’ Platt omits the earth. Nusbaum in HSCP argued that μοιχή were not mice but shellfish of the same name; in MA she recognized that that would not be a familiar image, and so follows a suggestion by Diels for her emendation to fresh-water tortoises, which might be seen trying (and failing) to climb river-banks.

Michael paraphrases here, as the single quotation marks indicate; he adds the more common word ἔρεξεν to Aristotle’s ἀνοδώσας – both mean ‘yield’. Also, Michael errs in assuming that absolute stability is required for movement, for Aristotle clearly means relative stability. Cf. IA 3.705a9 and Farquharson ad loc. The mice (or tortoises) and men walking in loose earth, grain, mud, sand, or whatever, need some friction, but not absolute immobility of the footing.

105.30-106.2: I preserve Michael’s tedious repetition here; sometimes I shorten sentences by leaving out this sort of thing.

698b18-21 / 106.5 ff: “no part of that which moves” (cf. 106.26). Michael’s paraphrase of this passage makes the argument less plausible than the original, as it would seem from his version that it would be impossible to row a boat; one rows from within the boat, and the water is not absolutely unmoved. Aristotle might well have mentioned rowing here, but even though he did not Michael should. If one thinks of rowing rather than sailing, perhaps one might think of jet propulsion in connection with Boreas (see the following note).

698b24 / 106.13: Titus and Boreas. Titus is a huge and powerful giant, son of Earth (Od. XI.576). He tried to rape Leto, and was shot down with arrows by Apollo and Artemis; tied down in Hades, he covers 9 acres. Aristotle mentions him just because he is huge. See Nusbaum’s refutation of Torracca’s proposed emendation. Boreas is the North Wind, strongest of the Mediterranean winds, today known as the Magiast or Melteme. The depiction of Boreas
blowing into the sails seems as familiar to Leonicus as it was to Aristotle; Farquharson says that he couldn’t find any examples, but Lucian Timon 54 describes a philosopher as resembling Boreas in a painting by Xeuxis. Boreas is often represented on vases, although apparently not sitting in a boat blowing into the sails; I am reminded, however, of Odyssey X, where Alcius gives Odysseus a bag of winds which is unfortunately opened by the crew, and which, blowing from within the boat, sends them back where they came from.

Aristotle and Michael both miss the opportunity to envisage jet propulsion: if Boreas were to blow backwards off the stern rather than into the sails he could move the boat quite effectively. Blowing into the sails would move the boat backward, because the sails would not be 100% effective. In Meta. 1.13, 349b1, Aristotle again mentions a painting of a self-producing wind. For another discussion of the ‘man in the boat’ problem, see Physics VIII.4, 254b50.

107.1-3: I don’t see what Michael is driving at, especially as the text of Aristotle is fairly clear here. Generally one would stand on the rock, so it would be the feet which are supported, if one is out of the boat; if one is in the boat, pushing on a rock or something outside the boat, then the hands are supported on something unmoved. Leonicus reproduces Michael’s story without further comment.

699a31 / 107.4: Michael has καυκέα, but the Aristotle ms have καυεί. I translate the standard text. Michael’s difficulty is over the word αντρός, which he takes in reference to the boat, while I take it as a reference to the boatman (‘to him’).

3.699a13 / 107.8: For a discussion of the text, see Nussbaum HSCP p. 142. Michael’s text has δηλει where most Aristotle texts have re δι; Nussbaum correctly argues that we need a strong verb of conditional necessity. Michael’s verb would make the sentence mean ‘if something moves the whole earth, does it prefer to be unmoved.’

699a15 / 107.23: Michael refers to Physics VIII.10; the argument is a reductio, and has a long history in proofs for the existence of God. Cf. Carteron, pp. 134ff, Mignier, 128ff, and Nussbaum ad loc.

699a18 / 108.1: “conceptual existence” (in the Michael translation) may look like an anachronistic translation, but it is not. Lungus has, “intentione naneque

tantum in nostra essentiam habent.” Leonicus adds an explanation of the story about the poles and that of Atlas which follows; he points out that Plato must be among the guilty here exposed by Aristotle. See Rep. X.616, where the Fates turn the “spindles of Necessity” made of “adamant.” Leonicus notes that Aristotle understands the poles mathematically, and Plato would not disagree with that— he writes mythically in Rep. X, suggesting indeed that the spheres are moved by the mind of God. See Tn 40b, with Cael. II.13, 295b50, and Guthrie’s note in the Loeb edition. When Aristotle says “mythically representing Atlas,” he may have in mind Hesiod Theogony 517 ff, 746 ff; cf. Homer Od. 1.55-54, and some artistic representations of Atlas: Pausanias III.18.10; V.11.5; VI.19.8, and the Atlas Farnese in Naples. Aristotle clearly has in mind Pythagorean uses of this mythic representation: de An. I.2, 405a32; Cael. II.11, 284a18 ff; II.8, 290a8; Metaph. V.25. See also Dicks, Early Greek Astronomy; Vlastos, Plato’s Universe; and Nussbaum Essay 2— she thinks that Aristotle’s comments here include an element of self-criticism, which I see as entirely possible.

699a26: Leonicus and Platt read δι’ αντρόν, ‘those things which move themselves,’ but this is not an improvement of the text.

108.5: Michael refers to Physics VIII.6, 259a18. (The argument is not very clever, since the believer in Atlas can say that there is just one pole which goes all the way through.) Aristotle might be exonerated, since he puts the blame for the whole way through of argument on his opponents, but Michael seems to take it all very seriously.

699a34 / 108.29: “Forca” = ἰοσθεν. (Aristotle’s δύναμις should be translated ‘power’ if not ‘potentiality.’) Lungus uses ‘robur’ and Leonicus ‘vis.’ It’s obvious that Aristotle is struggling with the problem which led to the concept of inertia, but he is far from achieving the subtlety of some of the medieval investigators of the theory of motion (see, e.g., J. F. O’Brien, “Some Medieval Anticipations of Inertia,” New Scholasticism 44.3 [1970] 345-371). Torrance and Louis seem to suppose that Aristotle already has the Galilean and Newtonian laws of motion, but that would be obviously anachronistic, and inconsistent with Aristotle’s general position.

Although Leonicus usually follows Michael’s text very closely, he does not break here.

699b2-3 / 109.6: “moved away from the center and out of its own place” shows just how primitive Aristotle and Michael are in their understanding of the
laws of motion with which they briefly flirt at this point. Aristotle could say
that even if the mass of the earth were many times that of the heavens (and he
might, since the heavens are made of aither, than which nothing is lighter),
the earth would still move proportionately, were the heavens moved by Atlas
standing on the earth. Furthermore, the earth need not be moved “away from
the center,” it need only revolve in the opposite direction from the revolution
of the heavens. But of course once one recognizes the possibility of diurnal
rotation, all sorts of other simplifications of astronomical movements are
possible too, including the Copernican.

If anything, Michael is less subtle than Aristotle here, since he seems to
suppose that an equal force of rest in the earth would be sufficient to keep
it at rest.

699b6/109.8: ὅ ῥεμάζων πρὸς ἀντίστασεν is ambiguous: Albertus, Farquharson, Forster,
and Torraca all take this phrase to be the object of the verb κομεῖ, while
Michael, Louis, and Nussbaum take it as the subject. Farquharson even
inserts the prime mover where it does not belong: “the prime mover moves
that which is first at rest.” Nussbaum finds that Michael’s interpretation is
by far the best, and convincingly argues against the alternatives.

109.15: I paraphrase Michael slightly; Lungus too paraphrases, but not in the
same way.

4.699b12 / 109.17: Nussbaum’s discussion of this chapter in her Essay II is
excellent.

699b16 / 110.2: “infinite” / “Physics”) Michael refers to III.5, as well as VIII.10.
Aristotle’s belief that the earth is in the center of the universe is here considered
possibly controvertible, which may indicate a maturing of his thought about
natural places. For the principle that force is proportional to weight, see
Phys. VII.5. Cael. II.1 not only has a complementary reference to Atlas,
but also supports the position that the heaven does not need to be held up
because it is so light; that theory could damage the present argument, under
Michael’s interpretation.

110.5: Michael refers to Cael. I.5; cf. Mete. I.3, 340a7; 14, 352a27.
699b17 / 110.6 (“impossible” / “invisible”): Nussbaum wonders whether the
contrast is between necessity and contingency, as in Cael. I.10-12, or between
“logical and physical necessity” (note ad loc.). She notices two other places
where the impossibility of seeing a sound is used as an example, Phys. III.4,
204a4, and de An. II.10, 422a27; cf. Met. V.22, 1022b22. These passages do
not decide the issue, since they make different points. The scholastic inter-
pretation is that the two senses are “simpliciter” and “secundum quid” (Leonicus
so notes); I would want to say that the distinction is between simple necessity
and conditional necessity (cf. Science and Philosophy ch. 4). Aristotle generally
maintains that the structure of the universe is simply necessary, which seems
to be contrasted with simple impossibility (seeing a sound) in the present
passage. Seeing men on the moon is a conditional impossibility, I suppose;
not just contingent, but dependent upon our naturally necessary conditions of
life.

Michael is not particularly helpful here; for one thing, he doesn’t even
mention the men in the moon. Cf. Diels, Darm. Gr. 36, and Golen, History of
Philosophy 71: the Pythagoreans believed in lunar beings. Leonicus notes
that Plato, Chersonesus, and Plutarch believed in such extra-terrestrial beings
(unfortunately, he does not give us his sources). Aristotle’s theories of
moon and fire creatures are explored by W. Lamere, “Au temps où Franz
Cumont s’interrogeait sur Aristote,” L’antiquité classique 18 (1949) 279-
324; cf. OA III.11, 761b16 ff, and Science and Phil. pp. 36-40.

699b23-25 / 110.10 ff: Michael refers quite generally here to Cael. I and II;
at 110.22, the reference is specifically to I.10.12; he also has in mind Physics
VIII. On one interpretation, Aristotle argues here that the force great enough
to destroy the universe would itself be destroyed in the process, or by parity
of reasoning there would be an even greater force, which would destroy it,
ad infinitum. That there cannot be an infinite series of this kind is argued
in Cael. I.6, 274a24 ff. But on the other hand, Physics VIII.10 argues that
it takes an infinite force to continue to move the finite heaven for an infinite
time. Nussbaum finds Michael’s interpretation helpful here; it is not as helpful
as it might have been, because Aristotle’s reasons for his difficulties about
necessity and impossibility do not come across clearly. Aristotle’s concept
of natural necessity is based on teleological (paradigmatically, biological)
considerations; he seems to feel that he should have a conditionally necessary
or functional account of the structure of the universe, but it is just that which
is in doubt in the present passage. He has no alternative concept of physical
necessity, particularly not the kind which Nussbaum looks for, which we
might characterize as “causal” or proto-mechanical. This is the problem which
Hintikka ran into in his essays on necessity, and it seems still not resolved.
111.1-2: Michael tries to explicate the modal terms. He uses ἐνδεχόμενον as 'not necessary' and ἐπιθετόν as 'not impossible'. Aristotle's argument seems to require, however, that 'not necessary' and 'not impossible' be equivalent, i.e., 'possible', so that when Aristotle says ἐνδεχόμενον that means the same as οὐκ ἔδωκεν. 699b34: "exist" = ἐπιθετόν; Nussbaum translates, "hold true", which is looser. 699b37-700a2 / 111.21: Aristotle quotes, from memory no doubt, Iliad VIII.20-22. For differences between the quotation and the received text of Homer, see Nussbaum; Michael does not repair. My translation in the Aristotle is somewhat more free than that in the Michael, and is a rough equivalent of Homeric meter. Fato Theaetetus 153c refers to the Golden Cord to be used for this tug of war, and gives a cosmological significance to the passage. 111.27: "fixed stars" = ἀστέρων; the last heavenly sphere. 700a4 / 111.30 ff: "solve that old problem" there is an oddity in Aristotle's cutting off discussion by asserting that some other place would be more appropriate for a full examination of the cosmological problem (699b31), then taking it up again (calling it 'old') in the next paragraph. It's this sort of thing which leads commentators to believe that Aristotle went through this set of notes at least twice, and never really polished them. The scribes must have sensed something odd too, because at 700a3 most ms read λέσα, 'resolved', but some have δότεα, 'sunk'. The problem to be resolved or sunk is whether or not the structure of heaven could be διαλυθής, 'dis solved'. That sort of pun is not beyond Aristotle. Michael notes the discrepancy in the ms (112.3), and seems to favor λέσα; oddly enough, he uses several forms of δότεα in the next few lines, e.g. εἰς δότέα, 'gotten into'. Lungus too notes the problem of the reading. By 112.7-8, Michael seems to flounder; Aristotle probably means to say that the problem is solved by what he says, but that is not really plausible. Michael perhaps wants to suggest that the alternative reading δότεα could mean 'gotten into' or the like; we might say that the problem is raised but not removed. 700a10-11: Nussbaum HSCP 143 for the reading. She does not note the reading Cherriss gives, "as if upon a body at rest." Louis is wrong to contrast animals with inanimate self-movers, I think. The passage is not unambiguous, but it does seem to involve a contrast between 'all animals', which must have an external origin, and moving animals, which must have something internal which is unmoved. Michael skips the sentence. 700a14-16: Aristotle is even more than usually telegraphic in his style; the words "be looked for in those things" are not actually in the text, but are supplied in the translation. Nussbaum corrects the standard text. 700a16-20 / 112.9.14: "the origin for all things thus moved is those things which move themselves." Nussbaum translates the last phrase 'something which moves itself,' but her text has it in the plural. Michael suggests that "such origins" includes both animate and inanimate movers, which leaves Nussbaum rightly dubious; Aristotle must be comparing and contrasting celestial movers in this sentence. 700a20: Farquharson takes this as a reference to Met. Lambda 8; Louis thinks it is to de An. and possibly Phys. VIII.2, 6. Both Farquharson and Louis take the "already mentioned animals" to refer to IA, but that is stretching things. I very much doubt that Aristotle is thinking of that treatise as he composes this one. Probably he refers back to the earlier chapters of the present treatise, and ahead to chapter 6 and so on. 700a21-25 / 111.15-21: Farquharson takes Michael's reference to be not to the PA but to IA 3; this is implausible—see the beginning of Michael's commentary on the IA. It is not easy to determine just which passage Aristotle has in mind, however. Michael does not catch the significance of the passage for physics: Aristotle seems to notice the possibility of something like jet propulsion, action and reaction. If Boreas were to cough back over the stern of the boat, would he move it? Hero of Alexandria understood the principle very well; his famous 'steam engine' is really a rocket system, propelled by expanding steam (Pneumatiokon II.6, Schmidt ed. p. 220; 11, p. 230). See also Physics VII.2, 245b12: breathing in is an example of 'pulling' and breathing out is an example of 'pushing.' 5.700a26 / 112.22-27: Michael here makes clear the distinction between the middle and passive voices of the verb. 700a28 / 112.30: "original generation" = πρωταγωγείον. Lungus, in conformity with Renaissance Aristotelian theories of sexual generation, translates 'syrtasis' as 'coagulation'. Michael incorrectly takes the passage as limited to embryonic development— that would be only one example of γένεσις ἐκ ἀρχής, as Leonicus sees. Aristotle, referring no doubt to OC, raises this problem: is change in the first category, entity, prior (change in the unqualified sense, 'genesis'), or is change in place, local movement, prior? Cf. Phys. VIII.7, 260a26ff. Michael correctly sees that Aristotle implies (at least) that change in the
first category requires a prior change in location, but it fails to see that Aristotle is trying to summarize his account of the origin of any sort of change whatever. His brevity causes obscurity; Aristotle must be talking about agency at least. The agent must move locally, for most sorts of actions, but how is it possible for something to act as an agent, in general? For Aristotle's account of embryological development, see *Science and Phil.*, ch. 2.

700a29-31 / 113.1 ff: "first movement" is in the nominative in Nussbaum's text and most others; Hayduck prints it in the accusative, following some of the mas, pointing out that it follows the verb, 'we say', but that is not grammatically necessary. Michael refers to Phys. VII.7-9; Leoninus refers to Coel.; Partsch/Barzansy adds *de An.* 1.3; Met. Lambda 2; Nu 1; GA 1.4; Nussbaum adds OC I.3-5. There are two interpretations of "first movement." Some take it as *genesis*, others, including Michael, take it as local movement. Nussbaum finds Michael's comments helpful, and is surely right in supposing that previous editors and commentators who have taken this tack are following him.

Leoninus, in his translation at 113.8, takes *μορφήν* and 'nobilior'. This is an error, because change in place is prior in other senses, but not in excellence. The argument defending the priority of change in place makes the Movement of Animals an important source for the understanding of Aristotle's theory of change in general.

700a32: Nussbaum reads "primary motion" as cause of growth, while I take it that a creature which grows is cause of its own growth, once it has begun to develop.

700b35 / 113.11: Aristotle says rather cryptically, *εἰ δὲ μὴ, οὐκ ἔχειν*, 'but if not, then not necessary.' Nussbaum quotes Michael in her commentary, and follows him in her translation, as do I. Forster too followed Michael; Platt, Louis, and Torraca are all dissatisfied with Michael's interpretation, although in different ways. It might be possible to read Aristotle as saying that nothing is prior to itself, as in *Physics* VII.7. Louis puts a question mark after 'alteration', and then the next sentence goes to 'other means'; the cryptic sentence comes out 'qu'il soit cause de sa propre croissance.' Torraca cuts from *εἰ δὲ ρήσει* to *δεσποτεύει*, an application of the Gordian Knot solution.

NOTES, MA

113.21: Michael's commentary jumps without warning or transition to 6.700b17. Leoninus makes up the difference with a discussion of the origins of inanimate movement, and of Aristotle's possible belief in a world-soul.

6.700b4: Aristotle refers quite generally to the *de An.*, see especially I.3-5, II.4, III.9; cf. GA II.1, 755a13. Nyugen thought that the *MA* was prior to the *de An.*, but this reference argues against that ordering, unless the same topics were discussed in an earlier recension of that treatise. Indeed, MA 6 summarizes many of the findings of Aristotle's most mature works. The reference to *On First Philosophy* must be to the *Metaphysics*, e.g. Lambda 7, in which the motion of the heaven is closely compared to telic movement of animals. Some discussion of the topic: J. M. LeBlond, *Logique et Méthode chez Aristote*, Paris, 1959; P. Siwes, "Comment le premier moteur meut l'univers," *Divinitas* XI (1967) 377-392; G. Cardona, "E autentica la teoria aristotelica del primo motore immobile?" *Riv. Crit. di Storia della Filosofia* 1968 (2) 123-148; D. Frede, "*Theophrastus Kritik am unbewegten Bewege der Aristoteles*," *Phronesis* 16.1 (1971) 65-79.

700b17 / 113.22: Michael, listing phantasia, nous, and oreyis, probably refers to *de An.* I.5, 407a32. Aristotle's list here has two generic faculties, nous and oreyis, which are compared and contrasted also in *EN* VI.2 and VII.5, cf. *de An.* III.3, 427b14 ff; *Rhet.* I.10, 1368b37 ff; *de An.* III.3, 414b2; *Sens.* 1, 456a8 ff, et al. Both oreyis and nous have as objects unmoved movers, *de An.* III.10, 435a17; for real and apparent goods, see *EN* III.4, 1113a16; *Rhet.* I.10, 1359a19; *EE* VII.2, 1235b27.

Aristotle's list here continues with dianoia (thought), proaireisis (choice), bouleusis (will or wish), episthēma (appetite); he adds thymos (temper) a line or two later. See also Nussbaum *HSCP* 143-4. The contrast between critical and intentional faculties is one of great historical importance—reason versus will has been a central opposition in accounts of action ever since. Aristotle's contrast is not as strong as, for example, Hume's, but he does distinguish. For discussion of the problems involved, see for example Gauthier and Jolif *EN* 1959, vol II, p. 189, commenting on III.5, 1113b12; Gauthier's review of Aubenque, *La Prudence chez Aristote*, in *R.E.G.* 1963, p. 267; John Cooper, *Reason; Nussbaum ad loc*.

700b21: "elsewhere" probably refers to *de An.* III.3, 427b14 ff.

700b24 / 113.25: "object of intention and thought." The ending -rov in words like ἥρκτον, διαυγεῖν is ambiguous between -ed and -able; Aristotle may be
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talking about the 'intendable' and 'thinkable', or about the 'intended' and the 'thought', or he may not be aware of the distinction, as his language hides it. Nussbaum and others drop the word προαναφέρειν, which several ms have; William of Moerbeke supports her reading, but Michael must have had the word here; judging from his comment, he had something like "choice shares in both intellect and intention, so the first mover is the object of choice and thought." Incidentally, this and several other places indicate that William of Moerbeke had a manuscript tradition other than Michael's to draw upon.

113.29-30: Michael may have been in mind de An. 1.5.4, rather than anything in II, where Plato is not directly criticized.

113.32: "for the sake of this" = τῷ τοῦτον ἡκέκειν.

114.10: δὲ is the standard reading.

700Bi55 / 114.11: Farquharson and Nussbaum read πρὸς κατέχων with ms P and William, translating, "to be relative to anything else;" Nussbaum thinks that "to have anything prior to it" is not a relevant point here. Her argument makes sense, but I follow Michael's reading for the sake of conformity between translation and commentary. Incidentally, Michael goes back to the 'for' just rejected.

701a4 /114.18: Michael's commentary helps clarify the sense of this passage, and generally supports Nussbaum's emendation of the text (which I follow in the translation). Farquharson has a quite misleading version of the sentence.

114.25: "we will write" = παραγράφομεν; Lusung has "transcriber" and "interpretation" which might mean that the Greek verb implied to Lusung that Michael was admitting that he was copying (from someone else). The implication of the passage, and the references to On Impulse and the Impulsive Power, is pretty clearly that this is his own work, however. When he wants to, he can refer easily to Alexander, as he does to On Where the Governing Part is Situated. As we said in the Introduction, Donini (1968) called attention to the fact that Michael here quotes almost word for word from Alexander of Aphrodisias, On the Soul, pp. 73 ff in the Berlin edition (CAG Suppl. II.1). A. P. Fotinis has recently translated this work (University Press of America, Washington D. C., 1979); for convenience I refer to his pagination in comparing parallel passages here. Michael 114.25 ff summarizes Alexander 1.2.78-9, Fotinis pp 92-93. Incidentally, Leonicus p. 210 writes as though Aristotle were the author of On Impulse, and further suggests that he himself had read it and used it!

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114.28: Aristotle does not have the Greek equivalents of 'gnostic' and 'hormetic' in his text; they are Alexander's words, 73.23 in the Berlin edition. Aristotle distinguishes between 'epistemic' and 'critical' powers. He does use the word 'gnostic' in APo. III.19, 100a11, which warrants Alexander's using it in the context which he does. Since these distinctions are all made quite differently in Greek, particularly Aristotle's Greek, than they are in English, I think it best to translate or transform into English words several of the terms in this and similar passages. Alexander's version of Aristotle's theory of the intellect is important, and was influential in the middle ages and Renaissance. Michael's borrowings, here and in several other places (e.g., "pseudo-Alexander") Metaphysics Epsilon through Na), contributed to Alexander's influence.


115.6: "neuroscopic" should mean 'drawn by strings or sinews' in classical Greek, but it would mean 'puppet-like' in modern Greek. Alexander's account does not suggest the 'puppet' image here. For Aristotle, the neurae are all the stringy parts—muscles, sinews, and nerves— he does not distinguish. Nerves were clearly distinguished from muscles not long after his death, by Herophilus and Erasistratus (F. Solmsen, "Greeck Philosophy and the Discovery of the Nerves," Museum Helveticum 18 (1961) 150-197); conservative commentators on Aristotle frequently ignored the physiological discoveries, however; neither Alexander nor Michael is as clear about the physiology of movement as is Galen (de Usu Partium VII.14 ff). Fotinis, by the way, blithely translates Alexander's neurae as 'nerves'.

Lusung assumes that Michael uses neurae as synonymous with the Latin 'nervis', which include sinews and nerves; Leonicus tends to identify neurae as muscles, which does make more sense of some of the things Aristotle says. On 6.700b17, p. 210, he says, "Parf autem actae, scilicet appetitio, motiva defectus virtus, et musculorum attractiva potestas, quam unico vocabulo sed composito graeci neurosartiken appellant. . . . quum excito et moto caedatibus quaedam et frigditates necessario consequuntur, spiritum videlicet motio et excitatio, nervorum movatur extrema in ipsis animalium membris et musculis constituta: quorum motionibus postmodum per locum movetur animal, ab ipso videlicet appetitu commoto et excitio a re extrinsecus posita que natura sui vel declinavit vel expeti nata est." (cf p. 212, 222.39).
Leonicus here distinguishes nerves from muscles, and identifies Aristotle’s *neura* as muscles. Michael approaches identifying *neura* and muscles at 8.702a7 / 120, below. The importance of the term ‘string-drawn’ or neurospastic becomes clear in Michael’s commentary on 7.701b2, where Aristotle compares the movement of animals to what Michael takes to be some form of puppets.

115.22: The list of alterations occurs at 701b30; Alexander and Michael add heating and cooling for good measure, though that confuses the issue since Aristotle is trying to explain how qualitative differences in the external parts are brought about by heating and cooling in the internal parts.


115.25-116.1 = Alexander I.2.92-93, Fotinis 100.9-33.


115.23 - 116.14, drawn from Alexander, is a very interesting analysis, comparing and contrasting the prepositions ἐν (hypothetical) and κατά (kata). In translating these prepositions ‘by’ and ‘according to’, I must choose between several possible renderings, particularly in the case of kata. Lungus begins with ‘ab’ and ‘per’, and then switches from ‘per’ to ‘propter’ at 116.2 (‘the animal perceives etc. kata the soul’). Fotinis uses “by” and “in virtue of”, which is reasonable, except that perhaps “in virtue of” suggests “by power of”, an imprecise rendition. Alexander’s analysis here is a good deal more sophisticated than Michael realizes. The contrast between hypothetical and kata (with the accusative) points up two sorts of causal relations: hypoth indicates agent and patient, two entities, one active, the other passive. Alexander argues that Aristotle’s theory of the relation between soul and body is not captured by this construction, but rather by kata with the accusative. Alexander’s phrasing at Fotinis 100.20 (= Michael 115.30) probably indicates that the verb preceding the clause would be in the middle, as well. The senses of the preposition include ‘down’, ‘throughout’, and distributively, of object, purpose, or fitness, and so on. It appears in phrases like κατὰ φύσιν, ‘naturally’, which might suggest that the phrase κατὰ φύσιν could be translated ‘soulfully’ or something similar. I am reminded of Gilbert Ryle’s positive concept of mind, for example. Alexander, in the passages which Michael calls *On Impulse*, captures Aristotle’s anti-dualism; elsewhere, Michael fails to maintain that high standard. Although Alexander inserts an extra concept (*homē* into the explanation of motivation, his interpretation goes in the right direction.

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116.10: Michael’s reference to *On Impulse* here takes the place of Alexander’s reference back to an earlier part of his *De Animalibus*.

7.701a/9 - 116.22: “unmoved objects.” Forster suggests that there are the objects of science on the basis of APo. I.2, 71b8 ff; Michael’s *mathematika* could mean something that is general. In Cael. III.6, 305a25, Aristotle says that if an object is *akineta* then it is *mathematikon*; Phys. II.7 implies that mathematical objects are just examples of *akineta*. GA II.6, 742b30 ff distinguishes between *akineta* and things which come into being and pass away; in the case of *akineta* the essence (to ti estin) exhausts what can be known of them, but in generated things the other causes must also be included. A most general sense of *akineta*, and probably most relevant here, appears at EN VII.12, 1143b1, where the universal concept in the major premise of the practical syllogism is said to be *akineta*, and grasped by nous.

701a15 / 116.30: Michael notices that Aristotle reverses the ‘normal’ order of the premises in the second syllogism. These syllogisms have often been discussed in the last several years; Nussbaum’s Essay 4 is a quite full account. In the next syllogism, the premise “I ought to make a good” is translated by Louis, “Il faut que je fasse quelque chose qui soit bon pour moi,” in which the ‘pour moi’ is a mistranslation of μοι, the subject of ποιεῖν.

701a20 / 116.31: “He acts from an origin.” Michael’s comment is a propos, cf. EN III.5, 1113a6, but not sufficiently pointed to prevent Farquharson and Forster from mistranslating. Chernis has it right, as does Nussbaum. Note also the contrast of two kinds of premises: ‘through the good’ corresponds roughly to the major premise, and ‘through the possible’ to the minor, but see Nussbaum Essay 4. *mathematica* can be translated as ‘practical’ here, but at 701b1, ‘poetical’ and ‘practical’ are contrasted. *ax* and *y* stand for pronouns (‘this’, ‘this’). Louis incorrectly inserts ‘propositions’ here.

701a27 / 117.4: “waste time” (eîdei) (pass over, leave out). A syllogism of this sort is called an “anthemene” cf. APo. I.1, 24a24; Rhet. I.2, 135a14 ff: “If any of these propositions is a familiar fact, there is no need even to mention it, the hearer adds it himself.” Cf. Top. VIII.1-3. Aristotle’s phrase is οὐκ εἴδει stirrētai which Michael glosses with παραλημμένοις; at 117.7 Michael uses a form of Aristotle’s verb, έδιδομένων (kill time).

701a29 / 117.8: “actually using” = ἐνεργήθη, following Nussbaum. It might also be inceptive, ‘become active,’ but there are few appearances which
support that sense. Phys. Il.3, 195b17 ff is closest to doing so, perhaps.

‘Intend’ translates ὑπομικτή; Nussbaum and others have ‘desire’. Michael (Alexander) again inserts ἡρμηνεύει into the process.

701a34 / 117.10-14: “start” = ἴδαμου; Farquharson, Forster, and Nussbaum all have ‘are impelled’, which is the right verb but the wrong voice; Louis has ‘sont poussés’; the verb is active, not passive. The standard translation suggests a causal account of action which is not present in Aristotle’s text. Aristotle says that “animals impel to move” in this place; “impel” sounds odd to us, so I substitute “start”. This use of the verb form of ἡρμηνεύει tends to justify the inclusion of this concept in the account of action presented by Alexander in the passage which Michael calls On Impulse, and its successors in the tradition, including Leonicus for example. However, for Aristotle the verb ἴδαμου expresses the active process of perception, imagination, or thought, which leads to an ἔρεξις event.

701b1 / 117.14-17: The faculties listed include ἐπιθυμία (‘concupiscencia’, appetite), thymos (‘ira’ in Lunag, ‘spiritedness’ in Nussbaum, temper), and boullēsis. Boullēsis could be either ‘will’ (Lunag has ‘voluntas’) or ‘wish’ as the English translators have it. I think that Michael takes it as ‘will’, or rather Alexander takes it that way. Thus my translation. Nussbaum adct. ἴδαμου at 701b1, and thus reads the last part of the sentence, “it is sometimes from appetite or spiritedness and sometimes from wish that they make or act;” the emendation is defended in HSCP 146 on the ground that ἔρεξις is the genus of which ἐπιθυμία, thymos, and boullēsis are species, see De An. Il.3, 414b2. Boullēsis is a rational ἔρεξις (thus the translation as ‘will’), and the other two are non-rational. I keep the words omitted by Nussbaum for conformity with the text of Michael, and because I do not think it essential to omit them.

701b2 ff / 117.18 ff: This extremely interesting passage is full of difficulties of several sorts, one of them discussed briefly in the Introduction, above. Aristotle presents two mechanical analogies, one of automata or puppets, the other of a cart with wheels of unequal size. The object of the puppet analogy is to explain how a small movement (in the body) may have many complicated consequences in the limbs, without any further causes acting from without. In the case of the cart, apparently a push forward is eventually translated into a movement in a circle, again without additional external interference. The puppet analogy is used for much the same purpose in

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GA Il.1, 734b10 ff, and 5, 741b9; those passages are discussed in my Science and Philosophy 69-71. Nussbaum’s account of the automatic puppets in HSCP 146-52, calling attention to Plato Rep. 514b and Laws I, 644b ff, where the analogy between puppet and man is made explicit; she also notes the pseudo-Aristotelian de Mundo 6 (where the puppet is a marionette, not the case here), to Galen de Usu Partium I.15 and III.16, and to Hero of Alexandria Automatopaistika II.22. A major difficulty in reconciling these passages is that Hero’s description of his own automaton seems less complex than that implied by the other passages, and his description of the automata of the ‘ancients’ seems even cruder. My impression of Aristotle’s automata is that they were powered by a weight on a string wound around an axle; the puppet master would release the weight, and the ‘wooden pieces and strings’ would make the limbs move. Michael’s reference to the magicians at weddings recalls that such puppets often had a sexual character, not only in the Byzantine middle ages, but also in antiquity; Herodotus II.48 says that the Egyptians have puppets a cubit tall, with a phallus almost as big as the rest of the body; this part is made to move up and down with a string (neuropasta) by the woman who carries it around the village. Herodotus remarks at the fact that this is the only part made to move. Cf. Lucian de Des Syra III.465. For ορφεῖα as windlass, see Aeschylus Suppliants 441. Burley and Buridan correctly understand the powering of the automata as they substitute a weighted clock as an example; that would be quite similar in this respect. Furthermore, Hero’s problem about the differences between his puppets and those of the ancients may be clarified with reference to the clocks: Hero developed a mechanism which was deterministic, as a clock is deterministic, with the rotation of wheels determining the precise moment in which a movement will occur; the Aristotelian automata seem to have pieces of wood which strike strings, causing the limbs to move (jerk around, probably), an arrangement which would have seemed haphazard to the precise Hero. Albert takes this example with reference to the non-voluntary movements of chapter 11; was he aware of the sexual character of the puppets, and thus compared them to the sexual non-voluntary movements? See also Furley, Two studies in the Greek Atomists, p. 216.

Nussbaum emends at 701b5 (ἀλληλον τῶν ἱλιοκτίστων) which gives ‘the pegs strike one another,’ rather than the strings. She may be right, but I keep what Michael must have had in his text for conformity.
to cylinders, baffling as it seems, would actually help this interpretation. Louis, in his notes to this passage, points out that the word may be applied to a truncated cone, and Galen (18.1.462) says, “I mean by cylinder not those with which children play, but that which has the shape of a column,” i.e., not the conical children’s cylinder, but the truly cylindrical cylinder. If Aristotle were describing an ancestor of the skateboard, then the alternate increase and decrease in the radius of the wheel (b12) might help to move the vehicle forward, once it had an initial start. Skateboarders propel themselves by shifting their weight back and forth, effectively carrying out Aristotle’s recipe for movement of this kind.

Another vehicle which would conform to his description would be something rather like a bicycle with training wheels, three wheels on the back axle, or even just two, with the central wheel (or one of the two) larger than the other(s). With the front wheel fixed in line with the larger rear wheel, it would be possible for the vehicle to go either straight or by shifting one’s weight to turn.

In general, four-wheeled vehicles with solid tires have a bit of the skateboarding characteristic, and if the wheels are rather loose on the axle, as they often are on a relatively primitive cart, the characteristic increases dramatically. A small cart with wheels shaped like truncated cones would act as Aristotle describes. τὸς γρήγορος τύπον χωσίν could mean that the inner and outer diameters of the same wheels (truncated cones) are unequal, rather than referring to different wheels.

We now turn to Michael’s explanation.

117.30: Michael’s claim that it is ‘clear to anyone who gives it a bit of attention’ is gammanship, since he surely does not understand what Aristotle is saying. “It is big” seems to refer to the carriage, though it is not easy to see why he would say that.

117.31: “they must stand still in turning so that the larger may move:” Michael is talking about forward motion, as we shall see in more detail. Lungus correctly perceives that Michael is talking nonsense, and translates, “it is necessary that they be relatively at rest, being smaller in circumference.” Michael is not talking about how an oxcart turns: Greek ox carts may turn by pivoting on one of the large back wheels, making a 180° turn on a roadway twice the wheelbase of the vehicle; indeed, by turning both back wheels, one forward and the other backward, the two-wheeled version at least
can turn around on a surface little larger than the wheelbase. It would be nice to be able to say that Michael refers to this method of turning an oxcart, but he says that it is the front wheels which (relatively) stand still; on no account can the four-wheeled cart pivot on one of the front wheels, at any rate, not the standard Mediterranean cart.

The Mediterranean oxcart traditionally has quite large back wheels, with the weight balanced over the axle of these wheels. When there are front wheels, they are much smaller and placed well in front of the load, and have little weight on them. The large size of the loadbearing wheels makes possible clearing obstacles on very bad roads (or no road at all), facilitates rolling over uneven places, and helps in dumping the contents of the cart by making it possible to unrich the animal and hand-lift the front end. With the larger wheels, the angle of the box becomes sufficiently steep that its contents slide out unaided with the box tipped back. The two-wheeled cart just has the back wheels; the vehicle is serviceable, less expensive and less difficult to produce, easier to turn in the way described above, but with the disadvantage that it cannot easily be loaded when the animal is not in harness, nor can its load be easily left in it.

117.32-118.4: The notion that relatively slower movement is a compound of motion and rest sounds like some bad Platonism. The theory as expounded here implies that every movement which is not instantaneous is a compound of motion and rest; slower movements have more 'rest' in them. Michael clearly thinks that this means that the movements would be discontinuous, and that this discontinuity should, in principle, be observable. A charitable interpreter might introduce the cinematic theory of motion at this point; according to that theory, moments of time are discrete units—each moment, everything is at rest, but each moment differs from its immediate predecessor and successor in terms of the relative positions of some of the spatial entities which each contains. But in that theory the 'rest' involved in slow movement would be no more observable than the 'rest' involved in fast movement. Michael obviously has a most peculiar mechanics. For an account of good Platonism, see J. B. Skemp, The Theory of Motion in Plato's Later Dialogues.

118.5-9: In Michael's celestial example, the equator is more properly the celestial equator or the circle of the equinox, as Lunus notes. The example shows where Michael's problem lies: in a mathematical analysis of circular movement, the central point is at rest, as Aristotle says in MA 1, and the circumference,
Malebranchean parallelism. For Aristotle, imagination is simultaneously a movement; see my “On Dreams...,” and Nusbaurn, Essay 5.

“Momentarily.” the adverb is temporal, not spatial, as other translators have it. “Imperceptibly small.” Michael wants the part to be the heart, which is not small, so he thinks that it is imperceptible, because it is inside the body. But Aristotle means that the change occurs in a small part of the heart. Leoncious expands his commentary here, using different terms (‘dolce’ and ‘horror’ for example), and refers to Mech. 5 for the example of the change in direction of the boat’s bow; a small change in the ‘apex’ makes a big change in the ‘hypotenuse’ of the isosceles triangle. See also de An. 1.1, 405a21; HA VIII.2, 590a3; GA I.2, 716b3; IV.1, 764a24 ff; V.7, 788a13.

8701b54 / 119.14-21: Aristotle here gives an exceedingly simple account of the mechanism of animal movement, ascribing the relation between thought and action rather exclusively to heat and cold. At 701b37 / 702b1, I follow Moraux and Nusbaurn (HSCP 153-4) in transposing the two phrases of the sentence. Michael adds ‘of them’ (in parentheses) and omits ‘some’ (in brackets). No one takes his substitution of γάφι for δέ seriously. Michael thinks that pleasure is hot and pain cold; see PA IV.5, 679a25, where cold and lack of blood is associated with fear (and consequently of avoidance behavior); of PA IV.11, 692a24.

702a2 / 119.22: The passions, or παθήματα, were to become the subject of much philosophical study in antiquity. Diogenes Laertius lists a work on the subject under Aristotle’s name. θυσίατωματικός, elsewhere of sexual intercourse, is here used of sexual arousal. Michael’s ἀνεμομυγμός, “wet dreams,” is literally ‘dream-plowing’; in Galen and other medical writers it is limited to sexual dreams. See also J. Henderson, The Maculate Muse, p. 46.

702a5 / 119.25: “image” = εἰκόνα. Elsewhere Aristotle uses such words as φαντασμα, εἰκόνα, ζωγραφία, ζωγραφίσμα. The MA theory may be an improvement over the Mem. representation theory, as Nusbaurn argues. In a general way, we may say that Aristotle sees perception as essentially involving a physical process resulting in, for example, heating and cooling of the various parts, and consequent feelings of fear, pain, pleasure, and so on; imagination is a reverse process, starting from fear (as a change in the heart), and resulting in heating, cooling, and movements of the parts of the body. Farquharson compares Descartes’ theory in Traité des Passions, but Descartes is more inclined than Aristotle to think of mental experiences and physical events as accidentally rather than essentially related.

702a7 / 119.28: Farquharson says, “A., though free from the vulgar Teleology of Design, is fond of calling Nature a cunning artificer, especially in the Nat. Hist. treatises. His language becomes coloured with enthusiasm in such passages as P. A. 645a5; de Inc. 711a18; and G. A. 750b27, 753b25.” Remarkably, Aristotle does not actually mention φυσικ in the present passage; as in a few other places, he has δημομογματικον alone. In general, MA does not much appeal to Nature in explanation, at least not by comparison with IA, where Nature is repeatedly said to ‘do nothing in vain’ and so on. The relative absence of this sort of appeal in the MA may be a sign of Aristotle’s maturity. See also Phys. VIII.1, 252a13: τὰς τῆς πάντων καταλύει.

119.30: Michael distinguishes, as Aristotle does not, between νεῦρα, nerve, and μυς, muscle. For Aristotle, as we mentioned in the Introduction, neurae covers all the stringy parts. Michael seems to use it for nerves and sinews. He seems to be aware of a distinction, but does not make it clearly. In the translation, ‘nerves’ is used for neurae fairly consistently.

702a9 / 120.1: Aristotle’s contrasts here are between πεπτωμα and νταν, ‘stiffened’ and ‘fluid’; and μαλακία / ακαλάκα. Aristotle seems to suppose that ‘stiff’ vs. ‘fluid’ is a different sort of opposition than ‘soft’ and ‘hard’, but Michael reduces the one to the other, by way of ‘dry’ (for stiff and hard) and ‘loose’ (for fluid and soft).

120.10: The translation of Michael follows ms CPR and the standard Aristotle readings at 702a11 for ἄφρω, rather than the ἄπρω which Hayduck prints.

702a20 / 120.15-20: The relationship between active and passive is a typically Aristotelian approach to explanation. GC I.7, 324b1; 9, 326b29; GA II.4, 6; IV.5, 768b15 ff; Metaph. Delta 15; Phys. III.1.

702a21 ff / 120.21 ff: Aristotle here begins to argue that the origin of animal movement must be the heart. Michael refers to Alexander by name here, safely enough, because he paraphrases rather than quotes directly, from de Anima I.94-100, Fokinis pp. 125-136. To the extent that Alexander does refer to dissection in this part of his work, his references do not support Michael’s claims (cf. 96.26, Fokinis 129-30; 98.7, Fokinis 132-3). The best
‘dissection’ evidence which Alexander gives for the cardiocentric theory is really a refutation of the encephalocentric theory (100.8, quoting from Fotinis p. 136):

Nor does the amputation of some part of the body— an experiment performed on certain animals— afford any proof that the commanding power is located in the head, because the evidence from amputation is ambivalent. There are animals, like the tortoise and the chameleon, that do remain alive for a considerable time after their heart has been removed; but it is equally a fact that some animals continue to show signs of life in the rest of their body long after they have been decapitated. Often, indeed, both the heart and the head continue to function.

No doubt the movements of decapitated chickens are what he has in mind.

121.9: The example is Alexander’s; the concept of time involved is properly Aristotelian, though only mysteriously relevant to the present issue. Cf. Phys. IV.10-14; cf. de An. III.10, 433b13-31.

121.13: Michael refers to HA I.15, 495b27. ‘The word for ‘hand’ is somewhat ambiguous, since it might include anything up to the elbow. Aristotle’s reference at 702a21 is to the first chapter of the present treatise.

702a32 ff / 122.2 ff: Nussbaum’s interesting discussion of the ‘stick’ example might well have considered also Wittgenstein, Philosophical Investigations I.626. Cf. Phys. VIII.5, 256a6 ff. She is very worried about the argument that there must be just one arché and not many, since Aristotle concedes that insects and other lower animals have potentially several ‘origins’. Why couldn’t each joint be an independent source of movement? Aristotle has several lines of attack; one is that the organism moves in a coordinated way, as a unit, and therefore the subsidiary origins may be controlled by some central authority. This argument is developed especially in the following chapter. The present argument seems to claim that if the hand moves the stick, the stick obviously has not got the origin in it, but in fact the hand doesn’t either, because the hand bears the same relation to the forearm, via the wrist, as the stick does to the hand. Yet the same argument would also lead to the theory that the soul is in the stick, in some sense; in a more general way, Aristotle argues elsewhere that the art is, in a way, in the tools of the art. GA I.22 is most instructive in this regard; if Aristotle had been aware of artificial limbs, I am confident that he could have fit them into his general system of explanation in a most satisfactory way. Nussbaum

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9.702b12 / 122.23: Aristotle means that neither right nor left, neither up nor down, could be the origin of movement, since all the extremities are moved, even at the same time. Cf. IA 4.705b16 ff. Michael obscures the issue by the introduction of the notion of παρά μέτρον movement, which I understand as alternate movement, following Lunge. Farquharson reads καρδά, which might be a little clearer, but still theoretically unsatisfactory.

702b16 / 122.23: “the middle is the last term of both extremes.” This recalls the many passages in which Aristotle uses and abuses the concept of the mean; cf. T. Tracy, Physiological. For my reading of Michael here, I follow ms CPR, rather than Hayduck. Lunge says, “We make the right and left moving parts rest in it.”

125.4: The analogy of the general is from Ἡμετ. Lambda 10, most notoriously; Michael here copies from Alexander de An. 97.20 ff, Fotinis p. 131.

125.10: “impulse” — Lunge reads ‘impulsoria vis’, which is closer to Alexander’s parallel sentence, 98.1 (Fotinis p. 132), “this shows that the impulsive and intentional power is around the heart.”

125.12: “dissection” — Obviously Michael did not carry out any anatomical dissections himself. He probably is referring to Alexander 98.7ff: The heart lies in the safest part of the body (for it is surrounded by the strongest bones and flesh) and is wrapped in the strongest membrane, the so-called ‘pericardium’, which is not easily divided by iron.” (My translation, not that of Fotinis.) Alexander goes on to say that the material of the heart is a combination of ‘neuron’ and flesh. Michael may refer to 96.26: here Alexander claims that dissection reveals that the heart is the origin of the senses; he does not mention nerves however. Aristotle does suggest, but not very enthusiastically, that the nerves
originate in the heart: HA III.5, 515a26-b26; PA III.4, 666b14-17; GA V.7, 787b11-15. In the GA passage, the *neura* are said to set the pneuma in the heart in motion. See C. R. S. Harris, The Heart and the Vascular System in Ancient Greek Medicine, Oxford, 1973, pp. 121 ff; the heart as the origin of the *neura* is explored pp. 160-162.

123.16: We see here how Michael prefers alternate movement to simultaneous movement in explaining the passage. He, unlike Aristotle, believes that one part of the body moves then the other, while Aristotle has some realization of the complexity of simultaneous movement, and consequently the necessary complexity of changes in the origin of movement.

123.21-25: Leonicus (225) adds the explanation in IA 3, based on the six directions and their differentiations in relation to the up and down, forward and back, right and left, of human and quadruped bodies.

702b13-21 / 123.25-28: For the text, see Nussbaum HSCP 154-5; the head is up in man, the spine is up in quadrupeds. Michael's suggestion that 'those from the spine' means the system of bones is picked up by Nussbaum. Michael refers to PA II.9, 654b10, which is closely related to the present passage. There aren't many other places to which one may refer: one is HA III.7, 516a10, quite similar to the PA passage. See also Alexander 96-97. Farquharson suggests that Aristotle believes the heart to be the center of the bone system because of its relation to the spine, as well as being the center of the blood system, and the sensory and motor system. This is contrary to Alexander's interpretation, at least.

702b25 / 124.4 ff: Michael insists that the middle of the body is potentially two (not more), while Aristotle leaves open the possibility of the exercise of several potentialities simultaneously.

124.11: "the nerves begin from it..." Leonicus adds here, "ut omnem cum physici tum medicum affirmet." That was false in Aristotle's day, false in Alexander's day, probably false in Michael's day, and most certainly false in the days of Leonicus, since Galen makes quite clear how the system of nerves proceeds from the brain.

124.19-20: "some of the water" - Leonicus repeats the example, but it does show a lack of observation about fluid mechanics, since any motion of water in a tub will have some effect throughout the tub.

703a5-703a1 / 124.22-27: In Aristotle's text, "the limits and origins in A" *αὐτήρεθων* on each other, "and the persons who move their legs *αὐτήρεθων*.

Hayduck follows some of the Michael mas in repeating a form of the first verb for the second instance. But mas CPR make the same distinction which Aristotle does, and that would be the preferable reading. In the Hayduck reading, one would be tempted to see Michael imagining a man who lies on his back and moves his legs; that might be a counterexample, and not a support for the point which he is trying to make. The two verbs are sufficiently similar to make plenty of room for confusion. Aristotle's point seems to be that two limbs (e.g., legs) which both start from the same place (the midline of the body) must have a common origin if they are to move in a coordinated way; two persons standing back to back do not make one coordinated organism.

703a1-3 / 124.30 - 125.2: "both are moved by the soul!" - Michael here goes back to *hypo* instead of *kata* despite the excellent analysis he earlier cribbed from Alexander.

Nussbaum follows William of Moerbeke and Albertus Magnus in inserting the word "one" into the text here; she rejects Jaeger's suggestion, based on Michael's comment, that "unmoved" be inserted, HSCP 155-6.

"Dispositions" = διάταξις.

125.11: Although it is quite true that the movement of the limbs is described in considerable detail in IA, Michael seems to use this reference to focus the issue; he has problems over the passage because he has approached it wrongly.

702b30 / 125.25 ff: A / AE. Editors agree that 'A' is correct in the text of Aristotle, although there are mas with AE (as Michael), and even AB. If 'AE' were correct, the 'E' would be next to the 'A' in the diagram, or added in the process of explanation. Michael's text had the 'E' since he is at pains to explain its significance. The object would be to distinguish between the mathematical point (A) and the whole section in which pivoting occurs. See Farquharson's note; he compares a compass.

126.2 ff: Michael tangles with an issue which is crucial in the tradition of the commentators— is the soul an incorporeal form, or is there a sense in which it is material? Paul Moraux explores the problem in his Alexandre d'Aphrodise. Stoic thought identified the soul with the pneuma, while the Neoplatonists argued that the soul was a separate form; Aristotelians in late antiquity had difficulty steering between this Scylla and Charybdis. Leonicus here follows Michael closely. Farquharson compares Descartes' pineal gland, the unitary physical center, corresponding to the necessary unity of the soul; no doubt Descartes was persuaded by some of the very arguments which had persuaded...
Aristotle to suppose that the heart is the source and center.

126.11: Lungus translates παρά μέρος with ‘alternatim’ here (p. 52a); Leonicus always has ‘vicissim’ (e.g., 225.9). “Part of the heart”— Leonicus, more aware of anatomy perhaps, writes ‘cordis ventriculum.’ I continue to translate neuron with ‘nerv’, although that does not catch the idea completely. At 702b32, Aristotle wants to claim that both parts can be moved at once; that would complicate Michael’s simplistic mechanic of the heart. One has to suppose that a part which is moving can ‘lean’ on another part which is also moving; Aristotle sees nothing difficult in that, but Michael does not catch it.

702b32 / 126.15-20: Aristotle’s argument is more abstract than Michael thinks; Nussbaum believes it to be entirely too abstract, and that Aristotle would have been well advised to rely on some precise anatomical description in this chapter.

126.26 ff: Michael definitely has ‘those who lean on their backs’ rather than ‘those who lean on each other’s backs’; Lungus translates, ‘Ut n. qui terga firmunt et quasi opposulent muro,” envisaging someone leaning back on a wall and moving his legs.

10.703a6 ff / 126.26ff: Aristotle here introduces the concept of connotate pneuma; Michael has of course been relying on the idea for some time. Aristotle begins with a general theoretical argument, then tries to cash it in with the physiological data; Michael confuses the abstract argument with the material description. It would be worthwhile comparing this chapter with de An. III.10, 433b13 ff, where pneuma is not introduced, despite the similar argument that there must be a ‘motive instrument.’ See also J. B. Skemp, “... de An. III.10.” in Lloyd and Owen, 1979. “Explanatory definition” is not a traditionally Aristotelian rendering (Nussbaum writes, ‘the account which gives the reason’) but it fits the text, τὸν λαγὸν λέγοντα τὴν αἰτίαν.

127.3: “driving at”— προσωποκειμένων, rendered ‘subjacentis’ by Lungus, and thus nearly ‘sous-entendu’ in French. There is no good English equivalent.

127.15: It is not obvious why Michael would want to appeal to the analogy of the dancer and the dance when Aristotle is pushing for the necessity of pneuma; in a way, that analogy belongs to a different aspect of his theory of soul, the soul as the functioning of the entire body in a certain way. In that part of the theory, pneuma is unnecessary, as anyone who has been impressed by de Anima II will agree.

Leonicus appeals to the distinction between formal and material causes here; ‘appetitio’ is formal and thus unchanging, cf. pp. 226-7.

705a10 / 127.17: “elsewhere” / On Nutrition. Nussbaum discusses the uses to which this reference has been put. Michael has not seen the book, obviously. Nussbaum suggests several extant locations to which Aristotle may be making reference: GA II.6 says the right sort of thing but she finds that difficult on chronological grounds. I think the chronology is possible, but the explanation of pneuma in II.6 is too brief to be worth a back reference. If that’s all Aristotle wanted to say, he could have said it again here without difficulty.

Sonn. 2, 456a5, also says the right sort of thing, but refers ahead to a separate discussion of the problem. Could Aristotle have Resp. in mind? He there is much more concerned with the external breath (pneuma) than with the connotate pneuma (breath). Resp. as it stands is probably relatively early; Aristotle may have intended to revise it to bring it into line with MA and GA. Several other passages indicate the sort of thing Aristotle would have written had he completed a treatise on the subject: de An. II.4, PA II.1-4, GA V.4. Nussbaum figures that the second “elsewhere” at 703a16 is even more likely to point to a treatise On Nutrition; I think it looks even more like an intention to revise Resp.

705a20 / 127.20: “pushing and pulling” / “flowing in and out”— for Aristotle’s theory, see de An. III.10, 433b25-26; IA 2, 704b22; Phys. VII.2, 243a16, 243b16ff. Michael may have misunderstood ‘pushing and pulling’ here as a reference to pneumatic flow, rather than pneumatic expansion and contraction. It may be that Michael (or his source) envisaged the flow of pneuma as analogous to the flexing of the joints, or it may be that he has taken a cue from someone influenced by Galen’s pneumatology— there, the pneuma flows through hollow nerves to carry information and stimulate movement. But the nerves lead to and from the brain in Galen. Leonicus is here reminded of Heraclitus’ ‘flowing in and out’. Oddly enough, Michael here says little about pneuma, in comparison with his comments on passages in which Aristotle says little or nothing about it.

705a21-24 / 128.5-6: see Nussbaum HSCP 156-7 for the text.

τε καὶ ἐκτενεῖς ἡμᾶς is inserted by Farquharson, with some justification, and the ἡμᾶς of the following phrase is emended to ἡμᾶς. Nussbaum's
reading thus gives her translation, "for it contracts and expands without constraint, and is able to push and pull for the same reason." The received text may be rendered: "for contracted it is without force, and it is forceful and thrusting for the same reason." Farquharson's ἔθικορος in the first clause would give, "for it contracts without being forced," which is how Louis translates, although his text keeps the ms ἔθικορος.

127.25: Michael's suggestion is not helpful, although one may be tempted to translate Aristotle loosely here, as Louis in fact does.

705a22-27 / 127.26 ff.: For the theory, see Pat. I.2 and GC II.3, 331a1. Fire is opposed to water, and in a way to the other elements, air and earth. Pneuma is represented as an intermediate between fire and air; it is 'hot air' in GA II.2.

At 127.32 - 128.2 the ms CPR have a somewhat different text which renders, "... it holds against the light things which push or throw it upwards (for carrying the heavy things down it must be carried up)." Michael's conclusion that pneuma, midway between heavy and light, is in the middle, and the soul is in the middle, is rather fantastic, with at least one if not two non sequiturs. But the passage is crucial for the reconstruction of the text, as we have noted.

705a30 ff. / 128.8 ff.: The analogy between the animal and the state is important and enlightening. Plato's Republic developed the metaphor, and it thus became central for many later thinkers; Farquharson notes comparable passages in the Stoics. See also T. J. Andersson, Pois and Psyche, Goteborg 1971. Cf. PA III.7, 670a26; EN III.5: Pol. I.5, 1254b5. "Well-governed city"—Lungus adds "with holy and good laws." Michael's comments represent the political reality of the Byzantine state; his psyche is a monarch, but Aristotle's soul could be quite analogous with the politeia.

Louis argues that the passage demonstrates a mechanistic relation between soul and body, following Nuyens 54-56 and 161, thus placing it before the de An. The arguments of Block and Hardie against Nuyens also destroy the position of Louis. Louis adds that the image is traditional, which may be, but it can lead to an enlightened Aristotelianism which approaches some aspects of modern systems theory.

11.705b2 / 128.17 ff.: The final chapter ties up loose ends, provides some summary, and points to further studies in philosophical biology. Michael's reference is to EN III.1, a fuller and rather different account. Nussbaum has a note which explains the difference.

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128.21: "Beautiful woman"—Lungus has 'virgo' here. Michael's sentence is none too clear; I follow Lungus, more or less, in my translation.

128.24: "Woman"—Lungus has 'paelam' (no longer a 'virgo'). Michael's story is quite unlike Aristotle's; he seems to be describing the circumstances of masturabation. Nussbaum here distinguishes between systemic processes, which are involuntary, low-level desires resulting in such things as the hero's heart skipping a beat at the sight of the enemy, and the momentary sexual excitement of the temperate person, which are non-voluntary, actual pursuit or avoidance is voluntary. Michael's notion of 'ensus' (128.27) as the distinguishing mark of the voluntary goes back to the Stoics, for whom this concept was central.

129.4: "The previous book"—Michael had MA in the midst of the Parva Naturalis; he refers here to On Sleep and Waking (Somm.) 3. Cf. PA II.7, 65s30 ff.

705b11 - 17 / 129.5 - 16: "Natural alteration"—Michael had τόνησι in his text, as modern editors do not. Nor is his suggestion of a full stop followed; a comma is standard; nor do they understand 'appearance' in their translations. The parentheses were introduced by Torraca, followed by Nussbaum. For the healing and cooling, see PA II.2, 64s22 ff.; IV.5, 67n25.

705b20 / 129.21 ff.: the involuntary movement of the heart is not the regular heartbeat, but unusual movements, particularly in moments of fear. Michael's reference might be to Juv. 3, which says that the senses extend to the heart, but is more likely to Resp. 20, 479b17 - 480a16, near the end of that treatise. Resp. follows Juv. in the Parva Nat., so Michael may think of them here as one treatise. "Jumps"—ἀλαγριν (Lungus: 'emict'), which probably means something like 'palpitates'; in Resp. 20 this is called μολῆς.

705b22 / 129.29: Jaeger brackets this sentence on the ground that it is not Aristotelian in doctrine and in contradiction with what follows; Forster and Nussbaum follow him. Michael quotes the sentence, but does not depend on it for his explanation of the passage. Leonicus and Lungus find the phrase significant; Leonicus appeals to Plato Tim 91, where 'vital moisture' does play an important role in the explanation, and Louis refers to PA IV.10, 689ab (for the sexual organs), and II.4, 650b29 and III.4, 666a20 ff, for the heart.

130.1 ff: This sentence looks like an alternative, and better, explanation of the heart and sexual organs as independent animals. The words, "is like an animal"
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are inserted for clarity. The reference to GA may include I. 18, for example.

703b28 / 130.8: “and thus reach each other”— Michael does not quote these words, and he may not have had them in his text, to judge by his interpretation.

703b32 / 130.15: “the origin of B goes to B”— Nussbaum brackets ἀρχή and understands κίνησις, “ the movement of B goes to B.” I keep the text and make the best of it to conform to Michael’s commentary.

130.22: “right and left origins terminate”— Michael has a singular subject and a plural verb; he is not sure whether there is one origin or two here. Lungs puts the verb into the singular.

In the following sentence, Michael refuses to accept the text with the word ‘not’, and consequently misunderstands Aristotle’s point. Aristotle wants to say that from limb B, a movement can go to origin A, and thence to limb C. To adapt one of his examples, touching the body of the beautiful girl with hand B would set up a movement which would go to heart A and thence to phallic C. Leonicus rather tentatively departs from Michael’s text and more closely approximates Aristotle’s meaning.

704a1 / 151.2: Leonicus amends, giving cases of the lack of correct material.

cf. de An. I.1, 403a19ff; Sens. 7, 447a15ff.


Aristotle’s name for the MA is περὶ τῆς κοινῆς κίνησις, On Common Movement; GA is announced as following. That does not necessarily mean that that treatise was written later, only that it was meant to be read (listened to) after MA. GA may have been revised after the composition of MA; it shows signs of having had at least two versions.

Aristotle

ON THE PROGRESSION OF ANIMALS

1. As for the parts useful to animals for local movement, we should investigate why they are as they are, why these particular animals have them, how these parts vary in the same kind of animal and among animals of different kinds. Let us first decide which matters we should investigate.

The first is, what is the smallest number of points at which animals move, then why animals with blood move at four, and bloodless more, and in general why some animals have no feet, some two, some four, and some many, and why all with feet have an even number; generally, why the points of movement are even in number.

Further, why are men and birds bipeds, but fish footless; and yet men and birds, both bipeds, flex their legs in the opposite ways. Man flexes his legs toward* the circumference and the bird toward the concave.

Man himself flexes his legs and arms in opposite ways; he flexes his arms concavely and his legs convexly. The viviparous quadrupeds flex the opposite way than man, and opposed to themselves, for they flex their front legs convexly and the back concavely. Besides, quadrupeds which are not viviparous but ovi parous uniquely flex to the side. In addition, why do quadrupeds move diametrically?

We should try to discover the explanations of all these facts, and of related matters. That this is what actually occurs, is made clear in the Natural History; now we will find out why.

2. The beginning of the investigation is in the propositions which we are accustomed to use often in natural science, accepting those which are this way in all the works of nature. One of these is that nature does nothing in vain, but concerning each kind of animal always does the best of what is possible for the entity; so if it is better thus, it is also naturally thus.

Also one should accept the spacial dimensions, how many and what sort are present in various types. There are six dimensions in three pairs: the first is up and down, the second is front and back, the third right and left.

Besides, the origins of motion in place are pushing and pulling. These are per se movements— that which is carried by something else moves per accidents, for that which is carried is not thought to move itself but to be moved by something else.

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3. Having made these distinctions, let us say what follows from them. Of those animals which change in place, some change the whole body together, e.g. jumpers, but others part by part, e.g. all the walkers. In both cases the mover always changes by supporting itself on that which underlies it. Thus, if this (substrate) slips off faster than the one walking on it can support his movement on it, and if it gives no resistance at all to movers, one would not be able to move on it. For a jumper jumps by leaning on its own upper part and on that which is under its feet; for the parts rather lean on each other at the joints, and generally the presser presses on the pressed. Thus competitors in the pentathlon jump farther if they have the ‘dumbbells’ than if they do not, and runners run faster if they swing their arms; for some support is generated in the extension toward the hands and wrists. The mover always uses at least two organic parts to make the change, \( \text{705a} \) the one as it were compressing, the other being compressed. The part at rest is compressed because it carries the weight, the lifted part is extended by that which carries the weight. So something without parts could not move in this way; for it would not have in it the distinction \( \text{20} \) of passive and active.

4. The dimensions by which living things are naturally defined are six in number; up and down, front and back, right and left. All living things have up and down; for not only animals have up and down, but also plants. They are distinguished functionally, not just by position in relation to earth and sky— for there from where the distribution of food and growth starts in each sort of thing, is up; the part at which it finally ends, is down. The one is the origin, the other the finish; \( \text{705b} \) up is the origin. Yet it might seem that down is more special in plants; for in them up and down do not have the same position as in animals. They do not have the same relation to the universe, but they have the same function. For the roots are the ‘up’ in plants; from them the food is distributed to the growing parts, and they get it with them as animals do with mouths. Those things which not only live but also are animals have a front and back as well. For they all have perception, and on account of this front and back are distinguished; for the direction in which perception naturally functions and whence it is derived in each kind is front, and the opposite back.

Those animals which not only share in perception but are able to change in place by themselves have in addition to the distinctions named, that of right and left, each of these, like the previously named, distinguished by some function and not by position; for there from where the origin of change in place by a body is naturally, that is the right for each thing, and the opposite to it, which naturally follows, is the left. This distinction is more articulated in some than in others. Those which use organic parts (I mean, for example, feet, wings, etc.) for change in place are more articulated in the respect mentioned, but those which proceed, not with such parts, but by making separations in the body itself, as some of the footless do, e.g., the snakes, the class of caterpillars, and also the so-called earthworms, have in them the distinction mentioned, but it is not as obvious. Evidence that the origin of movement is from the right: one always carries burdens on the left; in this way that which carries can be moved, the mover being set free. Thus too one hops more easily on the left; for the right is naturally the mover, and the left the moved. So the weight must not rest on the mover but on the moved; if it were placed on the mover and origin of movement, either it would not be moved at all, or with difficulty. Further evidence that the origin of movement is from the right is how one steps out, for everyone puts the left foot first, and when standing have the left forward by preference, unless by chance they do not. One moves not with the extended foot but with the remaining one; also one defends himself with the right. For this reason too the right is the same in all. There where one finds the origin of movement is the same in all and has its natural position in the same part, for the right is the location of the origin of movement. This is why even the stromboid testaceae all have their shells on the right, for they do not move toward the spiral but all proceed in the opposite direction— e.g., purpura (murex) and ceryx (e.g., a chiton [mussel]). Now since everything moves from the right, and the right moves in the same direction as the whole, necessarily everything is similarly right-sided. Man has the left the most detached of all animals, because he is the most natural of animals; the right is
5. Animals in which up and front are distinct, as in men and birds, are
bipedal (for the wings or hands are arms are two of the four points).
Those which have front and up in the same place are quadrupeds,
polyponds, or footless. I call ‘foot’ a part at a ground point which is
used for movement in place; the feet (πόδες) seem to have gotten
their name from the ground (πέδων).

Some animals have front and back in the same direction, e.g.,
the ‘softies’ (malakia) and the stromboid testaceans; we have talked
about them earlier elsewhere.

Of the three places, up, middle, and down, bipeds have their up
5 toward the up of the universe, polyponds and footless toward the
middle, and plants down. The reason is that plants don’t move,
toward the food is up, and their food is from the earth. Quadrupeds
are toward the middle, like polyponds and footless, because they
are not erect. Bipedal are toward the up because they are erect,
most of all; for he is naturally most biped. It’s reasonable
that the origins should be from these parts; for the origin is more
honorable, and up is more honorable than down, front than back,
and right than left. It works well to say it the other way around,
that because the origins are in these parts they are more honorable
than their opposites.

6. What has been said shows clearly that the origin of movement
is from the right. Since, necessarily, in anything continuous one
part moves and one rests, the whole being able to move while one
stand stands, where both move in opposed movements there must
be something common by which these are continuous with each
other, and here the origin of the movement (and of standing still)
of each of the parts must be located. Clearly, in respect of whichever
of the contraries mentioned, a particular movement belongs to each
of the opposed parts, all of the previously mentioned interconnec-
tions of the parts have a common origin; I mean right and left, up and
down, front and back. The separation (διάλειψις) of front and back
does not apply in this way to that which moves itself, because nothing
has a natural movement backwards, nor does the moving animal have
a distinction (διαφορά) by which it makes a change in each of these
directions; but there is a distinction between right and left, up and down.

Thus those animals which proceed by use of organic parts do not have
the distinction of a difference (διάφορα) between front and back,
but have both others, first the distinction of right and left (because
this must be present as soon as there are two things) and then that
which arises when there are four.

Now since up and down and right and left are connected to each
other at the same common origin (I mean the control of the movement,
in everything which is going to bring about movement from each
direction, the cause of the movement mentioned must be somehow
defined and arranged in the separations toward the origins we named,
the opposites and the non- opposites of the origins in the limbs
(this cause is the common origin from which originates the movement
of right and left, and also of up and down, in the animal), thus
must have approximately the same relationship to each of the
origins in the parts we mentioned, (7) so it is clear that local move-
ment belongs only or especially to those animals which make local
change with two or four points. So since this occurs above all in
animals with blood, clearly no blooded animal moves at more
than four points, and if anything moves at four points only, it
must have blood.

7. What actually occurs in animals agrees with what we have said.
No animal with blood can live any time, so to speak, divided into
several parts, nor can it share in the local movement which it had
when continuous and undivided. But some of the bloodless many-footed animals can live a long time in each of the parts, and move
with the same movement which they had before division, as the
centipede (skelopendra) and other long insects; for even the back
part of all of these continues to progress in the same direction
as the front. The reason why they live when divided is that they
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are as it were something continuous composed of many animals. Why this is so is clear from what has been said before.

The most naturally constructed animals move at two or four points; this is also true of the blooded footless animals, for they too move at four points, and thus progress. They progress by using two flexes; in each of their flexes, front and back, there is a right and a left in the breadth; in the part toward the head there are front right and left points, in the part toward the tail the back points. They seem to move at two, the front contact point and the back, because they are so narrow. In these animals, as in the quadrupeds, the right leads and the back parts respond.

The reason for the flexes is the length. Just as tall men walk swayed-backed, and the right shoulder leads with the left hip leaning rather back, and the middle becomes hollow and swayed-backed, so one should think of snakes as moving swayed-backed on the ground. Evidence that they move like quadrupeds: in each part the concave and convex alternate. When the left front again leads, the opposite side becomes concave, for the right becomes the inner. Let the right front be A, the left B, the right back C, and the left D.

Of land-animals, the snakes move this way, of water-animals, the eels, congers, lampreys, and any others having a snake-like form. However, some of these water-animals do not have fins, e.g. the lamprey (imurana), but use the sea as snakes use the land and sea (for snakes swim as they move on land); some have two fins only, as the conger, the eel, and a kind of cestreus which breed in the lake of Sinpa. Because of this those accustomed to live on land, e.g. the eels, move with fewer bends in the water than on land, but the cestreus, which has two fins, makes up the four points in the water with the bend.

8. The reason for the footlessness of snakes is that nature does nothing in vain but in every case looks out for the best possible arrangement for each thing, saving its special entity and essence; besides, as we have said before, no blooded animal can move at more than four points. Clearly those blooded animals which are disproportionately long in relation to the rest of the nature of their

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body, as snakes, cannot have feet. For they are not the sort to have more than four (then they would be bloodless), but with two or four feet they would be practically immobile, so slow and useless the movement would have to be.

Every footed animal must have an even number of feet; those which change from place to place by jumping only do not need feet for this sort of movement; those which jump but for which jumping is not sufficient, and need to walk, for some it is better, for others it would be entirely impossible to progress (otherwise). Therefore every animal must have an even number of limbs. As this sort of change is part by part, not all together like jumping, some of the feet must remain at rest and others move during change, and each one must do this with opposite parts, transferring the weight from the moving to the remaining parts. Therefore nothing can walk with either three legs or one; for with one it will have no support at all for the weight of the body, but in the other case it has support for the body on one side only, so that if it tries to move thus it must fall. Many-footed animals, e.g. centipedes (scolopendra), can indeed progress on an odd number of feet, as you can see right away if you mutilate one of their feet, because the maiming of opposing feet is remedied by the number of feet remaining on each side; for they rather drag the maimed part by means of the others, but this is not walking. Anyway it's clear that they would progress better with an even number of feet, lacking none, having the corresponding feet; that way their weight would be equalized and not oscillate to one side, if they had the corresponding supports and not one of the opposed places empty. A progressing animal proceeds with each of its parts alternately; thus there is a restoration to the original arrangement. So we have explained that all animals have an even number of feet, and why.

9. The following shows that if nothing were at rest, there would be no flexing or extension. Flexing is the change from a straight line to a curve or angle, extension change from either of these to straight. In all changes mentioned, the flexing or extension must occur in relation to one point. Furthermore if there were no flexing there would be no walking, swimming, or flying. Since footed animals
stand and carry the weight on each of the opposed legs alternately, as one leg advances the other must flex. For the corresponding limbs are naturally equal in length and the one carrying the weight should be straight and approximately perpendicular to the ground. But when one advances, it subdues the right angle and has the power of the one which remains plus that of the line between them. Since the limbs are equal, the stationary one must flex, either at the knee or at the joint, as would be the case if some kneelless animal would walk. Evidence of this: if someone walks on the ground along a wall, the line drawn would not be straight but crooked, because the line is lower (less) when he flexes and higher (more) when he stands up straight.

It is possible to move even if the limbs do not flex, as children crawl. The old story that the elephant does this is not true. This sort of movement occurs by flexing at the shoulders or hips. However, nothing could walk ‘stiff’ continuously and safely; it would move like those in the wrestling schools who go along on their knees through the dust. The upper part of the body is large, so the legs must be long; but then there must be a flex. Since one stands erect, if the leg moved forward were unflexed, either one will fall as the right angle becomes less, or one will not proceed. For if the one leg is at right angles and the other advances it will be both longer and equal; it will have the power of the one which remains at rest, and of the hypotenuse. So the one which pushes forward must flex then, and flexing extend the other leg, and leaning over top out, and remain perpendicular; for the limbs generate an isosceles triangle, and the head becomes lower when it is perpendicular to that on which it walks.

Of the footless animals, some advance by undulating; this occurs in two ways: some, like snakes, make the flexes on the ground, and others up, like ‘flexers’ (caterpillars), and the flexing is undulating. Some use ‘oozing’ as the earthworms and leeches. These advance with one part leading, then they pull up the whole rest of the body to this; this is how they change from place to place.

Clearly if the two (lines) were not greater than the one, undulating animals would not be able to move. For, if it were to subdue an equal line when the flex is extended, they would not proceed; but in fact extended it is longer, and when this part has stopped, the rest comes up.

In all the changes mentioned the moving thing advances by sometimes extending straight, sometimes flexing together, straight in the leading parts, flexed together in the following parts. Even the jumpers all make a flex in the lower part of the body, and this way jump. Also the fileers and swimmers either fly by flexing and extending the wings or swim with either four fins or, when the form is longer, as in the class of eels, with two; these swim by flexing the rest of the body for the rest of the movement, instead of two fins, as we said already. Some flatfish use two fins and the flat part of the body instead of the other two; those which are completely flat, like the ray, make their swimming by flexing and straightening the fins themselves and the outside circumference of the body.

10. Perhaps one might wonder how birds move at four points, either flying or walking, as if we had said that all blooded animals move at four. But we said not that, but not more than four. Anyway they couldn’t fly if their legs were removed, nor walk with their wings removed—just as a man does not walk without moving his shoulders. Everything brings about change by flexing and extension, as was said; everything proceeds on a substrate which is, to a point, yielding, so there must be a flex, if nowhere else, at least at the origin of the wing of insects (holoptera) and birds and the analogous part in others, e.g., fish. In some, e.g., snakes, the origin of the flex is in the flexes of the body.

The tail in winged animals is for straightening the flight, like the rudders in boats. This too must flex at the attachment. Therefore insects (holoptera) and those of the split-winged (ischoptera) whose tail is unfit for this use, as the peacock, the rooster, and in general those which are not fileers, do not go straight. None of the holoptera has a tail, so they are carried like a rudderless boat and bump into whatever they happen on, which is also true of the sheath-winged insects (coleoptera), as the dung-beetle and cockchafer, and the sheathless, as bees and wasps. The tail is useless in birds which do not fly much, as the porphry, heron, and all floaters; they fly holding out the feet instead of the tail, and use the legs instead of a tail for straightening flight.

The flight of holoptera is slow and weak because the nature of the
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wings is not in proportion to the weight of the body, for the weight is great and the wings small and weak: in flight they work as a barge trying to travel with oars. Both the weakness of the wings themselves and of the attachment contribute something to what we describe. In birds, the tail of the peacock is useless sometimes because of its size, sometimes because of its moulting. Birds are quite opposite to the holoptera in respect of the nature of the wings, especially those birds which fly fastest. The curved-taloned birds are an example— their speed of flight is useful for their life. The other parts of the body too seem to follow for the specific movement— they all have the head small and the neck not thick, the breast strong and sharp, sharp to be well-strung like the prow of a light boat, strong in the growth of flesh, in order to push away the air it hits on, easily and painlessly. The back parts are light and come together to a narrow part, in order to follow the front parts, not dragging the air because of the width.

11. Let's leave this as it is. It is obvious that an animal which is to walk erect must be a biped and have the upper part of the body lighter and the lower heavier. That’s the only way it can carry itself easily. Thus man, the only erect animal, of all footed animals has his legs proportionately longest and strongest in comparison to the upper part of the body. What happens in children makes this clear— they are not able to walk erect because they are all dwarflike and have the upper part of the body larger and stronger than proportional to the lower. As they get older the lower parts grow more, until they get the appropriate size, and then their bodies walk erect. Birds, being light, are bipeds because their weight is in back, the way they make bronze horses with the front legs lifted. The main reason birds, being bipeds, can stand, is that they have a hip like a thigh and so long that they seem to have two thighs, one in the leg to the joint, and the other to this part from the seat; but it is not a thigh, but a hip. If it were not as long, a bird would not be a biped. If they were like men and quadrupeds, the thigh and the rest of the leg would be straight from a really short hip, and their whole body would have a great tendency to fall forward. In fact the hip is long,

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stretching all the way to the middle of the belly, so that the legs support the whole body from there. It’s also obvious from all this that birds cannot be erect in the sense that men are. In fact the nature of the wings is useful to them as they have their body, but would be useless if they were erect, as they draw the winged cupids. It is also clear from what we have said that neither man nor anything else with this sort of shape could be winged, not only because it would move more than four points although blooded, but because the possession of wings would be useless to them when moving naturally; yet nature does nothing unnatural.

12. We have already said that if there were no flexing in the legs or in the shoulders and hips none of the blooded animals with feet would go anywhere, and that there would be no flexing if nothing were standing still. We have also said that men and birds, both bipeds, flex their legs in opposite directions, and that quadrupeds flex oppositely to themselves and to men. Men flex their arms toward the concave, but the legs toward the convex; quadrupeds flex the front legs toward the convex and the back toward the concave, and the birds do the same. The reason is that nature creates nothing in vain as was said before, but everything for the best of the possible alternatives. So since in all animals which naturally have the power of local movement on two legs, when one leg is standing still the weight is on it, but the leading foot when moving forward must be put out without weight on it, and progression continuing the weight must be put on it again; consequently the leg once flexed must obviously become straight again, the point on the preceding foot and the shin remaining at rest. This can happen while the animal goes forward, if the leading leg has a forward flex, but if it had a backward flex this would be impossible. In the one way, extension of the leg occurs as the body is carried forward, but in the other as it is carried back. Besides, if the flex were backward, placing the foot would occur in two opposed movements, one backward and the other forward; for in flexing the leg one would have to pull the end of the thigh back and the shin down from the joint forward, to move the foot. With the flex forward, progression of this kind occurs not with
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opposed movements but with one forward motion.

Man, a biped which naturally moves from place to place by means of legs, flexes his legs forward for the reason we have given; it is also reasonable that his arms flex toward the concave. If they flexed the opposite way they would be useless for the use of the hands and for getting food. Viviparous quadrupeds must flex the front legs toward the circumference, as these lead their progression and are in the front part of the body; this is for the same reason as in man, as they are similar in this respect. So quadrupeds flex forward in the way described. With the flex occurring in this way they can lift their feet a long way off the ground; if they were to flex them the other way they would get them only a little off the ground because the whole thigh and joint where the shin is attached would get under the belly as it went forward. If the flex of the back legs were forward, the raising of the feet would be like that of the front (there would be a short lift of the legs, and the thigh and joint would both fall under the place of the belly); with the flex back, as it is, there is no impediment to the feet progressing in this type of movement. Besides, for the suckling quadrupeds it is necessary or better for this sort of function that the legs flex thus; for if they flexed inward it would not be easy to keep the young under themselves and to protect them.

13. There are four kinds of flexes in pairs, for necessarily: either both front and back flex toward the concave, as A, or in the opposite way, to the convex, as B, or inversely, not in the same direction, but the front to the convex and the back to the concave, as C, or the opposite of this, the convex toward each other, and the concave out, as D. No biped or quadruped flexes as A or B; quadrupeds flex as C; as D, none of the quadrupeds except the elephant, and man his arms and legs; these he flexes to the concave, and the legs to the convex.

In man the limbs always have their flexes alternately opposite, e.g. the elbow to the concave, the wrist convex, and the shoulder convex; similarly in the legs the thigh flexes to the concave, the knee convex, the foot again to the concave. Obviously the lower limbs flex the opposite way to the upper; for the origin is opposite:

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the shoulder is convex, the thigh concave, so the foot is to the concave, the wrist to the convex.

14. The flexes of the legs are thus for the reasons given. The back legs move diagonally in relation to the front; for after the right front, the left rear moves, the left front and after that the right rear. The reason is that if the front feet were to move at the same time and first, the walking would be interrupted or even have a tendency to fall forward as if the back feet were dragged along. Besides, this sort of motion would not be walking but jumping; but it is difficult for anything to move continuously by jumping. Evidence: those horses which make their movement in this way, e.g. on parade, soon get tired. So therefore they do not move the front and back separately; if they moved both right feet first, they would get outside the supports and fall. If they must move in one of these ways or diagonally, and these ways are impossible, they must move diametrically; moving thus they will suffer neither of the problems mentioned. And that's how horses and other such animals stand, with their feet advanced diagonally, rather than with the right or left feet simultaneously. Animals with more than four feet also move in this way; for the back feet always move toward the front diametrically in the four consecutive feet. It's obvious in those which move slowly.

Even crabs move the same way— for they are many-footed. They too move diametrically, wherever they go. This animal moves in a peculiar way, for it alone of animals does not move forward, but to the side. But since 'front' is defined by the eyes, nature has made the eyes able to follow the limbs; for they move toward the side, so, thanks to that, in a way crabs too move forward.

15. Birds flex their legs as quadrupeds do. In a way they have a similar nature; for the wings of birds replace the front legs. Thus they flex the same way as in quadrupeds, since the natural origin of change in birds, for their movement for progression, is from the wings; for flight is their proper movement. Thus no bird could either stand or progress deprived of its wings.

Besides, the bird is a biped and not erect, and the front part of the body is lighter, so it is either necessary or better for being able to stand up
that it has the thigh underlying as it is: I mean that it has grown toward the back. But if it should be that way, the flex of the leg has to be toward the concave, as in the back feet of quadrupeds, for the same reason which we cited for viviparous quadrupeds.

In general, in the case of birds and insects (holoptera), among flying animals, and those which swim in the water, i.e. those progressing in the water by means of organs, it is not hard to see that it is better that the parts mentioned be attached at the side, as indeed is true of birds and insects. The same for fish: wings are to birds as fins are to fish; also the wings of insects are attached at the side. Thus they bring about movement fastest and strongest dividing the air or water; the back parts of the body also would follow the front, carried on yielding water or air.

The troglodytic oviparous quadrupeds, e.g. the crocodiles, lizards, geckoes, turtles, and tortoises, all have the legs attached at the side and stretched on the ground, and flexed to the side, because that way they are useful for ease of crawling under things and sitting on the eggs and guarding them. As their legs are outside, they have to pull in the thighs and put them underneath themselves to bring about a lifting of the whole body. But when this happens they cannot flex in any other way than out.

Bloodless footed animals are all man-footed and none are quadrupeds, as we said earlier; thus all their legs except the extreme ones must be attached from the side and flex upward, and obviously they must be bent under toward the back. In all such animals the middle legs must both lead and follow. If that's how it is, they would have to flex both forward and back, because they lead toward the front and follow toward the back. Since both must occur, they therefore are bent and have the flexes to the side—except for the extreme feet. These are as their nature tends, as leaders or as followers. Besides, they flex this way because of the number of legs; there is less impediment and banging into each other this way. The 'bentness' is because all or most are troglodytes; it is not possible to be tall and live in this way.

Crabs have the oddest nature of the polypods; they do not

progress forward but, as we said before, alone of animals have many leading feet. The reason for this is the hardness of the feet, and because they use them not for swimming but for walking; for they always go on foot.

The flexes of all the polypods are to the side, as are those of the troglodytic quadrupeds—these are, for example, lizards, crocodiles, and all the ovipara. The reason that they are troglodytic is in some cases for giving birth, in others for the whole life.

17. Although the limbs of the others bend because they are soft, as lobsters are hard-skinned, their feet are bent for swimming and not for the sake of walking; the flex of crabs is to the side, and not 'bent' as in the oviparous quadrupeds and the bloodless polypods, because their limbs are hard-skinned and shell-like; they are not swimmers and are troglodytes, for their life is on the ground. Also the form is round, and does not have a tail like the lobster; that is useful to lobsters for swimming, but the crab is not a swimmer. Also it alone has the side like the back, because it has several leading feet. The reason for this is that it does not flex forward nor is it 'bent'. The reason it is not 'bent' was stated earlier, the hardness and shell-likeness of the skin.

Therefore they must proceed with all feet and to the side; to the side because the flex is to the side, with all of them because the feet remaining at rest would impede the moving ones.

Flatfish swim as one-eyed men walk, for the nature of these fish is perverted.

The web-footed birds swim with their feet, and because they take in air and respire they are bipeds, but because they have their life in the water they are web-footed; as they are, the webbed feet are a useful replacement for fins. They don't have their legs as other birds do, in the middle, but rather back; as they have short legs, they are back to make them useful for swimming. They have short legs because nature has taken away from the length of the legs to add it on the feet, and instead of length gave thickness to the legs and width to the feet; for thick and wide feet are more useful for pushing away the water than long ones, when they swim.
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18. It is reasonable that winged animals have feet, but fish are footless. Birds have their life in the dry element, but cannot always remain up in the air, so they have to have feet; the life of fish is in the fluid element, and they take in water not air. For fish, fins are useful for swimming, but feet would be useless. If they had both they would be bloodless. Birds are in a way similar to fish—birds have the wings above, and the fish have two fins toward the top; birds have feet underneath, fish have fins underneath near the top ones, in most cases; birds have a tail and fish a tail fin.

19. One might wonder about testaceans, what movement they have, and if they do not have right and left, where they move from; they obviously move. Or must the whole class be assumed to be maimed, moving as if someone cut off the legs of a footed animal, like the seal and the bat. These are quadrupeds, but badly. Testaceans move, but move unnaturally. They are not mobile, but in comparison to sedentary and attached things they are mobile, and in comparison to animals which progress are sedentary. Crabs have the right poorly, but they have it— the claw shows it, for the right is larger and stronger, as if right and left wanted to be distinguished.

So that's how it is concerning the parts, among others those concerned with the progression of animals and with all change in place; now that these things have been determined, we should next investigate the soul.
lengthwise to a circle, flexes his legs in the natural way, clearly they will flex toward the rump and backbone. If, falling backwards, we flex our legs as far as they will go, the heels touch the rump; so the natural flexing of the feet is toward the backbone. That is the same as flexing toward the convex circumference: this is what he means when he says, for man flexes the leg around the circumference. We must understand the word 'convex' here, so the gist will be: 'For man flexes his leg around the convex circumference of the circle generated by the flexing of his body. But in the case of the bird, as it naturally flexes the legs around the chest, and not around the backbone, clearly it flexes its legs around the concave circumference of the circle which it generates.' 'Around the chest' is the same as flexing around the concave circumference of the circle; this is again clarified by, but the bird around the concave (704a21).

Again, let the hand touch the head and make a circle having as convex circumference the elbow and the whole outside of the forearm and hand to the nails, and the whole inside concave; clearly the natural flexing around is the concave circumference of the circle. Now let the front foot of the quadruped touch the head, and generate a circle having as concave circumference the front part of the foot, in man called the 'shin', and the back part, in man called the 'calf', be the convex circumference; clearly the front feet naturally flex toward the convex circumference. Then let the back foot touch the head and a circle be generated having as the convex circumference the backbone, the concave the chest etc.; clearly, then, it flexes toward the concave. Obviously men and birds flex their limbs in opposite ways; the legs around the convex, the arms around the concave. Quadrupeds, moreover, flex the front legs around the convex and the back legs around the concave. But those quadrupeds which are not viviparous (704b5), e.g. lizards and the like, flex the legs to the sides, and not as the viviparous quadrupeds.

2.704b12: The beginning of the investigation is in the propositions which we are accustomed to use often.

When he has presented the problems to be solved, he says that 'the facts have been presented in the Natural History, but we must now seek the reasons why they are as they are,' and adds that we ought to have a principle, an axiom, and common notion of the investigation. 'Since we have set forth the subject, let us state that principle which we often use in natural investigations, that "nature does nothing in vain" (704b15).' The phrase, accepting those which are this way in all the works of nature (704b15) means, 'in all natural works nature crafts

her works in this way as much as possible.' For, of what is possible about each kind of animal (i.e., form or subject), she always does the best and that which fits the underlying entity and form. The words, to take the things which are this way, refer to the principle 'nature does nothing in vain, but always prefers that the best of all the possibilities be present in each animal,' as he points out himself, saying, one of those principles is that nature does nothing in vain (704b15). Having said that she always does the nobler and the best of what is possible, he adds, because of that which is better, by that it is also natural (704b17). Put a comma after διαντικρίνεται and continue with εἰσάγαγε καὶ ἔχει καταφύλαξις. Furthermore, δεικτίζει is not an adverb, but two words. The meaning is, 'things are naturally because of the better, which nature chooses.' What follows is clear; that all movement is by pushing and pulling, and what pushing and pulling are, is shown and explained in Physics VII.

3.705a3: Of those animals which change in place...

He lists the directions in which change occurs, and says that 'those animals which jump move with the whole connected body at the same time, but others move part by part; for the front foot extends forward, then leaning on this on the ground it pulls the rest—this is called 'walking'. Both walkers and jumpers move against something underlying; underlying the footed animals for stepping or jumping is earth or wood or stone or something else earthly and hard, for water animals it is water, for winged animals air. Therefore if the underlying stuff slips off and gets away, as happens in some cases—sand, grain, nuts, and many others—if this slips away and gets off faster than the one moving on it supports his feet, he would have absolutely no support, as happens to land animals in water (for they cannot support their feet, to progress in the water); and in a threshing floor full of grain without husks or full of nuts, walking is not easy, but very painful and difficult, because the grain or nuts slip away faster than those walking on them find support. If then, as was said, the underlying stuff is carried away, as in the threshing floor full of nuts or grain, or there is no support, which happens to land animals in water, it is not possible to move on these materials either by walking or by jumping. He says that in both kinds of movement the mover always moves by leaning against something (705a8) and adds that the jumper too leans on his own upper part (705a12), i.e., the jumper jumps not only supporting its feet on the substratum (for he is obviously talking about land animals with feet), but also on his own upper, meaning by 'upper' the upper parts of the body. For the upper arm leans on
the forearm, being higher than the forearm, and the forearm the wrist. Supports are

generated on the joints, of the upper arm on the elbow, which is called both

\( \delta \gamma \kappa \alpha \iota \nu \) and \( \omega \lambda \kappa \varepsilon \kappa \alpha \varepsilon \alpha \iota \varepsilon \); since the flexing of the arm occurs in the elbow,

its support is also in this part. The forearm is supported where the wrist bends,

and the wrist where the fingers bend. The higher is always supported on the

lower and generally the pressing on the pressed, meaning by ‘pressing’ the upper

and ‘overlying’, and by ‘pressed’ the lower and underlying. As our feet, when

we walk, press and push against the earth and are thus supported, so too in

jumping the upper arm presses the lower arm, and the lower arm the wrist, and

the hip presses the thigh and the thigh the lower leg. To show that every movement

is generated by leaning or support, he cites the case of the athletes in the

pentathlon who jump higher when they have the ‘dumbbells,’ meaning by

dumbbells the wooden balls which they hold in their hands when they jump;

for some support, as it were, is generated by such balls. Also, those who run

swinging their arms run faster (705a17); for in the extension of the arms there

is some support of the forearms on the hands. So all change in place happens by

means of support (\( \delta \pi \varepsilon \rho \varepsilon \iota \varepsilon \sigma \iota \varepsilon \)), which is the same as ‘by means of pressing

and being pressed,’ or ‘by means of compressing and being compressed,’ and

the mover must move using at least two parts, i.e., the mover must make change

in place from pressing or compressing and being compressed. Clearly movement

occurs from compression, for when Socrates extends his left foot, for example, and

pressing it on the earth pulls the right, the left foot, standing still, supports

and carries not only the right foot, but the whole rest of the body; since it carries

the rest of the body, it is pressed by it in order to carry it. The right foot, also

carried along, is extended (705a22), i.e., thrust forward and extended by

the left foot, which is bearing the weight; but when it has been thrust forward, it

takes the one which stands still and carries the rest of the body, being

compressed and thrust forward the left, and the left becomes the one taken

along and thrust forward. Therefore nothing without parts... (705a23), meaning by \( \delta \mu \varepsilon \lambda \varepsilon \xi \)

not having the organic parts for movement. Therefore nothing not having

organic parts for movement is able to move, so that which supports itself moves

by means of the organic parts; for things without parts do not have distinction,

meaning by this word the articulation of the organic parts. If something does not

have this distinction, then acting or ‘pressing’, on the one hand, and being acted

upon or ‘being pressed’, on the other, would not be possible. This is clarified

by the words, for it does not have in it the distinction of passive and active

(705a25).

4. 705a26: The dimensions are six in number...

Then he distinguishes which sorts of living things have the six dimensions, up and down

front and back, right and left, and which sorts have four, and which only two. He

says that these six are all of the dimensions, and that all animals have an up and
down. There is even an up and a down in plants; since we call ‘up’ the mouth, where

the food goes in, and ‘down’ that through which the residue of food goes out, and

since no living thing can live without food, all living things must have an up and a
down. In men and all animals which walk erect, up and down are distinguished

not only functionally but also positionally, relative to earth and sky. The mouth

is said to be functionally up for the reason mentioned, that ‘up’ designates the

part through which food enters, and it enters through the mouth. The mouth of

man has the upper place not only functionally, but also positionally, for it is toward

the up of everything. The entire head, including mouth, ears, and eyes, tends toward

the sky. The up of man, the mouth and whole head, is up both functionally and

positionally, but in quadrupeds this part is functionally up, but not positionally;

the head and mouth of quadrupeds are placed toward the sides of the universe.

If, for example, a horse or bull moves from south to north, or stands looking

north, his head and mouth especially the part analogous to the crown of the head

are placed toward the north; but if he moves toward the east, the part

analogous to the crown and the whole rest of the head is positioned to the east;

similarly if he moves or looks toward the west or south. So that if their mouth

and with it what is thought to be the head is called ‘up’ because of its function,
it is not positionally up. Similarly in plants, that which is functionally up is not

positionally up, for the function of the mouth in animals is performed by the

roots in plants; the roots are actually placed toward the down of the universe,

for they are rooted in the earth. Thus Aristotle says, Yet it might seem that

‘down’ is more special in plants (705b2), using the word ‘special’ instead of

‘better’ or ‘strongest’ or ‘principle.’ For up is better and stronger than down,

and is the principle of it and the other dimensions; if there were no up there would

be no down, and if there were no up and down there would be no right and left

nor the other two. Since up is better than down, and up is judged by position

and function or by function alone, but plants have their ‘up’ (roots) toward the

‘down’ of the universe (earth), and their ‘down’ (branches) toward the ‘up’ of

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the universe (sky), if one defines 'up' not positionally but functionally, it would appear that the 'down' of plants is better and more special. So, functionally, the roots are not down, but up, and the branches down, though positionally up. Up and down are functionally similar in animals and plants, but not similar positionally in relation to the universe. All living things have up and down.

4.705b8: Those things which not only live but are also animals have a front and back as well.

He explains which ones have front and back: 'All animals perceive; the direction from and toward which sense-perception functions is the front, and the opposite is the back. Those which, besides perceiving, move from place to place through their own efforts, have, besides the distinctions named, that between right and left, *functionally but not positionally; for up and down are not normally situated.* The function of 'right' is to be the origin of movement; there in the body whence change in place naturally originates is the 'right', and the opposite, which follows it, is the 'left'.

That all animals move in place have right and left, and that the origin of this sort of change is the right, is argued in the *Movement of Animals.* It was said that they have right and left, but 'in some it is more articulated than in others.' In those which have organic parts such as feet, wings, or the like, for local movement, are, in the aforesaid respect, more articulated (705b25), and more obvious, meaning by the aforesaid, right and left. Those animals which do not have these organic parts proceed by separating the body itself as if there were articulations of organic parts, for the flexes which a snake uses to move when it wants to go forward replace the use of organic parts. Such animals have right and left all the same, although not as obviously as do the organic parts of those which have them.

As evidence for his statement that 'the right is the origin of movement' (705b30), he mentions the fact that weights are carried on the left 'in order that the right, which is to initiate movement, might be free,' and also the fact that it is easier to hop on the left foot. It is easier to walk with a lame foot on the left than with a lame right foot, for since the right is the origin of movement, when it suffers, it fulfills its function very badly, but the left, because it is naturally constituted to follow the right, fulfills its function rather less badly. To show that the origin of movement is from the right, he says that the left foot is 'put forward' and extended first at the beginning of the race, as if the right were originating the

movement. He adds that the right is the same in all (706a10); it is not the case that the right is the origin of movement in some, and something else in others, but in all things the origin of movement is correctly said to be the right. The strombloids (the curved testaceae) have as origin of movement every part of themselves except the spiral; they do not move from the spiral or to the spiral, but in the direction opposite the spiral. Since they move from every part except the spiral, and the spiral is nothing in comparison with the whole shell, we may say that the right is every part of the strombloids, those with curled shells.

He then says that man has the left 'more detached' (706a18), i.e., more articulated, and the left differs more from the right, because man is the most natural of animals. Up in us is naturally toward the up of the universe, and down similarly toward the down of the universe, so man is naturally erect.

5.706a26: He continues: 'All those animals in which up is one thing and front another (in which these dimensions are distinguished and separated from each other), as in men and birds, are two-footed.' Since, as he will show, everything moves at four points at least, birds have wings and men have arms instead of legs at two of the four points. Those in which up and front are distinguished are bipeds, but those in which they are not distinguished have up and front the same, for the forefeet of horses, cows, and other quadrupeds are both up and front. That which is down in quadrupeds is the back feet; but the hands are up in man, for they are close to the neck, and these are the front feet in quadrupeds. Thus the same thing is both up and front in quadrupeds, they are not distinguished. But in man, up is different, for the top of the head is toward the up of the universe, the sky; for the top of the head we say to be a sign of a part of the sky; but the front, the part with the sense organs, is toward the sides of the universe, for it is toward the east, west, south, or north, or wherever the man happens to be looking. In the horse, the top of the head and the organs of perception are both toward the sides of the universe, so clearly it has up and front in the same place. He adds that quadrupeds, polypods, and footless animals are similar in having front and up the same.

Defining the word 'foot' (πόδα), he says that it is derived from the word for 'ground' (τέδεω) (706a33). Cephalopods (malakia), he says, have front and back in the same direction, for the back has been brough around to the front, and a circle has been made; he says the same thing in the *Parts of Animals.*
where the organic parts for movement are connected, that there be some psychic power and origin of movement of each of the organic parts (also of rest, for the cause of motion is the same as that of standing still; now since (2,3) the common part must be present and the origin and cause of movement and rest must be in the common part, clearly (4) there will be a particular movement for each of the aforementioned sets of opposites, up and down, front and back, right and left (movement up and down is different from those of the other two sets of opposites). All these parts, in which these oppositions are observed, have a common cause and origin of movement according to the previously mentioned interconnection of the parts (706b26). He means by ‘interconnection’ (symphysis) the nerves by which they are connected. When he says, ‘according to the interconnection of the previously mentioned parts,’ he specifies which parts by adding, I mean the right and left (706b27). I think that is what he means. The kit, where both move in opposed movements (706b20) amounts to ‘wherever that which moves naturally moves, whether in air, or water, or on land, it does so with one part resting and the other moving.’ The words, opposed movements, fit quite well with at which both move, for that which can move up, can move down. Instead of saying in the plural, ‘since there must be common parts, according to which they are connected with each other,’ he puts it in the singular and says, ‘since there has to be something common, according to which they are connected,’ and thus instead of saying, ‘and here are the origins,’ he says, ‘the origin,’ in the singular. Or one could understand, ‘that which is in each one,’ and thus he would mean, ‘since in each conjointing the organic parts there must be something common,’ and so on.

6.706b28: The differentiation of front and back is not such...

Next comes the demonstration that blooded animals move at four points. He has said that the organic parts are connected by a psychic power-- if this were not the case, these parts would be soul-less, senseless and completely motionless. Where there are no organic parts, there is no common part, but if there is no common part, there is no motive principle. There are six oppositions, in three pairs, so that if one shows that there are no organic parts for one pair, clearly there will be no source of movement, and if no source, no movement. So by elimination there is movement for two pairs, and there must be a motive principle for them. The two pairs are divided into four points, so movement of blooded animals is at four points; I have already said
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that. He now argues that for front and back there is no 'separation' (διάδωρηση), which means articulation of organic parts through which local motion is accomplished. This is obvious in men; for the right foot is the motive point of the right, and the left of the left. Since there is not only a lower right and left, but also an upper right and left, the right hand and shoulder are the motive point of the upper right, and the left of the upper left; the right foot of the lower right and the left of the lower left. So in man up and down, right and left, are clearly motive points, but front and back are not. Of course man moves forward, in the direction of perception, but this sort of movement is made by means of the right and left, upper and lower. That man moves at four points, like the quadrupeds, Aristotle will prove more generally as he proceeds. Anyway, in quadrupeds the feet called 'front' are not front points, but up, if they are analogous to hands, as he says in the Parts of Animals. What he says here is enough to show that those who think that there are front feet do not really believe that they are the turning points of the frontal parts. He shows that there is no separation or articulation of the organic parts for forward and backward, from the fact that there is no natural movement backward. If there were organs for backward movement, they would be useless (ματητήν), for nothing moves backwards naturally. So since there is no backward movement, and thus no organs for backward movement, there are no distinct organs for forward movement. Two pairs are left. 'And because of this, those animals which proceed using organic parts do not have organic parts with the distinction of front [and back], but with the other two distinctions, first and by the naturally prior argument (logos), with the distinction of right and left, since a difference between right and left is noticed first in those animals which are observed moving at four points.'

6.707a6: Now since up and down...

He now calls 'common origin and control (κορίσκοι) of movement' the soul in the heart, from which as from a root and spring the motive causes of the organic parts go forth. He calls it the control of movement because the other parts get movement from it and because of it. But when he first says that there is something common, from which as to some common limit the organic parts continue, how can he now say that the limbs themselves are connected and attached because of a common origin? or is this origin the cause not only of these but of all parts being together? for bodies expire and rot when it has left. Since, he says, the parts are connected because of it, the cause of all these movements, the origin and control of movement in everything which is to move well and directionally, must be defined, and ordered in the separations toward these origins; the separation of the control of the movements from the other origins 'colonized' into the connections of the organic parts and moving them must also be defined; there is not one definition for their connection and another for their separation, but one definition and measure of the relation.

Since that how it must be, clearly movement in place belongs only or especially to those animals which move at two or four points. He has said that no case of motion at two points has ever been shown, since even man moves at four. So, since this occurs almost exclusively in blooded animals (7.707a19) ('this' refers to the possession of a common origin, necessarily equidistant from the origins in the organic parts and giving them the power to move the organic parts), clearly no blooded animal moves at more than four points, and every animal which moves at four points is a blooded animal.

That's the sense of this section. By 'antistoichous' movements (707a11) he means the opposites, e.g., up and down, and by 'syntoichous' the not-opposite, e.g., say, up and right. When he says that 'the cause of the aforesaid movements must be defined and arranged with separations,' he explains what the 'cause of the aforesaid movement' is by inserting: This cause is the common origin from which the movement of right and left of all the parts in the animal (707a13). This origin must be related to each of the organic parts; he says how it must be related to each part: approximately the same relationship to each of the origins in the parts we mentioned (707a15). The word 'έχει' is left out in the text, so the whole thing should read 'it has the same relationship.' The text fits in like this:

'For it is not because the connections have the common origin 'colonized' in themselves, that I say that the common origin must be related to each of them; for the connections do not have it in themselves, that have the powers given them by it; but it must be related to each of the 'mentioned' or organic parts according as it equally approaches and draws near each of the origins in these organic parts.' That, in summary, is how the argument goes. Since right and left, and up and down, are connected to each other at a common origin, and since everything which is to move from place to place efficiently must have the cause of all the psychic powers definitely located in relation to these directions, not nearer one than another, it is clear that only or mostly, etc. (7.707a17).
Having said that blooded animals have one common and unitary origin, equidistant from the powers (dynamai) given by it to the organic parts, he adds: What actually occurs in animals agrees with what we have said (7.707a23): a clear sign and proof that things which move at four points have a common origin can be observed in animals. If a blooded animal is divided into several pieces, none of the pieces is able to live, for no part separated from the whole is able to take the vital power disseminated by the common origin; but bloodless animals have many origins and because of this are not naturally continuous. The naturally continuous has one origin, and the several psychic powers are derived from it and disseminated to the organic parts. In bloodless animals, the several parts which have origins resembling the common origin in blooded animals, are able to live even when separated, just as blooded animals do; for potential origins are scattered in the various parts of bloodless animals, as the nutritive power is in plants, and when the animal is divided these become actual origins. In blooded animals, however, the common origin is not potentially scattered in the parts, but is definitely in the heart. So it is clear from this that things which move at four points have a common origin.

Not only do the cut pieces of bloodless animals live a long time, they even move with the same movement which they had before being cut; 'for the back part of the centipede (skolopendra) continues to progress in the same direction as the front' (707a32). Let the centipede be represented by the line AC, and cut at B, let the head be represented by A and the tail C. So where AB goes, BC goes too, C (the tail) is not turned toward B, where the cut was made, but the cut BC looks toward the cut of AB. Having said that bloodless animals when divided live, he explains why: 'The reason why they live when divided is that they are as it were something continuous (707bl). The meaning is something like this: 'just as Socrates and, generally, each animal is an individual because it has a common origin and lives and exists through it, so too since each part of the bloodless animals has an origin in itself which is analogous to the common origin in each of the blooded animals, in a way the individual animal is constructed of many animals, and when divided the parts can live because they have origins in themselves which are analogous to the common origin in each of the blooded animals. It is also clear (he adds), that such animals are constructed unnaturally; for those constructed most naturally are made to move at two or four points.'
also in snakes. For when A becomes more convex and B, conversely, becomes more concave, C stretches out and follows; for if curve A is to become greater and more concave than it is, C must follow. Now the right, i.e. A, leads, and C responds (707b16), i.e. it follows; then concave and convex reverse, and B, which was concave, becomes convex, and A, which was convex, becomes concave; likewise D goes from concave to convex, and C from convex to concave; and again A is convex and B concave, and so on.

The general reason why snakes flex is their length, he says (707b17). Just as tall men are 'swayback' when they walk, so too snakes. Swaybackedness goes like this: 'when the right shoulder leads forward' (for as in quadrupeds one of the front legs leads, and one of the back follows, so too in man one of the shoulders leads and one leg follows: let it be the right that starts here), 'and the left hip follows,' but not as it should, rather leaning back and inclining toward the right, and the middle of the body between shoulder and hip generating a sort of arc of a circle having the convex curve the left ribs and the concave the right; when the left shoulder leads, the right hip will follow, the ribs become convex and the left concave. This concave, of this 'arc' he calls a swab (jordon).

Snakes move with "swayed" points or parts, because they too move diametrically. The rest is clear.

He says that some of the snake-like (water) animals do not have fins for movement, but use the sea; they move in the sea by flexing as snakes do both on land and in the sea, for as snakes move on land, so too in the sea or any water. Such animals which are accustomed to living on land and have only two fins, as the eels, use fewer or shorter flexes in the sea because their fins cooperate for movement in the water, but bigger flexes on land because the fins do not cooperate in movement on land. He says 'fewer' instead of 'one'; the meaning is that they use one flex in the water. Since they use the two fins in the water, if they were to use also two flexes in the water, they would move at more than four points, although blooded animals. But on land the fins are never useful for movement, just as oars are of no use to sailors on land. So they use more, i.e. two, flexes.

8.708b9. What he says about the footlessness of snakes is clear enough because he has said the same thing in the Parts of Animals and we have said enough about it in our commentary on that passage.
9.708b21: The following shows that if nothing were at rest, there would be no flexing or extension...

Having assumed that every change in place is brought about by moving and resting points, he now undertakes to demonstrate this, and says, if nothing were at rest, there would be no flexing; if the antecedent, so too the consequent. Obviously when flexing occurs, something remains at rest; if there were nothing at rest, how could extension of one leg be effected, so the other remaining could bend? In general, everything which flexes was previously at rest and straight. The consequent he demonstrates in many ways: first he reminds us very clearly what 'flexing' is, through what he says about it also in Meteorologica. He says too that in all the changes mentioned, i.e., those generated by feet and by flexes, the flexing or extension must occur in relation to a single point (9.708b26). This is obvious in animals with feet, for they flex and extend at the knee; similarly in footless animals. He does not say that flexing and extension occur at an 'indivisible' or mathematical point, but at a physical point.

Having said that if there were no standing and rest there would be no flexing, he continues, Furthermore, if there were no flexing, there would be no swimming, walking, or flying (708b27). He then shows that flexing is necessary for change in place; he shows this first for bipeds, and the same demonstration fits all polypods; then he shows the same thing for footless animals. This is demonstrated graphically and with geometrical necessity, thus: Think of Socrates standing with neither foot extended; clearly he stands at a right angle (to the ground), for everything stands at a right angle— if one of the angles were to become acute, the other would become obtuse, and the standing person would fall in the direction where the acute angle was generated. It is also true that when Socrates is standing he generates an isosceles triangle having the apex at the anus, the legs Socrates' legs, and the base the straight line drawn on the ground from one heel to the other. Now let Socrates begin to walk and extend, perhaps, the right foot. Clearly when the left stands and carries the weight of the whole body, it stands toward the right angle; if it did not, he would fall, as was said. Now a right angle is generated with the advancement of the right leg, the hypotenuse being the right leg with the knee straight. And since it is demonstrable that in right triangles the square on the hypotenuse is equal to the sum of the squares on the other two sides, clearly the hypotenuse (or right leg) is longer than either of the others; this is demonstrable by another theorem also, that the longer side subtends the greater angle. So the right leg is longer than the left leg because it subdends a larger angle, and because the square constructed on it is equal to the sum of those on the other two sides. But the right leg was equal to the left before it advanced; clearly then the left has been flexed at the knee, has become shorter than the right by flexing, or as it were, 'folding'. So the leg which stands and carries the whole rest of the body must flex, the part from the knee to the heel standing straight, the part from the hip to the knee flexed.

This is the demonstration that walking requires flexing and we have presented it in advance for the sake of clarity. Let us now proceed with the text. As one leg advances the other must flex (708b30). Since the 'limbs' (Socrates' legs) are equal in length and "corresponding" or relatively opposite (for right and left are relations), and that which stands under and carries the weight of the rest of the body must be "perpendicular," as he puts it, to the ground, but when the right leg, e.g., advances, it subtends the right angle and has the power of the one which remains plus that of the line between them (709a1)— that is, it has the power of the square equal to the sum of the squares drawn on the left leg and the base, 'now since,' he says, 'the two legs are equal in length, but in advancing the advance of the one remaining becomes shorter than the one remaining must flex; thus it becomes shorter than that which advances while being equal. He adds that one must flex at the knee or "at the joint;" the elephant, because it does not have knees, flexes at the "joint," meaning the one at the hip.

As evidence that the remaining leg flexes and becomes shorter during movement in place, and the advancing leg becomes longer, he adduces what happens when one walks along a wall. If we think of a man walking along a wall, having on his head a reed dipped in ink, touching the wall, the line drawn on the wall by the ink would not be straight but crooked, as in the diagram ABCDEF.

For when Socrates advances one leg and gets shorter because of the flexing, necessarily AB is drawn, but when this leg rests on the ground and the other is "pulled," BC is drawn, until it is level with the one left. For when the advanced leg "pulls" or is lifted and becomes taller, BC is drawn until both legs are even.
But when the one moving advances, then CD is drawn, because he has gotten shorter again in flexing. The same can be said for DE and EF. If someone were to walk along a wall as high as his eye-level, and someone else the same height were to stand on the other side of the wall, he would not see continuously the top of the head of the one walking, but when the walker extended his leg, he would not see the top of his head because of his becoming shorter, but when the advanced foot is pulled up, he would see the head because it is lifted and gets up to its height again.

He goes on to say that it is also possible to move without flexing the leg, as children crawl and those with their lower legs cut walk on their knees. But if there is no flex in the legs of children and menaced people, they have to flex at the hip. The old story that the elephant walks without flexing is false, for it moves by flexing at the shoulders and hips. But nothing move erect without flexing its legs; the menaced individuals mentioned and "those who proceed on their knees through the dust in the wrestling ring" move without flexing their legs. Nothing can move erect without flexing the legs because, "since the upper part of the body, from the head to the hip, is so great, the limbs must be long to be proportional to the upper part. If they must be long, flexing must occur, because a right angle triangle will be generated and the flex happens either in the knee or heel and the rest of the foot to the toes. But if it occurs in the heel and the foot to the little or big toes, the man will fall because the right angle becomes "less" or acute. But if, when one leg is advanced, a right angle remains, that generated by the foot which remains still, and this leg stays unflexed, it would be simultaneously longer and equal (709a18), i.e., the advanced leg would be both longer than and equal to the standing leg, which is impossible; 'longer' because it subtends a right angle and because it has the power of the remaining one plus the "subtending" (here he means the base line), but equal, since there has been no flexing in the starting leg, in order that it might become shorter than the advanced leg because of the flex." And he concludes by saying, "So the one which pushes forward must flex then (709a20). The word for is not two words, τό the article and τῇ the conjunction, but one word denoting time, and the meaning is, 'Then at the time that one of the foot advances, the remaining one must flex, and at the same time as this one flexes the other must extend.' By head (709a23) he means that of one who is walking, e.g. that of Socrates; for when, as was said, his leg is flexed, his head gets lower.

He shows that footless animals move from place to place by flexing, by showing that they proceed by undulating, which is flexing. Since footless animals proceed by undulating, and undulating is flexing, the footless then proceed by flexing. He says that undulating happens in two ways: some of the undulators flex on the ground, their flexes touch the ground, e.g. snakes; but some do not touch the ground with their flexes, they flex upwards toward the part analogous to the backbone, e.g. the animals called "flexers" (caterpillars); some move by "oozing" (709a29), as earthworms and leeches. He explains "oozing": these proceed with one part leading, and they draw the rest of the body up to it (709a31). The worm called earthworm extends the front part, and becomes very thin, but the back is thick; then after extension, the front part is at rest, and it brings the back up to it, and the front becomes thick, having been thin, and the back thin, having been thick. For when the back is at rest, and the front extended, the front is thinned and the rest part thickened; but when the front is at rest, and the back is pulled and drawn toward the front, again the front thickens and the back thins. Having said that some flex on the ground and some up, and having talked about "oozing", he gets back to 'undulating' again and says, Clearly if the two (lines) were not greater than the one, undulating animals would not be able to move (709a34-b2). The meaning must be this: let the flex generated by the body of the snake be ABC and let there be a line drawn AC; clearly if AC is equal to AB, BC, and not less, the animal cannot move, for ABC would describe a straight line. But if it were extended so that another line could not be drawn, how would it move? In the "oozing" animal, movement is possible even when the front part is extended forward as much as possible, because the back is gathered together, and there are, so to speak, two very short 'sections' (stout) which pull each other toward the front, and then it makes some 'sections' and flexes again, and thus it moves part by part. Except for them, it would be quite difficult to move without changing direction, the way oozers do. If someone says that AC would be equal to ABC, and that flexing and movement could be generated thus, let us see if one can generate on AC its equal. Let AC be a straight line and let it be flexed at D, so we have ADC; point A remains where it was before the flexing at D; only C moves and so AC has been folded, but in such a way that it has not changed in place. Obviously the two lines are longer than the one, and were moved.
diametrically, as was said just now.

He goes on to say that in all movement, whether with feet or undulation or eezing, the moving part proceeds by sometimes extending straight and sometimes flexing together. This is quite clear in man, for the leg which is extended and proceeds extends straight, and the one remaining and bearing the weight is flexed. If one looks, one can see this in a snake and other footless animals too; also the jumping animals make a flex in the lower part of the body (709b8), meaning by ἑπακέλευσις ('underlying', 'lower') the earth. But it is possible to understand the words 'the legs' underlying on the footing.

Man flexes at the knees to jump. The rest is clear from what is said about it in many places in the Parts of Animals.

10.709b20: Perhaps one might wonder how birds move at four points. . .

Someone might look at birds without understanding, and see them flying with wings only, which is the same as moving at two points, and walking with feet only, but since Aristotle has argued that all blooded animals move at four points, he says that anyone who wonders how do birds move at four points is on a wild goose chase. He resolves the problem in first by means of the so-called 'confrontation', and then by means of 'objection'. He says that he had not claimed that all blooded animals move at four points, but that they cannot move at more than four. For just as two points do not exceed that and cannot move at more than two, so four points cannot exceed four, and move at more. They cannot move at more than four points because then they would be bloodless animals. When he has dissolved the problem in this way, he also adds an 'objection': Anyway, they couldn't fly if their legs were removed. . . (10.709b24). If one cuts off the legs of a bird at the hip it won't be able to walk. So since the bird cannot fly or walk with two points removed, clearly it needs all four in order to move. Man too, in order to move his feet in walking, also moves at the shoulders; one cannot move without moving them.

The words up to a point go with for everything on a substrate (709b29); thus neither does any fish go through the whole sea, but swims a certain distance, nor does a land animal traverse the whole earth, but proceeds a certain distance. Also, as on something yielding makes sense, for if the air or water were hard and repellent, and neither yielded nor gave way, there would be absolutely no change in place. So clearly 'even if flexing were to occur nowhere else, it would have to happen where the wing in 'holoptera'

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(e.g., bees) and birds begins (is connected, whence it grows). He says that the tail is analogous to the rudders of the boat, adding that the tail flexes where it is rooted. In those which fly straight, the tail is useful for flying straight; in those which do not fly straight, but are carried along in a disorderly way like a mad animal, the tail is useless for straight flight. None of the 'holoptera' has a tail, so like a boat deprived of its rudders they are carried at random and run into whatever they happen upon. Likewise in birds which do not fly much the tail is useless; instead they fly holding out the feet. The rest is clear. Towed (710a19) boat means 'hug' boat.

He also says about the 'holoptera' that the weakness of their wings, and the weakness of the attachment of the wings (for they are not rooted deeply), contributes to what we have described (710a22), i.e., to the slowness of their flight. The tail is no use to the peacock because of its size and because it molts. It is not useful to the male peacock for both reasons, but to the female only because of the molting, for the female does not have the large tail. He says that the birds, and especially those flying fastest, have the nature of their wings opposed to those of the 'holoptera'; for the birds' wings are strong, and those of the 'holoptera' are weak. The curved-tailed birds, he says, have the breast sharp, like the prow of a 'light boat' (710a32), meaning a long narrow one. Their breast is also strong in the nature (growth) of flesh; for the flesh of their breast is strongest. He explains why it is strong.

11.710b5: Why an animal which is to walk erect must be a biped. . .

The cause (δύναται) instead of the fact (δύνατον) is now presented. The text continues, 'Clearly the animal which is to walk erect must be a biped and have the upper part of the body lighter, and the lower part heavier.' This and what follows is clarified in the Parts of Animals. Noting that if the hip of birds were not so long they would not be bipeds, he adds, for as in men and quadrupeds . . . (710b28); this is quite true; for if they had not a large but a small hip, and as in men and quadrupeds the thigh were straight with the hip, so it would be in birds too, the thigh would be straight from a short hip; but if it were thus, the body would have a strong tendency to fall forward.' Obviously, he says, even if the bird is a biped, and is said to be erect, it cannot be erect as man is. 'For otherwise the nature of the wings could not be useful to it, if the body did not have them placed as it does. If their body were otherwise, e.g., like that of men, the wings would be useless and not beneficial to them.
If they were erect like men, as they draw the cupids with wings, the wings would have drooped toward the legs; and in the first place they would drag on the ground (for they reach the end of the tail) and would impede them from walking well, and the tail would drag too, as it would be between the legs— that's where it would go if birds were erect like men; furthermore, when in flight the legs would hit the tail and give it trouble. Since birds can have wings only because they are not erect like men, if anything is erect it cannot have wings.

(12.711a7) He completes this account by saying, that, if there were no flexing... Clearly men and birds, both bipeds, flex their legs in opposite directions (711a12) and so on until similarly also in birds (711a17). Understand the word "clearly" so that the whole account would go, 'clearly men and birds'...

12.711a17: The reason is that nature creates nothing in vain, as was said before.

He here explains why man, being a biped, flexes his legs toward the convex circumference, and why quadrupeds flex their front legs convexly, but their back legs toward the concave. He shows this first in man, and says that men flex their legs and quadrupeds their front legs in this way for the same reason; afterwards he shows why quadrupeds flex their back legs the opposite way, and thirdly why birds, although bipeds, do not flex their legs as man does, but the opposite way. First, as usual, he explains that all footed animals flex their legs as they do on the basis that nature does nothing in vain, but always does the best possible in the circumstances; he has said that before.

12.711a20: So since in all those which naturally have the power of local movement on two legs...

Thence the explanation of the problem or problems. Put a comma between the weight must be put on it again and clearly the leg once flexed must become straight again... (711a24). The sense is, 'It has been shown that in whatever moves naturally by means of legs, the weight falls on the standing leg(s), and the advancing or leading foot is light; when it has gone forward, the weight again falls on it, so when continuous progress thus occurs, clearly, as was shown, the standing foot which flexes must again become straight, the point on the preceding foot and the shin remaining

at rest (711a26), i.e., the preceding foot remaining at rest.' This, he says, referring to the fact that one stands still, in part, and the other goes forward, 'this happens and at the same time the animal proceeds with it.' But if that's how it is, and the flex is forward (711a27), i.e., if quadrupeds flex their forward legs to the concave circumference, and man his, they can progress, but if they flex them backward it is impossible. He explains this impossibility obscurely and cleverly: In the first case, extension of the leg would occur when the body was 'preferred', and in the second when referred (711a31). 'Preferred,' and 'preference' mean progress forward, the natural movement for animals— they all naturally move forward except the crab— and 'referred' or 'reference' means motion backward, which is natural for nothing. I think that this is the meaning through (711a31): thus or in the first case, i.e., if the leg flexes to the convex circumference, when the body of the animal proceeds and goes forward the leg can be extended, so this sort of flexing of the legs contributes to forward walking; in the second case, i.e. if natural walking were backward, the second sort of flexing toward the concave would help; flexing inward to the concave, as it were a folding of the leg, the body would be assisted in going backward. Clearly that's how it would be: if our legs and the front legs of quadrupeds did not flex, there would be no extension of the leg. Let Socrates be walking forward, having advanced the right foot, the left going back and carrying the weight. Necessarily, if the left is to go forward, first it will have to get even with and go along with the right, and then go forward. For just as the moon does not go ahead of the sun nor pass it unless it first goes even with it, so neither does the left front foot get in front of the right unless it has gotten even with it. But if this were the case, the movement of the left foot would be up to the right, it would come up to it but never get farther; for this knee would not be able, being backwards like that of birds (for the knee would have to be back as in birds, if it is to flex to the concave) now this knee would not extend farther; this arrangement of the knee would impede and restrain it. Why birds, although having their knee backward, are able to extend the foot farther, he will say a little later. Since man requires a large forward extension of the foot to progress, it would not be possible; man could not walk, or would walk very slowly, because the advancement of the foot would be very short.
(12.711a31) Besides, he says, if backward..., meaning by 'backward' toward the concave circumference, 'when the leg flexed it would move in two simultaneous and contrary movements; it is unlikely, not to say impossible, for the same thing to move in two opposed movements at the same time.' End of the thigh (711b2) means 'knee.' The leg would move in two opposed but simultaneous movements thus: the part from the hip to the knee, called the thigh, would flex and move backward toward the seat (for the thigh would have to tilt in that direction in concave flexing), but the part from the knee to the ankle, which we usually call 'knucklebones,' toward the front. So half the limb, the thigh, would flex backward, and the rest, the calf, forward. Front and back are opposed, so too the relative movements. As the flex is forward and toward the convex circumference, local movement is generated with one movement, forward; for both thigh and calf move forward.

So Man flexes his legs forward, toward the convex, but his arms the opposite way (toward the concave), for those reasons, which make sense, for they would be useless if they flexed the other way. How would man lift food to his mouth if his arms flexed the other way? Viviparous quadrupeds (oviparous quadrupeds are different) flex the front feet convexly for the reasons given for man's legs. Besides, they are able to lift and extend the feet much more that way; if they flexed them the other way they would be able to lift them only a little way off the ground; for when the foot were lifted a little off the ground, moving with two opposed movements (as we said in the case of man) the whole thigh and the part from the knee to the hoof would run into the belly. Just as now, when the animal is going to lay on the ground to rest, the knees tend toward the head, so then in walking they would run into the belly. Notice that he calls 'thigh' in the front legs the part from the shoulder to the knee. Now the front legs flex toward the convex for those reasons, and the back legs indeed flex the opposite way, toward the concave, for the reasons cited for the front legs. For the raising of the back feet would be like that of the front (711b24), i.e., they would lift them from the ground as they do the front (and he says of the front that they would be lifted only a little way from the ground). They would have a short lift from the ground of the thigh and joint (711b26), meaning by 'joint' the remaining part after the joint. They would have a short lift from the ground and right away they would run into the part under the belly.

12.711b29: Besides, for the suckling quadrupeds...
Instead of 'necessary and better' he writes 'or better', as if to say, 'necessarily', but if one does not wish to say necessarily let him not hesitate to say 'better'. So it is necessary or better that suckling animals flex their back legs thus for this sort of function (711b30), or to give the teats to the sucklers. For since the newborn go under the belly to suckle, so too when they are afraid of something; if the back legs were flexed under the belly, they would not easily keep the young under them and protect them.

13.712a1: There are four kinds of flexes...
By 'bend' he means the knees and generally every joint at which flexing is possible. He lays out "four ways" in which flexing might be thought possible, rejects three because they are not in fact possible, and proceeds with the remaining one. Necessarily: either both front and back flex toward the concave (712a2), i.e., that as the back flex so too the front, and he calls this way A; or oppositely, to the convex, i.e., as the front flex, so too the back, and he calls this way B, or inversely not in the same direction, but the front to the convex and the back to the concave. This is the way quadrupeds naturally move; they flex the front convexly and the back concavely. He calls this way C. Or the opposite of this, the convex toward each other, and the concave (712a7), as in D.

A: Front feet Back C: Front feet Back
> > < >
> > < >

B: Front feet Back D: Front feet Back
< < < <
< < < <

The remaining way is to flex the front concavely and the back legs convexly; this way, the convexities are toward each other, and tend toward the same part, under the belly. If they had the front and back knees under the concave part,
they would have to have the convex parts toward each other. This can be seen from the diagram; you see in D how the convex parts are toward and 'looking at' each other. Having posited the four ways, he says that nothing flexes as A or B, but all the quadrupeds as in C except the elephant, which flexes as in D, because it does not have knees, but flexes at the shoulders and the analogue at the back. But it is not the only one to flex in these parts as in D; all the quadrupeds do so, for they flex at the knees as in C, but in the shoulders and thighs as in D. What he says about the opposition of flexing of arms and legs is clear from what we have repeated here. He says that the wrist moves toward the convex, but he ought to say that the wrist flexes concavely or convexly, for it flexes both ways.

14.712a24: The back legs move diagonally in relation to the front...

He goes on to explain why quadrupeds move diagonally. First he tells us what 'diagonal' movement is, and then why these animals move thus. After they move the right front leg they move the left back, then the left front and the right back. This is 'diagonal' movement. The reason for this 'diagonmetrical' movement is that 'if they moved the front feet simultaneously, and first, the movement would be interrupted and not continuous, or the procedure would involve a tendency to fall forward with the rear dragging along, as it were. Besides, moving the feet simultaneously would not be walking but jumping, and it is difficult to move by jumping continuously, over a long distance; those who move this way will soon get tired.' He means the horses in procession, whose riders hold in the reins and whip them, not allowing them to walk, but rather dress them to jump and thus they tend to go obliquely and toward the side. So then the front legs cannot move at the same time; but if the right front and right back feet were to move at the same time, they would get outside their supports (712b2); for the support is under right and left at the same time. When the horse advances the front right and the back left, the front left and back right stand and carry the weight; but if it moves both right or both left feet together, the left or right will remain. That won't work; support has to be under right and left simultaneously in quadrupeds, as was said. If continuous progress cannot occur simultaneously according to either of the ways described, then it must occur diagonetically: for moving thus they would suffer neither of these (712b6), i.e., to get outside the supports or fall. And that's how, i.e., because the supports are under

16.712b22: Birds flex their legs as quadrupeds do...

Here he explains why birds flex their legs as quadrupeds flex the back legs; birds flex their feet and quadrupeds their back feet toward the concave circumference, as has been mentioned several times. He says that birds flex their legs thus for the same reasons, already cited, as quadrupeds do. In a way, the nature of birds is close to that of quadrupeds; the reason, he says, is that 'the wings of birds are in place of front legs (712b23), and therefore they flex their wings as quadrupeds flex the front legs. Obviously the wings are in place of front legs, for as the origin of movement in quadrupeds is from one of the front feet, so in birds the natural origin of change is from the wings.' A bit of evidence that their natural change is from the wings is this: if one were to cut off the wings at the shoulders, as he said before, no bird would be able to progress or stand, just as if one took away the front legs of a quadruped. 'Besides, since the bird is a biped and not erect, and has the front parts lighter and because of this, closely fitting, 'it is necessary, or if not necessary better,' that it have the thigh thus underlying (712b33). When he says, thus underlying, he explains, I mean grown toward the back. So that's the gist of the explanation: it is better to have the thigh "grown," i.e., attached and rooted, "toward the back," which is "to approach the back more than the front." If it is better to have them toward the back, necessarily they will flex the way the back feet in quadrupeds do.
It's not hard to see that it is better for birds and insects to have the wings attached at the sides, and similarly also for animals which swim; thus they can move more quickly and strongly, compressing and clearing the air or water; the other parts of the body would follow the wings and the other motive points in moving forward and backward. 'Backward' is put in for completeness of distinctions, since nothing moves backward naturally. No one is unaware that that in which they are carried, as water or air, is yielding and not resistent.

(713a15) After this he tells why 'trogloidyic' (hole-dwelling) oviparous quadrupeds flex the legs to the side, as we do the arms. He says that all such animals have both front and back feet attached not as horses and other viviparous quadrupeds do, but to the side and stretched on the ground (713a18), i.e., touching the ground. This is contrary to wings, for they are attached to the sides in such a way that they do not stretch on the ground or touch it. The oviparous quadrupeds have the legs to the side and flex them similarly (to the side), 'for thus they can easily go into the holes and set on their eggs and guard them' covering them as birds do when they are setting. And when such animals are outside their holes, since they flex this way they have to pull in the thighs (713a23), put them under their bellies and thus raise the body. How do they raise their body by putting the thighs under their bellies? If you want to know, look at the lizards, frogs, and geckoes. The ἁκαλοῦμενος (713a17) is like a lizard, but shorter, and spends a lot of time in walls and fences. And since they put the thigh under themselves, there is no way to flex it but outward, as we do our arms.

(16) He also explains clearly why the many-footed animals, like flies, bees, and so on, have their feet attached at the side and flexed up toward the sky, except the front and back. These he calls the 'extreme' feet (713b6). The front and back legs are not attached at the side and do not flex up, but the flex of the front feet is forward toward the mouth, and that of the back feet is back. If you want to know what 'up and bent' flexing is, look at the flies; there is no shortage of them. Clearly the middle legs of such animals both lead and follow, for they follow the front and lead the back. These more naturally, these following, these leading, means, 'the legs between the extremes, the middle ones, naturally lead and follow.' Besides, many-footed animals flex this way because most of them are troglodytes; it is not possible to be a tall troglodyte.

16.713b11: Crabs have the oddest nature of polyopsids...
The word 'oddest' was chosen instead of 'peculiar' or 'different', in comparison with others; for they do not make progress toward the front, like the others, but to the side, and they alone of animals have more than two leading feet. He says, The reason for this is the hardness of the legs and because they do not use them for swimming but for walking (713b14-16), not to explain why crabs do not walk frontwards, but to explain why they alone of animals have more than two leading feet. The reason for the plurality of leading feet is the hardness of the feet; for being hard and not able, because of the hardness, to flex to the front or convexly, they do not have two front feet, but more. All which flex them frontwards, have two. They have more leading feet for this reason, and because they use 169 them for walking and not for swimming, so that if not all on one side led, but all the back followed, it would impede walking.

Going on to the 'bendedness' (βλαυμοτης) of the crab's legs, he says first that the flexes of all the polyopsids are to the side, as are those of the trogloidyic quadrupeds (713b18), these being lizards, crocodiles, etc. They flex to the side because they are trogloidyic, some only when they give birth, others for their whole life. They wouldn't be able to go into holes if they were tall and did not flex their legs in the way described.

(17) The limbs of the others are bent because they are soft, but those of the lobster are not bent because of the hardness and because he uses them for swimming, not for walking; bending is useful for walking, not for swimming. So the feet of lobsters are bent for this reason. The crab's legs flex to the side, for they are not swimmers, but walk, live in holes, and have a hard skin; because of the hardness, Nature makes their legs bent in generation; those of the others do not get bent in walking because of the softness, but they are bent immediately by Nature when they are first developed; for being hard they cannot be bent in walking like those of the soft-skinned animals. The general reason that they are bent is their many-footedness (for all the many-footed animals have their legs bent when they walk) and because they live in holes.

Similarly, he says, the lobster is the only one to have one side in back, "back" meaning the other side (713b31); the sides are like each other because it has many feet and they are equal in number; it has the same number of feet on both sides. It has more than two leading feet because it does not flex forward, and we have just explained why. The words, they have not been bent (713b29) don't
mean, as one might suppose, that they are not bent at all, but that they are not bent when they walk— they have always been bent; their hardness would not permit them to be bent in walking, if they were not bent from birth.

17.714a6: Flatfish, he says, proceed like one-eyed men; for one-eyed men turn the neck just enough toward the shoulder to walk. What follows is clear enough.

18.714a22: He says that birds have feet because they are not always able to be up in the air. Nature has given them feet so that when their wings are tired they can walk on the ground. Additionally, he says that birds are somewhat similar to fish: in a way (714b3), because the similarity is an analogy. It's obvious that there is a similarity: birds have two wings up and to the front, fish have two fins in front; birds have two legs in back, and most fish have two more fins underneath, near the front ones, instead of feet; birds have a tail, and fish a tail fin.

19.714b8: One might wonder about the testaceans, what movement they have...
As he argued that the right side begins movement in all moving things, he notes that someone might ask, 'what is the movement in testaceans, and if they don't have right and left, from whence do they begin the movement?' for they clearly move; if they move, they must have a right side. Having posed the problem, he resolves it: Or must the whole class of testaceans be assumed to be something maimed and crippled, moving as if someone cut off the legs of a footed animal (714b10-12). Such animals move by 'wallowing', which also occurs in the sea. Saying that we should assume the class to be maimed, he continues by admitting that it is true that 'testaceans move, but unnaturally. They are not really mobile, but like sedentary and attached things,' attached (714b15) refers to plants, sponges, etc. In comparison with attached beings they are mobile, but in comparison with mobile beings they are sedentary.

'Crabs have a right, but poorly; the claw shows that they have it, for the right is bigger and stronger, as though right and left wanted to be naturally distinct.' For right and left tend to be distinct from each other in crabs as in other animals (714b18).
A. Freus

One ancient development upon the theme of this treatise is Galen, de Usu Partium III; of the many modern treatments, I have consulted particularly Sven Carlsson, How Man Moves, London (Heinemann) 1972, and his bibliography; A. B. Howell, Speed in Animals, New York 1944 (reprinted 1965); the Dover republication of the Muybridge photographs; and some of the recent scientific literature.

704a19 / 135.23: καρπος and its cognates are translated ‘flex’ and so on throughout. Farquharson and Forster say ‘bend’. ‘Flex’ here means the natural turning at a joint; ‘bend’ is either a more general term, or is used for lateral elasticity of sections of insect or generally arthropod limbs. The distinction becomes important in chapter 16 ff.

At 7, Farquharson, Forster, and Louis all read θετ’, toward, but Michael insists on επηθ’, cf. 136.12. The nomenclature is difficult. Farquharson thinks (704a21) that Aristotle means the same thing by ‘forward and backward’ at HA II.1, ‘outward and inward’ at IV.12 and GA I.20, 729b9, and ‘toward the circumference and toward the concave’ here. Actually, the IA terminology is used in PA IV.B, 683b35 (the feet of crabs flex ‘toward the concave’ but the claws flex ‘toward the circumference’ for catching food), and the terminology of ‘backward and forward’ sometimes appears in IA, e.g., 11.711a8 ff. Farquharson’s argument is not very strong; to the extent that it is an hypothesis about Aristotle’s development, it is further weakened by the use of the terms ‘outward and inward at GA I.20, which should be later than the IA, even if it is the remainder of an earlier recension.

Peck explains the difference between the sets of terms in a note in the Loeb PA, p. 435: “backward and forward are relative to the direction in which the whole animal moves; inward and outward are relative to the bulk of the body itself.” Thus a quadruped could have all four legs flexing ‘inward’, with the front legs ‘forward’ and the back ‘backward’. κυματες as ‘convex’ and κολπε as ‘concave’ are attested in the later (and more advanced) passages in de. An. III.10, 433b23. See also the various illustrations included below.

Michael’s explanation of the passage otherwise makes sense.

704a20 ff / 135.25 – 137.8: Michael has probably understood Aristotle correctly; they both make what seems to us an important anatomical error, failing to make the proper homological comparisons. Fooled by the gross appearances, they take as the ‘knee’ of birds (and the back legs of most quadrupeds) that part which is homological with the ‘heel’ in man. The entire IA, and the commentary, is flawed by this error and its cousins; laying out the skeletons next to each other, and comparing the limbs bone by bone, might have helped to avoid the errors. However, nobody seems to have done that until the sixteenth century and later. Galen says several times that he intends to do such a study, but most of his extant work is concerned with man, with rare comments about the anatomy of other species, although he did do dissections with several species. He also examined human skeletons. Fabricius initiated the modern investigation of skeletal articulations. For comparison, here is a (much reduced) drawing of the human skeleton by Fabricius (as published by Dover, N. Y., 1950), and a cut of a horse skeleton, from Muybridge, Animals in Motion, N. Y. (Dover) 1957:

It is a little atypical of Aristotle to make an error this gross, but quite typical of Michael to be unable to correct it. In HA II.1, 498a3ff, Aristotle correctly analyzes the elephant, and almost gets the camel right, 499a20, and these are the difficult ones.
700b10: Here and in PA II.3, 650a32, Aristotle calls the ΗΑ λογοθής φωσκή; usually he says ἑιρογραφείς περὶ τῶν ζώων or something similar; see Bonitz 348b. The passages meant include HA I.15, 494b5-12; II.1, 497b18 - 498b10. The list of problems here presented (rather inelegantly) gives the flavor of the essay but is not exhaustive. The last named problem, the diometrical movement of quadrupeds, refers to the normal trot of horses (for example), with the front right foot moving with the left rear, then the front left with the right rear (see 71a25, below). The bone illustration above involves one moment of the diometrical movement. Farquharson notes that the camel violates this general rule; see illustration below, to 708b, and Peck's note at HA II.1, 498b6. Much of this essay is concerned with gait, and this is not adequately noted at the beginning.

2. 704b11 / 137.9 ff: Michael has προθεμένον instead of the ἱππευμένος of most of the Aristotle manuscripts. He also has ὤς instead of ὅς, and here is surely wrong. In order to explain 'propositions' (instead of 'principles') he introduces the terms φυσικόν and κοινήν φύσις; Aristotle would not call 'nothing in vain' an axiom, but it might be a 'common notion' in the Stoic sense of the term. 'Natural science'—τὴν μέθοδον τῆς φυσικής.

704b14 / 137.17: "Those which are this way"—This rather vague phrase becomes misleadingly clear in Forster's translation ("... accepting as true what occurs in accordance with these principles in all the works of nature."). Nothing corresponding to the word 'true' occurs in the text. Farquharson's "we must take for granted principles of this universal character which appear in all Nature's work," is doubtless closer to what Aristotle would say, but is not quite what stands in the text. Louis cautiously gives both a free translation and a literal one. Michael takes the phrase in too restricted a way—Aristotle is looking for a notion of natural law, and doesn't have it, nor does Michael. Farquharson gives here a list of the principles actually used in the course of this treatise.

704b15 / 137.20: "Entity"—ὄνος; "kind"—γένος. The relation between these concepts is tested by this sentence. Genos is a class or group (of animals), onos is the reality which corresponds to the true definition. 'Entity' summarizes what is possible for a 'kind', determines the range of its possible members. See further, J. Owens, Doctrine of Being, ch. 4; Louis n.6 to p.15; my Science and Philosophy ch. 4, and "Eidos as norm in Aristotle's biology," Nature and

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'Subject' and 'underlying' translate Michael's ἰπποκαμένον. Michael means to say that the principle applies both to the individual and to the species (form); otherwise he avoids the problems raised by the possible contrast of 'entity' and 'kind' here.

In the last part of Aristotle's sentence, Michael's text differs slightly from the standard reading; consequently I translate two ways. Forster and Louis read the adverb, διάφορα, where Michael wants a preposition and a pronoun. The texts differ in other ways too, see the apparatus in Louis.

704b18 / 138.1: "Spatial dimensions"—The Aristotle translation follows Forster's text and Louis' interpretation, based in turn on de An. III.9, 432a20, and 10, 433b25, for μέγεθος as spatial dimension in the abstract sense. Forster translates 'dimensions of size,' but Aristotle's concern here is rather with the natural directions, διακρισίας or διακρίσεως. See especially Phys. III.5, IV.1; Cael. II.2, 284b6; Met. V.6, 1016b25; and Top. VI.15, 142b24, where 'body' is defined as that which has three diastaseis. In the biological works, the subject of animal dimensions is discussed also in HA I.15, 493b17, 494a20ff; PA III.6, 669b20ff; see also G. E. R. Lloyd, Polarity and Analogy.

Michael omits discussion of the natural directions here; Leonicus lists them, referring to MA 6. 'Pushing and pulling' is discussed in Phys. VII.2, 243a16, of MA 10.705a20, and my note. The distinction between essential and accidental movement is also made in Phys. VII.2, at 243b19.

3.705a22 ff / 138.5 ff: Michael's comments here are borrowed from MA 2; Leonicus follows him closely. See also de An. III.10. Aristotle's assumption is that there must be something external unmoved if motion is to occur; Aristotle recognizes to some degree, and Michael less, that relatively unmoved is sufficient. Absolute immobility is refuted by immediate counter-examples—the swimming of land animals, or even the normal swimming of fish, and the flying of birds, argue against 'something external absolutely unmoved.'

705a12 / 138.30: I omit here Michael's gratuitous repetitions in my translation of his commentary. The translation of Aristotle follows the text and translation of Farquharson and Forster, who in turn follow Michael's reading and interpretation, though Michael hasn't got it quite right (at 139.5 he has it backwards). Louis
simply changes a breathing mark to make the upper part of the jumper lean on itself, αὐρή, αυρή.

139.1: "Elbow"—ἀγκῶς, a more general term, meaning 'bend', but applied especially to the elbow; the ἀκόλεψις is particularly the external point on the elbow, where the so-called 'funny bone' is to be found.

705α16 / 139.10: Leonicus explains that the pentathlon included 'saltus, lucta, pugna, curus, panarium.' Modern experiments have shown that jumping with weights, throwing them backwards at the height of the leap, can increase distance. No wooden throwing weights have survived, but I have seen both stone and metal examples, and they were demonstrated on the occasion of the 1976 Olympic Games. See Farquharson’s note, and Norman Gardiner, Greek Athletic Sports and Festivals. "Dumbbells"—δύναμις: the Greek word is derived from the verb for 'jump', but it is not easy to come up with a suitable word in English. The weights do often have this shape, and the word in English is as obscure as the Greek word. Michael obviously didn’t know what shape they were, for he calls them 'balls'. Aristotle adds that arm-swinging gives the same sort of effect that weight-throwing does, and that this sort of movement in part explains jumping movements. This is important later for the argument that one needs to have all four ‘points’ to proceed effectively.

705α20 / 139.15: "Compress"—δυσμενος, a peculiar word explained by Michael with several synonyms.

705α23 / 139.29: "Without parts"—most Aristotle ms have ἁμερος; Michael and a few Aristotle ms have ἁμερος, which Michael takes to be equivalent. "Distinction"—διαφημος. Leonicus notes that this text had διαφημως, but he opts for the now-standard reading.

705α26 / 140.5: Michael derives a syllogism from Aristotle’s argument. At 140.5, "walk erect" translated ἐρευνεσαρατησα, a marvelous word.

4.705α26 / 140.5: Michael does not see the absurdity which results when one states Aristotle’s theory as he does. If ‘up’ is defined simply as ‘where the food goes in,’ then the sky must be up because food goes in (to what?) there.
snake. For Aristotle’s earthworm, γῆς ὅφεια, and caterpillars, κάρπωδες, see note to 9.709a24-29, below.

706b29 - 706a1/142.13-16: Aristotle (and Michael) seem to mean that you get your movement in hopping by swinging your right foot, while in walking you get it by pushing with the right foot. Forster’s parentheses should be ignored: the following sentence refers to both cases, carrying weights and hopping. Leonicus discusses the word ὀεβελόντως, translated ‘hop’; he derives it from the movement made by men and boys on the second day of the feast of Dionysus, dancing on the goatkins. One may also be reminded of some modern Greek dances.

142.16-20: This ‘evidence’ is Michael’s, and has the look of autobiography. Leonicus repeats the story.

706a5/142.20: Aristotle’s words, αἰ πρόβατα, πρόβατολαγὸν are more universal than Michael’s explanation suggests. Faquharson remarks, on this passage, that the ‘determining cause’ of the tendency to move the left leg first ‘seems to be the development of the right hand and arm.’ He notes that fencing and boxing might be thought counterexamples to Aristotle’s generalization. The right-handed fencer or boxer plants his left foot for maximum extension in one move; the left-footedness is again, but in a different way, the consequence of right-handedness. Recent investigations indicate differences in specialization of the two halves of the brain, and thus neurological bases or consequences of right- and left-handedness. For the lighter side of the principle, see C. N. Parkinson, Parkinson’s Law, cited by Louis.

706a13/142.25-31: Michael’s Greek is confusing here; I translate with Lusugus. Probably the confusion stems from Aristotle’s text—although he seems to be presenting an argument, it doesn’t seem to make much sense in itself or as a summary of the discussion. Peck, in his notes to HA IV.4, 528b1, and PA IV.9, 684b30, agrees with Michael’s understanding of the passage: the shell is on the ‘right’ simply because the other part (the front of the foot) moves first, and ‘left’ is that which moves first. However, I think that Aristotle also means to suggest an observational relationship between the direction of the spiral and the direction of movement; cf. 19.714b8, where testacea are thought to move ‘unnaturally’, and really shouldn’t move at all, see note; GA III.11, 765a22, might clarify the direction of the spiral. The porphyra is the purple murex, the coryx the trumpet shell; see HA IV.4, 528a10 ff, and Louis’ index of species.

706a19/142.31: Leonicus takes this opportunity to argue enthusiastically for the advantages of right over left. “Man is the most natural of animals” because we take man as the paradigm; Xenophanes might have commented on bovine or equine biologists making the bull or the horse the paradigm.

‘Detached’ could also mean ‘independent’, see Peck’s note to HA II.1, 497b22. Farquharson, in his note to the present passage, seems to misunderstand that HA comment—the elephant is exceptional in that it is a polydactylous animal which cannot use its fingers. Farquharson also suggests here that what he calls the Principle of Sovereignty is of Pythagorean origin; see PA IV.10, 684b2, and 710b9, below. At a21, Aristotle plays on the sense of the word δεξιός, so Louis neatly translates, “la partie droite est la plus adroite.” I do not find a felicitous pun in English.

143.10: Hayduck marks a lacuna in the text, inserting ‘quadrupeds, polyponds, and apods,’ from Aristotle’s text; Michael would be quite capable of leaving these words out here, so I don’t think that there is a lacuna. Michael’s expression at 143.25 argues against a lacuna.

143.19: ἡ κορυφή is the crown of the head, and also the zenith of the sky. Perhaps there is more to it than that; the word is suggestive. Lungus translates ‘vertex’, which is also suggestive.

5.706b1/143.26: Michael no doubt refers to PA IV.9, 684b14; Aristotle could also mean HA IV.1, 523b21. The phenomenon is particularly striking in the cephalopods, e.g. octopus and squid, and it is to these that he refers. This observation was not especially noticed by Michael, but in recent years it has often been cited as an example of Aristotle’s careful observation of sea-animals. Louis mistranslates (and misunderstands): he says that these animals have front and back “conformes de la même façon.” See HA I.6, 490b6 ff, for the classification, and Peck on that passage for the translation of malakia as ‘softies’.

706b5: Farquharson throws in ‘quadrupeds’ for good measure, quite unnecessarily—see the next sentence.

706b11-16/144.4: Throughout this passage, as usually elsewhere, I translate ἄριστη ar’origin uniformly, to keep the argument straight. Michael seems to be relying upon an older and more sophisticated commentator here; the circularity of
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Aristotle's argument becomes clear. Or is the argument somehow less circular in that he turns the direction of the argument around at the end?

6.706b19 / 144.13: The middle infinitive κυνελώνει appears, suggesting 'cause of self-movement.'

144.17: Here Michael uses the active form of the verb. One misses Michael's speculations about the mechanics (or rather, hydraulics or pneumatics) of the distribution of motion, and one also misses suggestions of the Stoic or Galenic pneuma theory, which would be quite to the point.

Oddly enough, the remaining parts of the body are not the topic of the passage commented upon. Note the references to HA (cf. III.7, with Bonitz 1044a 40 ff) and Anatomy. Did the latter survive in Michael's day, or does he quote heedlessly a much older commentator, Alexander perhaps? Most of Michael's comments here could be based on a reading of MA.

144.25: "nerves"—neura, though it is not clear what tissue Michael means; see his comments on MA, 115, with my note. For Aristotel, the neura clearly include both sinew and muscle: at HA III.5, 515a28, the neura hold the parts of the limbs together, and make them pivot at the joints.

"Per aso" in the Michael translation is κατ' ἀφρή, which does not agree in gender—it has become a technical term. Aristotle would write κατ' ἀφρή with the feminine καρᾶ.


Leonicus more or less copies from Michael in this section, but adds the intriguing idea that there is a special 'soul power' where the legs meet—on the ground that copulation is there effected.

706b16 ff / 144.29 - 145.17: Michael has a long and complex sentence. Clause (1) is a presupposition, on which the rest of the supposed argument is based; (2) and (3) are presented as if they were premises leading to a conclusion (4), although (4) does not follow from them. (4) is an important premise for Aristotle in this passage; (2) and (3) show (at most) (5). Aristotle's sentence is also long for his biological works, and is complicated by the use of three words whose senses overlap: διακομή = 'separation', διαμεριμή = 'distinction', and διαφορὰ = 'difference'. I would restate the argument thus: 'In anything continuous, one part moves and one part rests; where the moving and resting parts pivot there must be some origin of continuity; where the moving and resting parts pivot there must be the origin of movement; therefore: in respect of any set of contraries, one of each pair belongs to one part, the other to the other part. But since the animal moves as a whole, in the whole animal right and left, up and down, front and back, have one common origin or pivot.'

145.20-45: This sounds like an alternative interpretation: either 'rest and moving' or 'up and down' (etc.).

145.29-31: Michael again presents alternative interpretations. In fact, he has a grammatical confusion: ὣσμα κυνελώνει is in the dual, referring to both parts, one moving, one resting; ὣσμα is singular, referring to the ὄργα στην between the two parts, and κοιτάζω κυνελώνει is in the accusative plural, partly because the dual was already archaic for Aristotle (cf. 706b20), partly because several pairs of movements are envisaged. The accusative is not the object of the verb, of course (whatever Michael may mean by πρόοπτερα at line 24), since the verb is in the middle, and reflexive.

145.34 - 146.4: Here is the argument for four-point movement. It is well stated, in contrast to the batting around in the previous section.

146.7: Literally, 'I have already told you that.'

146.23: Sec. 'and down' because it is senseless in this context. Hayduck keeps it.

The reference to PA may include IV.10, 686a24 ff, for example.

146.24-26: I follow Linguar's loose translation of Michael's obscure sentence; cf. Leonicus 148.57.

706b29 / 146.30: It's not quite true that nothing moves backward naturally; Aristotle talks about 'backwards grazing cattle' in PA II.16, 659a19, following Herodotus IV.183; in HA I.5, 490a2, he notes that lobsters swim most rapidly 'in the direction of the tail'; Farquharson notices rapid backward movement in badgers and weasels, and naturalists may add their favorite exceptions at will. The direction of movement of cephalopods does not count as an exception, since 'front' and 'back' are both opposed to the direction of movement (HA I.5, 489b35). Anyway, Aristotle is thinking especially of animals with blood in this passage; lower species do all sorts of non-conformist things. Incidentally, the backward grazing cattle are forced to do so, by the length of the horns and the way they turn, so perhaps that is not a natural movement.

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706b28 / 146.30: Forster says that Aristotle means, "an animal cannot divide itself into two parts, one of which goes forward and the other backward," but see Farquharson's note. Louis' translation is free, and suggests something alien to the passage: "... et que l'être qui est m'a n'a pas à distinguer entre les deux sens celui dans lequel il effectuera son déplacement. Au contraire, le problème se pose pour la droite et la gauche et pour le haut et le bas." Aristotle just means that as no animal moves backward naturally, none has special organs for that sort of movement; Michael makes the argument clear enough.

707a1 / 146.33. "Front and back"— I supply 'and back' in Michael from Aristotle's text; Michael would be capable of leaving it out, but it makes more sense to have it in. Michael does not notice the possibility that Aristotle may be contradicting himself here. Earlier, he argued that 'up and down' are prior distinctions, since all living things, not only animals, must have the difference between food-intake and residue-output. Now he says that right and left are prior, because as soon as you have distinct organic parts for movement, one must be right and the other left, even if there are only two. He now envisages the possibility of a genuine biped as the minimum mobile entity, and then supposes that 'up and down' appear when there are four limbs. Perhaps the contradiction is not that serious, since the two a priori arguments approach the problem from two very different directions, and they do not quite contradict each other; they add up together to the impossibility of a genuine biped.

707a6 ff / 147.2: Louis marks a lacuna in Aristotle's text; this would be one way of explaining why the text is so difficult to understand. Elsewhere, the kyrtan of movement is clearly said to be the heart: MA, Av. 467b31, 469a5; Resp. 6, 474a25; Somn. 2, 455b34 ff; PA II.1, 647a24 ff; III.4, 666a14 ff, and elsewhere.

147.5: "get movement!"— Michael uses the active infinitive here, kuei, which means that the organs are active in their own right, once started by the heart.

147.8-10: Translation after Lunger; Michael is obscure.

147.11: "move well!" is in the middle.

147.15: "colonized" = elgraxi. The translation is literal; the metaphor is enlightening; cf. 148.6, below.

707a11 / 147.30: Forster says 'opposite' and 'diagonal', referring to 704b7 and the two ways in which legs are there said to move in pairs— same side front and back or opposite sides front and back. Farquharson says 'coordinately' and 'diagonally', giving as examples "fore near and hind near; fore near and hind off," in his note. Louis says "parallèlement ou se croisent." I think that Aristotle means by systeolous any movements of the same 'side', including both front feet, both back feet, or both right limbs, or both left limbs; aristoleous movements would be those of diagonal pairs.

707a15 / 147.35: Michael reads παρθενος in this sentence, although the Aristotle text seems not to have it.

707a15 / 148.5: Farquharson and Forster insert έκεί on the basis of one manuscript; Lunger says that 'habent' is lacking in the Greek, so he inserts it to make the translation clearer. Louis manages to leave it out.

148.6: karwokozoepoi, 'colonized' again. Lunger says 'implicatum'.

707a22 / 147 - 148.22: The argument in this section does not succeed in showing that something moving at four points must be a bleded animal. The argument does perhaps make plausible the idea that four points is the most economical arrangement, but there is nothing to show that bleded animals deserve only the most economical arrangement. Leonis notes the difficulty, and argues that the passage is not meant to be a demonstrative argument, but only a presentation of the position. I fear that he is too generous; the passage seems to contain an argument, and a non sequitur at that. The following paragraph, 707a24 ff, presents observational evidence that only bleded animals move at four points. Cf. HA I.5, 490a22 ff. Pierre Louis tries to save Aristotle's reputation by marking a lacuna at 707a6, and follows one tradition by putting a full stop, new paragraph, at the beginning of chapter 7, at 707a16.

148.25: Lunger and Leonis suggest 'dissimilated'; Michael just says 'given to it.' 148.27: Cf. Cat. 6, 5a15 Phys. II.1, 192b8 ff; V.3, 227a10 ff.

707a27 / 148.28: Farquharson remarks that Aristotle is in advance of Galen, Unu Part. III.2, in his analysis of lower animals. Michael pursues the theory of subsidiary potential origins farther than Aristotle. Cf. HA IV.7, 532a2; PA IV.6, 682a5; Resp. 3, 471b22.

Parts of insects can continue to live for a while, particularly under laboratory conditions; in modern laboratories, parts of higher animals can survive for quite a long time separated from their original owner. In this passage, Aristotle and Michael envisage chopping centipedes in half, and what one gets is two wriggling half-centipedes, not for a very long time. The business about going
in the same direction is silly; if one tries the experiment several times, one finds that the two parts can go any which way. Cf. HA IV.7, 532a4. Leonicus tried the experiment, and also did it with eels (which are blooded animals), and found that their separated parts also continue to live; he does not say, though he ought, that this serves as a counter-example to Aristotle's theory. But there is a fairly close relationship between body heat and speed of death after separation from the heart; warm-blooded animals stop moving their parts more quickly than cold-blooded animals. Among the lower animals, some can regenerate an entire new individual from almost any piece—some starfish are notorious in this respect. See P. J. Bryant, S. V. Bryant, V. French, "Biological Regeneration and Pattern Formation," *Science* American 237.1 (July 1977) 66-81.

707b4 / 149.14-15: Michael is obviously paraphrasing, but he does suggest a somewhat variant text of Aristotle here: *παράφελου* may have been in the original, for example.

707b10 / 149.20: Michael says 'breathe', in the plural.

707b17 - b27 / 149.25 - 150.25: The woodcut in Leonicus accords with the text of Aristotle:

Michael has the back pans reversed in comparison with Forster. Farquharson has a more complicated diagram which succeeds in showing how snakes actually proceed; he also points out Aristotle's difficulty over how many "bends" a snake has. At HA I.5, 490a31, it has four, but here, as Michael clearly explains, two bends are presented as four points. Unlike Farquharson, I don't think that Michael forces the text. Farq. rightly reminds us of the function of the ribs of the snake in forward motion, and of the tail in newts and fish, for example (of HA I.5, 490a44; PA IV.13, 695b2 ff). Snakes in fact use at least four different methods of locomotion, either in conjunction or separately. The movement which Aristotle describes is typical of American rattlesnakes; the sidewise actually moves rapidly with two or three bends on the ground, and the rest of the body lifted up. Many snakes "coils", as earthworms typically move, see note to 709a24, below. Then there is the rib-generated movement, noted by Farquharson, and finally some large snakes actually have muscular control of the scales on the underside of the body—this can be seen very well by putting the snake on a sheet of glass or plexiglass and looking up at it from underneath.

The idea that snakes have only two bends is, of course, contrary to observation; see, for example, the illustration at comments to 709a24, below.

707b16 / 150.27: "Swayback" = *lórdos*; see 710b18, below, and "Hippocrates" de Artic. 807b, de Præcit. 763; the opposite is *kyphos*, hunchbacked. Forster translates "backs hollowed". Farquharson ‘bellied (undulated)’; Langus inadequately says ‘curvum’ (of Louis "courbier"). Leonicus more adventurously says, 'longiuntes,' from the word for a long slender pole or rod, as we say in America, 'beanpole'. Aristotle and Michael make clear that they refer to the common peculiarity of tall slender people to twist their bodies more than average; this involves a stance including a greater inward curvature of the spine (the characteristic picked out by "Hippocrates"). In modern technical vocabulary, 'lordosis' is curvature of the spine with forward convexity, and 'kyphosis' is curvature of the spine with backward convexity. Aristotle and Michael mean more than that. See Carpob, 75 ff.

707b27 ff / 151.2 ff: Michael has obviously looked at eels, and tries to make sense of what Aristotle says. It is accurate to say that eels use wider bends on land than in water, which is what Michael starts to say (μεγάλος, 151.9), and inaccurate to say that they use two bends on land and one in water, which is what Aristotle says and what Michael gets around to saying (περικόλακος, 151.16).

Farquharson: "The true reason of their fewer flexions in the water is the greater ease of their progress there, not the fins, which are practically of no help." In fact eels make more than two flexes even in the water, see N. B. Marshall, *The Life of Fishes*, 13-16; E. J. Marey, in *Movement*, p. 269. Cf. PA IV.13, 696a2 ff, which refers to the present passage. The lamprey (*murina, syphusara*.) is said to come out on dry land and thus is caught (HA V.10, 543a19-29). For eels (*φυσικος*) see HA III.10, 517b9, with Peck's note, and VI.16, 570a2-25; Peck QA p. 565; Leon Bertin, *Eels*, a *Biological Study*, London, 1956; Denys W. Tucker, in *Nature* 185 (1959) 495-501. Conger = *γρηγορος*, a particularly voracious eel-like fish. Cernus is usually a mullet, but this would be a strange sort of mullet indeed—if it existed in Aristotle's day, it seems now extinct. Leonicus explains the location of the lake at Sipha, on the Boeotian coast of the gulf of Corinth, *Pausanias* IX.32.3,
8.708a9 / 151.16: The footlessness of snakes is explored in PA IV.11 and 13, for example, where this essay is referred to at 690b16 and 676a15; it is possible that Aristotle is simply referring back to passages in chapters 1 and 7, above. At PA IV.13, 696a13, Aristotle explains that the fins of very long fish would be either widely separated or too close in proportion; the same explanation should hold for the feet of long animals. Farquharson points out that Aristotle could well have compared the proportions of lizards with those of snakes at this point. Skinks are even more instructive.

Michael does not add much in the PA commentary (Hayduck pp. 95-96) to what he says here—it may be that he avoids the theological problem of a providential nature. Leonicus adds a few words, quoting from other parts of Aristotle's work. The present statement (quoted already in Greek above in the note to 704b15) is an extremely full one of the 'nature does nothing in vain' principle. Aristotle adds that nature looks for the best possible for each thing (as at 704b15), and saves the 'peculiar entity' or definitive nature for each thing, and the 'what it is for it to be this thing', i.e., the essence.

708a26 / 151.20: "Otherwise"—Farquharson, Forster, and Louis use Michael to support the insertion of ἔναντιον here, even though that word does not appear in his text. What's really needed is "... without an even number of feet." The following sentence (bracketed) is not in all texts, and is deleted by Jaeger as a gloss; Louis emphatically keeps it. It could be that it represents the remainder of the previous sentence, edited beyond recognition.

708b1 / 151.32: Although everyone has seen dogs or cats, for example, managing on three legs, Aristotle and Michael don't think that that counts as 'walking'. "Or one"—Jaeger, Farquharson, and Forster, relying on Michael, read ὅ τι ὃς... Louis reads ὅλως' and translates, "C'est pourquoi avec trois pieds il n'y a pas moyen de marcher."

"Support"—Aristotle uses a word which seems rare to Michael, ἰσισυρμονία and Michael adds ἱπεραυτομαχία in explanation. Leonicus gives 'sustentaculum' and 'fulcrum'. Forster translates, "it will rest on a pair of opposite legs" at b3; Cherniss suggests, "it has support for its body on one side only," and this fits Leonicus' reading, which is otherwise close to Michael.

On the facing page, see illustration of a camel moving the way that no animal can, according to the present passage. Although the illustration is a drawing, it can be verified in Muybridge, plates 104-108.

708b19 / 152.20: The conservative point of view appears: restoration to the original arrangement is regarded as good in itself.

9.708b21 / 152.22: Hayduck's addition of a second ἔστω at 152.26 is unnecessary and inelegant. The words τὸ ἔγγορμεν and τὸ δῆγεν are translated 'antecedent' and 'consequent' after Langus; I am not pleased with any alternative rendering.
Leonicus 256 clarifies the argument; I paraphrase him: 'If, in local movement, nothing rests, there is no flexing. If there is no flexing, there is no motion. So if, in local movement, nothing rests, then there is no movement. But there is movement, obviously, and flexing too. So something rests, for anything which moves in place. This is demonstrated here by a hypothetical syllogism.'

Michael refers here to Mêve. IV.9, 386a2, see also I. Düring, Aristotle's Chemical Treatise. In that passage, the translation would normally be 'bending', and the generality of the expression might demand that word here too, but I use 'flex' for consistency. More difficult is the problem: what is the one point in relation to which change occurs? In the case of an angle, the point is in the angle (in the joint), but this is not obvious in the case of bending from straight to curved. An arc of a circle would have the theoretical center (which is not a physical point), but an arc of an ellipse or a parabola is not determined by just one point, and a complex curve would be even harder to analyze in this way.

As one leg advances, the other must flex.' This chapter is one of the most puzzling in Aristotle's biological works. At 708b27 he argues on *a priori* geometrical grounds that in walking the leading leg will be straight and the trailing leg must flex so that the leading leg will meet the ground. This notion of walking assumes that the weight of the person walking will remain over the trailing foot until the leading foot touches the ground, that there will be no flex at the hip until then. In other words, Aristotle envisages a sort of Russian dance step or goose step walk as the normal condition. It is more than a little odd that Aristotle argues this way, since the facts of walking are not that difficult to observe, and in fact the Greek artists represent walking, running, and other gaits in men and animals (horses, dogs, and so on), with considerable accuracy. Michael, rather than catching the oddity, compounds the errors.

Actually one can walk rather well without flexing at the knee at all (cf. 709a9)—that flex becomes more important in running. The most important flexes are at the hip, ankle, and in the foot at the base of the toes. When Socrates (to use Michael's example) advances his right leg, he does so by flexing the right hip; this action causes an imbalance of the body, and he will tend to fall forward, onto the right foot (cf. 709a16); as he moves forward, the left ankle flexes and the left hip flexes to maintain the upper body in an upright position (as Aristotle seems to recognize, it is not necessary to

maintain the weight-bearing leg in a perpendicular position, after all). Then the left knee flexes, not because of the Pythagorean theorem about right triangles (709a19), but in order to bring the left foot forward without dragging it on the ground. But it is not strictly necessary to flex at the knee, since Socrates can go up on his right toes a bit, increasing the length of the right leg.

Aristotle's confusion is most evident in 709a16-24, where there is some evidence that he does notice that the leading leg flexes, and that there is a movement forward of the center of gravity. But his desire to give a geometrical account leads him to appeal both to the Pythagorean theorem about right triangles (709a19, cf. 709a1), and to describe the figure made by the legs as an isocèles triangle, at the mid-point of the step, to account for the lowering of the head (709a22, cf. 709a5). In other words, his description is inconsistent, partly right and partly wrong, and both the right parts and the wrong parts are expressed in rather hasty appropriations of overly simplified geometrical figures.

By the time of Galen, biologists had become more concerned with the muscles used in movement; the geometrical analysis came to be seen as leading to an understanding of the way the muscles work. Both Aristotle and Michael ignore that aspect rather completely.

Adequate scientific investigation of human and animal gait and movement began only in the second half of the nineteenth century, particularly in the work of E. Myrbridge and others, with rapid time-lapse photography, now readily available in the Dover publications. See University of Pennsylvania, Animal Locomotion, Philadelphia 1888, reprint NY 1973; E. J. Marey, Movement, trans. E. Pitchard, N.Y. 1895, reprint NY 1972; and the Myrbridge volumes. These studies, done less than a century ago, answered adequately for the first time a good many of the questions raised by Aristotle's analysis of gait.

"anus": Literally, 'the seat from which the dry residue comes out.' Michael may be trying to be amusing. Less amusing is the fact that he has the reference to the isocèles triangle wrong. Michael envisages Socrates standing facing the observer, while Aristotle envisages (Socrates) walking, in profile, generating an isocèles triangle in mid-stride. The sides of the triangle are his legs; the perpendicular is obviously shorter than the legs, so consequently the top of his head is lower at this point than when he is
standing still. Thus the wavy line along the wall. Michael does not catch that, though of course he has the wavy line. Lungus prints a bounding wavy line:

\[ \text{Diagram} \]

709a1 / 153.22: Forster remarks, a bit quaintly, that the leading leg does not actually subtend the right angle "because it is not long enough to reach the ground, and so... the other leg must be bent in order to enable it to do so."

His explanation of the mathematical terms is helpful: Louis puts it this way (I translate from his French): "the line formed is the hypotenuse, and it is potentially the length of the leg which is stationary plus the space between the lifted leg and the ground."

153.36: "heel"—πτέρος; instead of Hayduck's erroneous πτέρος.

709a3 / 154.15: "at the joint"—The Aristotelian sse have κινεῖται, but Michael insistently reads κινεῖται μετακίνεται. He rightly understands that Aristotle means the hip; however, to his shame he retails the old story about the elephant, rejected by Aristotle both here and at 712a11, and commented by Michael at the second place, 155.11, though he hasn't got it right there either. Cf. HA II.1, 498a8; PA II.16, 659a29. Ctesias may be the originator of the tale, cf. GA II.2, 736a2. Leonicus repeats it. Harrison Allen, "Materials for a Memoir on Animal Locomotion," Univ. of Pa., Animal Locomotion, has a discussion and drawings of elephant gait, pp. 35-99. The Maybride photographs 110-112 in the Dover edition show all the flexes quite clearly; it is evident, however, that elephants do not flex as horses do, since they are polydactylyous. The drawing on the facing page illustrates the 'straight-leg' phase of the front legs, which might have started the story.

709a5 / 154.17 ff: There is a textual problem in Aristotle's text; I translate after Forster's text, as Louis does, although Forster feels obligated to give an interpretive translation, with notes. See also Farquharson's note—he tries to adjust the text, comparing Plut. Conviv. III.1 (II.658F). Michael's text may have been significantly less corrupt than ours; for example, he seems to have had the word ἔλεγη in it. But his text isn't perfect. Aristotle clearly means to say that the reason the man's head describes a crooked line when he walks is that his legs form an isosceles triangle in the stride, and the height of an isosceles triangle is not as great as the length of one of its sides. See Louis, n. 2 to p. 26, and Michael's reference to the isosceles triangle at 153.15. There, Michael uses it of a standing man, rather than of a stride.

We learn from this section that for Aristotle, a mathematical analysis is a geometrical analysis (rather than algebraic, statistical, or whatever). Aristotle uses geometrical analyses to bring the necessity of mathematics to bear on the explanation of natural events. Michael makes use of the same sort of thing, and certainly makes clear what Aristotle is up to. Both Michael and Aristotle have the geometrical analysis more wrong than right, but there is nothing wrong about analyzing the process geometrically; if the analysis were carried out correctly, one could indeed say that the explanation had gotten its force from the mathematical necessity inherent in the geometry of the process.
See also the diagram in Carlsöö, p. 96. Michael does more geometrical analysis, for example p. 157, below.

70qa9 / 155.7: Aristotle’s example of the crawling children is augmented by Michael’s example of people whose legs have been cut off; his may have been a crueler day. Leonicus repeats the story.

Michael again misunderstands Aristotle’s account of the elephant, cf. note to 70ra3, above.

70qa16: “if the leg moved forward were unflexed!” is attested only by ms Y; Bekker and Louis leave it out, Jaeger and Forster include it. Another ms, Z, has, “the moving one would be unflexed.” It’s not easy to guess why Aristotle would want to argue that the leading leg should flex, although of course by observation one readily learns that the leading leg does flex – but not for the reasons which Aristotle adduces. He argues at 708b30 and 70qa20 that it must be the trailing leg which flexes. The difficulty of the text at 70qa16 seems to have been resolved by a partial omission which at least leaves the matter ambiguous (ms Z) and a total omission of the phrase (PSU). The phrase does not look like a gloss (because it does not explain anything), so I retain it despite the difficulty. Michael does not seem to have anything to say about this.

70qa18-20 / 155.24 ff: Louis, appealing to A. L. Platt, “Notes on Aristotle, De Motu Animalium,” Journal of Philology 32 (1912/13) 57-42, 295-298, at 297, argues that the term ἀκροβιατῳ is used in a different sense here than at 70qa1, not ‘hypothenuse’ as there, but the line on the ground (“ligne du sol”). This is Michael’s interpretation too, at 155.29-30. I think that Michael, Platt, and Louis are wrong; Aristotle means to say that physically the leg is the same length as the other, but mathematically it would have to be the same length as the hypotenuse if it were to touch the ground, and it cannot be both lengths.

70qa20-24 / 155.31 - 156.3: “Then”—Michael points out that the two parts of the word would be ‘the’ and ‘and’. “Pushes forward” = προώ: Forster and Louis want this to be the foot that goes forward; Cherniss argues that it is the foot which is behind, and pushes the body forward. Cherniss has logic and Michael on his side: the previous sentence says that the προβιβασις, or ‘advanced’ leg is going to be too short to reach the ground (because it’s not as long as the hypotenuse of the right triangle of which the other leg is one of the sides), “therefore it is necessary that the προώ flex”— not the leg which is too short already, but the other. The leg which goes forward extends rather than flexes, according to Aristotle. This is part of what I call the ‘Russian Dancer’ theory of walking. See also the note to 70ali, above, Farquharson, and Louis p. 159. The rest of Aristotle’s sentence seems to fit the appearances: one leans forward, extending one leg, keeping the upper part of the body perpendicular. Michael does not make much notice of the ‘isocoles triangle’ theory, as we have remarked; this might avoid some of the problems of the ‘Russian Dancer’ theory. Forster and Louis explain the last phrase as the head being perpendicular to the base of the isocoles triangle formed by the legs, but Michael thinks of the isocoles triangle only in reference to the standing man, not the walking man.

At the end of his commentary on this section, Leonicus remarks, “Vel igitur hic locus hoc intelligenus est modo: vel huiusmodi me latere literam libere et ingenua fateri non dubitaverim.”

70qa24-29 / 156.4 ff: “Caterpillars” = κάπυα; καπυα = “flexes.” Aristotle no doubt thinks of those which move as the inchworm caterpillar does. Lungus translates ‘erucas’.

“Oozing” = νυαστὸς, from νῦς, ‘mud, slime’. Forster misleadingly says ‘crawling’; Farquharson more accurately says ‘telescopic action’ and calls it ‘concertina-like’; Louis says ‘retraction’. Cf. HA I.1, 487b20. Aristotle’s observation is correct, and Michael has seen the same thing; neither seems worried about the difficulty which this sort of movement poses for the general theory, especially the part of the theory about moving at two or four or some even number of points. Here, the movement seems to be continuous, rather than divided into points, just as in the small and its cousins, see 706a13 and note, above. “Earthworms” = γῆς ἔρῃα. At HA VI.16, 570a25 ff, Aristotle says that the eel is generated from this animal, cf. GA III.11, 762a27 ff; either earthworms were thought to be the young of eels, or someone may have correctly identified the young eels—D’Arcy Thompson pointed out that the term γῆς ἔρῃα was indeed applied to young eels in Sicily. However, it would be more normal in this passage to take the term as applying to the ‘lombricus’, as Lungus translates; Michael certainly takes Aristotle to mean that, because he describes correctly and rather fully earthworm movement under this heading. Tiny eels do not ooze, but wriggle or undulate. See above, 4.705b28, and note. “Leeches” = βήδηλα; these could also be ‘slugs’ (French: ‘limaces’). Lungus leaves this one out; Leonicus says ‘hirudines’, popularly
called 'sanguiusga', i.e., bloodsuckers. Louis: 'sangues'.
Cf. Herodotus II.68. But slugs move this way even more than
leeches, which also 'undulate'.
155.14ff: The translation is abbreviated.
709a31-b5 / 156.25 - 157.11: Aristotle's text is rather obscure
here, and all translations are bound to be influenced to some
degree by Michael's interpretation. Louis seems apologetic.
However, I find it difficult to believe that Michael has Ari-
stotle's geometrical analysis right; if Michael were right,
Aristotle could as easily have said, 'an animal which moves
by flexing cannot move unless it flexes; the only footless
animals which can move in a straight line are those which
move by contraction and extension, or 'oozing'.' No, I
think that the geometrical analysis of the movement of
'undulatores' means to make a stronger claim, that the
line subtending the angle of the flex must be shorter
that either of the other two sides of the triangle; to use
Michael's example, AC must be shorter than either AB
or BC. Aristotle could have considered that on the basis
of watching inchworm caterpillars, which make AC as
short as possible, and by observing snakes on a low-fric-
tion surface, or eels out of water. (Aristotle refers here
to 7.707b10 ff, for the motion of eels) For snakes on a
high-friction surface, angle ABC can be quite acute,
however, as in the earlier diagram, Michael may have
observed that, and thus chosen an interpretation which
makes of the passage an elaborate tautology. There is no
diagram in the text, and there need not be; a little imagina-
tion will serve for constructing it for oneself. The illus-
tration at right supports this interpretation of Aristotle's
text at this point, and holds against the theory of four-
point movement, elsewhere in the treatise. For photo-
grahs of snake and eel movement, see E. J. Marey,
Animal Movement, pp. 267-269.

10.709b20 / 157.24-31: "Wild goose chase" is a loose translation of Michael,
but in the spirit of his text; Lunus too translates loosely. Leonicus, cleverly
enough, mentions ostriches, which never fly.
Aristotle here refers to 1.704a11, and 7.707a19. The technical rhetorical
terms used by Michael are antiparastasis and enstasis, referring to two sorts
of rebuttal: the first is the head-on approach, redefining the question or
claiming that it cannot arise; the second assumes that the problem is sensible,
and shows how it can be resolved on its own terms. Lunus does not translate
these terms; Leonicus explains them.

156.1: Michael here recalls the theory that the blooded animal has just one
origin (archē) and that four points are the maximum number controlled
from a single origin.
709b24 / 158.4-10: Leonicus adds an experiment: tie a man's hands behind
his back and make him run. Obviously he won't run very well.
Undoubtedly the utility of the feet in flying can be great, as in the heron, mentioned below (710a14), but is less in some other birds, to such an extent that the Greeks called one sort of swallow *îsrov* or ‘footless’, *H.A* I.1 487b24-31; IX.30, 618a31 - b2. The utility of the wings in walking seems generally less, to such an extent that some flightless birds have their wings quite vestigial, the kiwi (apteryx) especially. Probably a chicken, for example, would be able to walk quite well without wings. Aristotle’s argument is at its most aprioristic here. The ostrich, which dualizes between bird and quadruped (PA IV.13, 697b14-26), runs very well. This Muybridge photograph series should help to illustrate much of what Aristotle says about the walking of birds, since the flexes are particularly clear:

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**NOTES, IA**

709b26 / 158.10-16: “Flexing and extension”— cf. 7.078b20ff. “Everything proceeds on a substrate which is, to a point, yielding...” Aristotle means that animals must be flexible enough to adjust to the compaction of air, water, or even earth beneath their wings, fins, feet, or bodies. Michael does not construe the sentence correctly—he puts ‘to a point’ in the wrong place, with ludicrous results; Leonicus follows him, and embroders with the idea that mountain animals rarely go to the plain, and animals of the plain never go into the mountains! *ἐκ τὸ βροχεφθέν* is more or less hidden in the translations of Farquharson and Forster, but not of Louis. Also, Forster follows me Z here, but the standard text (which Louis keeps) makes more sense; cf. *H.A* IV.12, 694b15, and below, 15.707a3-14.

Aristotle’s argument is a sensible additional reason for the flexions in the limbs of animals; it is a radical shift in the course of the argument— he should be explaining why birds have to have feet in order to fly, which he gets back to at 710a12. Farquharson notes in this place that Aristotle does not get around to examining the effect on birds or fish of having the medium all around them, rather than just under, as land animals.

709b30 / 158.16: “Insect” = ὀλικετα, supposed by Forster and Farquharson to mean all flying insects; Michael appears to suppose that it refers to a class of insects, perhaps on the basis of 710a8-12. Langus translates ‘integripennibus’; Leonicus says, ‘*ex fragili membrana integras habent alas,*” following Pliny, who seems to translate the Greek word with ‘vaginipenna’. *Holoptera* means literally ‘with whole feathers’ or ‘whole wings’, in contrast to *schizoptera* with divided feathers or wings, applied to birds. Actually, Zoltán Kádár (in an essay on Aristotle’s classification of birds in *Acta Classica Universitatis Scientiarum Debrecensis* VI [1970] 27-33) says that schizoptera is actually a class of birds, opening the possibility that holoptera may include certain birds. Louis thinks that holoptera could include bats, as their wings are solid and not divided (feathered). The standard way of reading the distinction would be that the holoptera have a wing which is (very like) a feather (*ερτοπόρ* and birds have a *σφίσσα*, bird-wing. Michael preserves this distinction, and it remains in modern Greek.

710a1 / 158.19: Note the plural of ‘rudder’, in accord with ancient and Byzantine Greek nautical practice. Until modern times, the rudders were very like oars, extending back behind the boat for some distance; for sailing, this is not as efficient as the modern hinged rudder. See Ernle Bradford, *Mediterranean*, 64.
Louis cites other passages comparing the rudder of a boat to parts of living things; see also Science and Philosophy 235 ff. The ouropygion is a tail with feathers, only. Birds use their tail even more for elevation and vertical attitude, which Aristotle does not note; contrast Albertus Magnus IX.296. Medieval falconry led to better accounts of birds, for example in the essay by Frederick the Second of Sicily.

710a7 / 158.21: I omit vain repetitions in the Michael translation. Aristotle's word coleoptera is now applied to a family of beetles, probably overlapping with his classification: cf. HA I.5, 490a13ff; V.19, 655a15ff; PA IV.6, 682b26 ff. κανθάρος definitely include dung-beetles (Louis: 'scarabæi'); μυλαδοθέα are identified as 'cookhafers', as in modern Greek (Louis: 'hannetons').

The erratic flight of insects might seem aimless, but most insects have excellent guidance—think of bees homing on their hires. Drifting flight is perhaps protective against birds and bats; the poor flight of beetles stems from being over-heavy in the back part of the body. Aristotle falls to notice the use of the length of the abdomen as a tail in some insects, e.g. dragonflies.

710a14 / 158.29: "Fly" is in the middle voice.

We might have profited from Michael's identification of some of the species of birds. The 'prophyry' has been variously identified. Leonice thinks that it is the flamingo, and calls it 'Diomedean'; he refers to the long legs, so obviously used as a tail in flight; Aubert and Bonitz follow this tradition. D'arcy Thompson, in his Glossary of Greek Birds, identifies it as the purple gallinule, Porphyrio Porphyrio, as Louis (table, poulie sultane); I think that this is what Thompson means by 'purple coot' (ad HA II.17, 59a11; VIII.6, 595a13), and W. W. Merry too, as noted by Forster. I do not recognize the bird called 'purple heron' by Farquharson here. For the manner of flight, see PA IV.12, 694b12 ff. Incidentally, in migration many of the water birds are exceptionally fine fliers indeed. See illustration of a flamingo, elsewhere in this volume.

710a19 / 158.29: "Barge", "Towed boat" = ὄξωσκευα πλοῖον. Michael adds the medieval word for cargo vessel, πάμμεγα. In my translation of Michael, I render these words very literally. See Bradford, Mediterranean 235 ff, Cecil Torr, Ancient Ships, London, 1894.

710a20 / 158.30: "Attachment" = ἐκφόνον. Forster has 'manner of growth'; Michael clearly understands 'manner of attachment'. Compare what Aristotle says about fast-flying birds immediately after. Words built on φονο are tricky—there is always an implication of 'nature' and 'growth', even in ἐκφόνον. Aristotle implies that the wings of holoptera are 'outgrowths', even 'appendages'.

159.2: "Birds"—the text of Michael should read ἔρπανα with PR, rather than Hayduck's ἑρπαν.

710a28 / 159.5: "Specific" translates the ὀξώον of PSU and Forster; Jaeger conjectured ὀξώον, rapid, and is followed by Louis. "Well-string" translates the ἐκδορον of PSU, Farquharson (q.v.) and Forster; Leonice and Louis have ἑρπον, 'pour pouvoir avancer'. "Light" translates λευθδον, an adjective built on λευθος, a small, sharp-proved boat, identified with the felucca; Louis conjectures λαμβδοναχος, in the shape of a lambda (λ), as we would say 'V-shaped'. "Growth" translates ψυζης, which could also mean 'nature', of course.

This passage might suggest that sarx is muscle for Aristotle, and strongly suggests that for Michael. Farquharson argues that Aristotle does not realize the function of muscles, pointing to PA IV.12, 695b18: "All birds have a sharp-edged, fleshy breast: sharp-edged, for flying (a wide surface displaces so much air that it impedes its own motion); fleshy, because a sharp-edged thing is weak unless it has a good covering?" (Peck translation). Farquharson thus supposes that Aristotle here is relying upon what he calls "the principle of compensation" or what I elsewhere discuss as 'katachresis', nature's habit of taking away from one part to give it to another. Farquharson is doubtless right about Aristotle, but I feel sure that Michael is aware of the function of the breast muscles in birds.

As for the aerodynamics of the rear of birds, Aristotle's description is noteworthy not only because it makes clear that he is thinking of the crooked-tailed birds throughout this section, as a paradigm of flying animals (in this Farquharson is misled), but also because it should modify the popular interpretation of Aristotle's account of the flight of missiles. Most people think that Aristotle believed, and continued to believe, that missiles are carried along by the air pushing from behind, once they get started; but if that were Aristotle's normal aerodynamics, it would be better for birds to have a wide rear, so that the same effect would work for them.
11.710b5-15 / 159.9: Aristotle’s appeal to ‘dwarftleness’ in explaining the erect stature of man, in contrast to the non-erect stature of birds, is developed in PA IV.10, and 12, 695a5, to which Michael refers. Michael does not develop comments on the subject, but Leonicus does, referring to Mem. 2, 453b1. See also GA II.6, 741b27, 742b14; V.1, 779a24; HA II.11, 500b55, and Science and Philosophy 209-220.

Michael begins the section with a contrast between the fact (ροή σνιξ) and the reason for the fact (ροή σνιξ).

“Proportional” reading κοιπετόν with Forster and SUZ at 710b14; “light” (710b18) reading κοινές with Forster and Louis; Pararhaisur’s κυψός from Z is also attractive.

Note in this passage that the unnatural in art imitates the unnatural in nature. 710b20 / 159.14-22: Aristotle uses the word υμώρω to refer to the femur of birds, saying that it looks almost like a second thigh (!). He says much the same thing in HA II.12, 504a1 ff; cf. PA IV.10, 689b11; 12, 695a1. Most quadrupeds are similarly treated, so that finally one is not sure whether Aristotle is more mistaken about birds and horses, or about men. Olge, at PA 689b1, says, “As he shares the popular misconception which identifies the knee-joint of man with what is really the tarsal joint of other vertebrates, the tibial segment in man with its fleshy calf (κυψός and γαθροκυψώματα) and the strong metatarsal segment of quadrupeds and birds come to be the ωκελη απο, which he supposes to correspond anatomically and compares with each other. The same misconception as to the knee-joint causes him to find the counterpart of the human femur in the tibial segment of the other vertebrates; but this leaves him in the case of these vertebrates with an extra limb-segment (the femur) unaccounted for. The human femur is jointed to the pelvic ischium, and therefore A. calls this extra segment an ischium, though it is a separate bone, and looks, he is bound to admit, when detached from its surroundings, just like a femur.”

“Man alone has calves”... HA II.11, 499a31 ff; PA IV.10, 689b14. Leonicus carefully equates υμώρω with ‘coxa’ or ‘clavus’, and μερος with ‘femur’; he insists (against the Gaza translation, which is guided by knowledge of avian anatomy rather than the dictionary) that this is the usage not only of Aristotle, but also of Celsus and Pliny.

711a1 / 159.22 ff: Aristotle does not actually tell us why the wings of cupids would be useless; Michael’s explanation is fairly plausible, especially if the wings of the cupids are long, like those of Byzantine angels or some classical amores. Representations of winged cupids in antiquity and more recently do not always have such long wings, but in that case one wonders by what magic they would get off the ground. Some literary references: Euripides Hippolytus 1268-1281, Plato Phaedrus 252b. Michael’s delicate handling of the passage might be motivated by some mistrust of orthodox believers in winged angels.

Aristotle’s own explanation appeals to the principle that nothing could have six points for movement and still be a blooded animal (cf. 7.707a19, above), and to the more empirical proposition that an erect biped could not have the right proportions for flight. He might also be suggesting that the natural movement of an erect biped is walking, and that wings are useless for walking. Cf. Galen, Unu Part. III.1. In this context, the tag about nature doing nothing in vain is obviously tautological.

159.1: ma S omits οὐκ and should be followed; the lacuna indicated at the end of the line by Hayduck is not strictly necessary; the sentence makes sense, even if not in good classical grammar.

12.711a7-14 / 160.3-8: Michael separates the phrase about men and birds at 711a12 from the preceding phrases by the word ‘clearly’; Forster and Louis make it depend, like its predecessors in the sentence, on ‘we have already said’. I compromise by putting a semi-colon instead of a comma. See chapters 1, 6, and 9, above, and compare HA I.15, 494b5 ff; II.11, 496a5.

711a17 / 160.9: “Nature creates nothing in vain,” cf. 2.704b15-17, etc. Louis lists references to nature as demicaspera here; see also Science and Philosophy 238-240.

711a26 / 161.3: ‘Shin’ = κυψός, see note to 710b20, above. Lunus translates ‘tibia’.

161.10: Both Lunus and Leonicus say ‘obscure et concise’.

711a30 / 161.10: Aristotle’s words for ‘carry forward’ and ‘carry backward’ are rather obscure for Michael (σπουδεα, ἀνεα, ἀνεα); so there follows an explanation which could seem absurd in English, depending on the translation. I have kept the obscurity in my translation of Michael, by inventing on Latin roots words and senses of words equivalent to Aristotle’s words. Lunus uses ‘lario’ and ‘portatio’ which might have had the same effect for his audience. My translation of Aristotle is normal.

161.15: For ‘backward motion’ see note to 706b29, above.
161.16: Michael actually quotes the entire passage, but we need not do this, as we can simply give line numbers.

161.30: The example of the sun and moon is purely Michael’s, and is of dubious relevance. We are reminded of how close to the surface some simple astronomical facts must have been for him and his audience.

162.20-23: This sentence finally catches the sense of Aristotle’s account. Aristotle means that the human knee moves forward when man walks, whereas the major joint in the bird’s leg moves backward while the bird moves forward—these are the two opposed movements. (Compare the photograph of the ostrich, above, with any person’s strids.) Michael is in error when he supposes that the opposed movements are in two parts of the leg, since that would be true of any limb which flexed, whether backward or forward.

711b10 / 162.26: For the use of hands, see PA IV.10, 687a6 ff. Aristotle fails to notice a problem he will have with the polydactylous animals—these, although viviparous quadrupeds, use their front limbs partially like hands; HA II.1, 497b18 ff.; PA IV.10, 687b26 ff. It would have been instructive for him to lay out the bones of the front legs of a cat, for example, beside human or monkey bones.

711b23 / 165.6-12: Much of the obscurity in Michael’s commentary is dispelled by the diagram which he provides. In the text, I have followed the Lusus version; Leonicus has a much fancier drawing:

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Anterior, post.  Anterior, post.
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A

Anterior, post.

C

Anterior, post.

b

Lusus, 62-63.

The obvious model of quadruped movement here is the horse; bearing in mind that Aristotle and Michael discount the true thigh of the horse, one should be able to visualize the description given in the present passage.

711b31 / 165.14-21: For an alternative explanation of the placement of the luteal glands, see PA IV.10, 688a11-b33, cf. HA II.1, 500a13-32. In PA, Aristotle says that the chest of man is broad enough to allow the placement of the mammea at the level of the arms, whereas the front feet of quadrupeds demand too narrow a chest for the placement of the mammea there. But the polidactylous animals do have some mammea well forward anyway, because they have many. This leaves the elephant, which has two, well forward—because the animal is polydactylous, and polydactylous animals have the first mammea near the front legs. Farquharson characterizes this explanation as ‘farfetched’ and ‘a priori’, pointing out that the considerations raised here, at 711b31, would result in a good explanation of the placement of the elephant’s mammea. I discuss explanations like that in PA IV.10 in my “Eidos as norm.”

13. 719a1 / 165.23: "Pairs" / "Bonds"—Farquharson and Forster read oυδαπαςματος with ms Z, translating ‘pairs’, and I follow them in my Aristotle translation. Michael and other mss. have oυδαπαςματος, ‘bonds’, and Louis defends this reading, saying that Aristotle never elsewhere uses the word syndysmos for anything but sexual intercourse. His argument is not conclusive, as the word in that sense is obviously a euphemism with its literal meaning close to the surface—like ‘pairing’ in English.

The diagrams above, from Lusus and Leonicus respectively, should be compared
The elephant does not flex much at what we would call the wrist and ankle, and these parts are indeed analogous to the major flexes in horses, called (in them) front and back knees. Farquharson asks, doesn't the elephant flex as at B? He points out that the mus are confused here. See also HA II.1, 498b5, and the Muybridge photographs of elephant movement, with H. Allen in U. Pa. Animal Locomotion, p. 90.

171a20 / 164.5: Michael is right about the wrist; he checked. Leonicus argues that Aristotle's account is correct, referring the PA.

171a23 / 165.20: "Horses": Farquharson notes that this is prancing or caracoling, and refers to Xenophon Equ. XI and the Parthenon frieze. Michael adds that horses thus trained tend to move somewhat sideways or obliquely, as I have noticed too, in the horses of algezairos in corridors. "Dragged along"— ὄψις ἀλήθειαν, see HA VIII.24, 604b1, for a sickness of horses with this symptom. "Get tired"— ἡπειροῦμαι means to get tired and refuse, thus Michael's reference to holding in the reins and whipping.

171a34: Farquharson omits [section], which also makes sense, as the sentence is rather vague and ambiguous. See Forster's comments.

Movement of the two right feet together does occur, and Aristotle observed it: see HA II.1, 498b9, with Peck's note, and the discussion of the camel, above. Some bits of the HA were perhaps added after the IA was written.

171b14 / 166.15: "Crab"— contrast PA II.13, 658a2, where Aristotle says that nature has given the crab movable eyes because of the hardness of its shell. Crabs have at least five pairs of feet; cf. below, ch. 16. Oblique movement: HA IV.2, 526a9, 5, 527b8.

171b22f / 166.19 f: Leonicus, pp 272-3, points out that birds fairly obviously flex their wings as men flex their arms, not as quadrupeds flex their front legs; he also goes on to criticize the account of birds back legs, identifying the parts correctly. Cf. 10.709b25, above, and PA IV.12, 693b12, 695a9; HA II.1, 498a28. Birds are more nearly related to reptiles or other oviparous quadrupeds, as one can see from a comparison of their feet and from their manner of giving birth, but Aristotle here compares birds to viviparous, not to oviparous.

Birds not erect: PA IV.12, 695a6, cf. II.10, 566a13; IV.10, 687a5, 689b11; Somm. 3, 457b25; Resp. 13, 477a21. Front parts lighter: than those of quadrupeds, not than the upper parts of man; Aristotle is thinking of mammals, cf. PA. IV.10.
167.5: “Closely fitting”— a guess at δημένα. Lungus leaves it out, Leonicus: “firmata”.
713a12 / 167.15: “Dividing”— Michael adds ‘compressing’ here, perhaps with a better notion of the motion of the wings. Aristotle does not even mention the fact that the wings move simultaneously, rather than alternately, like the front feet of quadrupeds. Contrast Albertus Magnus de Mot. Anim. II.2, ch. 3. Louis remarks that the holoptera could include bats, though it would be odd to think of their wings as πτερα. The analogy between the wings of birds and the fins of fish is embedded in the Greek language, as the words (used here) are πτεροεις and πτερογια. Cf. Homer Od. XI.125, XXIII.272.
715a14 / 167.18: “Back parts of the body” / “Backwards”— Farquharson conjectures κοκοδέλας μόρας and is followed by Jaeger, Forster, and Louis; this avoids the difficulty which puzzles and defeats Michael here. Leonicus, citing Michael’s explanation, offers something similar, but then goes on to say that some animals, e.g. crabs, do move backward at times. The nss are confused; there may have been something like a notice of the way in which wings really move.
715a15ff / 167.21 ff: Generally reptiles and saurians do not sit on their eggs or guard them. Aristotle gives several examples or supposed examples of tortoises and crocodiles sitting on their eggs, HA V.33, and notes that lizards do not. The troglodytic way of life of some of these species is discussed at HA IX.1, 610a12; PA IV.8, 684a5. Crocodiles are not troglodytic at all, nor are most tortoises.
Species identification: Aristotle lists κοκοδέλας, σαφης, αναλαβότας, κριδές, χελώνας. Leonicus gives: ‘crocodile’, ‘laceratae’, ‘stelliones’, ‘lurariae’, ‘testudines’, and notes that the ‘stellio’ is like the ‘lacerata’, but the color of ash; that ‘mydax’ are ‘testudines’ rather than ‘lurariae’. αναλαβότας has been identified as ‘lacerata mauretanica’, the spotted lizard, or the gekko. I translate ‘gekko’ as it allows three different names in English for three of the Greek words. Louis figures that the hylis is the fresh water turtle, and it is identified by Farquharson as emys luraria; the χελώνη is taken to be the terrestrial tortoise by Louis, and identified by Farquharson as either dermochelys coriceps or thalassochelys caretta or both. Note that Michael inserts ‘frog’ instead of the crocodile and the two sorts of tortoise. Cf. HA II.1, 498a15, and add the chameleon from 503a15 ff.
715a22 / 167.33: “Outside”— Farquharson, Forster, and Louis, follow the gloss in mss YZ and suppose that Aristotle means ‘outside the body’. Michael’s reading is not impossible, however, since ‘outside the body’ is taken care of by ‘to the side’. ‘Pull in the thighs’— Jaeger and other editors use Michael’s to read προστηλομενα instead of προστηλομενα. Aristotle adds μυριδέμα και Michael adds μυριδέμα in explanation. The description here seems more accurate than that at HA II.1, 498a13 ff.
167.13a26 ff / 168.6 ff: “Bloodless footed”— Aristotle mentioned these animals at 1704a12, and 7.707a27, for example, above. The word ‘attached’ here. Leonicus translates προστηλομενα, which can mean ‘grown on’. The feet are called ‘extreme’ by Aristotle not for the reason given by Michael, but because he is thinking of centipedes and like, rather than six-footed insects. This is obvious a little later, when he says that polypods are troglodytes, which is usually true of centipedes and like, but not true of many six-footed insects.
168.13: “No shortage”— Michael’s classroom or study undoubtedly had plenty of flies in those screenless sprayless days.
713b1 / 166.16: Aristotle’s obscurity, reproduced especially in the translation of the commentary, hasfooled Michael.
“Bent under”— τιθήλασσα; “bent”— βεβηλισσα— ‘bentness’— βασιλεις. This group of words is translated ‘bandy’ etc. by Farquharson, ‘bowed’ by Forster, and ‘capaneus’ by Louis. Peck, at HA II.1, 498a21, translates ‘ployed’; in that place the word is used of human arms. As Aristotle proceeds
here, it seems that one could interpret some of the appearances by ‘bandy’, i.e.,
‘with knees (or elbows) far apart’. However, at the beginning of the next chapter it
is clear that Aristotle means to say that βανάδρυς includes a bend in a section
of a limb, rather than a flex at a joint.
At 715a25, “If that’s how it is” follows Louis’ reading; Forster follows \( Z \),
getting ‘if they were underneath.’ The argument has nothing to do with ‘under
at this point – the front legs flex forward, the back legs flex backward, and the
middle legs have to do both. At any rate, Farquharson remarks that Aristotle
correctly observes from nature: a) that the intermediate legs are attached laterally;
b) that the principle flex is upwards; c) that the limbs bend under, or as he calls
it, ‘bandy’.

715b11 / 168.21: “Oddest” – Lunagus and Leonicus say ‘spectabilis’. Previous
reference to crabs: 14.712b20. Hayduck’s text of Michael, which I translate,
does not make a great deal of sense. Lunagus reads, “he puts the word ‘odd’
in because they are peculiar and different in comparison with other animals.”
Actually, crabs may be said to have three (or five) leading feet, making them
‘odd’ in this sense too; a joke like that could be expected from Aristotle.
Leonicus refers to PA IV.8, cf. HA I.5, 490b5. The genera of crustacea
distinguished by Aristotle include: 1) karaboi; 2) Astakoi; 3) Karides;
4) Karkínioi. Leonicus gives: 1) carabi (locutes); 2) astakoi; 3) aquilae;
4) caroni. Peck says that these are roughly equivalent to 1) lobsters, 2) crayfish,
3) prawns and shrimp, 4) crabs (note PA IV.8, 683b27). At 684a31, Peck
translates astakoi as lobsters, however. At HA IV.2, 525a50 ff, he identifies
karabi as crayfish and astakoi as lobsters. Ogle, at PA IV.8, identifies
karaboi palinuridae, or spiny lobsters (langoustes), and astakoi as smooth
lobsters (homard) and river crayfish. I believe Ogle to be right, but cannot
demonstrate it. There seems to be little disagreement about karides = shrimp
and karkínioi = crabs; in view of the present passage, there can be none about
the crabs.

715b16 / 169.1: This part of the text must have been in very bad condition;
Michael tries to straighten it out. These may be the remains of notes which
Aristotle never really organized, or they may be addenda, not necessarily by
Aristotle himself. See Farquharson’s comments.

17.713b21ff / 169.10 ff: This passage seems parallel to 16.713b11 ff, above.
In the case of the ‘lobster’, Michael, Farquharson, and Forster think that the
legs are not ‘bent’, because they are hard and not for walking but for swimming.
Louis translates the text as it stands – other animals have legs which ‘bend’ because
they are soft, but the spiny lobster because they are used for swimming, in spite
of the hardness. For the hardness of the lobster, see HA I.5, 490a2. In the case
of the crab, most mas start by saying that its legs are ‘bent’, but finish at 714a1
by saying that they are not. Consequently Bekker conjectured and most editors
follow a ‘not bent’ at 713b25. Michael seems to have followed a rather different
text – it may have said something like ‘because of the hardness nature makes the
legs “bend” during generation’; thus the reference to the other polypods would
mean that other animals have legs which ‘bend’ because soft, but the crab has
legs which ‘bend’ only in generation, because of the hard exoskeleton. Or Aristotle
might mean that they bend after moulting, while the exoskeleton is becoming
hard.

Our problem is aggravated by the difficulty of deciding the precise sense of
βανάδρυς – we can’t be sure whether lobsters and/or crabs have it or not. In
case, I do not find any interpretation which makes sense equally of the text
and of the observed facts. If βεβαλαίονται means ‘bow-legged’, I would say that
the legs of insects, especially the intermediate legs, have the character, that many
ovipara have it too, and crabs have it, but lobsters do not. If it means that the
sections of the legs have bends in them, you could say that of both spiny lobsters
and crabs.

169.25: “Lobster” – Michael, no doubt by inadvertence, says karabos, and so too
Lunagus translates, but it should be the crab (karkinos).

714a4 / 169.28: Given the text which Michael seems to have had, and a conservative
attitude toward it, this is not as bad an interpretation as Farquharson says, even
though he and Forster translate quite otherwise. Farquharson suggests, “since
a crab is odd enough to walk sideways, its legs are not bandy as they appear to
be if you take the line of progression through the eyes.” See also his other notes
to the passage.

714a6 / 169.31: Louis notes the descriptions of Camus and Cuvier of flatfish; note
the pun on δεκαναύρας – not only is their nature ‘perverted’ but it squints.
As these fish have both eyes on one side of the head, they proceed as if they
had one eye only. Leonicus calls these fish ‘passerina’ and discusses various
species.

714a8 ff: Michael does not discuss the webbed feet of water birds. “Thick and wide” –
some mus have ναρεκές, Ζ has παλαρέκ; Lasser suspected that the original had
both words, and I follow him here. For the use of the concept of 'katachrèsis', see Science and Philosophy ch. IV.

Aristotle seems not to worry very much about this difference between birds and fish. At PA IV.13, 695b4, he refers to some apparently earlier passage explaining why fish don't need wings; no such passage occurs. See also Peck HA Intro. pp. lvii ff, for the media of animals in relationship to their classification. Aristotle does not quite state the essential contrast between water and air animal movement, and land animal movement—the land animals move on their medium, so (short of tunneling) they are limited to the surface contours; water and air animals may also move up and down, so fins, wings, tails, etc. are adapted not only for propulsion but also for ascent and descent. Some of the similarities of fins and wings are due more to this function than to propulsive function. But there are also very great differences between water and air as media, requiring special adaptations to each. Water is about 800 times as dense as air: water animals can be weightless in their medium, which air animals never can; water resists progress through it, enforcing stringent streamlining on any creature which will move at all quickly, but at the same time water provides resistance to the locomotive parts, so that a relatively slow and short movement of the tail of a fish can propel it very well; air does not resist progress very much, but also it does not support weight very well, so that an air animal must either glide on thermals, or spend a good deal of effort both to maintain altitude and to progress. If a bird can fly at all, it can fly rather quickly in comparison with the velocity of water or even land animals; even the fastest fish or porpoise cannot rival a racing pigeon or a migrating waterfowl. Cf. Howell, Speed in Animals.

11b1: "Useless"—Aristotle has just said, in ch. 17, that webbed feet are useful for swimming. If fish had four fins plus feet they would have six or eight points of movement.

11b5: "Toward the top"—ἐν τῷ ἔπαν. Cf. HA 1.5, 489b25; II.13, 504b15; as applied to fish. See also Louis PA p. 54, n. 5. The term is otherwise used: HA I.1, 487a34, of the insections of insects; I.14, 494a14, of the upper back of the heel of the foot; II.1, 498b13, of the upper part or back of quadrupeds. The fins in question are the pectoral fins, but that is not the meaning of ἐν τῷ ἔπαν. Cf. Farquharson. For the varieties of fins in fish, see PA IV.13.

NOTES, IA

19, 714b8 / 170.10 ff: "If they move, they must have a right side"—a phrase of this sort may have been in the text of Aristotle used by Michael; the problem posed (the epistática) requires it. Leonicus refers to PA IV, i.e., 13, 697b1; cf. HA II.1, 498a32, for the seal, and PA IV.7, 683b4 ff, on testaceans; see also HA IV.4, 528a30 ff, where Aristotle remarks that scallops especially move remarkably well, practically jumping out of the device used to catch them, and that all the spiral-shelled testaceans move around. Some testaceans, e.g., pinnae, move less or perhaps not at all. For 'deformed' animals, see also GA 115, 573b32, and "Eidos as Norm." 714b15 / 170.22: Leonicus refers at last to Michael here, p. 279, but only to criticize his interpretation of 'not really mobile'. At 'attached' the text might read 'growing', see Farquharson. In general, ἐξορύξει and its relatives have something of both senses in this treatise. Mobile vs. sedentary: HA II.1, 487b6-18.

11b16 / 170.24: "Want"—the personal noun is typical of Aristotle, and should not be relied upon for any peculiar mentalism in his theory; note too that phylos is not the subject of the verb. Michael correctly perceives that it means no more than 'tend'. Cf. C. Darwin, The Descent of Man, I.330.

11b20 / 170.29: Farquharson wants to read On Life and Death here, on the basis of ms 2, a marginal note; while that may have followed IA in some edition, it is unlikely that that was meant by Aristotle. All ms seem to refer to de An. here; Farquharson refers to William of Brabant, Dittmeyer Aristotle HA (1907) p. xviii for explanation; cf. Wendland, CAG XXII.1, preface. Farquharson also thinks that PA IV.13, 695a12, refers to both IA and MA; consideration will show that it is uniquely a reference to the present treatise. Cf. Forster, Lanza and Vergeri p. 773 n. 72, Louis IA xx-xiii. The following order of Aristotle's botanical works is possible: HA (incomplete), PA (first version), IA, early version of de An. and PN, first version of OA, PA redone with 1, de An. and some of PN redone, OA as is, especially II, MA.
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