ARISTOTLE ON MATERIAL DISPOSITIONS IN *METEOROLOGY* IV

by

Tiberiu M. Popa

Licentiate in Classics, University of Bucharest, Bucharest, 1994

M.A. in Classics, University of Bucharest, 1995

Submitted to the Graduate Faculty of

Arts and Sciences in partial fulfillment

of the requirements for the degree of
Doctor of Philosophy

University of Pittsburgh

2005

UNIVERSITY OF PITTSBURGH

FACULTY OF ARTS AND SCIENCES

This dissertation was presented

by

Tiberiu M. Popa

It was defended on

April 18, 2005

and approved by

David Birnbaum, Associate Professor, Slavic Languages and Literatures

James G. Lennox, Professor, History and Philosophy of Science

Peter Machamer, Professor, History and Philosophy of Science

Mark Possanza, Associate Professor, Classics

Dissertation Director: Mary Louise Gill, Professor, Philosophy and Classics, Brown University

ARISTOTLE ON MATERIAL DISPOSITIONS IN *METEOROLOGY* IV

Tiberiu M. Popa, PhD

University of Pittsburgh, 2005

The purpose of this dissertation is twofold: to elucidate crucial aspects of an important but somewhat understudied Aristotelian text, the fourth book of his *Meteorology*, and, implicitly, to contribute to a deeper understanding of Aristotle's treatment of dispositions. *Meteorology* IV is concerned to a great extent with the properties of organic and inorganic homogeneous materials. The first chapter of my dissertation is meant to clarify the structure of this text, to demonstrate – by appealing to a few new arguments – that *Meteorology* IV is to be attributed to Aristotle and to point out that, contrary to most scholarship on this topic, not all homogeneous materials (*homoiomerē*) are mixtures. I subsequently build on these preliminaries and address three major questions in the next chapters: What are material dispositions, according to *Meteorology* IV? How does Aristotle account for the emergence of dispositional properties in uniform materials? What role do dispositions play in the context of Aristotle's scientific method? I answer the first question chiefly by distinguishing in the Aristotelian text between what one might call today dispositional differentiae (e.g. solubility) and categorical properties corresponding to them (a particular composition or microstructure) and conclude that dispositions are not reducible to categorical features in Aristotle's 'chemistry', but are properties, perceived as being part of a homogeneous material's nature (in a non-teleological context). The emergence of dispositions in the *homoiomerē* receives a more articulate treatment in *Meteorology* IV than in any other Aristotelian work, but its limitations point to Aristotle's preference not to engage in pure speculation, when he cannot rely on an acceptable degree of probability or plausibility; his treatment of the emergence of dispositions

points (in virtue of an understood conditional necessity) to the link between his ‘chemistry’ and his biological corpus. Finally, I give prominence to the central role of dispositions in Aristotle’s method of division and in his effort to gain insight into the composition and microstructure of homogeneous bodies. These aspects of the scientific method deployed in *Meteorology* IV also emphasize the dominant functions of this treatise and its place within the Aristotelian oeuvre.

TABLE OF CONTENTS

ABBREVIATIONS

De an. – De anima (On the Soul)

Meteor. – Meteora, Meteorologica (Meteorology)

Metaph. – Metaphysics

Categ. – Categories

Ph. – Physics

APo. – Analytica Posteriora (Posterior Analytics)

PA – De Partibus Animalium (On the Parts of Animals)

GA – De Generatione Animalium (On the Generation of Animals)

GC – De Generatione et Corruptione (On Generation and Corruption)

HA – Historia Animalium (History of Animals)

Non-Aristotelian works:

CH – Corpus Hippocraticum

Tim. – Timaeus

Note on the translations used in this dissertation

The passages quoted from *Meteorology* IV largely follow Lee's translation – often modified (as indicated) whenever I thought that clarification was needed. Translations of passages from the *Metaphysics* are by Ross, occasionally modified. Passages quoted from *On the Parts of Animals* follow the 2001 translation by Lennox.

PREFACE

I am immensely grateful to my advisors – Mary Louise Gill, David Birnbaum, James Lennox, Peter Machamer and Mark Possanza – for helping me to better appreciate the richness and depth of philosophical and scientific texts such as Aristotle's *Meteorology* IV.

I have been fortunate to assist Professor Lennox in his work on two substantial projects centered on Aristotelian science; although my tasks were of a predominantly technical nature, I was able to get better acquainted with the substance of his inspiring studies and with the philosophical density of Aristotle's biological corpus.

Professor Gill has guided me through the maze of Aristotelian scholarship from my very first year of graduate studies. My interest in Aristotle's 'chemical treatise' was sparked by her memorable lecture on this text (at the University of Pittsburgh) several years ago. With extraordinary generosity, kindness and patience she has helped me to take my dissertation from *dunamis* to *entelecheia* and has greatly impressed me with the acuity of her comments and the ease with which she would clarify my sometimes blurred thoughts. By providing an example that I will do my best to emulate, Professor Gill has also contributed crucially to my becoming a better teacher and has helped me to define my intellectual aspirations.

While I fully assume the shortcomings of this inquiry into Aristotle's treatment of dispositions, I should emphasize that whatever is good about it is essentially the fruit of my interaction with some of the finest persons and minds I have ever met.

I. INTRODUCTION

A. PRELIMINARIES

The fourth book of Aristotle's *Meteorology* enjoyed a remarkably long and rather sinuous career through late antiquity, the Middle Ages and the Renaissance, and formed the object of hundreds of commentaries[1] that ranged from minute philosophical analyses to alchemical interpretations. However, it was relatively understudied in modern times, most probably for two main reasons: persistent doubts about its authorship,[2] and the impression that it was just a moderately curious piece in a vast gallery of barren scientific theories.[3] It is rather recently that this treatise on chemistry – to use a widely accepted anachronism – has become again the focus of intense scrutiny.[4] As a result, *Meteor*. IV has been revealed to be far more than a reliquary for obsolete

[1] A recent doctoral dissertation by Craig Martin (Harvard University 2001) offers a useful synopsis of many of these commentaries. See also Düring 10-1, 22-24 and Viano (ed.) 2002.

[2] For details, see Ch. 1 of this dissertation.

[3] In the 17th century Pierre Gassendi offered a scathing critique of the *Meteorology* in his *Exercitationes paradoxicae adversus Aristoteleos* (e.g., at 130a). Three centuries later, Lee himself, author of the Loeb translation, did not appear to be enthralled by the content of the four books of the *Meteor*.: "That the *Meteorologica* is a little-read work is no doubt due to the intrinsic lack of interest of its contents. Aristotle is so far wrong in nearly all his conclusions that they can, it may with justice be said, have little more than a passing antiquarian interest" (1952, xxv-xxvi).

[4] To mention a few important examples: Düring 1944 (1980 repr.), and, more recently, Furley 1989b, Gill 1997 and ms., Lennox ms., Lewis 1996 (dwelling especially on Alexander's commentary), Gill and Lennox (forthcoming at Oxford University Press).

theories: indeed it can prove a very effective tool in our effort to better understand, among other things, aspects of Aristotle's theory of matter as well as the relationship between material necessity and final causation – especially in a biological context. Besides, if we are looking for an Aristotelian text that causally explains material dispositions, *Meteor*. IV appears to be the most promising candidate,[5] as it details the conditions for the coming into existence and for the manifestation of such dispositions.

Meteor. IV is not a book about meteorology, even in an Aristotelian sense.[6] Its position, after *Meteor*. I-III, may be an accident related to the early tribulations of Aristotle's manuscripts.[7] As far as the subject matter goes, *Meteor*. IV would more naturally come after *Generation and Corruption* II, as Alexander suggested (179.3). *Meteor*. IV has rightly been considered[8] transitional from works that are primarily concerned with the study of inorganic materials (*De Caelo* III-IV, *Generation and Corruption, Meteorology* I-III) to Aristotle's biological works (such as *Parts of Animals* and *Generation of Animals*). This idea has become common currency with the publication of David Furley's 'The Mechanics of *Meteorologica* IV: a prolegomenon to biology' (1983), although the point was possibly suggested by Aristotle

[5] For causal explanations of other types of dispositions (*meta logou*), one will have to take into account primarily the *Nicomachean Ethics*, *De anima* and the *Metaphysics*.

[6] Aristotelian meteorology covers phenomena occurring in the sublunary sphere due chiefly to the dry and the moist exhalations meant to account for the appearance of the Milky Way, for comets, meteors, earthquakes, and for what we would consider today to be meteorological phenomena proper (all these topics form the substance of Books I-III).

[7] This is not to say that there are not tantalizing connections with *Meteor*. I-III (perhaps I 1 - depending on one's interpretation of 338b25; the end of Book III; the mention of the *anathumiaseis* in IV, at 384b33 etc.). On the relationship between Books I-III and the final book of *Meteorlogica*, cf. Alexander 179, 4-11, and Olympiodorus (*In Meteorlogica*) 173.

[8] Notably by Furley, Gill, Lennox.

himself, in the first chapter of *Meteor*. I, a chapter that is both retrospective and programmatic.[9] Besides, in the final chapter (Ch. 12) of Book IV, at 389b23-28[10] and 390b15-23, Aristotle explicitly states that, after dividing homeomers into kinds (*genē*) in the bulk of *Meteor*. IV, his next task is to consider organic uniform bodies individually (*kath'hekaston*); a crucial factor in determining their nature individually will be, in his biological corpus, the use of functional accounts, involving constant appeal to final causes.

Thus, chapter 12 gives prominence to one of the emblematic motifs of Aristotle's natural philosophy. The study of organisms and of individual parts should combine an inquiry into their material constitution (a task largely assumed by *Meteor*. IV – at a generic level) with an account

[9] "After we have dealt with all these subjects [viz. that together constitute 'meteorology'] let us then see if we can give some account, on the lines we have laid down, of animals and plants, both in general and in particular; for when we have done this we may perhaps claim that the whole investigation which we set before ourselves at the outset has been completed" (*Meteor*. I 1.339a6 ff.). Both the 'general' and the 'particular' (*katholou – chōris, kath'hauto*) approaches can be found *within* Aristotle's biological corpus and may have been present in some lost treatises on botany, especially if Theophrastus' own works roughly reflect the nature of their models. But even *Meteor*. IV is overtly meant to offer a generic account of uniform bodies; its 'particular' counterpart can be found in *PA* and in *GA*, in so far as the *organic* uniform parts are concerned (and, we can conjecture, Aristotle probably also intended to give a more detailed account of *inorganic* uniform bodies, although, as Olympiodorus assures us at the outset of his commentary on *Meteor*. IV, Aristotle never actually carried out that project).

[10] The beginning of *Meteor*. IV 12 (389b23-28) reads: "Having dealt with these matters, let us proceed to give separate accounts of flesh and bone and the other homoeomerous bodies. We can tell from their generation what is the constitution of the homoeomerous bodies, what are the kinds into which they fall and to which class each (*hekaston*) belongs." This passage seems almost echoed by the end of *PA* II 5: "We have stated, regarding blood, serum, and soft and hard fat, both what each of them is, and owing to what causes each of them is" and may be reminiscent of the end of *Meteor*. III: "So much for a general (*koinēi*) account of these bodies; we must now take each kind (*idiai...peri hekaston genos*) separately and examine it in detail." Depending on one's take on the relationship between *Meteor*. I-III and *Meteor*. IV, some might wonder whether, to a limited extent, *Meteor*. IV does not stand to *Meteor*. I-III in a relation similar between *PA* II and *Meteor*. IV; in other words one might argue that *Meteor*. I-III (or at least some of its portions, especially the ones dealing with the formation of minerals) are a 'subordinate', to echo the *APo*. Terminology, to *Meteor*. IV, just as *Meteor*. IV may be subordinate to *PA* II (see my Ch. 4).

of the functions that essentially determine the nature of those parts (this being fulfilled by various segments of Aristotle's biological works).

The views expressed in Ch. 12 are of utmost importance to our correctly placing *Meteor*. IV within the Aristotelian oeuvre (the 'missing link' between works dealing with the inorganic and works devoted essentially to biology) and to our correctly assessing the role of the homoeomerous bodies within a biological context. Nonetheless, the actual, dominant achievement of *Meteor*. IV lies elsewhere: most of the fourth book (Chs. 1-11) is devoted to the study and division[11] of kinds of homeomers (or: homogeneous stuffs, uniform mixtures) and of various effects of heat and cold on such uniform mixtures – an enterprise that will turn out to be profitable in the study of simple and complex 'parts' in treatises like *Parts of Animals*: Aristotle does not have to embark on lengthy and detailed inquiries into the nature of uniform bodies every time he considers the material nature of some tissue, such as blood or flesh, in his biological works. Instead, he can conveniently glimpse back, as it were, at his earlier investigation in *Meteorlogy* IV and, based on the perceptible properties of some tissue, he can presumably determine its composition: watery, mostly earthy etc.[12] The second book of *Parts of Animals*, to mention only the most obvious example, contains numerous such details that appear to draw upon *Meteor*. IV.

[11] More on this point in my section on division.

[12] This is, I think, in keeping with the 'economical' approach that – as Lennox (2001c) has shown – is displayed *within* the *Parts of Animals* itself: Aristotle starts, in *PA* II (esp. Chs. 1-9), with accounts of tissues and uniform parts, before engaging in a discussion of non-uniform parts in books III, IV (had he done otherwise, he would have had to account for the nature of tissues whenever talking about complex organs).

Let me turn to dispositional properties[13] and indicate in the next few of pages why I believe they are at the heart of *Meteor*. IV and why their study is, implicitly, worth pursuing. First, I should make a terminological clarification here. In numerous translations and commentaries of Aristotelian treatises, 'disposition' translates the Greek term *diathesis*. In the *Categories* (8.8b25 ff.) Aristotle defines *diatheseis* as being "qualities easy to move or to change…" – whereas states or habits (*hexeis*) are "more lasting and stable." This distinction, however, is only partial since it turns out (see *Metaph*. Δ 20) that *hexeis* are occasionally considered *diatheseis*. In order to dispel as much conceptual and terminological haze as possible, I should say that, in this dissertation, I am using the term 'disposition' in a broader sense, covering more than just *diatheseis* as defined in the *Categories*. Nor am I concerned here with disposition as *dis-positio*, arrangement of parts (a sense of *diathesis* that is explored in *Metaph*. Δ 19). I am rather interested in disposition as power, capacity or potentiality – for which *dunamis* would be the best Greek equivalent, and much of this study will attempt to clarify various aspects of *dunamis*. Recent studies on dispositions have offered divergent views on this notion; let me quote here two relatively uncontroversial definitions. The first one was proposed by Tim Crane (in Armstrong, Martin and Place 1996, 1-2) and seems to echo what Aristotle himself wrote about powers or capacities:

> …A disposition is a property (such as solubility, fragility, elasticity) whose instantiation entails that the thing which has the property would change, or bring about some change, under certain conditions. For instance, to say that some object is soluble is to say that it would dissolve if put in water… The fragility (solubility, elasticity) is a disposition; the breaking (dissolving, stretching) is the *manifestation* of the disposition… These characteristics of the

[13] The distinction between dispositional properties and their manifestation is made clear in a passage representative for most of *Meteor*. IV: "…All will exist either actually or in the opposite sense, [i.e., potentially – not in Gk]: this, for example, is the relationship borne by the process of melting to the capacity for being melted" (IV 4.381b27-28).

> world – fragility, poisonousness, flammability, nourishingness, loyalty, honesty, courage and humour – are all dispositions.

And, in Goodman's (1955, 40) suggestive words, we are urged to notice that

> Besides the observable properties it exhibits and the actual processes it undergoes, a thing is full of threats and promises. The dispositions or capacities of a thing – its flexibility, its inflammability, its solubility – are no less important to us than its overt behaviour, but they strike us by comparison as rather ethereal

More than any other extant Aristotelian text, the 'chemical treatise' provides causal explanations especially for *derivative* material dispositions[14] and describes conditions for their manifestation. In addition to this, I would claim that material dispositions fulfill *two chief functions* in *Meteor*. IV: (a) they play a crucial role in *determining what the 'chemical' composition of a body is*, and, connectedly, (a) they are instrumental in Aristotle's *division* of the homeomers.[15] Let me spell out these two points.

(a) Dispositions are supposed to allow Aristotle to gain insight into what would otherwise remain invisible, by establishing what the 'chemical' composition of this or that body is (usually a certain ratio between earth and water or dry and moist), and what its 'microstructure' is (say, a particular type of *poroi*, arranged according to this or that pattern). As becomes clear in *Meteor*. IV (especially in Chs. 5, 6, 7 and 10), the 'chemical' composition of the uniform stuffs is indicated by their dispositions, which, as I mentioned, play a central role in Book IV.

To take a few examples, we learn (388a30 ff.) that, according to Aristotle, liquids that tend to evaporate easily (this being, of course, a disposition) consist mainly of water (which amounts to the 'chemical' composition), whereas those that tend not to evaporate easily are

[14] That is, dispositions that emerge when new uniform mixtures come about or when already existing uniform stuffs are altered.

[15] My distinction between the two functions - (a) and (b) – is not meant to suggest that they play out in two separate sections of the text; they are more or less intertwined throughout Book. IV.

mixtures of earth and water (e.g., milk) or contain water and air (e.g., oil). Also the fact that heat increases the density of some liquid (disposition) is a sure sign that it is a mixture (say, of earth and water – which makes for a rudimentary 'chemical' formula), etc.

(b) A second important function fulfilled by dispositions, tightly bound up with the fact that they can presumably bridge the gap between observable phenomena and the 'invisible' (the microstructure and 'chemical' composition of the homoeomerous bodies) is the role of dispositions as differentiae. In Book IV, Aristotle's effort is concentrated on dividing and defining the main types of organic[16] and inorganic homoeomerous bodies in an articulate fashion.[17] This generic division is achieved by means of three main types of differentiae:[18] (1) the 'chemical' composition, that is – the nature and proportion of the original ingredients of the homoeomerous stuffs, (2) the specific dispositional properties of these uniform bodies,[19] and (3) physical features – like the presence of certain types of *poroi* or minuscule channels pervading such bodies. Given that dispositions can be inferred from the behavior of uniform bodies and are more easily accessible than the composition or texture of these, they are accorded a great deal of attention in *Meteor*. IV. Accordingly, a reader of this book might be in for some disappointment if looking for stiffly delimited accounts of metals, sorts of wood, various minerals, etc. Instead, one will find curious kinds such as: (1) 'the earthy' (or: 'the earthy ones', i.e., stuffs containing predominantly earth) and 'the watery'; (2) the breakables, the solidifiables, the meltables, the

[16] The organic ones being principally the various tissues dealt with in Aristotle's biology.

[17] Although in a quite different way from standard modern taxonomy (see my chapter on 'Scientific Method').

[18] Other sets of differentiae in the biological works will be: the functions (*erga*) fulfilled by organic bodies, the very presence / absence of a part or other; the shape and size of a part or other.

[19] The (active) basic dispositional differentiae are dealt with in Ch. 11; derivative dispositions are discussed in most of *Meteor*. IV.

combustibles, the stuffs giving off fumes, and so forth; (3) stuffs whose *poroi* are arranged by fascicles or are disposed lengthwise or in some other fashion.

To sum up these two points – (a) and (b) – one of Aristotle's main achievements in this book is that he manages to provide a relatively clear generic division of homoeomerous stuffs (in preparation for a more specific discussion in *PA* and *GA*). He outlines kinds (*genē*) of homeomers according to their characteristic dispositions (e.g. in Chs. 8-9: the fragile ones, the flammable ones etc.), according to their physical structure (*poroi* of various sorts), and according to their 'chemical composition' (esp. in Chs. 5-7 and 10: stuffs consisting mostly of water but also including some earth etc.). Now, in order to establish the composition of the homeomers and to make such a generic division possible, Aristotle needs to rely on the dispositions or *expected* behavior of such uniform stuffs and, as I will show in my chapter on scientific method, also on undemonstrated assumptions about the material nature of the uniform stuffs. Dispositions are, accordingly, crucial to *Meteor*. IV on at least two accounts: they form one of three series of differentiae of uniform materials (at a strictly material, non-teleological level) and they help Aristotle peek, as it were, at those uniform bodies' 'chemical' nature – which would otherwise remain inaccessible.

Given the massive emphasis placed on dispositions in *Meteor*. IV and their tight connections with metaphysical issues (the nature of matter, and the potential and actual aspects of being) as well as with aspects of Aristotle's natural teleology, I believe that a thorough study of material dispositions in this 'chemical' treatise can be a fruitful enterprise. It can shed new light not only on some of the intended achievements of *Meteor*. IV and on the relationship between its various segments, but also on Aristotle's scientific method and on his ontology.

B. THE MAIN SEGMENTS OF THIS DISSERTATION

This dissertation is intended to tackle three principal questions: What are material dispositions (Ch. 2)? How do material dispositions come about (Ch. 3)? How are dispositions put to work in Aristotle's scientific apparatus (Ch. 4)? While some of my answers will have the firmness provided by what I take to be plausible or even indubitable evidence, others will be more tentative and will acknowledge the obscurity (or, at best, the chiaroscuro) in which today's students of Aristotle are compelled to leave a few aspects pertaining to his 'chemistry'.

Chapter 1. In order to prepare the ground for my main inquiries, I first address several fundamental aspects of and point out outstanding problems with *Meteor*. IV; my attempt to solve some of those problems is meant to contribute to a better understanding of the central topic of this dissertation and of *Meteor*. IV in general. My preliminaries start there with a survey of the contents of *Meteor*. IV, followed by an evaluation of its argumentative structure and emphasize the occasional incoherence or tautology of the text, as well as the connections that we can establish between a few structural anomalies and the authorship of *Meteor*. IV. I note there that Gottschalk's argument about Aristotle's appeal to *poroi* is indeed troubling, but I try to alleviate this trouble later in this chapter. Although absolutely definitive conclusions as to who wrote certain portions of *Meteor*. IV are near-impossible, what matters more is that, in light of its Ch. 12, it seems clear that Aristotle readily accepted the explanations and implicit definitions provided in Chs. 8-9 (largely a list of dispositions shared by most uniform bodies). In other words, while we may never know with any satisfying degree of certainty who actually wrote much of Chs. 8-9, we can safely affirm that they reflect Aristotle's views; this conclusion is

important to my topic since a considerable number of dispositions seem to depend on the presence of *poroi* in uniform or homoeomerous stuffs. My next note is on Aristotle's resort to *endoxa*; although my conclusion is purposely aporetic, at least the very mention of this otherwise important aspect of Aristotelian methodology in general is worthwhile here, I think, precisely because Aristotle's use of *endoxa* in the chemical treatise is indeed uncharacteristically and vanishingly tenuous; accordingly, it may be take by some to form an additional reason for doubting that Aristotle is really the author of *Meteor*. IV. Most of these issues grouped and discussed in my first chapter deal with problems that are quite significant in their own right, but also clustered around the issue of this book's authorship. The final segment of my first chapter is no exception in this respect. It deals with the very notion of homeomer, and assesses the possibility that, against a generally held view, some homeomers may indeed consist of one element. This is not just a discussion about a possible argument against Aristotle's authorship of the 'chemical treatise', but also a clarification of a concept central to *Meteor*. IV and an attempt to shed some new light on it; it is also directly relevant to the emergence of secondary dispositions. My conclusion in this respect is that, although *Meteor*. IV is somewhat hesitant on the topic, it does afford sufficient evidence for us to think that Aristotle did not exclude the possibility that some homeomers consist of only one element, such as earth or water. Finally, I propose that it is different microstructures (chiefly different types of *poroi*) that can ultimately account for the distinctive properties of such uniform stuffs, in the context of *Meteor*. IV.

Chapter 2. Once these aspects have been clarified, we can turn our attention to the nature of the material dispositions discussed in *Meteor*. IV. Following a few succinct observations on the polisemy and history of the term *dunamis* in the Greek thought, I take my starting point in the eighth chapter of the *Categories*, which lists *dunamis* among various types of qualities. That

material dispositions are just qualities or properties has been disputed, especially in so far as the basic *dunameis* (or contraries) are concerned. This approach, however, is not well founded, as proven by Gill and also, in a different way, by the very text of *Meteor*. IV (where the apparent interchangeability of dry and earth, of moist and water do *not* signal that the passive contraries are stuffs, in the way in which earth and water are). If dispositions, basic and derivative alike, are properties or qualities, the next step is to see just what sort of properties they are. I start by analyzing the theoretical treatment of *dunameis* as sources of change in agents and patients (in *Metaph*. Δ 12 and Θ 1-5); I discuss then in what ways *Meteor*. IV roughly matches the *Metaph*. account and I show that the 'chemical treatise' enriches the *Metaph*. Discussion, e.g., with further criteria for distinguishing types of *dunameis* (this section also prefigures one of the points I make in Ch. 4, namely the fact that *Meteor*. IV causally explains material *dunameis*). My analysis focuses first on active and passive *dunameis*, since they receive most attention both in *Metaph*. Θ 1-5 and in *Meteor*. IV (more specifically, on the 'context-dependent' nature of *basic* active and passive powers, and on the rather elusive notion of heat). This 'positive' outline of *dunameis* as sources of change is followed in my second chapter by considerations regarding what material dispositions *are not* (this move too being directed, of course, at further clarifying what they *are*). By relying on *Metaph*. Θ and on the causal explanations included in Chs. 5-7 and 10 of *Meteor*. IV (and, with due caution, on contemporary studies on dispositions), I point to the fact that dispositions are reducible neither to categorical properties, nor to their own manifestations. If this is indeed right, then one might find it puzzling that *dunamis* is sometimes quasi-synonymous with *pathos*, this term referring often to actual processes like doings and instances of 'suffering', as well as to categorical properties. Therefore, I take up a comparison between the use of *dunamis* and that of *pathos* in *Meteor*. IV and conclude that, when apparently

synonymous, they are, as it were, two facets of the same state, in a way comparable with the relation between second potentiality and first actuality in the *De anima* II 5 model. Finally, I complete this last section with my thoughts on the relationship between *dunamis* and *phusis* (and I suggest there that, according to the 'chemical treatise', the manifestations of dispositions function as actual signs of the nature of some uniform stuff, while the dispositions themselves are part of its nature), a connection that leads me to the next segment of this dissertation. Yet, the account of the uniform bodies' natures in *Meteor*. IV 1-11 is a markedly incomplete one (or: is complete a strictly material level), with a few exceptions – a discussion that leads into the next chapter of my dissertation, dealing in part with the implications of conditional necessity for organic bodies.

In order to preserve the unity of the second chapter, I placed additional observations in four appendices, which are meant to complete my inquiry into the nature of dispositions. In Appendix I, I point out some limitations of the similarity between *Metaph*. Θ 1-5 and *Meteor*. IV (*hēi allo, kalōs, meta logou*), believing that a 'negative' approach to dispositions will further reveal what they actually are. Appendix II dwells on two distinctions made explicitly and implicitly, respectively, in *Meteor*. IV: essentially perceptible vs. more intrinsic dispositions, chemical vs. physical, and I underline again the fact that *Meteor*. IV offers, among other things, not only causal explanations of material dispositions (unlike more theoretical texts, like *Metaph*. Θ), but also a quite nuanced typology of dispositions. Appendix III is meant to emphasize a significant imbalance in Aristotle's account of derivative dispositional properties, almost all of the examples offered in *Meteor*. IV referring to passive derivative dispositions. The next appendix clarifies the place of the resistive powers in *Meteor*. IV and completes my discussion of *dunameis* most relevant to change; I try to clarify there the philosophical importance of

adunamia, extricating it from the terminological snares of Aristotle's texts (*Metaph*. and *Meteor*.).

Chapter 3. The central topic here is the emergence of derivative dispositions. This chapter has two main sections: (I) The principal stages in the emergence of derivative dispositions. After summing up the results of recent studies on the topic, I try to provide further analysis and, in the process, clarify issues such as: ways in which the *Meteor*. IV account of the emergence of dispositions is insufficient for our thorough understanding of that process, and Aristotle's reliance on admittedly *possible* solutions (the first book of the *Meteorology* being illuminating in this respect). (II) After considering in the previous section difficulties that might hamper our understanding of how derivative dispositions are supposed to emerge, according to Aristotle's 'chemistry', I focus on the more theoretical aspects of the issue, namely on the twofold application of *De anima* II 5 to the line of argumentation in *Meteor*. IV. I accept in the first part of this section that *De anima* II 5 can be interpreted variously and that it applies best in contexts that include final causation; my reading of *De anima* II 5 yields an account of (a) the acquisition and (b) the manifestation of *dunameis*. There are several advantages to looking at *Meteor*. IV from the perspective of the (*De anima* II 5) two-step or three-stage model. More light can be cast on the structure of Book IV; besides, I hope that this section will further clarify why and in what sense material dispositional properties are *potencies* while also being *actual*. Most importantly, I would like to show that *Meteor*. IV connects two distinct orders of *dunameis*: material dispositions such as solubility and elasticity, and capacities of homeomers to perform specific functions as parts of complex organs (and of artifacts – when these are wielded appropriately). To explain the links between these two orders of *dunameis*, I enlist Aristotle's own help and I essentially follow the distinction between two levels of potentiality and actuality

(marked out in *De Anima* II 5), which accounts, on each of these two levels, for the emergence and for the actualization of *dunameis*. I then propose that *conditional necessity* is the principal key to integrating the two orders of *dunameis* ('simple' material dispositions and capacities of homeomers to perform specific functions as parts of more complex structures) into a unitary picture and possibly to acquiring more insight into the relationship between Aristotle's chemistry and his biology. In short, the second major segment of the third chapter is intended to clarify the way in which the material *dunameis* that claim Aristotle's attention in *Meteor*. IV 1-11 are to be connected with the significantly different type of *dunameis* discussed in Ch.12.

Chapter 4. My discussion about the nature (Ch. 2) and emergence (Ch. 3) of material dispositions in *Meteor*. IV is followed in this dissertation by a study of how they are actually put to work, i.e., of their functions in Aristotle's scientific method. My prolegomena to the bulk of this chapter include notes on Aristotle's effort to delineate a new science and on one of the main disputes around Aristotle's 'applied' science: its (in)compatibility with theoretical texts (chiefly *APo.*, but also *PA* I); my claim is that *Meteor*. IV bolsters recent studies devoted to Aristotle's 'applied' biological works, studies which stress significant links with the more theoretical and programmatic scientific texts. *Dunameis* play a dominant role in *Meteor*. IV in virtue of (a) their explanatory power, as they seem to reveal otherwise undetectable features of the homeomers (chemical composition; *poroi* of a particular kind) and (b) the generic division of the homeomers. Therefore, I start with precisely these two aspects of Aristotle's scientific method in *Meteor*. IV and I give the more weight than I give to the other aspects. (I) Observation and inference. I point out in this section that the natural direction of Aristotle's investigation is from dispositions (or from their *expected* manifestation) to chemical composition and microstructure; this should not be obscured by the fact that Aristotle's scientific discourse and effort to put order

in the enormous number of homeomers occasionally exhibits the opposite direction ('stuffs that contain mainly water and some earth behave in this or that way'). It is also important to note that many, if not most, of the inferences regarding chemical composition and physical microstructure are carried out not simply by a transition from observing dispositions to finding out the 'chemical' composition etc., but usually *also* by importing into such explanations postulates or undemonstrated (and indemonstrable) principles. My analysis goes on to tackle briefly the use of analogies, comparisons and experiments. In a partial corollary to these sections, I also note that many of the aforementioned inferences are easily syllogizable, and so the scientific discourse of *Meteor*. IV is not quite at odds with *APo*. I conclude the section on observation and inference with a careful look at the law-like formulations of the connections between the chemical composition and microstructure of uniform bodies and their derivative dispositions, and I list several types of laws and discuss their recurrent structure. (II) In preparation for my inquiry, I begin my section on division with a few remarks on the criteria provided by *Meteor*. IV for a generic division of the homeomers and on the function of division in Aristotle's science. In studying the use of dispositions in Aristotle's method of division in *Meteor*. IV, I follow Balme's and Lennox's seminal papers and I focus on the following aspects: successive differentiation; multiple differentiae; the fact that one should not divide by essential accidents, but rather by differentiae that are in the being (*ousia*); the use of negative differentiae; the fact that one should divide only by opposite differentiae; the use of "the more and the less." As a result of this analysis, I re-emphasize the compatibility of *Meteor*. IV with theoretical texts such as *APo.* and *PA* I. (III) Teleology. Since this facet of Aristotle's scientific method in *Meteor*. IV has received relatively great attention from scholars and since I make frequent references to it throughout this dissertation, I choose not to insist too much on it at this point. I review here the results of

previous studies; then I point out again (cf. Ch. 3 of this dissertation) that Chs. 2-3 of *Meteor*. IV may have something to say that is relevant to teleology. This topic also serves as a natural transition to the concluding part of this chapter and of my dissertation, namely (IV) the section on the relationship between *Meteor*. IV and Aristotle's biological corpus (esp. *PA* II and *GA* V). I try to show that *Meteor*. IV is *subordinate* to the biological works dealing with various tissues (with their material natures *and their functions*) in that the latter provide a firmer grasp on the nature of homoeomerous stuffs; this, however, is not to say that *Meteor*. IV is subordinate to some of the biological works in the sense set forth by *APo*., since *PA* II 1-9, for instance, hardly displays a higher degree of abstraction than *Meteor*. IV. This section brings me back to my initial discussion (see the first part of the Introduction) about the place of *Meteor*. IV in the Aristotelian corpus and is thus a natural conclusion of the main part of my dissertation.

In the end, I summarize my intended contribution (a) to a better understanding of *Meteor*. IV (structure, line of argumentation, methodology, overall purpose, and its main tenets – especially in so far as they involve dispositions, which, I believe, are critical to the substance of that book), and (b) to a better understanding of several aspects of Aristotle's treatment of *dunameis* in general, but especially of material *dunameis*.

Let me begin then by reconsidering several basic aspects pertaining to the line of argumentation in *Meteor*. IV, to its authorship and to the very notion of homogeneous bodies, which defines the main object of this book.

II. ON SOME FUNDAMENTAL ASPECTS OF *METEOROLOGY* IV

A brief description of the contents and structure of the fourth Book of Aristotle's *Meteorology* is opportune, I believe, before I embark on a detailed treatment of material *dunameis*. This map will make it easier for the reader to place in the appropriate context the references that I will make to specific passages in *Meteor*. IV. A merely descriptive approach, though, will not elucidate the interconnections underlying the text. Therefore, I am also taking up at this point a brief analysis of the interdependence between some of the main sections of Book IV and of the major steps in Aristotle's line of argumentation. This purposely succinct survey will be considerably enriched with further details and comments throughout this study. I will also discuss the issue of this book's authorship and will state why I believe that we should assign this treatise to Aristotle. Finally, before I get to the core of my investigation, I would like to reconsider the notion of homeomer in light of Book IV and to compare *Meteor*. IV in this respect with *GC*.

A. A BIRD'S EYE VIEW OF *METEOROLOGY* IV

In order to provide my discussion with a clear framework, let me first outline the content of Book IV. As I noted in the Introduction, unlike the first three books of the *Meteorology*, the twelve chapters of Book IV do not form a treatise about (what Aristotle takes to be) meteorological phenomena, and are not concerned primarily with exhalations (*anathumiaseis*), which are introduced as fundamental principles in Books I-III. Combinations of two types of exhalations (dry and moist)[20] are, according to Aristotle, responsible for meteorological phenomena as well for the formation of metals and stones; in *Meteor*. IV there is only one mention of the exhalations, made at 384b33: metals are composed of water, earth, and of their exhalations "when, as has been explained elsewhere (cf. 378a15 ff.), they are enclosed underground."[21]

Book IV centers on Aristotle's "theory of chemical combination", to use one of Düring's (1944) favorite expressions; thus, it shares less with the first three books of the *Meteorology* than with, e.g., *De Caelo* III-IV, *GC* and *PA* (especially Book II). Unlike *De Caelo*, but very much like *PA*, Aristotle is more concerned with the four opposites (dry, moist, hot, cold) than with the four – improperly called – elements (earth, water, air, fire). The nature of each so-called element is determined by a pair of features, one from the hot – cold spectrum, one from the dry – moist continuum (earth is cold and dry, water is moist and cold, air is hot and moist, fire is hot and

[20] The concept is also used occasionally in Aristotle's biology (e.g. in *PA* II 2, at 649a21).

[21] Therefore, one should probably suppose that Aristotle's theory of exhalations is still in the background of Book IV and is not discounted or replaced, although it is clear that the two *anathumiaseis* are not at the heart of *Meteor*. IV. A potentially important issue – which, nonetheless, can only be addressed conjecturally – might be why Aristotle did not bridge the apparent gap between Books I-III and Book IV in a more robust manner (the second major paragraph of Theophrastus' *De lapidibus* suggests that such a scientific enterprise was indeed possible).

dry). Among the four contraries, hot and cold are considered active *dunameis*, since they act upon and inform the dry and the moist (often assimilated by Aristotle with earth and water), and combine them, separate them, or alter some characters of their various combinations: cold solidifies, heat sometimes solidifies and sometimes dissolves, depending on the composition of the *homoiomerē*,[22] and so forth. Book IV also discusses a host of secondary[23] or derivative properties – hardness, meltability, fragility, etc. The final section of Book IV brings up new considerations, especially the importance, in biological investigations, of combining and balancing material and functional accounts (the latter entailing particular analyses of final causation and conditional necessity).

To enhance the clarity of my brief overview, let me summarize the content of Book IV *by chapters*.[24] Aristotle's discussion naturally starts in the first chapter with the role of the four contraries (as causes, *aitia,* of the 'elements') – hot and cold, moist and dry – in the formation of compound bodies and the coming about of their secondary qualities. The first three chapters are unified by their emphasis on the active factors (heat, cold). In the first chapter, especially prominent are the notions of generation and destruction. Aristotle goes on in Chapters 2 and 3 to

[22] Or, as I also call them occasionally, uniform, homogeneous, homoeomerous stuffs or bodies.

[23] In order to prevent misunderstanding, I should caution my readers that phrases like 'primary' and 'secondary' (or: 'derivative', 'emergent') properties in this study are not semantically coextensive with the primary and secondary qualities famously advocated by Boyle and Locke, and criticized by Berkeley. In Locke's terminology, hot, for instance, would be a secondary quality. By 'primary' dispositional properties I mean the four basic contraries or qualities: hot, cold, moist, dry, which (barring possible counterarguments from some advocate of the prime matter theory) can be safely said not to be derived from anything else On the contrary, by 'secondary' qualities or dispositional properties I mean any property (such as meltable, inflammable etc.) that was produced as a result of the effect of the active contraries (hot, cold) on a mixture of dry and moist (passive contraries or *dunameis*) present in different ratios in homogenous bodies. A certain hierarchy can be noticed among the secondary dispositions, hard and soft being considered 'first' among secondary qualities (382a8).

[24] Aristotle certainly did not divide what we call the fourth Book of the *Meteorology* into its twelve chapters; it may have been done by a late medieval *scriptor*.

discuss various sorts of alteration (specifically: action of heat and cold on already – *ēdē* – constituted complex bodies), which he groups under two headings: concoction (*pepsis*)[25] and inconcoction or insufficient concoction (*apepsia*), each including three subtypes (in standard translation: ripening, boiling, roasting, and rawness, scalding, scorching). In Chapters 4-10 (to some extent in 11 as well) Aristotle's attention is concentrated on the passive factors (dry and moist, or: earth and water), occasionally referred to as 'matter' or 'underlying matter'.[26] Part of Chapter 4 is devoted to the 'first' (*prōta*) secondary qualities: hard and soft – which characterize all solid bodies. Chapters 5, 6 and 7 discuss solidification and liquefaction (due to heat or cold) of watery liquids, of compounds of water and earth (earth predominating in some, water in others). Chapters 8 and 9 are mainly a list of descriptions, examples and definitions of eighteen dispositional properties and of their opposites that are generally explained by appeal both to the physical structure of the bodies (*poroi,* etc.) and to their 'chemical' composition. I should mention that the incomplete[27] nature of the list in Chs. 8-9[28] and the fact that, more generally, the

[25] Aristotle defines *pepsis* (concoction) as an effect of heat (379b12), more specifically, a sort of "maturity, produced from the opposite, passive characteristics by a thing's own natural heat" (379b18-19). As for *apepsia* (inconcoction), it is "a failure to reach maturity owing to a deficiency in natural heat, and lack of heat is of course cold" (380a7-9).

[26] The keynote is struck by a passage close to the beginning of Ch. 4 (381b24 ff.): "The passive elements of physical bodies are moist and dry and all bodies come from them, the nature of the body varying according as to which predominates, dry doing so in some cases, moist in others" (Lee with modifications).

[27] The list in Chs 8-9 includes mainly dispositional properties that belong to solids. This may be due to the fact that Aristotle thinks that there is a wider variety of properties among solids. While liquids are certainly not ignored, and receive indeed a careful treatment and are divided according to their composition, far greater attention is accorded to solids (whose primary properties, according to Ch. 4, 382a9, are, again, hardness and softness). In Ch. 8 Aristotle notes that "The great majority of bodies are differentiated by these qualities [i.e. the eighteen *dunameis* and eighteen *adunamiai*]", but this just underlines how important and widespread those qualities are in the sublunary world, rather than suggesting an attempt to offer a near-complete list of material dispositions that are worth mentioning.

[28] Besides the absence of a detailed discussion of derivative active dispositions, note the absence of some passive ones from that list – e.g. *tasis*, mentioned fleetingly in Ch. 12 as if it were in fact part of the list in Chs. 8-9.

treatment of derivative dispositions in *Meteor*. IV in general is not exhaustive may be revealing for the status of this scientific treatise. It does not appear to have been meant as a definitive statement on the topic of uniform stuffs, but rather as a generic and perfectible account, intended to have its intrinsic worth and also, mainly, to serve as a useful synthesis completing the *GC* and supporting claims in the biological works. That Aristotle did not have time or did not find it necessary to bring this account to a higher degree of 'perfection' is also shown by a certain measure of structural incoherence and tautology, as I will attempt to suggest later in this chapter. In Ch. 10, Aristotle offers a division of homoeomerous bodies according to their compositions (liquids that are watery or earthy; solids of different sorts) before turning his attention, in Ch. 11, to hot and cold in bodies composed of water, of earth or of both. Aristotle lets us find our way out of the bulk of a treatise concerned with uniform stuffs (without always taking the trouble to explain how some of these sub-topics are connected) and with material dispositional properties before compelling us to look back and reconsider much of the first eleven chapters in the light of Chapter 12, which brings final causation into discussion, and invokes the *Ph.* II and *PA* I motif of the necessity of taking into account both matter and form in natural philosophy.

B. ON THE ARGUMENTATIVE STRUCTURE OF *METEOROLOGY* IV

A clear understanding of the connections between the various segments of this book is, I believe, vital for an adequate analysis of the topics that Aristotle explores there. The articulation of this

---

However, I do not exclude the possibility that *tasis* may correspond imperfectly to an item on that list (maybe *helkton*?). For a mention of *tasis* among other derivative dispositions, see *PA* II 1.646b19 (cf. *PA* II 8.654a16).

work looks deceptively clear. But, despite formulas that sometimes mark the transition from one topic or aspect to another, it is difficult to integrate the different sections of *Meteor*. IV into a thoroughly coherent picture.[29] Three examples should suffice in this chapter devoted to preliminary issues and should be enough both to give a clearer picture of some of the difficulties that a reader of *Meteor*. IV would encounter and to serve as an introduction to my discussion about the authorship of the 'chemical treatise'.

A. Chapters 2, 3 as well as chapters 5, 6, 7 investigate the effects of the active factors (hot and cold) on underlying matter (dry and moist, or: earth and water), but Aristotle offers no overt explanation as to why this topic needed to be treated in two distinct ways in this book. In short, the question I am raising here is: what is the relationship between, say, ripening and rawness – species of concoction and inconcoction respectively (in Chs. 2-3) and solidification/drying or liquefaction/moistening (in Chs. 5-7)? Let me propound at least a few tentative answers for now.

It is likely that these two series of phenomena overlap to some extent, e.g. that virtually any form of concoction or inconcoction entails some degree of drying (when the natural heat of a body is expelled and draws along moisture) and / or moistening. Conversely, it is also plausible that most, if not all,[30] instances of solidification/drying or liquefaction/moistening occurs in the course of some instance of *pepsis* or *apepsia*.

---

[29] That the argumentative structure of this book is not quite as easy to grasp as it may appear is proved, I think, among other things, by the titles dividing Düring's interpretation of the text (he entitles Chs. 10 and 11 'On inorganic homogeneous bodies' – in contrast to Ch. Ch. 12 entitled by him 'On organic homogeneous bodies'; this rather stark distinction seems to me a rather uninspired and misleading move, as Chs. 10-11 apply to both organic and inorganic stuffs, and the inorganic ones are not entirely excluded from the discussion in Ch. 12).

[30] This would be rather difficult to determine, since the scope of the three types of *pepsis* and the corresponding kinds of *apepsia* is quite unclear; it is especially unclear in what measure we can talk about *pepsis* with regard to inorganic stuffs (Aristotle's mentions, e.g. the cupellation of gold, but more examples or clearer boundaries for such processes would have been indeed welcome).

Do the two sets of phenomena stand in relation to each other as causal processes to effects, or as accounts presupposing a richer context and set of conditions to a more 'neutral' explanation of the same sort of phenomena? The former possible solution, while only partial may be quite plausible, since the beginning of Ch. 2 (before Aristotle actually embarks on a discussion of *pepsis* and *apepsia*) announces that the focus will be (I should supply: in Chs. 2 and 3) on "the kind of effect which the properties in question [i.e. the hot and the cold] produce when operating on already constituted natural bodies as their material", whereas the opening paragraph of Ch. 4 inaugurates a long section on the "forms taken by the passive factors, moist and dry". In other words, the emphasis in 2-3 seems to be on the *active* basic *dunameis* as causal factors, while Chs. 5-7 (or 4-7) are centered on the effects suffered by the *passive* ones.

As for the latter possible – and complementary – solution that I have mentioned above (difference in the degree of complexity), it appears, indeed, that the two sets of chapters tackle two sets of processes of quite clearly different complexity (e.g. fruition, in Ch. 3, vs. a simple change in the state of aggregation like melting or solidification, in Chs. 5-7, corresponding perhaps to a certain – purposeful – shift of emphasis from organic to inorganic stuffs); of these – the less complex ones are generally reversible while the others are not (or: are but only in theory). At least some of the more complex processes addressed in Chs. 2-3 seem to involve natural *telē* and final causation (whether in a full-fledged fashion or not) while liquefaction and solidification as such (lying at the heart of Chs. 5-7) do not involve teleology in any obvious way. Accordingly, the acquisition of a definite *eidos* is more central to the accounts of certain processes than to others: 2 and 3 refer to changes that crucially affect the very *eidē* of uniform bodies while in Chs. 5-7, and in fact throughout 4-11, this is not necessarily the case (e.g. in the manifestation of the elasticity of a uniform body). This may also indicate that in chapters 2-3

there is more room for *genesis* (rather than mere *alloiōsis*) than in Chs. 5-7. And perhaps Chs. 2 and 3 focus more on processes that lead to the *emergence* of some of the dispositions discussed in *Meteor*. IV, while Chs. 5-7 deal mainly with processes that amount to their *manifestation*.

B. Connectedly and rather similarly, chapters 5-7, as well as 10-11 appear to classify uniform bodies according to their ingredients and by resort to dispositional properties. Why did Aristotle propose two similar classifications (or sets of definitions)?[31] Why this apparent and pervasive argumentative redundance? I will attempt to further explore this point in the section on 'Observation and Inference' (see my chapter on Scientific Method). Let me just raise this issue for now in a purposely aporetic tone and, in what follows, let me point out a third, even more striking structural anomaly – on which I would like to dwell somewhat more, since it will lead me into my section on the authorship of *Meteor*. IV.

C. A careful analysis of the structure of *Meteor*. IV yields that most of Chapters 8 and 9 disrupt the natural flow of the book. This was noticed by Gottschalk in his 1961 paper. To this general impression I would like to add more specifically that the beginning of Ch. 8 sounds remarkably like the beginning of Ch. 10 but these two passages have rather little to do with the portion of text that they actually delimit (most of Ch. 8 and the entire Ch. 9).

The introductory section of Ch. 8 (384b24-11) stresses that bodies contain not only the basic active constituents (hot and cold; this general point prefigures Ch. 11), but also the two basic passive ones: moist and dry. Aristotle goes on to list vegetal, animal and mineral uniform bodies, all of which are supposed to be composed of water and earth (as well as of the two exhalations discussed in *Meteor*. III, in the case of the mineral stuffs) and then offers a list of

[31] For a tentative solution to this issue, see my section on 'Observation and Inference'.

differentiae of the aforementioned uniform bodies, corresponding to the five senses: white, fragrant, resonant, sweet, hot and cold.

The first part of Ch. 10 (right before a set of succinct references to the various types of causation usually associated with Aristotelian physics: 388a20-26) displays a reversed symmetrical order. One finds there prominent references to touch, taste, smell and sight and corresponding *perceptible* differentiae of homoeomerous bodies, as well as a list of such bodies (bronze, gold, silver, tin, iron, stone, flesh, bone, sinew, skin, entrails, hair, veins, wood, bark, leaf etc.). Before he begins his division of uniform bodies according to their material composition[32] in the rest of Ch. 10, Aristotle announces his next step: "Let us therefore consider which of the homoeomerous bodies are composed of earth, which of water, and which of both" (388a25-6). Also, a terminological indication of the relatively close correlation between these two sections of *Meteor*. IV, the opening portions of Chs. 8 and 10, is maybe the fact that the key word (*ta*) *homoiomerē* is used in Book IV, with the exception of Ch. 12 (390b5, 15), only in the first part of Ch. 8 (384b30, 385a10) and in the first part of Ch. 10 (388a11, 13, 25).

This reversed symmetry boils down to the following structure:

Ch. 8 (passage A)	**Ch. 8 (passage B)**	**The bulk of Chs. 8-9**	**Ch. 10 (passage B)**	**Ch. 10 (passage A)**
List of uniform bodies	Announcing a discussion about essentially perceptible properties	About more intrinsic properties (firmly contrasted with essentially perceptible ones)	Recapping discussion about essentially perceptible properties	List of uniform bodies

So far, it looks like the description and causal explanation of the eighteen (or rather thirty-six) dispositional differentiae in Chapters 8 and 9 are simply introduced (at the beginning of 8) by

[32] Still, there is some confusion, much like in the rest of Book IV, between state of aggregation and 'chemical' composition, e.g. 'fluid' and 'containing predominantly water'.

and then 'crowned' (at the beginning of 10) with passages that have a somewhat similar content to each other, which would only make for an expected and inspired way of articulating this scientific discourse. In fact the repetition of the lists I have mentioned sounds awkward (as they are not separated by a sufficiently long text that would warrant a recapitulation) – and this is far from being only a stylistic grievance. The discussion of the 18 / 36 qualities belonging to homoeomerous stuffs are relevant to sense perception only incidentally (I can see or feel that something is elastic or brittle or can give off fumes etc., but my sensing is not essential to the manifestation of those dispositions). In fact, in Ch. 8, at the end of that introductory passage, Aristotle makes a sheer distinction between (essentially) perceptible differentiae (385a1: "all these bodies differ from each other, firstly, in the particular ways in which they can act on the senses", *tauta de diapherei allēlōn tois te pros tas aisthēseis idiois hapanta*…) and more proper or intrinsic qualities (*oikeioterois pathesin*).[33] The 18 / 36 characteristics or kinds of stuffs displaying those characteristics (listed in the bulk of Chs. 8 and 9) are plainly an illustration of the "more intrinsic" qualities and so are at odds with the beginnings of Ch. 8 and of Ch.10.

Consequently, the beginning of Ch. 10 is surprising indeed: "These are the characteristics (*pathēmasin*) and the differentiae (*diaphorais*) that, as we have said, distinguish homoeomerous bodies from each other to touch; and they are further distinguished by taste, smell and color" (388a10-13; trans. Lee, slightly modified).[34] The absence of such characteristics from the list in

[33] At this point Aristotle offers a second list of homoeomerous stuffs, maybe in order to make it clear that organic as well as inorganic ones are divisible both according to perceptible and to "more intrinsic" (*oikeioterois*) dispositional qualities.

[34] This sentence seems more like a continuation of Ch. 4 (at 382a16-21), where hardness and softness, presented as the "first" or primary among derivative differentiae of uniform bodies, are defined with respect to touch (*haphē*): "Degrees of hardness and softness are indefinable with relation to each other; but since we judge all sensible qualities by sensation, it is clear that both hard and soft are defined absolutely with reference to touch, which we use as a mean saying that what exceeds it is hard and what falls short of it is soft." The presence of *pathēma*

8-9 is notable; on the contrary, 'more intrinsic' dispositions that had been previously discussed are mentioned there (liquefiable, solidifiable – dealt with in much of 5-7).

Assuming that the beginning of what we refer to today as Ch. 8 and the beginning of Ch. 10 were indeed the framework of a list of dispositional properties, one may legitimately venture the hypothesis that this list could have looked somewhat different from the bulk of Chs. 8 and 9 as we know it today (i.e., there may have been considerably more emphasis on perceptible qualities), if the initial passage in Ch. 10 is to make full sense.

Even if *Meteor*. IV did undergo successive revisions – as it probably did – and if some of its parts may have been replaced or considerably refurbished, Aristotle likely thought of it in the end as a rather unitary (if not 'definitive') scientific discourse, constituting, through its interlocking pieces, a comprehensive and unifying picture of the formation, alterations, nature and division of homoeomerous stuffs. However, one should not take for granted that *Meteor*. IV is a smoothly flowing 'chemical' theory and collection of examples. Rather, one should critically assess just how anomalies like the ones I have mentioned are to be dealt with and how compatible the main sections of *Meteor*. IV are with each other, and to see exactly in what way sets of chapters (2-3 and 5-7 or 5-7 and 10-11)[35] are complementary, if they are indeed so. Let me add that sometimes issues concerning the argumentative structure of Book IV and doubts

---

(*pathēmatōn* at 382a8, *pathēmasin* at 388a10) in Ch. 4 and Ch. 8 may also be an indication that there was a closer connection between these two chapters maybe in an earlier version of *Meteor*. IV. The word occurs only three times in *Meteor*. IV.

[35] As I have already mentioned in this section, like chapters 2 and 3, but from a markedly different angle, chapters 5-7 tell us about the effect of active primary powers upon the dry and the moist. Like chapters 10 and 11, chapters 5-7 connect the possible manifestation of material dispositions with the otherwise imperceptible 'chemical formula' of the uniform stuffs displaying such dispositions – and it is not particularly clear that chapters 10 and 11 are meant simply to summarize or re-systematize what is already expounded in a fairly pithy and articulate manner in chapters 5-7.

regarding its 'paternity' can be fused together. As a result, we may wonder not only whether *Meteor*. IV is by Aristotle, but also whether *the entire* Book IV is by him.

C. NOT AN APOCRYPHAL WRITING (AND SOME CAVEATS)

1. Poroi

This discussion about the flow of Aristotle's argumentation would probably be of purely philological interest if it did not center on the very chapters (8-9) that afford most ammunition to the scholars who regard or regarded *Meteor*. IV as spurious. The fact itself that Chs. 8-9 are not particularly easy to integrate in their immediate context, as I have tried to suggest, is not necessarily a peremptory proof that significant parts of Book IV are not by Aristotle. But, given that the aforementioned structural anomalies of the text are accompanied by the heavy presence in 8 and 9 of notions such as *poroi* (only one mention elsewhere – in Ch. 3) and *ogkoi* (word which denotes in this particular context minuscule amounts or bodies, and has an apparently unsettling atomistic resonance about it)[36] should make one at least wonder whether the text suffered drastic changes at some point in its history – by Aristotle's own hand or by that of a

[36] The use of the term *ogkos*, I think, may be in fact less puzzling than it appears to be. The occasional mentions of (seemingly minimal) *ogkoi* (of water etc.) do not necessarily point to the spurious nature of parts of *Meteor*. IV. The notion of *ogkos* may simply have an empirical foundation, i.e. it may rely on the observation that the more fluid and elusive a stuff is (in increasing order: viscous liquids, watery liquids, mist, air, fire), the easier it is for it to penetrate another body. Thus it is not the case that, for instance, some solid, earthy stuff is not (theoretically) divisible ad infinitum, just like a quantity of water or *pneuma* etc.; it is simply that, empirically and practically speaking, some utterly fluid stuffs are very easily divided into minuscule (but *not* atomic) particles or portions, whereas other, more viscous or solid stuffs are not.

close associate. The notion that Book IV may include notes by one of his followers or associates is not absurd (besides the use of *poroi* and *ogkoi*, the catalogue-like nature of Chs. 8-9 and peculiarities pertaining to Ch. 3 may suggest that an un-Aristotelian hand was at work there).[37]

Meteor. IV has been a tug of war between those who cautiously urged assigning this work to Aristotle (among the ancients, Alexander and Olympiodorus) and perhaps a more dominant view, according to which *Meteor*. IV should be fathered on someone else.[38] More recently, the attitudes of Aristotelian scholars have ranged from blanket dismissal[39] to cautious or thorough acceptance. One of the most noteworthy inquiries into the authorship of *Meteor*. IV is a paper published in 1961 by H.B. Gottschalk. His article sides with Lee's rejection of Hammer-Jensen's attribution of *Meteor*. IV to Strato of Lampsacus (a Peripatetic who had little, if any, interest in final causation – which would seem to mesh well the apparent lack of interest in final causation in Chapters 8-9, and, indeed, in most of Chs. 1-11). But Gottschalk stops short of assigning the work to Aristotle. His conclusion seems to be a compromise between several

[37] Let me just add a few notes here. If Ch. 3 (tentatively suggested by Lennox in private communication) and much of 8-9 were indeed added to an Ur-*Meteor*. IV, by Aristotle or by someone else, they may have been 'contemporary' with each other (i.e. 3 with much of 8-9); it is not only, e.g., the references to *poroi* that plead for this, but also the spirit in which those segments of text were written – the rigorous treatment of contrastive pairs (in 3 – especially of opposite processes, though they suppose corresponding dispositional properties: boilable, etc.; in 8-9 – especially of opposite dispositional properties, though they suppose corresponding processes: stretching, burning, etc.). Chs. 4-7 too are centered around contrastive concepts (liquefiable-solidifiable) but not as articulately and rigorously as 3 and 8-9.

[38] Hammer-Jensen, Jaeger, Ross, Gottschalk considered Book IV to have been written by an author other than Aristotle (either Strato, Theophrastus or some still anonymous thinker); among scholars upholding the thesis that book IV of *Meteorologica* was in fact written by Aristotle, one can number Lee, Coutant, Düring, Furley, and more recently, Gill, Lennox, Lewis. For more detailed accounts concerning disputes around the authorship of *Meteor*. IV, see Gottschalk (1961), Lee (1962 repr.) xiii-xxi, Furley (1989b), Lewis (1996) 3-9, Pepe (1979) 504 ff., (1982) 27 ff.

[39] F.M. Cornford notes: "I am compelled to reject the *Meteorologica* in its entirety, although it is classed by Ross as 'undoubtedly genuine'…" (ap. Ross' *Aristotle - The Physics*, lxxiv).

possible solutions: the book does include numerous points that are in keeping with Aristotle's physics and theory of matter, but it also displays elements (among them the introduction of the *poroi* – tiny channels or capillaries pervading a uniform body) that supposedly remind one of Theophrastus' minor scientific tracts. Yet, Theophrastus would have probably given this book more unity; so *Meteor*. IV must be "a thorough revision of an Aristotelian work by a pupil of Theophrastus, using the results of his researches into chemistry and mineralogy" (1961, 78). Such scenarios can remain only conjectural; yet, at least at first sight, it is not easy to see how the categorical rejection of any theory that relies on *poroi*, rejection that seems to be articulated in *GC* 326b6-28, can be explained away or reconciled with chapters 8-9 in *Meteor*. IV. In *GC* Aristotle apparently rejects more than the explanatory worth of the invocation of void and of empty *poroi*; in fact, he does not even seem willing to admit that, if the *poroi* of a body are filled (with the same stuff as the rest of that body, or maybe even with a softer stuff), that stuff can be displaced and replaced by some other stuff that penetrates the body through its *poroi*. Furthermore, Aristotle cautions us in *GC* that "…To postulate pores is superfluous. For, if the agent produces no effect by touching the patient, neither will it produce any by passing through its pores" (326b21-23, trans. Joachim). Finally, in a passage where interaction and contiguity are dominant topics, he wonders rhetorically: since a body is divisible at any point, why should one assume the existence of *poroi* in order to explain how it can be divided? All this seems flagrantly contradicted by chapters 8-9 where *poroi* are put to work to account for various types of contact and interaction, more specifically, for compression, for breaking, for shattering, for softening etc.

Various scholars have pointed out this (real or apparent) incongruence between *GC* and *Meteor*. IV with respect to the treatment of *poroi*. I would like to add in the conclusion of this section that besides the very appeal to *poroi* in the 'chemical treatise,' the way in which the *poroi*

are introduced into the scientific apparatus of *Meteor*. IV may appear to be rather disconcerting. To take an example, in the passages meant to deal with fragility and fragmentability (*ta katakta kai thrausta*) in Ch. 9 (386a9-17), Aristotle notes that

> Things that solidify in such a way as to have numerous alternating pores are fragmentable (the pores allowing this degree of dispersion), and things that have long continuous pores are breakable, while things that have pores of both kinds also have both tendencies. (Lee, with modifications)

These notes about the presence of pores (in materials that tend to behave in a certain way) and about the arrangement of pores in uniform bodies sound as if they should be well understood by whoever reads or rather listens to such remarks, in virtue of some preliminary and persuasive accounts of the existence and nature of *poroi*; yet no such account is really to be found anywhere in Aristotle (the *GC* passages can hardly be assumed to form the backdrop against which such details are presented, since, among other things, the *GC* mounts an attack against explanations that rely on *poroi* rather than on *haphē*).[40]

However, despite all these caveats, which are necessary for an impartial outline of the problem at hand, I believe that the role played by *poroi* in *Meteor*. IV is ultimately *not* a credible and sufficient fulcrum that can support a demonstration of the supposedly spurious character of that book. I will explain my rationale for this view in section III of this chapter.

[40] Among other things, it is not clear whether *all* solid bodies are traversed by such channels and whether there is any other way of determining their position, diameter etc. besides a careful consideration of some uniform body's material dispositions.

2. Endoxa

Let me suggest another facet of *Meteor*. IV (this time pertaining to scientific method and discourse) that might undermine the view that this book is to be attributed to Aristotle without much reservation. It would be rather interesting to understand, if possible, to what extent some of the law-like statements in *Meteor*. IV (in which dispositions are pivotal) were based on earlier sources (Presocratics, Hippocratics, Plato etc.) rather than on Aristotle's own observation. The appeal to reputable opinions or *endoxa* is usually a staple of Aristotle's rhetoric of science; yet, in *Meteor*. IV, given their virtual absence, they are distinguished rather through their rhetoric of silence. In *Topics* I 1.100b21-26 Aristotle defines the *endoxa* as follows:

> …These opinions are 'generally accepted' which are accepted by every one or by the majority or by the philosophers – i.e. by all, or by the majority, or by the most notable and illustrious of them. Again, reasoning is 'contentious' if it starts opinions that seem to be generally accepted, but are not really such… (trans. W. A. Pickard-Cambridge).[41]

Aristotle, however, is in no polemic mood in *Meteor*. IV and 'reputable opinions' seem to be tacitly incorporated into the substance of his book. This is quite atypical for him and is surprising especially if one compares *Meteor*. IV with other scientific writings, like *Meteor*. I-III, where he takes his predecessors to task as often as he can. Indeed, one of the most obvious features of treatises such as *Meteor*. I-III is Aristotle's 'dialectic' approach, his constant review and censure of earlier *endoxa* or the reputable opinions of other thinkers (as well as popular views). That

[41] On de-emphasizing the role of the *endoxa*, see Kullmann 1990, 336.

Aristotle's critique of his predecessors is a significant aspect of the methodology illustrated by Books I-III is emphasized by Freeland (1990, 317): [42]

> In his preliminary studies of the *endoxa*, I have argued, Aristotle both focuses his theoretical inquiry by refining why-questions, and directs his search for empirical data by noting failures and missed predictions of earlier scientists.

Yet, in the fourth book of the *Meteorology* he is content to quote Empedocles only twice (382a1-2, 387b3-6), rather as an indisputable authority or merely for the suggestiveness of some dictum. Occasionally we find an impersonal *legetai* (e.g. 382b9), but, again, this is not meant to suggest a difference of position from Aristotle's. At most, Aristotle sometimes appears to complete or clarify earlier accounts (e.g. in Ch. 11, at 389b13 ff., a passage that reflects less a rebuttal than a search for clarification: "So there are two obvious views about them, and some regard them as cold, some as hot, seeing that as long as they… Nevertheless…").

Is it the case that Aristotle may have drawn upon many of his predecessors' writings (*phusiologoi*, medical writers, Plato), and maybe on some contemporaries as well, more than perhaps in any of his other writings? Horne (1966), for instance, is not willing to grant too much originality to Aristotle. According to him, Aristotle's attitude towards previous authors is manifestly mimetic in *Meteor*. IV. While Horne's assessment probably suffers from oversimplification, one may have to admit that Aristotle takes account of several authors and traditions in his chemical treatise. One can advance a few other – perhaps complementary – hypotheses: what was controversial for Aristotle in *Meteor*. IV had already been criticized in *GC* and maybe in sections of *Meteor*. III; what was completely new and had not been done by others did not need to be compared with *endoxa*; much was taken over from others and so Aristotle did

[42] Cf. the short section entitled 'The role of *endoxa*' in Taub's *Ancient Meteorology* (pp. 93-6), concerned primarily with the theoretical background of *Meteor*. I-III.

not need to adopt a radically critical attitude in those instances; finally, it may also be that there is quite a bit of *implicit* criticism in *Meteor*. IV that awaits further scrutiny. This topic, however, is very likely to remain a matter of speculation and, so, I will not futilely try to solve it in definitive fashion at this point; still, given the special importance of *endoxa* to Aristotle's scientific method in general, I thought that I should at least highlight the rather exceptional scantiness of the use of *endoxa* in *Meteor*. IV. This note is more opportune here, I think, than in my chapter on scientific method (Ch. 4), as this peculiar aspect of *Meteor*. IV may provide yet another angle of attack on Aristotle's authorship of the chemical treatise. However, as I have already implied, this particular problem should be approached with due caution, as it is likely to resist any quick solution. Let me end my aporetic note here and move on to reasons for claiming that *Meteor*. IV is actually by Aristotle; I will then discuss another problem (the meaning of *homoiomeres*) that is significant in its own right, but also relevant to the apocryphal or, in my view, non-apocryphal status of *Meteor*. IV.

3. Arguments in favor of attributing this treatise to Aristotle

After this battery of possible counterarguments, it is high time to mention that one can also find redoubtable arguments pro Aristotle's authorship. I will suggest at the end of the next section, on homoeomerous stuffs, that what may appear to point to grave discrepancies between *Meteor*. IV and, e.g., *GC*, may not be quite so damning after all. Besides, one can cite (again, as proof that *Meteor*. IV was written by Aristotle, wholly or partly) several sufficiently transparent references to this book in *PA* (e.g. II 2.649a30 ff. – echoing *Meteor*. IV 6-8, 10) and *GA* (II 743a3-7 ff. –

alluding to *Meteor*. IV 4-7; V 4.784b8 ff. referring to *Meteor*. IV 1).[43] And one could bring further arguments in support of the Aristotelian authorship: ancient testimonia, style and terminology (although these latter elements can be made to support the skeptical position as well).[44]

I believe there is another, quite robust argument that can be mustered in favor of attributing *Meteor*. IV, especially Chapters 8-9 (their text or at the very least their tenets), to Aristotle: the list in Chs. 8-9 is most likely later than the discussion about solidification and liquefaction in Chs. 5-7 (the first items on that list are 'solidifiable' and 'meltable/liquefiable': *pēkton*, *tēkton*), but earlier than Ch. 12, which refers to that list in no uncertain terms (390b6-8)[45] and which sounds just about as Aristotelian as one could reasonably expect (the prominence assigned to "that for the sake of which"; stressing the fact that, in order fully to grasp the nature of some natural object, one must consider both its material constitution and its formal aspect; the

[43] A somewhat weaker – but by no means negligeable – argument for attributing the treatise to Aristotle is that, in *Meteor*. IV itself, we find many a connection with earlier treatises (especially with *GC* – I 10 on *mixis*; physical properties – II 2; elements – II 3 etc.; also: *anathumiasis* in *Meteor*. IV 8, hinting at *Meteor*. I-III) as well as topics that foreshadow the content of later works, especially *Parts of Animals* (both in Chs. 1-11 and in the final chapter). Besides, the Aristotelian leitmotif that something is both for the sake of something and from necessity matches the diptych-like structure of *Meteor*. IV (Chs. 1-11; 12) is (the first eleven chapters give detailed accounts for what comes about of necessity; Ch. 12, on the other hand, places more emphasis on functional accounts and attempts, at a theoretical level, to integrate accounts based on material necessity with a teleological approach).

[44] See also Düring on the peculiarities of the vocabulary of *Meteor*. IV, which, against previous scholars – like Hammer-Jensen, Stohm and Sarton, he considers to be a toothless argument against attributing Book IV to Aristotle. For further details on the issue of authorship, see Pepe 1979.

[45] "…For these [i.e. the homoeomerous parts] are all distinguished by the differentia we have already described (tension, ductility, fragmentability, hardness, softness and the rest) which are produced by heat and cold and the combination of their motions." *Helxis* and *thrausis* in 12 clearly correspond to *helkton* and *thrauston* in 8-9. It is somewhat less clear what *tasis* would correspond to in that list in 8-9. If *tasis* does not correspond to *helkton* or some other item on the list in Chs. 8-9, this may be a further indication that Aristotle did not regard that list as being exhaustive. (As for *sklērotēs* and *malakotēs* in the same passage in Ch. 12, I take them to be retrospective hints at Ch. 4 principally.)

very formulation of such methodological demands etc.). Besides, the formulation of that passage in Ch. 12, at 390b5-10 (*legō d'hosa homoiomerē*…) is strikingly similar to other passages in which the word *homoiomeres* occurs, and for which there is no obvious reason to doubt the Aristotelian authorship.[46] Besides, I should note that a least one of the dispositional differentials listed in Ch. 12 (*thrausei*) is explained in Ch. 9 (386a9-17) in terms of *poroi*. Accordingly, if a chapter that can easily resist any doubts with regard to authenticity, namely Ch. 12, sanctions the points made in Chs. 8 and 9 as being Aristotelian, then it seems to me that we can safely attribute the sections dealing with *poroi* to Aristotle. Even if one of his associates might have had a hand in writing Chs. 8 and 9 (which has not been proven convincingly), the Stagirite, although possibly more interested in the "chemical" composition of the bodies than in their microstructure, found that discussion to be fully compatible with the rest of his theory (given that retrospective passage in Ch. 12). In this case Aristotle must have decided that such details were acceptable and even desirable in a 'likely story'[47] about the imperceptible chemical composition of the *homoiomerē*. Therefore, as long as we do not have an unassailable proof or theory that Chs. 8 and 9 were initially written or at least refashioned by Theophrastus or someone else, I will regard them as being part of Aristotle's treatise on and theory about homoeomerous stuffs (and the slight structural anomalies pertaining to the position of Chs. 8 and 9 – see my section on argumentative structure – should be blamed only on Aristotle's revisions of that book, which still remained somewhat unpolished in the end).[48]

[46] See the first part of Ch. 8 (384b31 ff. and 385a9-11) and the beginning of Ch. 10 (388a13: *legō d'homoiomerē hoion ta*…).

[47] To borrow a formula from Plato's *Timaeus*, with which *Meteor*. IV shares an interest in causally connecting derivative dispositions with some underlying structure or composition.

[48] The question remains: how should one explain the real or apparent tension between *GC* and *Meteor*. IV with respect to the *poroi*? It is unlikely that any scholar who takes *Meteor*. IV to be by Aristotle can offer an easy and

D. DOES *METEOROLOGY* IV REDEFINE HOMOEOMEROUS STUFFS?

Let me add another *possible* challenge to the Aristotelian authorship of *Meteor*. IV, while, at the same time, discussing a concept that is crucial to this book. I would like to claim that *Meteor*. IV provides evidence that, contrary to the traditional view, not all homoeomeorous stuffs are mixtures. Rather, some of them consist of only one element, and yet that does not prevent, for instance, bodies consisting entirely of earth from displaying different behaviors among them and, so, from being divisible into distinct kinds or *genē* according to their dispositions. Should we suppose that this thesis, which, I believe, is implicitly argued for in *Meteor*. IV is in stark opposition with the views expressed in *GC*? If so, then maybe *Meteor*. IV is not exactly,

---

impregnable answer. Did Aristotle change his mind? Probably, but in a way that did not compromise his earlier anti-atomist position. If we take *Meteor*. IV to be a sort of continuation of *GC* (a view embraced by Alexander, for instance), such an excuse might sound somewhat unconvincing; but *Meteor*. IV was not necessarily an *immediate* sequel of *GC* and the span between the writing of these two works or sets of lecture notes could have been sufficient to allow Aristotle to rethink certain topics. An alternative to my expedient but tentative answer can be found in Lewis. He relies heavily on what he takes to be a qualification in *GC*; here is the passage at *GC* I 8, 326b24-28 in his translation: "From what has been said it is apparent that the postulation of pores, as some entertain them, is either false (*pseudos*) or superfluous (*mataion*). And since bodies are divisible throughout, to assume pores exist is ridiculous (*geloion*), for that which is divisible [everywhere] can be divided [anywhere]." (P. 6 in Lewis 1996) Lewis suggests that "as some entertain them" (*hōs tines hupolambanousin*) marks a significant qualification: there is nothing inherently wrong with positing *poroi*; it is just that this concept was mishandled by certain authors – Empedocles included. In other words, there is no contradiction between *GC* and *Meteor*. IV, to begin with. The Greek text, however, does not appear to warrant such a strong interpretation. Besides, *GC* does not offer or even hint at a *positive* account of an acceptable approach to *poroi* (understood not only as the visible cavities in e.g. a sponge, but also as the minuscule, indeed invisible channels that pervade most if not all solid bodies). That is, it is not at al clear that *GC* actually leaves any room for the use of *poroi* as explanatory concepts. Therefore, I find the idea, unsophisticated though it may be, that Aristotle partly changed his mind (i.e. while he did not relent his attitude towards the atomists, he did come to accept the usefulness of hypothesizing *poroi* in order to explain certain types of change) more plausible than Lewis' attempt at reconciling *GC* with *Meteor*. IV.

thematically speaking, a sort of continuation of *GC* and, furthermore, maybe this apparent anomaly (the supposed existence of homeomers that are not mixtures) may be added to the panoply of those who may still have grave doubts about the authorship of the 'chemical treatise.' At the end of this section I will try to disarm this possible position, to show that *GC* itself does not press for the view that all homeomers are uniform compounds and to propose that *Meteor*. IV is most likely not in conflict with it.

Both the beginning and the end of *Meteor*. IV stress the intermediary status of the homoeomerous bodies, between elements and *ta anhomoieomerē* (complex organs or parts, such as a hand, which, in turn, are intermediary between the homeomers and organisms). This intermediary zone does not have a very prominent position in Aristotle's ontology,[49] especially when it comes to the inorganic uniform stuffs, which are conceivably substances but in a rather weak sense. Homoeomerous stuffs, such as wood and stone, marrow and iron, salt and blood, are the respective results of various instances of generation, which hinges on the thoroughly uniform *mixture* of ingredients like the four so-called elements (earth, water, air, fire) or of the two types of exhalation (dry and moist *anathumiaseis*).[50] Chapters 7 and, especially, 8 of *GC* II seem at first sight to leave no doubt that, at least when working on that treatise, Aristotle was rather keen on the idea that all the constituted things making up the sublunary world are mixtures (in different ratios) *of all four so-called elements* or, in the case of complex organs and of organisms, are made up of different such uniform mixtures. *GC* II 7 dwells on the mutual transformation of the elements and the variations along the hot – cold and moist – dry continua

[49] See Charlton 287.

[50] As I mentioned before, the (dry and moist or earthy and watery) exhalations, which are crucial to so many explanations of meteorological and other phenomena in Books I-III, are mentioned only once in *Meteor*. IV (384b33). Yet, there is no reason for us not to assume their presence in the background, so to speak, throughout much of Book IV.

(there is a certain hesitation there, much as in *Meteor*. IV, between saying that bodies are constituted by the mixing of earth and water and saying that they are formed as a mixing of the dry and the moist). Chapter 7 of *GC* II differentiates between two ways of accounting for the formation of homoeomerous stuffs – by appeal to 'com-position' or *sunthesis* (more suitable to an Empedoclean or atomistic theory whose explanation of change would rely massively on the notion of rearrangement of elements or minimal particles) and thorough mixing or *mixis*, a process which results in the constitution of a homogeneous stuff, whose original ingredients survive in them only potentially.

We should consider again the nature of the *homoiomerē*.[51] The very etymology of the word suggests that it refers to things in which a part is not different in its nature or composition from the whole,[52] or in which any part is like any other part (though it does not indicate whether such a stuff is compound or simple). But I should let Aristotle speak for himself. In *Meteor*. IV, Aristotle prefers to list examples rather than to give a definition:

> By homoeomerous bodies I mean, for example, metallic substances (e.g. bronze, silver, tin, iron, stone and similar materials and their by-products) and animal and vegetal tissues (e.g. flesh, bone, sinew, skin, intestine, hair, fibre, veins) from which in turn the anhomoeomerous bodies, face, hand, foot and the like, are composed; in plants examples are wood, bark, leaf, root, and the like (Ch. 10, 388a13-20).

There are two similar lists in Ch. 8 (384b31-385a1) and in Ch. 12 (390b3-10). All three passages are accompanied by reminders of how these uniform stuffs come about (through the agency of the active factors, hot and cold, on the passive ones, dry and moist or earth and water, in keeping

[51] For a study of the metaphysical implications of the notion of homeomer, see Thom 1990.

[52] In Aristotle's terms, in the case of the homeomers, the part is synonymous (*GC* I 1.314a20) or homonymous (*PA* II 2.647b17-19) with the whole (which, of course, cannot apply to anhomeomers or complex parts, like a face or a hand; another line of demarcation between homeomers and anhomeomers is that it is to the latter that *erga* and *praxeis* belong; see *PA* II 1.646b12, cf. *Meteor*. IV 12).

with the precepts put forth in Ch. 1) and of how they can be differentiated (through their *dunameis* or *pathē*: hard, ductile etc.). Even if *ta homoiomerē* are not defined in a direct and technical manner in *Meteor*. IV, the passage that comes closest to offering a definition is this one, from Ch. 8 (384b26-385a1):

> …Because they are manufactured by [heat and cold], all bodies contain heat and some contain cold in so far as they lack heat. So, since heat and cold are present as active constituents, moist and dry as passive, compound bodies (*ta koina*) contain them all. The homoeomerous bodies, therefore (*oun*), vegetal and animal, and also the metals, such as gold, silver and the like, are composed of water and earth and of their exhalations, when, as has been explained elsewhere, they are enclosed underground.

If, in the passage quoted here, we give sufficient weight to the inferential "therefore" after "the homoeomerous bodies", it appears not only that all compound bodies include (*dunamei* – see *GC* II 7) moist and dry or water and earth, but also that (all the) homoeomerous bodies are compounds. This reading seems to be supported by another passage, in the same *Meteor*. IV, at 4.381b24 ff. where we read that:

> The passive elements of physical bodies are moist and dry and all bodies are compound of them, the nature of the body varying according as to which predominates, dry doing so in some cases, moist in others.

In fact, this is the view that has been entertained traditionally by commentators. Olympiodorus, for instance, in trying to outline the thematic scope of the *Meteor*. IV, notes (272.5 ff.) that it is not enough to say that this is a book about *ta homoiomerē*; instead, we should more precisely define its central topic as "the homeomers constituted from the combination of the four elements." In the first part of the 20th century, Joachim (1926, 240-246), for instance, keeps using the term 'homoeomerous' in his notes on *GC* II 7 and 8, although Aristotle himself does not use it in that portion of *GC* (instead he mentions *ta mikta sōmata*), and Mugler marks the

beginning of his translation of *GC* II 7 with the title "La formation des homéomères". Düring (14) too seems to take as indisputable that all homoeomerous bodies are compounds.

Still, there may be some evidence, notably in *Meteor*. IV, that not all homoeomerous bodies are compounds but some may *consist of only one element*. Here is a list of examples from *Meteor*. IV that, I think, lend support to this view:

- In Ch 3, in the context of Aristotle's discussion of boiling, as a type of concoction (*pepsis*) that affects the overt and latent qualities of uniform stuffs through the "moist heat of the undetermined material present in the moisture of a thing," we read that there are uniform bodies which *cannot* be boiled, for instance stones, which contain no moisture (*mēden estin hugron*) – 380b25-26.

- Ch. 6 speaks of conditions that cause the liquefaction and solidification of *hosa hudatos*, the stuffs made of water (in Lee's translation, "watery liquids") and of mixtures of earth and water. The passage 383a7-13 can be taken to deal with liquid uniform stuffs that contain water alone (which seemingly would entail the difficulty of explaining their differentiae) or liquids that contain only negligible residues of earth. Later in the same Ch. 6, Aristotle devotes some attention to solidification as a result of the evaporation of water from a compound; such is the case with baked clay, *keramos* (383a20-21, cf. 383b11): "So things that are soft but not moist do not increase in density when moisture leaves them but solidify, like clay when baked (*optōmenos*)." There is no qualification attached to this process of evaporation, which can lead to the impression that what is left – namely, baked clay – is 'pure' earth endowed with a specific set of dispositional differentiae.

- The beginning of Ch. 7 seems to imply first (383b19-21) that clay (*keramos*), like soda, salt, and stone, comprises in its composition more earth than water – that is, it also includes

water. Although these stuffs seem to be here on a par with respect to the predominance, rather than exclusivity, of earth (still, see my next paragraph, on Ch. 9), later on Aristotle marks a distinction between clay on the one hand and salt and soda on the other. At the end of the same chapter (384b20-22) *keramos* is said to consist of earth only (*gēs monon*), since when dried it solidifies gradually and, while it is impermeable to water, it can let the vapor in it escape through some openings or, more literally, points of entrance (*eisodous*, which may well be the *poroi* mentioned in chapters 8 and 9; in fact Lee does not hesitate to translate *eisodous* as "pores").

- In Ch. 9, in a passage (385b6-12) dealing with *ta malakta* (the things softenable by heat) we learn that this material disposition is present in uniform bodies that contain predominantly earth, but *not* only earth – as it is the case with soda and salt, from which all moisture has evaporated (and thus end up containing *only* earth);[53] also, if a body is to be softenable by heat, its moisture must not be present in disproportionately small quantity, like in potter's clay – *keramos* again (which, by the way, seems to contradict other passages in *Meteor*. IV where *keramos* is thought to be thoroughly devoid of moisture). More significant here, however, is that a neat distinction is made between bodies that include a very small amount of moisture and those that truly lack any moisture whatsoever.

- Ch. 10, much like Ch. 6, appears to convey the notion that there are liquids (apparently distinguishable from each other) that are made entirely of water (388a30 ff.), their general and chief mark being a dispositional property, since they tend to evaporate easily (liquids that do not have this quality consist of earth, or of a mixture of earth and water, like milk; or of earth and air, like honey;[54] or water and air, like oil). A few lines further into the same Ch. 10 (388b9 ff.), we

[53] Cf. *Problems* VII 9 (whose authorship is a notoriously thorny issue, although it may include late reflections on genuinely Peripatetic theories), where salt, dust, niter are suggested to lack moisture.

[54] If we are to accept Vicomercato's conjecture; see Lee 360 (note b).

read that "bodies whose density is increased both by heat and by cold share in more than one element (*koina pleionōn*), like oil honey and sweet wine" (note again how dispositional properties are meant to differentiate between uniform bodies belonging to different kinds, according to their 'chemical formula', although dispositions can also help us distinguish between stuffs belonging to the same sub-kind or *eidos*). By implication, this passage leaves room for bodies made of only one element. This impression is strengthened by the conclusion at 389a3-6:

> If, then, all things are either liquid or solid, and if the things qualified by the characteristics we have described [*tois eirēmenois pathesin* – that is, dispositions, such as being prone to evaporate easily etc.] are covered by this alternative, and there is no intermediate possibility, it follows that we have enumerated all the criteria whereby we can distinguish whether a thing is composed of earth or of water or of more than one element [*ē pleionōn koinon*], and whether it is formed by fire, by cold or by both.

Aristotle also notes that solids which are solidified by cold consist of water, like ice, snow, hail, and frost; solids which are solidified by heat are composed of earth, such as earthenware, cheese, soda, salt. Finally, solids from which all moisture has been evaporated (*hapan exikmasthē*), for instance, earthenware or amber, consist of earth.

- To conclude this list of examples from *Meteor*. IV, let me mention a passage in Ch. 11 (at 389a29-389b7) that draws attention to the fact that cold is not simply a privation (of heat/warmth), but is matter in a way, and also remarks that

> …As dry and moist are matter (being passive), and find their principal embodiments in earth and water which have cold as a defining characteristic, it is clear that all bodies that are *made of either element alone* [*hekaterou haplōs tou stoicheiou*] tend to be cold…

Again, the *GC* notion that there are no bodies in the sublunary world consisting of only one element seems to be challenged quite blatantly (cf. in the same Ch. 11, at 389b8 ff: "things

composed of more than one element – *hosa de koina* – contain heat", which seems to hint at the fact that some homeomers consist of only one element, e.g. just of earth or just of water).

I should also draw attention to the presence of expressions like 'forms of water / earth' (e.g.: *hudatos eidē* – 388b14, *gēs eidē* – 388b25) which seem to echo similar formulations in the *Timaeus*[55] and several Hippocratic writings,[56] and where we may suppose that different stuffs can be made of the same (one) element.

Yet, there is obviously some wavering even within *Meteor*. IV between, on the one hand, talking about materials like (baked) clay and salt as if they were 'pure' forms of earth and, on the other hand, taking them to be mixtures in which earth is overwhelmingly preponderant.[57] This being said, the clarity and firmness with which Aristotle occasionally indicates that certain bodies contain strictly earth or just water is quite remarkable. Such clear-cut formulations are hard to dismiss as oversimplifying – that is, it would seem unwarranted to me to *always* take 'made of earth' as a shorthand for 'made mostly of earth, but containing also negligible

[55]In the *Timaeus* the *genē* of earth etc. are differentiated according to the variety of the triangles (for a convincing explanation, see Cornford, 230 ff.; 246-266) and the blending with other elements in small quantities. For passages referring to the variety of triangles (i.e. their sizes, presumably, not their types), see: 58d3 (*dia tēn tōn trigōnōn anisotēta*; cf. 58d6: *anisōn*); 58c5 (*puros te genē polla*); 58d3 ([*aeros*] *hetera te anōnuma eidē*); 58d6 (*tōn genōn tōn hudatos*); 60d (*gēs kathartikon genos litron*); 82a (*genē pleiona*). For passages about blending and admixture in the *Timaeus*, see: 58e2 *puros eisiontos;* 59b7 *gēs*; 59d4: *to puri memeigmenon hudōr*; 59d8-e1: *puros apochōristhen (hudōr) aeros te monōthēi*; 60b7 *to summiges hudōr*; cf. 60c5.

[56] E.g. in *On Regimen*: *genē* of earth etc. at IX 3 (the most moist fire), X 1 dry and moist water (these two examples may suggest mixtures, though), X 3 the most hot and the strongest fire, XXXII 1 the lightest water and the most elusive fire, 2 the strongest fire, the densest water, 3 the thickest water, the lightest fire etc. (cf. 4, 5, 6).

[57] That *Meteor*. IV is somewhat wavering about the nature of certain stuffs, like clay and salt, is maybe to be expected: the impression one is left with is that, as on other scores, with regard to the notion that certain uniform bodies can consist of only one element, *Meteor*. IV most likely underwent revisions, augmentations etc. and was not finished in a manner that would make it perfectly consistent from beginning to end.

quantities of water, and perhaps also of air and fire' (though, again, *sometimes* this may not be a misdirected approach).

Consequently, there is evidence in *Meteor*. IV of a distinction between two sorts of uniform bodies – mixtures and simple or pure stuffs (consisting only of water or only of earth).[58] This entails that a generic definition of the homeomers might not have to include a reference to their composite nature (although it is clear from the examples discussed by Aristotle in *Meteor*. IV, *PA* II, *GA* passim etc. that *the majority* of homeomers are indeed compounds). Furthermore, this is not simply an isolated and whimsical point, subsequently disavowed in Aristotle's works; on the contrary, in the biological works, in passages clearly echoing *Meteor*. IV (e.g. *PA* II 2.649a30, *hosa hudatos monon*), he still seems to maintain that some homeomers consist of only one element.

If we admit that Aristotle did conceive of certain bodies as consisting of only one element, we have to explain why a well-known Aristotelian precept seems to be downright contradicted, namely, the thesis according to which elements cannot be found in a pure state, so to speak, in the sublunary realm, but only in mixtures:[59]

> All the compound bodies – all of which exist in the region belonging to the central body – are composed of *all* the 'simple' bodies. For they all contain Earth because every 'simple' body is to

[58] This distinction would correspond on a higher level to the differentiation that Aristotle makes in no uncertain terms among the anhomeomers or non-uniform parts (*PA* II 1.646b3032): "…The non-uniform parts are capable of having been composed from the uniform parts, both from many of them and from one, as with some of the viscera; they are complex in configuration, though generally speaking they are composed of one uniform body (*polumorpha gar tois schēmasin ex homoiomerous onta sōmatos hōs eipein haplōs*)." (See my suggestion below that the differences between homeomers composed of the same element may be explained through differences in their physical structure, though in this case it is their *microstructure* that is at issue – *poroi,* interstices etc.) Cf. *PA* II 1.30-33 (on the heart and viscera).

[59] Which is in keeping with Aristotle's cautioning us in *Meteor*. I that the two fundamental types of exhalations cannot exist in pure state either.

> be found specially and most abundantly in its own place. And they all contain Water because (a) the compound must possess a definite outline and Water, alone of the simple bodies, is readily adaptable in shape; moreover (b) Earth has no power of cohesion without the moist. On the contrary, the moist is what holds it together; for it would fall to pieces if the moist were eliminated from it entirely (*teleōs*). …And they contain Air and Fire, because these are contrary to Earth and Water… (*GC* II 8.334b31 ff., trans. H. Joachim)[60]

The beginning of this passage shows that each compound body (and compound bodies are to be found mainly *peri ton tou mesou topon*) are mixtures of all four simple bodies; but this does *not* exclude the possibility that there are also simple bodies in this part of the cosmos.[61] If so, then the passages I quoted from *Meteor*. IV do not necessarily contradict *GC* II 7 and 8, and maybe we should rather renounce the traditional reading of Aristotle, according to which all homoeomerous bodies are compounds.

As for *mixis*, I should note that, based on the evidence afforded by *Meteor*. IV (see the examples I listed above), at least some of the stuffs that consist only of water or only of earth may be *originally* products of *mixis*. In such cases, one (or some) of the original ingredients is, at some point, thoroughly eliminated, especially as a result of extreme heating (e.g. water from clay, through a peculiar kind of transpiration, followed by evaporation proper). Thus the process of *mixis* remains important, but is followed by a process of separation that leads to the eventual formation of a uniform stuff consisting of only one element. In other cases – maybe salt? – however, it is possible that no *mixis* occurred at all, but rather that one element was sufficient to lead to the formation of a new uniform stuff, after undergoing various thermic processes.

---

[60] Cf. *Meteor*. IV 4, 381b29-382a4.

[61] The same can be said of a somewhat similar passage in the first book of the *Meteorology* (Ch. 2, 239a20-21): "The whole terrestrial region, then, is composed of these four bodies, and it is the conditions which affect them which, we have said, are the subject of our inquiry."

My discussion of the nature of the homeomers has bearing on the emergence of secondary dispositions as well. If it is indeed possible, according to Aristotle, that there are different stuffs each made of one element (e.g., salt, earthenware and soda, consisting only of earth), one should wonder what exactly accounts for the fact that they have different properties (salt is soluble in water, earthenware is not)? I would propose that we should look for an answer in their 'physical', rather than 'chemical' constitution. Especially in Chs. 8 and 9 we are offered ample and detailed explanations of the behavior of uniform stuffs with the help of the notion of *poroi*. The internal organization of some stuff can be revealed by some of its dispositions and can implicitly account for those dispositions (e.g., a particular type of *poroi* will explain why some uniform body is or is not splittable), as suggested in Chs. 8 and 9. If that stuff has such capillaries that are arranged in a particular fashion and that have various diameters (allowing water or only fire in etc.), it is probably such a physical organization that can also explain why different stuffs (clay, soda, salt etc.) could conceivably consist of only one element, while, at the same time, exhibiting distinct qualities.

I would conclude that the references to simple stuffs in *Meteor*. IV are not a flagrant contradiction of what *GC* tells us on this issue and that, if so, *Meteor*. IV's endorsement of the notion that some *homoiomerē* are not mixtures of two, three or four elements could not be a devastating argument against attributing this book to Aristotle.

After analyzing the content of Book IV at the beginning of this chapter, I shifted the focus to connections between the main steps in Aristotle's argumentation and I tried to caution the reader on some of the problems that need to be solved if we are to fully grasp these connections and to gain a deeper understanding of this text. Subsequently I pointed out the

significance of such a discussion with respect to assuming a position in the dispute over the authorship of *Meteor*. IV and I indicated why I believe that this book should be deemed in essence an Aristotelian work. I have also inquired into the nature of the uniform stuffs and tried to show that homeomers are not necessarily compounds, according to *Meteor*. IV (and, at the same time, that this thesis could not be taken to show that the tenets of Book IV are not non-Aristotelian). With these preliminaries in mind, we should be ready now for a closer look at what *dunameis* are and at the relevance of dispositional properties to various types of change presented in the fourth book of the *Meteorology*.

III. WHAT ARE MATERIAL DISPOSITIONS?

A. PROLEGOMENA

The fourth book of Aristotle's *Meteorology* is not merely a catalog of types of – organic and inorganic – homoeomerous stuffs clustered in overlapping classes according to criteria as diverse as their dispositional differentiae, their physical microstructure (e.g. arrangement of *poroi*) and the ratio between their elementary ingredients. This division is accompanied by, and to some extent intertwined with, numerous and sometimes suggestive accounts of the effects of active powers like heat and cold, under specific conditions, on mixtures of earth and water. The landscape conveyed by Book IV is one clearly dominated by change, although an important feature of the uniform bodies that come about and are altered as a result of such effects is that they tend to maintain their defining characteristics (their *eidē*, albeit in a rather rudimentary sense) as long as certain conditions obtain and a certain internal thermic equilibrium is preserved.

This chapter is meant to attempt a several-pronged answer to the question: what are material dispositions, according to *Meteor*. IV? I will start by affirming the apparently obvious fact that material dispositions are properties, and by reaffirming, on grounds provided by the chemical treatise, the thesis that the basic *dunameis* or contraries are not reified by Aristotle. My next task will be to answer the question: what kind of properties are material dispositions? I will

explore the nature of dispositional properties (active, passive, resistive), basic and derivative alike, as set forth in their theoretical analysis in *Metaph*. Δ and Θ, before assessing the compatibility of such texts with the treatment of dispositions in *Meteor*. IV. Stating what material dispositions are also involves taking a position on what they are not; I will claim that *dunameis* are not reduced in Aristotle's chemistry to categorical properties and do not amount to their own manifestations either. These points will lead me naturally to a comparison of Aristotle's use of *dunamis* in *Meteor*. IV with his handling of *pathos*, since the claim that material *dunameis* are not to be reduced to either categorical properties or to their own manifestations may seem to be contradicted by the occasional quasi-synonymy of *dunamis* and *pathos* in that text. This section will be completed by a study of the sense in which a uniform body's characteristic set of *dunameis* can be said to be part of its nature, at a strictly material level. We should then be ready to tackle (in Ch. 3) Aristotle's account of the emergence of *dunameis* in uniform stuffs, as *Meteor*. IV is not only an analysis of the nature and variety of uniform stuffs (and of their material dispositions), but also, although less transparently and less consistently, an investigation into the generation and alteration of uniform stuffs and implicitly into the emergence of derivative dispositions.

In *Meteor*. IV, as elsewhere, Aristotle's terminology applied to dispositions is rich and somewhat protean: material dispositions can be simply described without being assigned generic technical names, or they can be referred to as *dunameis* (as well as *adunamiai*) or *pathē* and *pathēmata*; alternatively, they are conveyed by verbal adjectives (usually passive ones ending in *–tos*, corresponding roughly to '-ible', '-able'); finally, sometimes an entire set of dispositions of a particular stuff is said to stand for a significant aspect of the *phusis* or *eidos* of that uniform stuff. Yet, amongst this variety of references, the term *dunamis* is, quite expectedly, the

paradigmatic name for dispositions in Aristotle's oeuvre.[62] It is more apt to cover the complexity of 'disposition' than any other Greek term and even transcends its semantic boundaries. *Dunamis* is variously translated as 'power', 'disposition' (cold can solidify molten wax), 'capacity' (falcons can spot their prey from far above), 'ability' (someone can prepare a medicine, compose a song, persuade a crowd) etc.[63]

Aristotle's use of *dunameis* and kindred notions is inscribed in a long and notoriously intricate tradition. A history of the concept should take into account the various uses to which it was put by the Presocratics, by the medical schools,[64] by the Sophists, by Plato, and also by

[62] However, in particular areas, like ethics, other terms, such as *hexis*, can prove a successful alternative.

[63] Translators sometimes hesitate between these renderings and as a result terms like 'ability' and 'capacity' are often used interchangeably.

[64] The heuristic function and ontological status of material powers or dispositions became a significant instrument and object of study with the *phusikoi* and with the Hippocratics. Later on, the notion of *dunamis* became central to much of Plato's natural philosophy and especially Artistotle's physical and metaphysical doctrine as well as to most of his scientific treatises. Considerable work has been done on Plato's debt to the Hippocratics (see, for instance, Souilhé and Plamböck). As for Aristotle, the novelty of his treatment of *dunameis* has sometimes been considered against the background of several Platonic passages where *dunamis* figures prominently. One is likely to acquire further insight into the semantic richness and the functional variety displayed by Aristotle's handling of *dunamis* if one compares it with the ways in which *dunamis* is treated in a number of relatively early Hippocratic (and other medical) writings. Thus, it is important to note – as Joseph Souilhé (1987 repr.) and Heinrich von Staden (1999) do – that the Hippocratics do not seem to consider the basic powers to exist on their own in the world. The building blocks of the physical universe are not the *dunameis*, but the elementary stuffs. Aristotle makes it clear at the outset of *Meteorology* IV, in a manner reminiscent of *Generation and Corruption*, that the four basic *dunameis* (hot, cold, moist and dry) are more 'elementary' than the elements (or elementary stuffs: earth, water, air and fire), without, however, being themselves stuffs. Besides, the *derivative* dispositions (emerging in homeomers) are ontologically justifiable only in so far as they hinge, as properties, on the existence of stuffs. These powers or dispositions, however, are crucial to understanding the nature of the materials to which they pertain. It is such powers that could help one make the transition from the visible, that is from the manifestation of dispositions, to the invisible, scil., to the 'chemical composition' of a certain stuff or to the nature of a certain internal organ (see on this topic Jouanna 1999). Similarly, a function fulfilled by dispositions in Aristotle's *Meteorology* IV (tightly connected with their role as differentiae) is that they allow Aristotle to establish what the composition of a body is (usually a certain ratio between earth and water or dry and moist) and what the microstructure of that body is (for example, it can be

successive generations of philosophers and scientists after Aristotle. A panoptic picture of this notion in Greek thought should cover senses as diverse as physical strength, military might, force of a discourse, monetary value, semantic value, quality or dispositional differentia, elementary power, the very elements displaying such power, capacity and ability, potentiality as a way of being. Let me start then by staking out what the *dunameis* at issue in this study might be in Aristotle's view, at a most general level.

B. DISPOSITIONS ARE PROPERTIES

1. *Dunamis* in the *Categories* and in *Meteorology* IV

The broadest determination of what a *dunamis* is can be found in the *Categories*, where *dunamis* is listed among several types of qualities. In Chapter 8, devoted to 'quality' or *poiotēs*, after an all too sketchy definition ("that in virtue of which certain people are called such and such"), Aristotle undertakes to list, define and exemplify the four main subcategories of 'quality':

8b27-9a13: States or habits (*hexeis*) – virtues, knowledge etc. – and dispositions (*diatheseis* – which are said here to be simply transient states, rather than 'dispositions'

---

traversed by a particular type of *poroi* or tiny channels, arranged according to this or that pattern); see on this my Ch. 4. Similarities between the earlier Hippocratics and Aristotle, as far as the treatment of powers or dispositions is concerned, are quite obvious also in the way in which *dunamis* is connected with other terms and notions. For instance, in *Meteorology* IV, *dunameis* are occasionally used interchangeably with *diaphorai* (differences or differentiae), much in the way in which they are used in *Parts of Animals* II. In the Hippocratics one can find a plethora of passages where some stuff, like a bodily humor or a potion that is supposed to heal a certain disease, is characterized by a definite set of (defining) differentiae – *diaphorai* or *dunameis*, often called *idiai dunameis*, this allowing one to distinguish between such stuffs.

understood strictly as latent states that can be manifested under specific conditions) like being well or feeling ill.

9a14-28: Natural capacities or the lack thereof (9a16: …*dunamin phusikēn ē adunamian*…; these cover dexterity, skills, bodily conditions that are not as rapidly shifting as the previously mentioned *diatheseis*, but also material properties like hardness and softness); being a good boxer or runner, being prone to become ill etc. are examples of such *dunameis*.

9a28-9b33: Passive qualities and affections (*pathē*), by which he actually means perceptible qualities that affect our senses, like sweetness and blackness; 9b234-10a10: coupled with the previous type are passive qualities and *pathē* of the soul (such as irascibility).

10a11-24: The fourth kind comprises shapes and figures, like crookedness, straightness, triangularity.

Let me point out here that, although only the second type of quality is presented in Ch. 8 of the *Categories* as a *dunamis* (or *adunamia*), elsewhere in his oeuvre Aristotle readily employs *dunamis* to refer, in addition to natural powers, to *hexeis* and *diatheseis*,[65] to *pathē* and *pathētikai poiotētes* (although, of course, never to categorical properties like shape or the arrangement of a thing's parts).

The chemical treatise offers, as one should expect, abundant illustrations of the status of dispositions (*dunameis,* but also *pathē, pathēmata*) as properties or qualities of uniform materials, whether organic and inorganic (e.g., at 382a5, 8, 385a5 etc.). But does *Meteor*. IV also provide support for the notion that not all *dunameis* are simply properties or qualities, but can be

[65] All *dunameis* appear to be *hexeis*, but the reverse does not obtain; besides, some *diatheseis* can be regarded as *dunameis*: e.g. one can briefly feel courageous, without usually being a courageous person, and accordingly can act courageously if necessary.

things on their own, such as (truly) elementary stuffs? Let me try to answer this question in the following section.

2. Basic *dunameis* are not stuffs

Aristotle does not seem interested in making a very explicit and emphatic distinction – in theoretical terms – between, on the one hand, the four primary or basic powers (hot, cold, moist, dry) that form the so-called elements as a result of binary combinations, and, on the other hand, the secondary or derivative dispositional properties that come about in homeomers, since this distinction is evident from the many examples he gives in, in no uncertain terms; there, following the definitions of the four fundamental powers (heat is the power to bring together stuffs displaying mutually similar qualities, etc.) he adds (at 329b33) that "From moist and dry (*ek toutōn*) are derived the fine and coarse, viscous and brittle, hard and soft, and the remaining tangible differences."[66] Interestingly, these properties are derived from a combination of some sort of all these basic *dunameis*, but each derivative property *Meteor*. IV. In the *GC*, however, he stresses this distinction, between basic and derivative *dunameis* is said in the same *GC* section to derive especially from one of the basic powers:

> …The viscous derives from the moist: for the viscous (e.g. oil) is a moist modified in a certain way. The brittle, on the other hand, derives from the dry: for the brittle is that which is completely dry – so completely that its solidification has actually been due to failure of moisture (330a5-8; trans. Joachim).

[66] Gill (1989, 81) sums up this process of derivation by writing suggestively that "The constitution and behavior of these materials – their solidification, breakability, combustibility, and so on – are ultimately due to the action of hot and cold and the response of wet and dry."

Aristotle's theory concerning the four basic powers is, thus, a consequence of his reflection on the immense variety of observable dispositional properties; in other words, the four fundamental opposites are not merely postulated, but are inferred from empirical evidence and are meant to account for the immense multiplicity of derivative qualities, such as viscosity and brittleness. While the distinction between basic and derivative material dispositions is thus fairly clear, questions still need to be answered about the material nature of the four basic *dunameis* and about the emergence of derivative *dunameis*.

Passages like this one may lead readers to assume that the basic *dunameis* are not simply constitutive properties of the elements and of compounds alike, but that they have a more robust material nature, in short – that they are themselves stuffs or come very close to being stuffs. *Dunamis* is routinely associated with matter, *hulē*,[67] in Aristotle, just as *energeia* (or *entelecheia*) is associated with form, *eidos*. Aristotle also indicates more theoretical but crucial connections between matter and *dunamis* (at Θ 1.1046a20 ff. both are said to be originative sources). In *Meteor*. IV dry and moist are repeatedly called *hulē* – the matter which is determined and informed by the active *dunameis*.[68] More rarely – cold is said to be matter of some sort (389a29: *hulēn tina*). Does all this point to the fact that the basic powers are not only material properties but are also stuffs? Lewis (1996)[69] considers the four primary *dunameis* to be indeed ingredients of the simplest bodies – the elements – which are not so simple after all (1996, 15-26); fire would be composed out of the dry and the hot, earth out of the cold and the dry etc. He believes

[67] E.g., in *Meteor*. IV, at 379b19; cf. *PA* 646a16 ff.

[68] E.g. at 380a9, 38218.

[69] See also Furth 1988 on the four basic contraries as "ultra simples" or ultimate ingredients of the so-called elements (earth, water, air, fire).

that such a theoretical scheme is developed in *Meteor*. IV and hinted at in *GC* – and that the elements are hylomorphic, like the things and being constituted by the mixture of the elements.

But such a view had been persuasively thwarted, notably by Gill (1989, esp. 75-82), who argues that the elements – earth, water, air, fire – are not made out of simpler ingredients and, accordingly, that the primary *dunameis* cannot possibly be stuffs. She notes (1989, 76) that Aristotle accepts, indeed firmly propounds, the notion that the four contraries perish in the course of elemental transformations (e.g. hot perishes when air turns into water, since what subsists is moist, whereas hot is overcome by cold); but if the four elemental contraries were to be reified, then Aristotle would fall into the Parmenidean snares of admitting the possibility that something can be reduced to nothing. In fact, there is no need to analyze the elements into simpler ingredients, and, Gill notes, "This immunity from further division is the reason why Aristotle claims that the elements are generated from one another" (1989, 77).

Let me add that Aristotle uses 'dry' and 'earth', 'moist' and 'water' interchangeably in *Meteor*. IV and this can also lead to the view that the four contraries are material ingredients of the four so-called elements, since dry, moist and, more rarely, cold are matter or "some kind of matter", according to the text of *Meteor*. IV. Instead, in such cases, 'dry' should be taken to be a shorthand for 'earthy or predominantly earthy uniform materials'. In Ch. 10, for example, Aristotle makes this sufficiently clear when he distinguishes between various types of causation (in a way partly reminiscent of a similar distinction at the beginning of Ch. 5):

> The non-homoeomerous bodies [i.e. complex parts: face, hand etc., and possibly artifacts] owe their constitution to another cause [*allēs aitias*, which I take to be final causation]; the material cause of the homoeomerous bodies which make them up is dry and moist, that is, water and earth, which display most clearly these two characteristics [*tauta gar prophanestatēn echei tēn dunamis hekateron hekaterou*]… (388a20-24).

This passage lends no support to the view that the basic opposites are actually ingredients of the so-called elements, earth, water, air and fire, and that these are actually compounds consisting of dry and cold, moist and cold etc.

That material dispositions are properties is perhaps less obvious (especially at the level of the four basic *dunameis*) than it may appear at first sight, but it is certainly easier to ascertain than exactly what the nature of those properties is – the topic of the following sections of my second chapter. Let me begin the next stage of my investigation, on the nature of material dispositions, by placing the fourth book of the *Meteorologica* in a broader Aristotelian context.

C. WHAT KIND OF PROPERTIES ARE DISPOSITIONS?

1. *Metaphysics* Δ 12 and Θ 1-5 on dispositions as principles of change

Aristotle fine-tuned and enriched some of the physical and especially metaphysical senses of *dunamis* and he was careful himself to distinguish between the type of *dunamis* most appropriate to change and the one meant to be central to much of his theory of being (along with *energeia* and *entelecheia*). In a physical sense, the realm of *dunameis* is generally confined to what does not exist of necessity[70] (see 1050b6-34) and *Meteor*. IV seems indeed to map aspects of the realm of "for the most part" (a point that I will elaborate towards the end of this dissertation). Accordingly it is the sense of *dunamis* most appropriate to change that will also be the most

[70] Although potentiality can be applied even to the stars in so far as their locomotion is concerned (i.e. when a star is situated at point A on its trajectory, it is potentially at some other point, B, on the same path).

relevant to my discussion of *Meteor*. IV. Yet, before exploring that topic in detail, let me provide a more comprehensive framework at this point.

Dunamis has a vast area of philosophical applicability in Aristotle, going beyond the representation of change. In a metaphysical setting, Aristotle's treatment of *dunameis* exhibits more innovation than in any other context.[71] At the end of Ch. 1 of *Metaphysics* E Aristotle memorably declares that it belongs to the first philosopher to study being qua being, "both what it is and the attributes that belong to it qua being". Subsequently, at the beginning of E 2, preceding a discussion of accidental being (which, Aristotle concludes, cannot form the object of a science) we find a list of four perspectives from which one can contemplate being:

> But since the unqualified term 'being' has several meanings, of which one was seen to be the accidental, and another the true ('non-being' being the false) while besides these there are the figures of predication (e.g. the 'what', quality, quantity, place, time, and any similar meanings which 'being' may have), and again besides all these there is that which 'is' potentially or actually (*dunamei kai energeiai*)…[72]

This last point will be developed considerably in *Metaph*. Θ. After carefully examining being as substance, in Z-H, Aristotle largely dedicated Book Θ to analyzing two modes of being: power or potentiality (*dunamis*) and actuality (*energeia*) or fully achieved reality (*entelecheia*). This

[71] To be sure, one can take up the 'archaeology' of Aristotle's *dunamis* and track passages in Plato that seem to be forerunners of passages in *Metaph*. Θ and ⊗, as well as in *De an*. II 5 etc. (see the distinction between *ktēsis* and *hexis* in the *Theaetetus*), but Plato never quite fashioned a clearly articulated theory of *dunamis*.

[72] Cf. *Metaph*. Θ 10 (probably a late addition to that book, but an important one), 1051a34-1051b2: "The terms 'being' and 'non-being' are employed firstly with reference to the categories, and secondly with reference to the potency or actuality of these or their non-potency or non-actuality, and thirdly in the sense of true and false." Cf., in a more applied context, *De an*. I 1.402a23-27: "First, no doubt, it is necessary to determine in which of the *summa genera* soul lies, what it *is*; is it a 'this-somewhat', a substance, or is it a quale or a quantum, or some other of the remaining kinds of predicates which we have distinguished? Further does soul belong to the class of potential existents, or is it not rather an actuality? Our answer to this question is of the greatest importance" (trans. J. A. Smith).

discussion is overtly meant to be complementary to books Z and H of the *Metaphysics*, while offering a new angle of attack:

> We have treated of that which is primarily and to which all the other categories of being are referred – i.e. of substance… Since being is said to be the what or the quality or the quantity and is, on the other hand, distinguished with respect to potency, and to complete reality and to function, let us lay down definitions regarding potency and complete reality (1045b27-35; trans. Ross, with modifications).

Aristotle's introduction of *dunamis* in his metaphysical enterprise, however, is not thoroughly new, even within the confines of the central books of the *Metaphysics*.[73] His previous analysis of substance does rely, mostly implicitly, on the notion of actuality, while matter (in general or a particular amount of unwrought stuff) is naturally regarded as a set of possible realizations.[74]

A simplified outline of the structure of Book Θ will afford a clearer picture of the project that lies at its heart. I would represent its structure as a triptych:

- Chapters 1-5 are concerned basically with the kind of potency *most relevant to change*[75] (first division: active-passive in 1; second division: *aneu/meta logou* in 2; potency is not reducible to its manifestation: 3; defense of its reality; potency as possibility: 4; how powers/potencies can be actualized: 5); this section is most obviously in keeping with the *Physics* and relevant to *Meteor*. IV.

[73] Book H, for instance, includes numerous references to potentiality and actuality.

[74] See e.g. *Metaph*. H 2: "It is obvious what sensible substance is and how it exists – one kind as matter, another as form or actuality, while the third kind is that which is composed of these two" (1043a26-8).

[75] See *Metaph*. Θ 1.1045b35-1046a4: "And first let us explain potency in the strictest sense, which is, however, not the most useful for our present purpose. For potency and actuality extend beyond the cases that involve a reference to motion. But when we have spoken of this first kind, we shall in our discussions of actuality explain the other kinds of potency as well."

- Chapters 6-9 dwell mainly on actuality (within this segment: second type of potency, *more relevant to Aristotle's theory of being* – briefly but conspicuously dealt with in 6; when can one legitimately talk about potency in matter and substances? – 7, chapter in which actuality is treated only implicitly; priority of actuality: 8; good actuality is better than good potentiality: 9).

- Ch. 10, an addition both to Z-H and to Θ 1-9, considers the relation between being and truth.[76]

Thus Aristotle appears to think in Θ that the natural way to start his discussion of power / potentiality is with the most proper sense (*malista kuriōs*) of this concept, which is different from the kind of *dunamis* that makes a weightier contribution to his discussion of being. At the beginning of Ch. 6 of *Metaph*. Θ (1048a25) he explicitly points out the topic of the previous chapters: they treat of the sort of power or potency that is relevant to motion (although here 'motion' – *kinēsis* – is probably accorded the more general meaning of *metabolē*, 'change'). As a result, a scrutiny of the meanings that are "the most useful" to the core of his investigation of substance will have to be put off for a while (the positive implication of this is that the study of *dunamis* in its strict sense, *kuriōs*, will allow him to prepare the terrain for the "more useful"[77] sense and will confer Chapters 6-8 with enhanced clarity).

The first chapter of *Metaph*. Θ is largely a reformulation of *Metaph.* Δ 12, which is devoted virtually only to *dunamis* and barely touches on actuality. After trimming down the semantic sphere of *dunamis* by the exclusion of several 'homonymous' uses of the term (e.g. in geometry), Aristotle proceeds in Θ 1 to outline three major types that need to be clearly circumscribed, if one is to properly capture its polysemy: active powers, passive powers,

[76] Cf. *Metaph*. E 4 on the same topic.

[77] I.e., to Aristotle's metaphysical doctrine in the central books.

resistive powers. This triad, mirroring, as I have noted, much of Δ 12, provides crucial elements for a mechanics of change and seems to form a more successful alternative to the privation-form-and-substrate model favored in the *Physics*.

Active powers. A *dunamis* can be a principle (*archē*) of movement / locomotion (*kinēsis*) or change in general (*metabolē*) (1019a15, 1046a10). The intuitive way to analyze such a principle into sub-types is to start with its active aspect. Thus the primary (*prōtē*) sense of *dunamis* (Θ 1.1046a10-11)[78] is that it is a thing's principle of change in some other thing or in that very thing qua other[79] ("an originative source of change in another thing or in the thing itself qua other" in Ross' translation). A flame has the active power to burn or melt; a physician has the ability to cure certain diseases.

This is also the paradigmatic sense of *dunamis*, according to Δ 12. It is quite likely that the primacy of this sense is due to its common use in Greek and concomitantly to its intuitive priority, so to speak: what I mean is that the thought of any passive power seems to entail that of a corresponding active power (while the reciprocal is less obvious, just as – on a different level – any instance of potency or potentiality entails a reference to some corresponding actuality). This point is supported by a passage in *Metaph*. Δ 12, where, after listing the dominant types of *dunameis* and after a brief discussion of the notions of possibility and impossibility, Aristotle concludes with a reminder of the 'cardinal' sense of *dunamis*:

> …The senses which involve a reference to *dunamis* all refer to the primary kind of *dunamis*; and this is a principle of change in *another*[80] thing or in the same thing qua *other*. For other things are

[78] Cf. *Metaph*. Δ12.1029b35-1030a2.

[79] See my observations on *hēi allo* in the Appendix.

[80] This notion of otherness is essential to passive powers as well (see next paragraph), but in an opposite sense, and should be contrasted with another type of *dunamis* – a thing's natural capacity to grow into something (e.g. a seed

> called 'capable', some because something else has such a potency over them, some because it has not, some because it has it in a particular way. The same is true of the things that are incapable. Therefore the proper definition (*ho kurios horos*) of the primary kind of potency will be a source of change in another thing or in the same thing qua other (1019b35-1020a6; trans. Ross with modif).

Passive powers. Conversely, a *dunamis* can be the principle of a thing's being moved or changed by *another* thing or by itself qua *other*; in Aristotle's concise formulation: [a principle of change brought about] by *another* [thing] *or* [in the same thing considered] as *another* (1019a20-23; cf. 1046a12-14).

These two large categories, active and passive powers, relevant chiefly but not only[81] to Aristotelian physics, can be theoretically collapsed into one (1046a19 ff.), since 'capable' (*dunaton*) can be used both in an active and in a passive sense; besides, the passive sense (susceptibility to change) seems to be somehow analogous to or rather parasitic upon the notion of active powers, which Aristotle considers in Δ to be the primary sense of *dunamis* (namely a source of change in another thing or in the thing itself qua other).

On the other hand, the two types of powers can be plainly distinguished (1046a21-27) by the fact that one resides in the thing / being that brings about a change (in virtue of that active power or principle of change) and the other belongs to the thing / being that suffers an action (in virtue of that passive power or passive principle of change).

---

growing into a plant; see e.g. *Metaph*. Δ 12.1019b1 ff; Θ 8.1049b9 ff.: "For nature also is in the same genus as potency; for it is a principle of movement – not, however, in something else, but in the thing itself qua itself").

[81] If change is considered at a high level of abstraction, metaphysics can easily encroach upon the territory of physics, of course, and the *Physics* itself is imbued with theories and observations that we would readily regard today as metaphysical.

Resistive powers form a third major category, listed by Aristotle along with active and passive powers both in *Metaph*. Δ (12.1019a26-32) and in Θ (1.1046a29-35). Resistive powers are distinct from both passive and active powers, but in a way they are, conceptually speaking, akin to the passive ones. Resistive powers and corresponding passive dispositions are situated on the same continuum. To take an example, specific instances of 'resisting melting' and 'meltable' seem to be situated at various points on the same continuum (Aristotle, given the 'qualitative' nature of his science, speaks in *Meteor*. IV in terms of 'more and less' rather than attempting to attain any significant degree of exactness). One can imagine the theoretical extremes of such a continuum to be 'absolutely non-meltable (or *apēkton*)' and 'extremely easy to melt', bounding a wide spectrum of degrees of 'resistance to melting' and 'meltability'.[82]

In broad outline, this is the *Metaph*. account of the active, passive and resistive powers. In what follows (2),[83] we should try to find out whether *Meteor*. IV is a faithful or distorting mirror of the picture afforded by *Metaph*. Δ and Θ.

2. The compatibility of *Meteor*. IV with the *Metaphysics* (Δ 12 and Θ 1-5) account

In the fourth book of the *Meteorology*, Aristotle makes several explicit distinctions among kinds of dispositional properties:

- between active and passive *dunameis* (e.g. at 378b12-13);

- between (essentially) perceptible dispositions and more intrinsic / proper (*oikeioterois*) dispositional qualities (385a2-5), and, among derivative dispositions, that emerge in mixtures or compounds, belonging to solids, he marks a distinction

[82] I am thankful to Professor Gill for helping me to clarify this thought.

[83] See also Appendix I.

- between primary ones (softness and hardness) and other such properties (382a8).

The text of this treatise, however, furnishes, if only implicitly – but unmistakably, a greater number of lines of demarcation along which Aristotle differentiates between types of dispositions: dispositional properties can be accidental or essential (defining) properties,[84] basic or derivative, they can be related directly to (and can stem from) a particular chemical composition or physical structure; dispositional differentiae can be 'simple' in nature, such as the power of heat to combine similar things, and more complex, such as 'boilable' (380b13-381a12), i.e. being liable to be concocted as a result of heat in a thing's moisture.

a. Change – and the active and passive *dunameis*

The opening paragraph of *Meteor*. IV establishes the distinction between active and passive primary qualities (or: causes, causal factors) in a spirit reminiscent of the *GC* II 2, without listing, however, some of the derivative properties that stem from them. The *GC* (esp. 329b25-33) clearly foreshadows the tenets put forth in *Meteor*. IV 1 in explaining what the active and passive character of the four basic powers amounts to:

> …Hot and cold, and dry and moist, are terms, of which the first pair implies power to act and the second pair susceptibility. Hot is that which associates things of the same kind (for dissociating, which people attribute to fire as its function, is associating things of the same class, since its effect is to eliminate what is foreign), while cold is that which brings together, i.e. associates, homogeneous and heterogeneous things alike. And moist is that

[84] We can certainly grasp this distinction more easily when it comes to organic *homoiomerē*, since their essential *dunameis* are determined by their defining functions. In the inorganic ones some dispositions are subjectively essential, so to speak – according to the use we put those stuffs to. (Also, some properties are more important than others from a theoretical point of view; in *Meteor*. IV, Aristotle gives prominence to certain dispositions that point to the 'chemical' compositions of various *genē* of uniform bodies and contribute implicitly to a meaningful and generic division of the *homoiomerē* – one of the principal aims of that book.

> which, being readily adaptable in shape, is not determinable by any limit of its own: while dry is that which is readily determinable by its own limit, but not readily adaptable in shape (trans. Joachim with minimal modifications).

It should be mentioned that an active force is situated on the range bounded by the extremes 'hot' and 'cold' (which cannot be normally found in 'pure state', but as such are useful theoretical instruments in capturing the nature of elemental transformations); and a passive power is to be found at some point on the dry-moist continuum. Exactly how active and passive powers interact is not the object of a distinct and fully elaborate section of the fourth Book of the *Meteorology*, although it does include numerous short passages that tackle that topic from different angles. One would have to find a compromise between the *GC* account insisting on contact and contiguity and the references to *poroi* in Ch. 3 (in connection with *pepsis*) and especially Chs. 8-9 of *Meteor*. IV. The resort to *poroi* does not pervade the entire Book IV, and where it is not used at all (e.g. in Chs. 5-7, on liquefaction and solidification), it remains quite unclear whether one should still suppose the *poroi* in the background, so to speak, or whether an alternative sort of mechanics of change (along with the obvious 'thermodynamics') is to be assumed. For instance, it is possible but not obvious that Aristotle expects the reader to give more heed in *Meteor*. IV 5-7 to the natural motions of the elements in the changes affecting the state of aggregation of a uniform body. Similarly, in Chs. 2-3, with the exception of one passage appealing to the explanatory power of the *poroi*, in connection with roasting as a form of concoction, at 381b1 and 3, one may have to suppose that the interaction between active and passive qualities may have to do more with the natural motion of the elements – only potentially present in the homoeomerous compounds and with the function of the internal heat as a factor of stability, under the right circumstances – than with the *poroi*. If this topic is bound to remain an

area of quick sand in the landscape of Aristotle's natural science, a few general features of the active and passive factors (in *Meteor*. IV and elsewhere) are beyond doubt.

I should add that, when it comes to uniform bodies (although this applies to other realms as well), the nature of active and passive powers is strongly context-dependent. For example, a source of heat, such as the sun or a flame, does not have simply the tendency to heat up; rather it has 'specialized' tendencies, according to the possible passive powers with which it may interact. Depending on the stuff it affects and the dispositional properties of that particular stuff, and depending on the environmental conditions, the aforementioned source of heat can – by imparting heat – scorch, liquefy, bring to a boil etc. (although presumably all of these phenomena will reflect the overarching power of heat to associate things of the same kind: see *sugkritikon* at 378b23; cf. the passage from *GC* II 2). In order for an active property and for a passive one to be actualized, they will have to correspond to each other ('bitter' will not actualize the passive power of a body to be set afire, except accidentally, if 'bitter' belongs to a body that can also ignite things). This becomes evident in the course of Aristotle's scrutiny into at least three sets of processes (concoction and inconcoction in Chs. 2-3; liquefaction and solidification in 5-7 and a portion of Ch. 8, and a great variety of processes in Chs. 8-9). This rather precise correspondence between active and passive agent and patient, or rather active *dunamis* and passive *dunamis* is given full prominence in *Ph*. III 3, where Aristotle spiritedly defends the notion that corresponding active and the passive powers tend towards the same point of convergence, that is, that their realizations – action and 'passion' – coincide in a way. Both teaching and learning tend towards the same result (e.g. at 202a331-7); Aristotle tries to prevent any objection to the idea that there will be only one actualization, since otherwise we would have to accept that there are two alterations (*alloiōseis*) in the same thing (i.e. the 'patient') and in the

same respect. The text of *Meteor*. IV largely confirms this account, but contributes, through its many and varied examples, a certain refinement to it: one can imagine a radial structure, where the center or the hub is apparently a single and simple active power (the example I gave before was the power of heat), and the spokes stand for the correspondence between that active power and various passive powers that correspond to it. Now, such an active power turns out very often in the 'chemical treatise' to be firmly context-dependent and to be (liable to become) actualized in radically different ways, if the body that possesses it comes in contact with bodies that react very differently to heat.

b. Active and passive basic contraries

The distinction between active and passive powers or causal factors (*aitia*) plays a cardinal role in *Meteor*. IV at the level of the basic[85] *dunameis* and Aristotle marks it firmly and repeatedly. This demarcation is crucial to the entire apparatus of arguments on and descriptions of the effects of heat and cold upon uniform stuffs. From the first paragraph of the first chapter (378b10-14) we learn that the four elements are the result of combinations (and recombinations) of four causes or causal factors (*aitia*), two active (heat, cold) and two passive (dry, moist). That the four *aitia* are also called *dunameis* (e.g. at 378b29) is to be expected, I believe, on two accounts: firstly and most importantly, they (sometimes along with other factors) are referred to as *dunameis* in previous authors, like some of the Hippocratics, since these four factors and the proportion or disproportion between them were actually perceived as 'powers' responsible, among other things, for a great number of physiological processes and states, and for one's

[85] There is far less emphasis on the contrast between active and passive derivative dispositions in this treatise; see Appendix III.

wellness or poor health etc.; secondly, in *GC*, *De Caelo* etc. the basic *dunameis* do not assume separate existence (e.g. we are not to suppose that one can come across 'pure heat' or 'pure moist'; rather, they are theoretical extremes on the hot-cold and moist-dry continua respectively), but exist potentially (*dunamei*) in the constitution of the most elementary bodies: earth, water, air, fire and in their combinations.

In the first chapter of *Meteor*. IV the active factors (whether they are intrinsic / 'innate' or external / belonging to the environment) are presented as being responsible, through the motions they initiate,[86] for the generation (*genesis*)[87] and destruction (*phthora*, or – in a more specialized sense: *sēpsis*, decay) of uniform bodies.[88] Chapters 2 and 3 offer six scenarios of how the underlying matter (organic or inorganic uniform stuffs that are constituted mainly by various combinations of earth and water) undergoes or fails to undergo processes of concoction or *pepsis*. In what way and in what measure internal and external heat and cold affect a homoeomerous body will decide whether it will be 'concocted' and how. An important role is assigned to the active factors in chapters 5-7 too, although here more emphasis is placed on the passive ones (the ratio between moist and dry is meant to explain why a body is liquefied or solidified by cold or by heat). Chapters 8 and 9 do not overlook the interaction between the active and the passive factors entirely, but preeminence is given there to mechanical (rather than thermodynamic) processes. Finally, I should mention chapters 10 and 11, which, based on the insight provided by dispositional properties, seek to shed light on the proportion between earth

[86] Cf. Ch. 12.390b3.

[87] "Simple, natural generation is a change effected by these properties (*hupo toutōn tōn dunameōn*), when present in the right proportions, in the matter underlying a particular natural thing, this matter being the passive properties (*dunameis pathētikai*) of which we have spoken. The hot and the cold produce change by mastering the matter: when they fail to master it, the result is half-cooked and undigested" (378b32-379a2).

[88] "Destruction takes place when what is being determined gets the better of what is determining it with the help of its environment…" (379a11-12).

and water (or dry and moist) and, somewhat surprisingly, between hot and cold (not necessarily as perceptible qualities) in the nature of homogeneous bodies.[89]

A special role is assumed – in the context of the basic powers – by the interplay between *internal and external heat*. Both internal and external heat (*entos kai exō*, 382b18) can cause the solidification or drying of a certain body (usually a mixture of earth and water; watery stuffs are expectedly solidified by cold, rather than by heat), by reducing its amount of moisture and by conferring it with clear limits. According, e.g., to the final passage in Ch. 5, sometimes the cold appears to dry out things such as wet clothes, but in fact it is the internal heat that achieves this by dragging along the moisture when the heat is expelled by the surrounding cold (382b18-13), i.e. causing the moisture to evaporate (*exatmizein*). Thus, the interaction between internal heat and the cold or heat in the environment (in the air or in the water or some watery liquid, in the case of boiling – 382b26) is a continuous balancing act, already alluded to in the first chapter of *Meteor*. IV (379a26 ff.). In the case of objects like wet clothes (382b19), internal heat appears to be an accidental feature; the same cannot be said of living beings, plants and animals alike, since internal heat is, if not a constitutive aspect of their forms, at least tightly bound up with them.

In his translation of the end of Ch. 5, Lee mentions twice (pp. 317-8) that heat is an active cause, although this is not warranted by the Greek text and he seems occasionally to replace the translation with a sort of minimal commentary; he probably hearkens back to the beginning of Ch. 5 (382a27-382b1), where Aristotle distinguishes between different types of causes: matter (*hulēn*), moving or efficient (*to men oun poioun hōs hothen hē kinesis*) and formal, although

[89] Ch. 11 is a somewhat intriguing text, since hot and cold are dealt with there less as active factors, and more as the constituent factors (quite naturally so, especially for the cold, which is in part constituent of water and earth; besides, if air and fire too are to be assumed to contribute to the material make up of uniform bodies – and they probably do in most cases, then it certainly makes sense to talk about heat as being an important aspect of the material nature of the *homoiomerē*).

presumably in a rudimentary sense devoid of teleological nuances (*to de pathos hōs eidos*). He goes on to note that the active or efficient cause (*to poioun*) acts through or in virtue of two powers (*dunamesi – thermōi kai psuchrōi*), whereas the *pathos*, which he had just equated with the form, is determined by the absence or presence of heat/hot and cold. The language of this passage may suggest that the hot and the cold are not exactly seen as efficient causes (*poiounta*), although we know of course that they are active factors (e.g. 378b12: *duo poiētika*), but one should not make too much of such an apparent distinction, since throughout *Meteor*. IV the hot and the cold are clearly regarded as efficient causes.[90] It is more noteworthy, however, that, while they can affect the form (*pathos, eidos*) of a uniform body, they do so as instruments, as it were, of efficient causation. But this does not fully reveal the connection between (internal) heat and form.

To clarify this point, let me turn now to other sections of *Meteor*. IV. In Ch. 1, at 379a23-25, we read that "…As [a thing's] own heat leaves it, its natural moisture evaporates, and there is nothing to suck moisture in it (this being the function of its own heat, which attracts and draws moisture in)." Sometimes Aristotle uses 'fire' (*pur oikeion* – 379b3) with the sense of *thermon*; when he refers to hot air, the usual term in *Meteor*. IV is *pneuma* – e.g. at 382b20 (cf. *De sensu* 443b3, *GA* 736a1). Düring (65) points out that *oikeia thermotēs* is a notion inherited by Aristotle from Empedocles (who preferred the form *emphuton thermon*) and distinguishes (68) three senses of *thermon* / *thermotēs*: temperature as a relative quality; elementary active force; the innate heat of a body (which may actually be… cold – see *Meteor*. IV, 379b3). As though prefiguring Freudenthal's intriguing book (*Aristotle's Theory of Material Substance – Heat and Pneuma, Form and Soul*, 1995, repr. 1999) Düring (ib.) writes that "The obvious inconsistency

[90] E.g. in Ch. 10, at 388a24: "…Their efficient cause is heat and cold (*ta de poiounta to thermon kai psuchron*), which produce concrete homoeomerous bodies out of water and earth."

in Aristotle's treatment of this question is due to the fact that he never succeeded in amalgamating the theory of the two elementary forces and the theory of the *emphuton thermon*, originally set forth by Empedocles." I would like to add that heat and cold appear sometimes to have a rather hybrid status – something between basic and emerging *dunamis*; the short Ch. 11 of the 'chemical treatise' is devoted to establishing which uniform bodies are hot and which are cold, based on their chemical composition and on the processes that led to their generation. At 389b7 ff. Aristotle writes that uniform stuffs which consist of more than one ingredient (chiefly earth or water) contain heat (*echei thermotēta*), since they were formed through concoction by heat (*hupo thermotētos pepsasēs*). Therefore, I find myself in agreement with Düring's observation.

The more interesting aspect of heat in Aristotle's 'chemistry', however, is that, as I mentioned before, heat has to reach a certain equilibrium (*logos*: 379b36, cf. 390a5; see also: *PA* 652b35 – *summetros krasis*; *Topics* 139b21, *Ph.* 264b4 – *summetria thermōn kai psuchrōn*) and to maintain it in order to resist the disintegration and to preserve the unity and the nature of the compound uniform body which displays that thermic balance. Chapters 2 and 3 of *Meteor*. IV are especially illuminating, since they deal with forms of thorough and incomplete concoction. According to Ch. 2, concoction amounts to some sort of completion (or maturity: *teleiōsis*, 379b18) in the natural becoming of a (usually organic) uniform body. It occurs when the natural heat (*thermotētos oikeias*) masters the passive factors, i.e. the matter proper: the moist and the dry. External heat may contribute to that process of completion (e.g. a bath can help digestion, 379b23), but ultimately it is the internal heat that initiates and accomplishes such processes. The end of concoction, Aristotle tells us (379b25 ff.) is a thing's nature in the sense of some underlying shape or form (*hupokeimenēn tina morphēn*), when moisture acquires certain

qualities and a certain quantity (*toiondi ... kai tosondi*) in the process of being heated (when 'cooked', 'boiled' or putrefied; e.g. must, pus, tears etc.). In the final analysis, concoction is a gradual increase in density and temperature (379b33-380a1, 380a4-6) in a uniform stuff: "…For this is the material that is determined by a thing's natural heat (*tēs en tēi phusei thermotētos*), and as long as the proportion (*logos*) holds, a thing's nature (*phusis*) will abide." Just a few lines earlier, Aristotle had explained what should be meant by 'nature' in such a context: form and substance (*phusis de hēn legomen hōs eidos kai ousian*). In some instances (especially inorganic stuffs) the form should be regarded simply as a limited set of defining 'chemical' and physical, categorical and dispositional features; in others (e.g. fruition, at the beginning of Ch. 3) one should take into account teleological implications as well. In any case, the causal connection between the inner thermic equilibrium of a uniform/homoiomerous body and its nature should be by now quite clear. In fact, that connection appears to be so tight, that, one could argue, inner heat is not simply a moving cause but, rather, comes very close to constituting a central aspect of an organic stuff's nature (i.e. form, to follow Aristotle's own clarification of the term *phusis*), in virtue of a stable and determining *logos*. [91]

In conclusion, the basic (i.e. un-derived) dispositions play a crucial role in explaining natural processes, this discussion constituting a significant addition to the generic account of active and passive powers that we find in more theoretical treatises, such as the *Metaphysics* and the *Physics*, and provide a helpful and illuminating background for some of Aristotle's biological investigations (such as *PA* and *GA*, where concoction remains a significant topic and explanatory instrument).

[91] Later in this chapter I will also assess the relationship between *derivative* dispositions and the natures / forms of *ta homoiomerē*.

The preceding segments of this chapter are meant to show or confirm: that material dispositions are properties in *Meteor*. IV (including the basic powers or opposites, which, given various tantalizing passages in this book, might appear to be elementary stuffs); that *Meteor*. IV is in essential agreement with the *Metaphysics* examination of *dunameis*, but explicitly or implicitly propounds further criteria for distinguishing types of *dunameis*[92] and gives a richer account of the nature of dispositions and of the conditions that lead to their emergence as well as to their manifestation (topics on which I will dwell at greater length later in this chapter and then in Ch. 3 of my dissertation). Yet, we are still to delve deeper into just what dispositions are, according to the 'chemical treatise.' In the remaining sections of this chapter I will analyze clues provided by the fourth book of the *Meteorologica* that might point us more precisely in the right direction .

D. WHAT DISPOSITIONS MAY SEEM TO BE, BUT ARE *NOT*

1. Derivative dispositions are not reducible to chemical composition or physical microstructure.

If material *dunameis* are properties (as indeed Aristotle considers them; see, for instance, *Categ*. 8), it is important to indicate just what sort of properties they are, both by analyzing relevant Aristotelian texts and by mustering some contemporary distinctions – without, however, foisting upon Aristotle views that he did not hold. I am arguing here against Charlton's view that distinguishing between a body's material powers and the underlying material constitution of that

[92] See also the notes appended to this chapter.

body is ultimately an enterprise doomed to fail. In his 1987 paper on 'Aristotelian Powers', he observes (287-8) that "[T]he identification of causal powers [covering Aristotelian active and passive powers] with matter may seem more problematic. That is because we regularly speak of materials as possessing powers, and following Locke (*Essay* III.iii.15) we think that their powers depend on an 'internal generally unknown constitution.'" He then enlists Rom Harré's help and cites from his *Principles of Scientific Thinking* when noting that "At the deepest level in nature there can be no distinction between a power and what possesses it: the basic constituents of matter have no 'internal constitution' (p. 312) but are, so to speak, bare powers or centers of power… The non-basic powers of a knife to cut and a bottle to intoxicate are the steel in the one the brandy in the other… The notions of matter and causal power become less puzzling when we recognize that they coincide."

The simplest way to tackle this problem is by claiming that dispositions are non-categorical properties. Indeed, a question that lies at the heart of several recent philosophical inquiries into the nature of dispositions (e.g. by Armstrong, Martin and Place 1996; Mumford 1998) is whether such properties are reducible to what they call categorical properties, such as physical structure and chemical composition.[93] As Mumford notes (1998, 4, 21-22), there are several ways to define *categorical* or *non-conditional* properties. Typical categorical properties would be, e.g., shape and structure (belonging to Locke's class of primary qualities). It seems to me that Aristotle too was preoccupied with marking similar distinctions. For instance, in *Categ.* 8 (10a11 ff.), he indicates that shape and configuration (and possibly structure) form a fourth type of quality, clearly distinct from *dunameis* (which are themselves considered among

[93] I should at least note in passing that the term 'categorical' is somewhat ambivalent in other authors, notably in Nelson Goodman (1955), where it can refer to the instantiation of some disposition, rather than to the microstructure on which that disposition hinges.

qualities).[94] He seems quite reluctant to reduce derivative material dispositions, e.g., to the 'chemical' composition (ratio between water and earth etc.) or to the inner structure of that body (the presence of micro-capillaries – *poroi* – arranged in such or such a way etc.), although he repeatedly points to the connection between what we might call categorical and dispositional properties. In the first chapter of the *Metaphysics* Aristotle distinguishes between agent and patient and intriguingly mentions matter (*hulēn*) as being a sort of principle (*archēn tina*):

> For the one is in the thing acted on; it is because it contains a certain principle, and because even the matter is an originative source, that the patient undergoes something, and one thing by one, another by another; for that which is oily can be burnt, and that which yields in a particular way[95] can be crushed; and similarly in all other cases. But the other potency is in the agent, e.g. heat and the art of building are present, one in that which can produce heat and the other in the man who can build (trans. Ross with modifications).

In light of much of *Meteor*. IV (especially Chs. 4-11), this statement appears to suggest, in so far as material *dunameis* are concerned, that characteristics like the ratio between ingredients in a compound (its 'chemical formula') and the presence of certain structural elements (*poroi* of a this or that type) directly account for the dispositions specific for a particular material (although its dispositions are not reducible to its composition and microstructure). Thus, because of their composition and structure, soda and salt cannot be softened (are not *tegkta*); a material can be softened, according to *Meteor*. IV 9.385b19-22, if it contains predominantly earth and has pores with a diameter sufficiently large to allow minuscule amounts of water through, and if they are

[94] Some, like Armstrong, would blithely *reduce* dispositional properties to categorical properties. With regard to this, Place notes that "For [Armstrong], dispositional properties reduce to categorical properties of the microstructure. For Place and, perhaps, for Martin, dispositional properties are emergent properties of wholes which depend on, are partly explicable in terms of, but are *not* reducible to the parts composing the microstructure and their dispositional properties" (in Armstrong, Martin, Place, 1996, 22).

[95] To understand this *hodi* more precisely, see *Meteor*. IV, 386a18-26.

porous throughout. To take another example, mentioned in that passage in *Metaph*. Θ 1, oily stuffs burn easily because they contain fire; this is plain also from *PA* II 5, dealing with fat and suet.[96] Still, he seems to suggest in *Meteor*. IV that a dispositional differential such as 'squeezable' is not just a convenient shorthand for saying that a uniform body has this particular microstructure (including certain types of *poroi*) and this particular chemical composition (essentially the ratio between the original ingredients), although it is legitimate to claim that dispositions do depend causally on categorical properties and on the processes that lead to the emergence of those dispositional and categorical features in a given uniform body. If there is an Aristotelian text that systematically maps the relationship between dispositional and categorical features, it is the 'chemical treatise.' The problem that its readers will encounter, however, is that Aristotle is less univocal on this topic than he is (in *Meteor*. IV, but mainly in the *Metaph*., *Ph*. etc.) , say, with respect to the relationship between a disposition and its actualization. This being said, I think that one can still tease out Aristotle's view on the relationship between categorical and dispositional properties. Let me quote two passages to this purpose; in the first one the categorical aspect amounts chiefly to a certain chemical composition, while in the second one the focus is on a physical feature.

In Ch. 10 (at 388a30 ff.) Aristotle divides uniform bodies into liquids and solids. Liquids, in turn, can be divided into several kinds and sub-kinds or forms, according to their material

[96] The list of 18 / 36 material dispositions in *Meteor*. IV 8-9 focuses firmly on solids (exceptions: solidifiable and viscous stuffs; 'giving off fumes' and 'inflammable' (*phlogista* – a species of 'combustible' bodies, *kausta*, which can be reduced to ashes) can be predicated of both relevant liquid and solid bodies). Solids that are combustible, we learn from that section (specifically 387a18-23), have longitudinal pores that do not contain any significant amount of moisture and can thus be penetrated by fire. In his discussion of liquid inflammables (Ch. 9, e.g. 388a5 ff.) no mention is made of the presence of fire in oily stuffs.

constitution and to their capacities; in the course of this division Aristotle proves to be a fine connoisseur of Greek varieties of wine:

> Liquids which evaporate are made of water; those which do not are made of earth or are a mixture of earth and water, like milk, or of earth and air, like honey, or of water and air, like oil. Liquids whose density increases are a mixture. (Among the liquids, wine presents a difficulty, for it evaporates and also thickens, as new wine does. The reason is that there is more than one kind of liquid called wine and that different kinds behave differently. For new wine contains more earth than old, and so thickens most under the influence of heat, but solidifies less under the influence of cold; for it contains considerable quantities of heat and earth, as in Arcadia where the smoke dries it up in the skins to such an extent that it must be scraped off before it is drunk. If, then, all wine has some sediment, whether earth or water predominates in it will depend on the amount of sediment present). (Lee, with slight modif.)

In Ch. 9, at 385b12-26 the focus is on materials that can or cannot be softened by water, *tegkta* (this being one of the eighteen pairs of *dunameis* and *adunamiai* examined in Chs. 8-9). In the second half of that section we learn that

> Anything which is earthy and has pores larger than the particles of water and harder than water can be softened by water. But bodies that can be melted by water are porous throughout. But why is earth melted and softened by moisture while soda is melted but not softened? Because soda is porous throughout and so its parts are dispersed at once by water; but in earth the pores alternate and the effect differs according to which set the water enters.

In these passages Aristotle does *not* equate a disposition with a set of categorical property, but marks their concomitance and implies the dependence of a given disposition on certain categorical features (bodies that tend to exhibit behavior A under circumstances B have composition C or physical characteristics D). In conclusion, although Aristotle perceptively demonstrates the tight *causal connection* between composition (and texture), on the one hand, and dispositions, on the other, there is no attempt in *Meteor*. IV to *identify* them or reduce one to

the other. Just as Aristotle avoids the Megarian reduction of *dunameis* to their own manifestations (see the following section), he appears to reject the downright reduction of *dunameis* to underlying material factors like composition and microstructure.

In order to prevent any confusion, I should restate that this irreducibility of dispositional properties refers quite simply to the impossibility or at least implausibility of equating dispositional differentiae with categorical properties (a problem addressed – from various angles – by a considerable number of recent studies on dispositions) and does not imply, e.g., the special sense in which Gotthelf uses the term 'irreducibility' in the context of his attempt to elucidate final causation (*to hou heneka*), as I am not concerned with teleology at this point. In the postscript to his 1987b paper (p. 230), Gotthelf clarifies his notion of ontological irreducibility as follows:

> The development, structure, and functioning of living organisms cannot be wholly explained by – *because it is not wholly due to* – the simple natures and potentials of the elements which constitute these organisms. No sum of actualizations of what I have called 'element-potentials' is sufficient by itself for the production of those complex living structures and functionings for which Aristotle offers teleological explanation.

Rather, my terminology echoes here that of T. Crane and other authors of studies on the nature of dispositions. For instance, in his introduction to Armstrong, Martin, Place1996, Crane notes (p. 8):

> …On Armstrong's view, then, properties may have dispositional characterisations; but they will always have other characterisations too. 'Pure powers' do not exist. A different perspective is provided by U.T. Place, who believes that the dispositional is distinct from the categorical. The latter he characterises in terms of spatio-temporal relations between the bearers of properties. The dispositional is not reducible to the categorical: both are equally real.

I have been careful, however, not to import modern theories of dispositions into my interpretation of Aristotl's treatment of *dunameis*, and, in so far as possible, I have tried to let him speak for himself.

2. Dispositions are not reducible to their actualizations either

On one occasion in *Meteor*. IV (at 381b27) Aristotle distinguishes in no uncertain (technical) terms between *entelecheia* and its opposite (his example there is the opposition between melting and meltable). At the same time, he often seems to speak of the differential potentials of a uniform body in terms of actual doings and undergoings; in Ch. 6, for instance (at 382a31 ff.) we read that what is solidified (not: 'is solidifiable') is made of water or is a compound of water and earth; what is solidified (not: 'is solidifiable' or 'can be solidified') as a reaction to cold or heat and is dissolved (not: 'can be dissolved') is dissolved by heat or cold etc. At first sight such formulations may leave the false impression that he is committed to the view that the existence of a power is inconceivable without its manifestation or, moreover, that it is reducible to its manifestation. However, a careful scrutiny of the entire 'chemical treatise' leaves no doubt that in such contexts Aristotle is primarily concerned with the *possibility* of that object's or being's undergoing a change or instigating it (a piece of silver is *liable* to be melted when sufficiently heated etc.) and that the aforementioned formulations reflect the conceptual priority of actuality over potentiality in general, i.e. that a discourse on dispositions necessarily involves implicit or overt references to the corresponding actuality.[97] It is such dispositional properties (that we may

[97] Cf. *Metaph*. □8 on the various senses in which *energeia* has priority with respect to *dunamis*, although that discussion is applicable mostly to substances in the stricter sense of the word (uniform stuffs too can be regarded as substances and can be analyzed into matter and form, but at a more rudimentary level).

be aware of from experience or from others' reports) rather than their very manifestation that form an important set of differentiae in Aristotle's division of homeomers. This is, I think, in agreement with *Metaph*., where Aristotle is not content to take it for granted that a thing possesses some capacity even when that capacity is not actualized.

Relevant to this point is Aristotle's attack on the Megaric school, in Ch. 3 of *Metaph*. Θ. On Aristotle's account, the Megarians held that "a thing can act only when it is acting," virtually reducing *dunameis* to their own manifestations (and ignoring the effectiveness of a clearer distinction between *dunamis* and *energeia* in accounting for the very occurrence of change). Aristotle deplores the absurdity (*ta atopa*) of the view, noting that, if something is not capable of perceiving (1047a7 ff.) when not actually in the act of perceiving, it will never perceive anything at all, for that is the meaning of being incapable of perceiving. Conversely, a perceptible quality, like cold or sweet will not exist unless actually perceived. Similarly, a builder should not be reckoned capable of building when not actually engaged in the activity of building.

Essentially, Aristotle wants to salvage a certain ontological solidity for *dunameis*, even in the absence of their manifestation; a fragile vase does not need to be shattered in order to be fragile (i.e. liable to be shattered). It becomes clear (and much of *Meteor*. IV will make this even clearer) that, if a vase is fragile, it is *actually*, not potentially fragile[98] (meaning that the vase would be broken *if* subjected to a shock of a suitable intensity or a very sudden and drastic change of temperature etc.), even if its fragility is never manifested. The vase unconditionally possesses a conditional power, if I may borrow D.F. Pears' formula (in Freeland 1979, 27). Thus the fragility of a vase is an actual disposition of that object, corresponding to the first level actuality (or the second level potentiality) of the *De anima* II 5 scheme. On the other hand, that

[98] See also the second half of my third chapter.

object's ingredients – that make it up if mixed in the right proportion and if the mixture is exposed to the right conditions – are, while being still unmixed ingredients, fragile etc. only potentially, since they are the right sort of thing to be (and constitute the proximate matter for) a fragile vase but are not one just yet.[99]

3. What are material *dunameis* with respect to *pathē*?

The claims I made in the two preceding sections (arguing that dispositions are not reducible to categorical properties or to actualizations of those dispositions) may seem to be weakened by the fact that *dunamis* is often used seemingly interchangeably with *pathos*, which can and frequently does refer to manifestations of *dunameis* (instances of 'suffering') and to categorical properties. This is, therefore, the place for a comparison between the functions of these notions in the context of *Meteor*. *IV*.

At the beginning of this chapter I mentioned that *pathos* (often translated as 'affection'; also: 'quality', 'property' etc.) can refer to dispositional properties, especially passive ones, as this term can accompany occurrences of or can simply replace *dunamis* to this purpose. However, one should not fail to notice that in Aristotle's oeuvre passages where *pathos* and *dunamis* are used interchangeably or apparently so may often alternate with passages where they are clearly distinguished from one another. Like *dunameis*, *pathē* are properties that qualify some substratum. In the two-stage stripping act described in *Metaph*. Z 3 Aristotle is grappling with the distinction between matter and substance (if substance is that which is *not* predicated of a substratum, but of which everything else is predicated, then, at first sight, substance would be nothing but matter). This is not the place for a detailed analysis of this notoriously controversial

[99] Metaphysical considerations on this point are made in Ch. 7 of *Metaph*. □̃

chapter; what is relevant to the topic at hand is the list of types of predicates at 1029a13 (which should be theoretically stripped off in order for us to get to that of which they are predicated). The types of predicates listed there are: affections, actions (lit. doings), and powers or potencies of bodies (*sōmatōn pathē, poiēmata, dunameis*), as well as 'quantities' (*posotētes*) – length, breadth and depth.[100] Aristotle is thus careful to include among the predicates of substance (or matter) both what we would call dispositional properties (*dunameis*) and results of the actual processes of 'action' and 'passion', which appear to correspond to active and passive *dunameis* as well as the results of such processes, and, finally, 'categorical' aspects (overt physical qualities like length and breadth).

Pathos and *dunamis* are occasionally assigned different functions and meanings also in our 'chemical treatise'. For instance, in Ch. 5 (382a32-382b1) where *dunamis* is rather on a par with *pathēma* (both signifying the basic contraries) but quite distinct from *pathos*, which has the same meaning as in the *Metaph*. Z 3 passage I invoked earlier (viz. the effect of an actual instance of 'suffering'). In the sense of 'result', 'consequence', 'effect', *pathos* occurs also in *Meteor*. IV in Ch. 7 (increase in density - 383b32) and in Ch. 9 (dispersion of soda by water, at 385b26). In Ch. 1 of *Meteor*. IV (at 378b19), the word *pathē* displays a more dynamic aspect and sums up the very undergoing of processes like moistening, drying, hardening and softening, rather than their effects. Finally, *'pathos'* can refer to presumably more complex processes as well (the natural processes corresponding to roasting and boiling, *optēsis, hepsēsis* at 381b6;

[100] See also the very end of *De Caelo* III (Ch. 8, at 307b19-24), where *pathos* is clearly distinguished from *dunamis* and both of them (along with *ergon*) are firmly distinguished from qualities like *schēma*, shape: "From what has been said it is clear that it is not shape which differentiates the elements from one another. In fact, the most essential differences between bodies are differences in properties and functions and powers, for these are what we speak of as pertaining to every natural object. These, therefore, must claim our attention first, in order that from a consideration of them we may come to grasp the differences between element and element" (trans. Guthrie). Cf. the Hippocratic *On Regimen* III 1, where the distinction is between *dunamis* and *chrēsis*.

such *pathē*, I take it, are actualizations of the more complex *dunameis* of certain – especially organic – uniform bodies for undergoing such and such a type of *pepsis*.

It is also noteworthy that *Meteor*. IV includes quite a few passages where *pathos* is virtually synonymous with *dunamis,*[101] mainly when *dunamis* denotes a secondary dispositional differentia, rather than one of the four basic contraries (hot, cold, moist, dry): 385a5 – *pathesin* as derivative passive *dunameis* (more specifically: intrinsic ones or non-dependent for their ontological condition, as e.g. green and fragrant would be, on perception: soluble, flammable etc.); 385a20 – *pathesin,* pointing back to the eighteen *dunameis* and the eighteen *adunamiai* listed just before;[102] 389a4 – derivative dispositional properties that allow one to determine what

[101] Cf. *PA* II 2.648a33, *GC* I 4.319b21-4.

[102] Let me make a clarification here. *Dunamis* and *pathos* seem more or less synonymous in Ch. 8, at 385a20, their significata being the eighteen material dispositional properties and their corresponding incapacities (*adunamiai*). But I should acknowledge that an alternative reading might be possible in this passage and one could claim that Aristotle goes on to say that he will describe what *dunamis* each *pathos* has: "It is by these [passive qualities] that bone, flesh, sinew, wood, bark, stone and all the other natural homoeomerous bodies are differentiated. Let us begin by enumerating them, grouping each capacity (*dunamin*) with its corresponding incapacity (*adunamian*). They are as follows: [list of eighteen *dunameis* and eighteen corresponding *adunamiai* – meltable / unmeltable etc.]. The great majority of bodies (*sōmatōn*) are differentiated by these qualities (*pathesin*); let us say what capacity (*dunamin*) each of these has" (385a9-12, 19-20; trans. Lee with modif). It may well be that, in this context, *pathesin* is more emphatic than *sōmatōn* and, accordingly, *hekaston* would refer more naturally to *pathos* / *pathesin*. Both Alexander's commentary and Lee's translation (p. 339-41) seem to encourage this reading. The same goes for Pepe's translation (p. 163): "La maggior parte dei corpi dunque si distingono tra loro per tali proprietà; diremo ora quali sono le caratteristiche di ciascuna." (Düring – both in his 'interpretation' and in the commentary – is, I am afraid, not helpful at all.) If so, one can take "these" (*toutōn*) to refer here to the just mentioned qualities (*pathesin*), or to 'bodies'. On the first reading, which some might find preferable (since similar contexts, qualities possessing *dunameis*, can be found in Greek sources like the *Corpus Hippocraticum* – see Souilhé passim and von Staden 267 ff.) – although, in order to gain more support for this choice, it is in Aristotle that one should find similar contexts and expressions), it appears that an affection can be said to have a 'power'. But then what is the meaning of *dunamis*, when Aristotle says that a *pathos* "has a *dunamis*"? It may hint at a causal account of the sort that Aristotle offers when examining the eighteen pairs of dispositional properties in some detail, namely that a *pathos* like the presence of a certain type of *poroi* entails the presence of a particular type of *dunamis* (say, splittable).

the composition of a body is. It becomes apparent that *dunameis* are regarded sometimes as a sub-class of *pathē*, when the latter concept assumes a more static character (that is, *pathē* can have a rather static nature – dispositional or non-dispositional qualities – or a more dynamic one: processes, instances of suffering).

The question that should concern us at this point is: what exactly is the relationship between *pathos* and *dunamis* when they are used quasi-interchangeably? In the absence of the author's own theoretical elaboration of this point, this matter is, I admit, rather elusive. Yet this should not prevent one from propounding a hopefully plausible hypothesis. Therefore, I should reemphasize the tight connection that is usually visible between *pathos* and actuality of a kind or other. This, paradoxically, is very likely the case even when *pathos* seems to replace *dunamis* seamlessly; what I mean[103] is that *pathos* and *dunamis* can be thought of as the two sides of the same thing, much in the way in which the second level potentiality and the first level actuality can be two complementary aspects of the same thing (cf. *De anima* II 5). If a heap (of various stuffs) includes the right stuffs to acquire, through *mixis* etc., a certain dispositional property, for instance flexibility, but is not yet equipped with it, then that heap has that property potentially (first level potentiality). Once it has undergone a process of *mixis* and the action of heat, under certain conditions, and, as a newly formed uniform body, has acquired that dispositional property, the property is *actually* present in the nature of that uniform body (first level actuality), but it is still to be manifested (second level potentiality). This view on the relationship between *pathos* and *dunamis* finds support, I think, e.g. in *Metaph*. Δ 21, in the section devoted to *pathos* (following those on *diathesis* and on *hexis*) and listing, among other things, derivative active dispositions like color and taste, as well as two, what we might call, emergent elementary

[103] I am grateful to Professor Gill for her enlightening reactions to my earlier fumbling with this distinction.

dunameis (heavy and light). The first two senses attributed to *pathos* in *Metaph*. Δ 21, at 1022b15 ff., seem to cover both its potential aspect (...*endechetai*...) and, more explicitly, its actual one (*energeiai*...*ēdē*):

> 'Affection' (*pathos*) means (1) a quality in respect of which a thing can be altered, e.g. white and black, sweet and bitter, heaviness and lightness, and all others of the kind. (2) The actualization of these – the already accomplished alterations. (3) Especially, injurious alterations and movements, and above all, painful injuries. (4) Misfortunes and painful experiences when on a large scale are called affections.

While the third and fourth meanings are more relevant to contexts involving the human *psuchē* and *dunameis meta logou*, I should note briefly that a sort of negative value of *pathos* can be perceived in several passages of *Meteor*. IV, like in the list of eighteen *dunameis* in Chs. 8 and 9, *dunameis* which appear to be mostly susceptibilities for destruction or deformation and, even more clearly, in Ch. 1 (at 379a21), where *pathos* stands for *sēpsis* (decay), which is a frequent variety of *phthora* (destruction).

In conclusion, the relationship between *dunameis* and *pathē* is governed by rules that can change from one Aristotelian text to another, or even from one passage to another. The two terms can be used interchangeably (*pathos* amounting then simply to a *dunamis* for change) or they can fulfill distinct theoretical functions (when *pathos* indicates the categorical features underlying and causally explaining some *dunamis*, i.e. *pathos* as an effect of change, of the actualization of some *dunamis*). The main point, however, that I have tried to suggest here is that, when *dunamis* and *pathos* appear to be used synonymously, they constitute two facets of the same thing; namely, *pathos* would correspond to first actuality (in the *De an*. II 5 scheme) – the fully acquired and actual power of, say, salt to be dissolved in water, whereas *dunamis* would correspond to second potentiality (the capacity of salt to dissolve in water; this is different from a

dunamis for dissolving in water present in the ingredients of salt, before salt has actually been formed – which would correspond to first potentiality). I meant to mark this distinction in order to prevent the readers of *Meteor*. IV from taking *dunameis* to be reducible to either their own actualizations or to some underlying categorical (chemical and physical) properties – which *pathos* can *sometimes* stand for. This section, therefore, completes the previous two sections of this chapter and confirms what dispositions may seem to be, but are *not*.[104]

E. DISPOSITIONS AND NATURES

In this chapter I have outlined the *dunameis* most relevant to change in the context of Aristotle's 'chemistry'. I have investigated the nature of active, passive and resistive[105] powers in *Meteor*. IV and highlighted the very robust connections between their functions in the applied and specialized context of that book, on the one hand, and Aristotle's corresponding theoretical

[104] I would add, however, that this somewhat negative conclusion (about what dispositions are not reducible to) hopefully has the merit of narrowing down – *more Socratico* – the range of possibilities for what material dispositions *are* in *Meteor*. IV and elsewhere in Aristotle. One such intriguing possibility, that I should at least raise at this point, is that, while dispositions are not reducible to *either* their manifestations *or* to categorical properties, *or*, one could add, to the conditions that allow for the manifestation of those dispositions, perhaps dispositions still remain reducible in some sense. After all, such material capacities are *defined* with respect to what they are capacities for (certain manifestations / actualizations) *and* with reference to a material of an appropriate kind (cf., e.g., *De An*. II 5.417a27) *and*, in keeping, e.g., with *Metaph*. 5, with regard to a set of specific conditions that make the manifestation of certain dispositions possible. A particular disposition, then, lies, as it were, at the intersection of these three axes, as it depends on the (theoretical) co-presence of the aforementioned factors. While Aristotle's texts present us with quite tantalizing clues to this effect, this is probably bound to remain a matter of – interesting and fertile – speculation, an enterprise that I will take up on another occasion.

[105] See also Appendix IV.

disquisitions – mainly in *Metaphysics* Δ and Θ – on the other hand. *Meteor*. IV also offers less obvious illustrations of the senses and roles of *dunamis* discussed in *Metaph*. (see chiefly the appendices to this chapter) and aspects in which *Meteor*. IV deepens and enriches the *Metaphysics* account, by affording a more complex typology and a clearer causal link between dispositional properties and 'categorical' ones; while dispositions are tightly bound up with both the notion of actualization and with specific chemical and physical characteristics, they are not reducible either to their own manifestation or to categorical properties of uniform bodies (the latter point being a response to Charlton who seems to cherish the opposite view). Finally and relatedly, I have tried to cast new light on the relationship between *dunameis* and *pathē* in *Meteor*. IV and beyond, suggesting that, even when they appear to be synonymous, they stand for complementary aspects of the same state. (Besides, I should point out that the fourth book of the *Meteorologica* does not affirm or imply at any point that dispositions are mere reflections of the regular behavior of the homeomers in our minds;[106] in other words, they do not boil down to our expectations about the behavior of the homeomers; the solubility of salt is not just a way of expressing my expectation that, if put in water, salt will dissolve in virtue of its specific categorical features, but, rather, dispositions are properties of those bodies themselves.)

Earlier on, I have also linked *dunameis* with *phusis*, two mutually clarifying concepts; while that link itself is, of course, no innovation, let me conclude this chapter by further explaining the connection between a body's dispositions and its nature. In keeping with a certain hesitance in the *Physics* between associating nature with matter, with form, or with both, and also in keeping with the eventual preference for taking nature to cover both matter and form (and

[106] This way of considering dispositions is not spelled out in this very manner, but it seems to be implied, for instance, in Goodman's very influential book, *Fact, Fiction and Forecast* (1955), which explores, among other things, the connections between induction and dispositions.

the latter more than the former), *phusis* in the 'chemical treatise' seems to mean primarily (a) the material composition of a uniform stuff (i.e. the ratio between its ingredients), (b) a set of defining material dispositions, or (c) the capacity of some organic uniform stuff to perform a function. Accordingly, *phusis*, *eidos*, *logos, aitia* and *ergon* become closely related concepts in the *Meteor*. IV discourse on dispositions.[107]

Aristotle makes it quite clear at the end of Ch. 12 of *Meteor*. IV that a satisfactory (biological) account needs to cover form as well as matter:

> …We know the why and the what (*dia ti kai ti estin*) of a thing when we understand either the material or formal factor in its generation and destruction, or best of all if we know both, and also its efficient cause.

"The what" is translated as "nature" by Lee, and he is not off the mark here. Let us take a look at the beginning of the same Ch. 12 (389b23-28):

> Having dealt with these matters, let us proceed to give separate accounts of flesh and bone and the other homoeomerous bodies. We can tell from their generation what is the nature (*phusis*) of the homoeomerous bodies, what are the classes into which they fall and to which class each belongs; for the homogeneous bodies are composed of the elements, and serve in turn as material for all the works of nature [*phusis* again, but, I take it, in a wider sense] (trans. Lee with modif.).

In this context, *phusis* refers to more than the ingredients which are potentially present in the mixture that a homoeomerous body is; that is, *phusis* can very well include material dispositional properties that emerge as a result of the mixing of those ingredients and the action of external factors, like heat of a particular sort and intensity. Thus, while the *manifestations* of a thing's material dispositions are signs of that thing's nature,[108] its very dispositions are part of what it is,

[107] E.g., in chapter 12, nature appears to correspond to the essence of a thing, to its *ti esti* (389b23 ff., 390b15 ff.).

[108] See Ch. 4 of this study.

part of its nature.[109] At a non-teleological level, powers straddle both the domain of matter (in so far as they are intimately related to, though distinct from the material constitution of a uniform body) and that of form (since the *phusis*, understood as *eidos* of a uniform stuff can be seen both as the ratio between its ingredients, present in it only potentially, and as a set of defining dispositions to change).[110]

So far, I have kept my focus mainly on material dispositions (like the tendency of oil not to freeze easily). But getting to know (in addition to what the ingredients of a uniform mixture are and what the ratio between them) what the characteristic material dispositional properties of some stuffs are – does not boil down to fully understanding its nature. In order to get a firm grasp of what an *organic* uniform stuff (e.g. blood) is, one needs to pay due attention to its function(s)

[109] Occasionally, however, it is quite clear that *phusis* and *dunameis* are meant to be distinguished rather than merged; at 383b22 f. *dunamis* (here – the material disposition of oil not to be easily solidified by cold) seems to be distinct from (and non-revelatory with regard to) *phusis*, taken as material constitution: "The nature of olive oil is the most difficult to determine. For if it contained more water, cold should solidify it…" But, more often than not, the *dunameis* that characterize a particular sort of uniform stuff have a somewhat amphibian condition, so to speak, straddling both the territory of matter and that of form. Of matter – because matter is, in Aristotle's conception, a set of capacities or potentialities (for acquiring form, in the full sense of the word, or, at a lower level, for behaving in specific ways in virtue of its active and passive powers). At the same time, in a largely non-teleological context, like the one staked out by chapters 1-11 of the fourth book of the *Meteorologica*, the affections, especially the dispositional properties of a body, come remarkably close to constituting its form, to making it what it is. In *Meteor*. IV, in a passage including a rare occurrence of *eidos* meaning 'formal cause', *eidos* is virtually synonymous with *pathos*, and, as Aristotle puts it, in Lee's translation, "Now there are two causes (*aitia*) besides matter (*hulēn*), the efficient (*poioun*) and the qualitative (*pathos*), the efficient being the source of movement or change, the qualitative being the formal element (*eidos*). This will apply to solidification and dispersal and to drying and moistening. The efficient cause acts through two properties and the thing acted on is affected in virtue of two properties as has been explained: the two properties (*pathēmasin*) by which action takes place are heat and cold, and the qualitative effect (*to pathos*) is produced either by the absence or presence of heat and cold" (382a28-382b1). It is plausible then to affirm that the *eidos* of some uniform body, in addition to the ratio between its ingredients, is also determined by the derivative dispositions (at least the essential, defining ones) of that homoeomerous body.

[110] This point is investigated in McGuire's paper on Philoponus' comments on *Ph*. II 1, where the ancient commentator equates the *phusis* of inanimate things with the possession of a *dunamis* (see esp. pp. 254-5).

as well; so it may well be the case that what the reader of *Meteor*. IV gets in Chs. 1-11 is only a partial grasp[111] of the nature of (especially) organic uniform stuffs. For a fuller account of their nature, one should also take into account biological works like *PA* II, where we can find explanations of the functions, *erga*, of such organic *homoiomerē*. In the formulation of *Meteor*. IV 12, a thing is what it is in virtue of its *logos* (*hōs de kat'ousian tōi logōi,* 389b29), where *logos*, translated by Lee as 'formal definition', seems synonymous with *eidos*. Furthermore, a thing's form, *logos* or *eidos*, is clearly given by that thing's function, *ergon* (indeed, as it is well known, notions like *eidos*, *ergon* and *to hou heneka* are often so closely interrelated in Aristotle, as to become almost interchangeable). An eye is an eye not primarily because of its shape (an eye of glass is an eye only homonymously, Aristotle would say) or because of the ingredients that make it up (the eyes of a corpse are, similarly, eyes only in name),[112] but because of the function that it is able to perform: seeing (390a12). (And we may suppose that the optical sensors of a robot or, better, an artificial eye that would enable one to see, would qualify as 'real' eyes on Aristotle's account, since they can fulfill their specific function.)

Intriguingly, even outside a manifestly teleological text like Ch. 12, it is clear that, when a thing loses its nature, even if the stuff that used to make up that thing is now still lingering around, so to speak, it is certainly not the stuff that it used to be (e.g., to continue with a similar example, the flesh of a dead man is not flesh, except in name only; cf. *Meteor*. IV 12.390a14). Thus, in chapter 11 – to quote from a largely non-teleological portion of *Meteor*. IV – we read that

> Things composed of more than one element contain heat, having most of them been formed by concoction by heat, though some are the products of decay like the waste products of a body. So as long

[111] Cf. *APo*. II 8.

[112] Cf. *PA* I 1.640b32 ff.

> as blood, semen, marrow, rennet and the like keep their proper nature they lose their warmth, for all that is left is their material factors, earth and water (389b7-13).

Earlier in this chapter I mentioned that the presence of a certain thermic equilibrium (*logos*) in a uniform body – whether organic or inorganic – is, according to Chs. 1-3 of the 'chemical treatise', a condition sine qua non for the survival of that body as what it is. A thing's internal heat can initiate certain processes of *pepsis* (see 379b23) that make that thing evolve in a certain natural way (grow into something, for the better or worse, to echo the language of *Metaph*. Δ 12, similar in turn to that of *Metaph*. Θ, esp. Ch. 8). This internal heat is in fact a dominant tendency or disposition of a natural thing to acquire new properties (in order to reach a certain *teleiōsis*) and contributes subsequently not only to the unity but also to the persistence of that thing (say a fruit, which does not fall apart or decompose into its original ingredients, as long as that thermic equilibrium obtains).

Beside this internal or proper (*oikeion*) heat, it is the very exercise of a being's or thing's function(s) that helps it remain what it is.[113] If a thing is "most itself when engaged in its proper activities", then flesh is most itself when functioning as a medium for touch, blood is most itself when distributing food throughout the body etc. And the insistence of *Meteor*. IV 12 on this point is unmistakable.

A question still remains to be answered. If both *dunameis* of what I call 'the first order' (dissolvable, elastic, malleable etc.) and *dunameis* of 'the second order' capacities to fulfill some function, e.g., (the *dunamis* of bones to support the weight of a body and allow for movement, the *dunamis* of flesh to make touch possible, without actually being a sense-organ etc.), if both orders of *dunameis* seem to constitute the formal nature of organic uniform bodies, although in

[113] Gill's 2003 article is indeed illuminating in this respect.

distinct contexts (non-teleological and teleological, respectively), how are they to be connected in a coherent scheme reflecting Aristotle's central distinction in *Metaph* Θ? The answer, I think, should take its starting point in my analysis of the two applications of *De Anima* II 5, in the next chapter of my dissertation.

The following passage conveys chiefly the idea that, while complexes – whether artificial or natural – cannot be accounted for solely in terms of heat and cold and of the motions / changes that they cause, on the other hand it is possible (*endechetai*) to explain the coming about of uniform parts like flesh and sinews by appeal to the changes operated by heat / warmth and cold:

> Heat and cold and the motions set up by them are therefore, since solidification is due to heat and cold, sufficient to produce all parts of this sort, that is to say, all homoeomerous parts like flesh, bone, hair, sinew and the like: for (*gar*) these are all distinguished by the differentia (*diapherei tais…diaphorais*) we have already described (tension, ductility, fragmentability, hardness, softness and the rest) which are produced by heat and cold and the combination of their motions (390b2-10).

These differentiae (dealt with in Chs. 8, 9 etc.) are passive *dunameis*, so they probably correspond to the *dunamei tou…paschein* in the previous paragraph. The train of thought seems to be: these *dunameis* or differentiae are the result of the actions of heat and cold; these sets of differentiae / *dunameis* define what the uniform stuffs are at least partly; so, one can say that such stuffs are produced by heat and cold.

In the paragraph preceding the passage I have just quoted, Aristotle seems to be after the *ergon* of those uniform stuffs. But, as such, a sum or collection of dispositional differentiae of first order in some uniform body (tension, ductility etc.) cannot simply amount to a *dunamis* for fulfilling its *ergon*; the *ergon* of flesh is not merely to be elastic, but to be able to manifest its elasticity in a way that would make it possible e.g. for a hand to move in the right way, to grasp, squeeze etc.. The *ergon* of a uniform stuff becomes more or less evident only in the context of an

instrumental part and of an entire organism; it is equally true, however, that its *ergon* cannot be performed without the presence of all the *diaphorai* listed in that passage and throughout *Meteor*. IV.

So, back to my question, what exactly is the relationship between a set of *dunameis* like hardness, ductility, elasticity etc. and the *dunamis* of a certain organ to perform its proper function? It looks like the latter, a well functioning organ, cannot be the result of merely 'mechanical' and/or thermic forces and reactions, but necessarily involve teleology. The unifying principle appears to be a sort of *conditional necessity* in two steps or at two levels. (A) If a uniform stuff (e.g. bone) is to have certain material dispositions, say, if it is to be quite hard but also slightly flexible, it has to have this chemical composition and that physical structure. (B) If some 'simple part' (e.g. a bone) is to be able, as a constitutive part of an organ, to perform some function (*ergon*), it has to have such and such material dispositions, e.g. to be quite hard but slightly flexible. This is a topic that I will develop in Chapter 3. Thus, my discussion of the sense of *dunamis* most appropriate for change and of the connections between *dunamis* and dense concepts that define parts of Aristotle's metaphysics and natural philosophy, such as *eidos*, *phusis* and *ergon*, has brought me to the next stage in my inquiry: a study of how derivative dispositions come about in uniform bodies whose original ingredients did not possess those dispositions.

IV. ON THE EMERGENCE OF DERIVATIVE DISPOSITIONAL PROPERTIES

A. THE MAIN STAGES IN THE EMERGENCE OF DERIVATIVE DISPOSITIONS

More than *GC* and Aristotle's biological works, *Meteor*. IV offers interesting details about how dispositions such as 'elastic' or 'liquefiable' are derived from the four primary qualities – hot, cold, moist, dry. Still, I believe, it does *not* offer *sufficient* information for us to grasp with full clarity the processes that lead to the emergence of uniform compound bodies and of their secondary 'differential dispositions' (to borrow Lennox's formula) from the four primary dispositions or contraries. Therefore, much work is still to be done to shed light on the generation and on the alterations of homogeneous stuffs in Aristotle's organic and inorganic 'chemistry.' I will tackle first the more concrete aspects pertaining to the emergence of secondary or derivative properties, before considering this topic from a more theoretical perspective.

Significant studies on the topic have been conducted recently. In her comments on *Meteor*. IV and *GC* ('The limits of teleology – Aristotle's *Meteorology* IV. 12', p. 10), Gill notes that the so-called elements, like earth and water, do not maintain their natures intact when, as ingredients, they constitute, say, copper, although copper is produced as a result of the mixing together of water and earth in a certain ratio and under specific conditions (external heat – dry or moist – of a certain intensity etc.). Earth and water are only potentially present in the compound (copper); that is, no matter how far one may go in cutting up or grinding a piece of copper, one

could never come upon amounts of earth or 'pure' water in the process (although earth and water can be obtained presumably by chemical separation,[114] when melting a piece of copper under particular conditions). All that survives from the original ingredients after *mixis* in the compound is a collection of dispositional properties (like cold or heavy, which, as Gill notes, ibid., are not essential or defining, but, rather, accidental properties of the mixture), although some original properties are lost irretrievably and some, like fluidity, are only manifested under extreme conditions (e.g. some metals, such as silver, contain plenty of water, and this supposedly becomes manifest when they are melted if exposed to very intense heat). Like Gill, Lennox draws attention to the fact that decisive in the coming about of derivative or secondary differential properties ("laid out along continua such as hard/soft or pliant/brittle" ms. 1) are not just the ingredients or the ratio in which they are combined, but also the effects of the active *dunameis*, through processes like concoction.[115]

Let me add a few observations on this topic before tackling some intriguing lacunae in Aristotle's account. In *GC*, at 329b26 ff., Aristotle foreshadows the introductory chapter of *Meteor*. IV by defining the four basic *dunameis*:[116] hot is "that which combines things of the

[114] While *mixis* – as a process, not as a result – is scarcely treated in explicit fashion, the process of separation is brought up frequently in *Meteor*. IV (e.g. 380b20-22). Cf. 389b9 ff.: "…So as long as blood, semen, marrow, rennet and the like preserve their proper nature they are warm, but once they perish and lose their proper nature they lose their warmth, for all that is left is their matter – *hulē* – earth and water" (trans. Lee with slight modif.).

[115] Thus, Lennox writes that "The explanation is not mechanistic, but *thermodynamic*. A given uniform body has the dispositional differentiae it has in virtue of the way that heating and cooling have acted upon the elemental ingredients from which it is constituted (or more precisely, upon their primary passive dispositions, moist and dry). Such compounds acquire and lose these differential dispositions of necessity whenever acted upon by the appropriate sorts of heating and cooling."

[116] Or *aitia*, as they are called in the very first line of *Meteor*. IV.

same kind;" cold[117] is "that which brings together and combines similar and heterogeneous things alike;" moist is "that which, being readily delimited (i.e. by something else), is not determined by its own boundary" and dry is "that which, not being readily delimited (i.e. by something else), is determined by its own boundary." Notions such as 'delimiting' or 'determining' (*chorizein*) is imported into the discourse of *Meteor*. IV[118] along with what Solmsen (361) would call the warfare language, which consists chiefly of occurrences of the verb *kratein,* translatable as 'to dominate', 'to master' or 'to control.'[119]

What is the relationship between *kratein* and *horizein*? The moist is determined (i.e. it acquires a definite shape) because of the admixture of the dry – through the operation of the active properties, that is, if the dry and the moist are dominated by the hot and/or the cold (which cause the dry and the moist to merge and to undergo various changes). The hot and the cold produce change by mastering or dominating the matter (consisting essentially of combinations of the moist and the dry in a certain ratio, *logos*, that accounts in part for the *phusis* of that stuff at a purely material / non-teleological level; reaching the right *logos* is critical for the occurrence of natural generation). When the internal heat of an organic uniform body dominates the passive basic contraries, the moist and the dry, it stimulates the natural development of the plant or organism of which that uniform body is a part or a tissue. When, however, the hot and the cold

[117] In *Meteor*. IV there is a certain hesitation between taking cold as a 'positive' concept and regarding it as mere privation (of heat); cf. *De Caelo* 286a25 f., *GC* 318b16 f.

[118] At 379a12, 31, b33 etc.

[119] E.g., 379a31 *kratein…kratei* [*to de kinoun kratei*]; 379a33: *kratei*, 379b4 *kratein*. Aristotle's use of notions like *kratein*, *chorizein*, *logos* (in the sense of thermic balance), are reminiscent of and maybe tributary to some of his contemporaries and predecessors. See, for example, in Plato's *Timaeus*: 57b – *kratountos*; 56e – *kratēthentos* (also 31b ff. – *mesotēs, analogia* (*kat'analogian*)… *kata touton ton logon* 334b13-15). In Corpus Hippocraticum, *On regimen*: III 1, 2, 3 – *kratein, egkrates*; *Regimen* II 1. Cf. Jouanna 327 etc. on *logos* and *isonomia*.

proper to it fail to master the passive *dunameis*,[120] the result is half-cooked and undigested (e.g., 379a2 and12-13) and can even amount to the destruction (*phthora*) or, more specifically, the decay (*sēpsis*) of the uniform body so affected.

Some of the effects of the active factors, in addition to combining and making *mixis* possible, are listed at the beginning of *Meteor*. IV (moistening, drying, hardening, softening: 378b16-17) and are dealt with in detail in Chs. 5-7 and to some extent in Ch. 4 as well (where hardness and softness are called the first, *prōta*, among derivative properties that define the material nature of solid stuffs). Besides, Aristotle is concerned to describe and explain considerably more complex processes and effects of heat and cold upon the dry and the moist, notably in chapters 2 and 3. Central to these sections of Book IV is a division of *pepsis* (concoction) into three species. The generic definition of *pepsis* is: completion or maturity (*teleiōsis*) "produced from the opposite, passive characteristics by a thing's own natural heat,[121] these passive characteristics being the matter proper to the particular thing" (379b18-20). Here are its three species:[122]

(a) Ripening (*pepansis* – 380a11-26) is the first form of concoction discussed in *Meteor*. IV 3 and involves the attainment of some goal. The presence of the term *telos* does not always

[120] I.e., the active ones are not sufficiently intense or the passive ones overwhelm them through their sheer mass, or environmental factors prove a hindrance for 'chemical reactions' like the merging of similar or dissimilar bodies and their thorough combining into a uniform body with somewhat new or radically new properties.

[121] For a minute analysis of this concept in various Aristotelian contexts, see Gad Freudenthal (1995), Chs. 1-3 passim.

[122] Despite often neat definitions, it is not an easy task to delineate the areas on which these species of concoction have bearing. I agree thus with Lloyd who writes that "The great strength of Aristotle's use of the idea of concoction lies, in general, in the way it enables him to see the connections between widely disparate phenomena and processes. But the corresponding weakness is in the very vagueness or generality of the concept – which is what allows him to suggest those connections. To put it in another way, the connections he apprehends run ahead of the theoretical explanations he can offer" ('The master cook', 95).

signal that final causation (or 'that for the sake of which') is an important component of the topic at hand; here, however, in the context of *pepansis*, I believe that we can talk about natural teleology without much reservation (but this, I admit, is rather atypical within the first eleven chapters of *Meteor*. IV). Thus, a fruit – to take the most obvious example – can reach the state in which it is able to produce seeds (and thus to perform its *ergon*),[123] that is, a stage that marks the (initial or renewed) maturity of a plant, which is now able to produce other plants and to contribute to the perpetuation of its species. The process opposite to *pepansis*, namely *ōmotēs* or rawness (380a27-380b13), is not its mere absence, but an *incomplete* form of maturation or ripening.

(b) The second type of *pepsis* is *hepsēsis* or boiling[124] (380b13-381a12) which covers cases of concoction "by moist heat of the undetermined material present in the moisture of a thing." Its opposite is *molunsis* or scalding (381a12-23).

(c) Finally, *optēsis* or roasting (381a23-381b13) is "concoction by external dry heat;" the phenomenon opposite to it (insufficient 'roasting') is named, with a great deal of hesitation,[125] scorching (*stateusis*).

Especially the last two types of *pepsis* can take place either in purely natural fashion or can be the result of *technē* (e.g. in cooking) and can be integrated in teleological schemas in so far they are meant to serve a clear purpose, e.g. to produce edible food and thus to maintain the good health of an organism. The distinction between the two sorts of finality or directedness is suggested by Aristotle himself in the introduction to his discussion of *pepsis*:

> In some cases the end of the process is a thing's nature (*phusis*) in the sense of its form and essence (*eidos kai ousian*). In others the

[123] See also Düring (70) on this point.

[124] Düring takes this to be oxidation as well as "many other kinds of chemical processes."

[125] "It is less easy to find a term for it (*anōnumōteron de*, 381b16)."

> end of concoction is the realization of some latent form (*hupokeimenēn morphēn*), as when moisture takes on a certain quality or quantity when cooked or boiled [or rotted – uncertain reading] or otherwise heated; for then it is useful (*chrēsimon*) for something and we say it has been concocted.

The three subclasses of *pepsis* seem to focus on effects – both generation and alteration – on tissues or *organic* homeomers, although to some extent they can apply to inorganic stuffs as well. The description of these processes includes explicit and specific mentions of the emergence of derivative properties. The loss of moisture can be the result of the fact that the internal heat which ensures the preservation of a thing's nature escapes as it is overwhelmed by external heat (e.g. in the case of 'boiling'). Concoction is necessarily accompanied by the thickening of the stuff that undergoes that process and by an increase in its heat (380a4-6). "More compact", "denser", "hotter" or "drier" are not exactly derivative *dispositions*, but such changes at least seem to herald, as it were, the emergence of derivative dispositions (e.g. one can presume that a quite high degree of density may reduce a thing's elasticity). As I am going to stress in the next section of this chapter, Aristotle often gets tantalizingly close to explaining just how the derivative material *dunameis* emerge, without quite connecting the segments of his analysis in a fully satisfactory (and thoroughly intelligible) manner.

On some lacunae in Aristotle's account. The sequence of the main stages in the emergence of derivative material dispositions is not difficult to capture in rough outline (both in the first chapter of *Meteor*. IV and in the subsequent chapters). Let me bring up again some of the facets of this topic that I have already presented and synthesize them into a simplified and unitary picture. The basic contraries (hot, cold, moist, dry) form the basic stuffs[126] – the (so-

[126] *Meteor*. IV 1 is comparable on this point with *Meteor*. I 2 (where the four primary powers or contraries are also named *archai*); cf. *GC* II 3. The relation between the basic *dunameis* and the so-called elements in Aristotle very

called) elements: earth, water, air and fire – through *suzugiai* (yokings by teams of two, *Meteor*. IV 1.378b11). More precisely, these elements are formed at specific points on the hot-cold and moist-dry continua and each element, in addition to being 'heavy' (earth, water) or 'light' (air, fire), i.e. tending to move towards their natural places, towards the center of the universe or towards the periphery of the sublunary sphere, also display two fundamental differentiae: earth is dry and cold, water is cold and moist, air is moist and hot, fire is hot and dry (as well as a sort of elementary emergent properties, like 'heaviness' and fluidity). Thorough combinations (instances of *mixis* proper)[127] of the dry and the moist or of earth and water, and – in the case of minerals – combinations of the dry and the moist exhalations,[128] can lead to the formation of

---

likely betrays the influence of some of his predecessors and contemporaries. I should just briefly enumerate here some examples pertaining to medical authors and trends, since this may be the aspect of Aristotle's background that has received less attention than it deserves (precise chronology is next to impossible, with a few exceptions, so I will not attempt a strictly chronological list here). According to Anonymus Londinensis XX 25 ff., Philistion of Locri thought that our bodies are composed of four 'forms' or elements – earth, water, air and fire. Each element has a *dunamis*; fire is hot, air is cold, water is moist, earth is dry (somewhat comparable with passages in Plato's *Timaeus* as well as in his *Laws*, e.g. at 888e-890b). In the Hippocratic treatise *De carnibus* we read that the qualities cold and dry are associated with earth; warm and moist are correlated with air; while "the moistest and the wettest" are proper to water. In *De victu* (1.4) fire is aid to be hot and dry and water is cold and moist (however, it is quite possible that this treatise was influenced by the Peripatetics). Possible parallels with Aristotle's ascription of opposites to elements can be detected also in *De natura hominis* 1-6. There, however, they are correlated, not with the elements, but with the humors. See also *On Regimen* I, where its author writes that each living being is constituted by fire and water but 'the hot and the dry belong to fire, and the cold and the wet to water', though 'there is some moisture in fire' and again 'there is some of the dry in water' (Chs. 3 and 4, L. vi. 472.12 ff., 474.8 ff.).

[127] See *GC* I 10 (327a30 ff.) for a clear distinction between mere *sunthesis* (or com-position, juxtaposition of particles) and *mixis* (or process of thorough combination or rather blending).

[128] As I mentioned before, there is a certain hesitation in *Meteor*. IV between references to the basic *dunameis* (or *aitia*) and to the four so-called elements (dry / earth, moist / water, even hot / fire) that can lead to a certain degree of confusion for anyone trying to discern and interpret Aristotle's theories there; Düring (e.g. 68) vehemently complains about this relative inconsistency.

uniform compounds. Again I find Lennox's paper on *Meteor*. IV very helpful on this topic. Among other things, Lennox notes (p. 5) about Aristotle that

> His answer [to the question: How will there be something <else> from both, e.g. from cold and hot or from fire and earth?] depends on the theory of *mixis* found in *GC* I 10. According to that theory, two bodies at different points on the hot/cold and moist/dry continua, but sharing a common substratum, interact with one another, and as a result come to occupy a point within an intermediate range on at least one of these continua. Rather than one contrary on each continuum being converted to the other extreme these contrary powers are 'equalized', held at a mean point, in a sort of dynamic tension.

The mixture is constituted as a result of the effect of the active basic contraries (hot and cold), and the various thermic processes they set off, upon the passive ones (dry and moist), the passive being in-formed by the active ones. Indeed, hot and cold are defined (*Meteor*. IV 1, *GC* II 2) primarily in virtue of their bringing together similar things (hot and cold) as well as dissimilar ones (cold). 'Chemical reactions' are conditioned, among other things, by particular types of heat (see Chs. 2-3 of *Meteor*. IV). Also, the occurrence of the contact[129] between different bodies and the presence of *poroi* of a certain kind in those bodies (e.g. allowing water in and thus making dissolution/disintegration possible) are crucial aspects of Aristotle's 'chemistry.' The initial ingredients that were involved in a particular *mixis* survive in the mixture only potentially but, in many cases, they can be separated off again especially when that stuff is destroyed or decomposed or altered drastically. The homoeomerous bodies that come about are differentiated by specific sets of dispositions that are *not* present in the original ingredients, but are somehow derived from them (cf. *GC* II 7). As Aristotle would put it, "…tension, ductility, fragmentability, hardness, softness and the rest of [the emergent dispositional qualities] – all of them are derived

[129] *Haphē* – see *Meteor*. IV 9.386a20, *GC* I 6, cf. *Physics* V 3; see Solmsen 355 for a more detailed account of *haphē*.

from the primary qualities, the hot and the cold, and the combination of the motions set up by them" (390b6-10).

This sequence, from the basic contraries to the compound uniform stuffs, is, of course, mostly a theoretical one, in the sense that dry and moist do not have autonomous existence and the so-called elements also generally tend not to exist in pure form (still, see my section on homeomers, in the first chapter of this dissertation) – and the same goes for the two types of exhalations that produce various types of minerals. In the natural order of things, then, homeomers, which contain earth and water etc., are combined into other homeomers or are transformed by the *kinēseis* of hot and cold (chiefly forms of *pepsis* and *apepsia*) into other homeomers. (In other words, at the risk of a near-truism, it is *not* the case that we start with heaps, as it were, of dry and moist or of earth and water, that blend together to form uniform compounds.)

Relatedly, as Lennox (ms. 7) points out, from an investigative and propaedeutic perspective, it is important to focus on thermic processes that affect *already constituted homeomers* (see the beginning of the second chapter of *Meteor*. IV), equipped with specific sets of secondary dispositional differentiae. He notes (ibid.) with respect to the secondary differential potentials that

> Understanding their causal dependencies won't, primarily, be a matter of starting with objects that are 'simple' and observing the effects of combining them. It will be a matter of starting with 'already naturally constituted' bodies and studying the *differential effects* of the operations by which hot and cold affect them.

What I find intriguing about this sequence or progression (from primary *dunameis* and elementary stuffs to homeomers and implicitly to the emergence of secondary or derivative dispositions) is that the links between its main stages are sometimes left to the intuition of the

reader of *Meteor*. IV, instead of being subjected to keen analysis and overt, direct explanations. In Chs. 8-9, for instance, Aristotle describes the (micro)structural characteristics – *poroi* of a certain diameter and arranged longitudinally or otherwise, which, along with a certain chemical composition, e.g. predominance of earth, explain some of the derivative dispositions listed there: fragility, flammability etc. However, little – if any – effort is made by the author to account for the conditions that lead to the occurrence of those capillaries or channels in the first place. We can safely assume that the *poroi* and the interstices in most solid uniform bodies are caused by thermic reactions, i.e. by the movements instigated by internal or external heat, but exactly how that happens is rather hard to detect with confidence for a reader of *Meteor*. IV or is, at best, shrouded in a web of rather opaque hints.

Yet, upbraiding Aristotle for the insufficiency of his account could be a rather misdirected exercise. He was certainly aware that his scientific antennae could not possibly help him to provide enlightening proofs for every 'chemical' phenomenon and that he had to strike a balance, precarious though it might have been, between observation and speculation. The thesis that solid bodies are pervaded by invisible *poroi* is never quite demonstrated in *Meteor*. IV, but the apparent *plausibility of the inference* – from the behavior of fragile, splittable, flammable etc. bodies that they contain such capillaries seems to supplant the need for a more cogent proof. The text of Chs. 8 and 9 shows little hesitation in invoking the *poroi*, but in fact Aristotle may have regarded them as a possible rather than a certain solution or explanation. A generally neglected passage from the first book of the *Meteorology* indicates that he purposely grounded some of his theories on likelihood, rather than certainty (*Meteor*. I 7.344a5 ff). I would like to suggest, however, that, his reliance on probability notwithstanding, he carefully avoided unbridled speculations and preferred silence where a credible theory was not obvious. Accordingly, even if

the 'chemical treatise' is far more helpful in enabling us to understand the emergence of secondary dispositions than, say, *GC* II, part of the story about the emergence of derivative properties in *Meteor*. IV is left untold – and that, as I have said, includes how the *poroi* (which account for many, though certainly not for all,[130] material dispositions) come to pervade most solid homeomers and why a particular sort of *poroi* (which have a certain diameter, position and arrangement, and whose 'walls' are of a particular degree of hardness) consistently occur in a particular *genos* of uniform bodies. In short, while it is important to underscore Aristotle's contribution to the foundation of a scientific branch dealing with the nature and formation of

[130] In *Meteor*. IV *poroi* are mustered as explanatory factors only with regard to solids, but the chemical composition (the dry-moist proportion) and other factors are also responsible for the presence of various secondary potentials in uniform stuffs. As for utilizing the *poroi* with regard to liquids, in *GC* I 8, at 326b6 ff., Aristotle discusses the Empedoclean hypothesis that transparent bodies are transparent in virtue of being traversed by *poroi* – and one can assume that water and air are included there – but he dismisses that theory as worthless (he is less categorical, however, at *APo*. 94b29, where he uses the *poroi* as a possible explanation for transparency). Accordingly, *poroi* appear to be inoperative, as far as their explanatory force is concerned, with respect to liquids. Besides, a certain amount of ambiguity pervading *Meteor*. IV can only compound the occasional perplexity of that book's reader. To take an example, there is no direct mention of *poroi* in Chs. 5-7 which deal chiefly with liquefaction and solidification. Somewhat surprisingly, however, the sketchy recapitulation of that discussion at the beginning of the list in Ch. 8 (the first two items are: solidifiable and meltable – *pēkton* and *tēkton*) includes an explicit mention of the pores: "Bodies so affected by lack of moisture are melted by moisture, unless their composition is such that their pores [*porous*] are too small for the particles of water to enter, as, for instance, earthenware…" (385a23-26). The question, then, is whether such explanations for solidification and liquefaction should be applied retrospectively to chapters 5-7 as well. Whether because of that occurrence of *tous porous* in Ch. 8 or not, Düring seems to believe that *poroi* are essential to our understanding the processes described in Chs. 4-7, since he places a substantial excursus on *poroi* and on the authorship of *Meteor*. IV at the beginning of his comments on Ch. 4 (1944, 74-78). Let me conclude this note by saying that ambiguity in *Meteor*. IV goes beyond the scope of the resort to *poroi* and beyond the author's hesitation between invoking basic contraries (dry, moist, hot) and invoking elements (earth, water, fire) in his analysis of 'chemical combinations'. For instance, chapters 2 and 3 are beset by ambiguity in the sense that it is quite difficult to establish the range of applicability of the processes of concoction and incomplete concoction discussed in those sections of *Meteor*. IV.

uniform materials and with the emergence of their distinctive dispositional qualities, it is also necessary, I think, to set out the sometimes telling limitations of his explanatory apparatus.[131]

The success of Aristotle's approach to material dispositions as emergent properties depends in part on the *conditional* formulas that stud much of *Meteor*. IV. I would like to bring up what I consider to be two important applications of conditionals to Aristotle's discussion of powers: (a) from a 'generative' perspective, it is important to understand that, *if* a uniform body is to be, say, combustible or fragmentable, it has to have the appropriate 'chemical' composition and maybe certain physical features as well, like the presence of certain *poroi* arranged in some specific way – a sort of rudimentary conditional necessity; (b) at a 'higher', functional level, material dispositions acquire a prominent place in the context of final causation and full-fledged conditional necessity. The following section is meant to flesh out this twofold point.

B. TWO ORDERS OF *DUNAMEIS*

After considering the difficulties entailed by an analysis of how dispositional properties emerge according to Aristotle, I would like to take a more theoretical look at the dynamics of *Meteor*. IV. This book seems built as it were around two distinct applications of the model offered in *De Anima* II 5[132] (first potentiality – second potentiality / first actuality – second actuality), relevant to the present discussion about the emergence of dispositions:

[131] More on scientific method – in Ch. 4 of this dissertation.

[132] Let me sum up the passage in *De anima* II 5 relevant to this section of my dissertation. What Aristotle means to achieve in that chapter is to provide a general introduction to his discussion of perception; this preliminary discussion involves distinctions between opposite terms: agents and patients, potentiality and actuality. Aristotle

I. *This model considered at a strictly material level*: (1) The emergence in some uniform mixture or body of a secondary dispositional property (e.g., meltability, fragility) corresponds to the transition from first level potentiality to second level potentiality or first level actuality, whereas (2) the very manifestation of that disposition (e.g., melting) corresponds to the switch from first level actuality / second level potentiality to the manifestation of that disposition.

II. *The same model - in a teleological context*: An obvious example would be (1) the acquisition by a uniform body (as part of a living organism) of some capacity to perform a function (*ergon*) corresponds to the transition from first level potentiality to second level potentiality or first level actuality, while (2) the very actualization of that capacity corresponds to the switch from first level actuality / second level potentiality to second level actuality. These second-order *dunameis*, namely dispositions to perform some function, are applicable to organic homoeomerous stuffs (considered not merely as stuffs with a certain chemical composition and displaying a particular set of material dispositions, but as parts of living organisms), to more

---

thinks that the latter contrastive pair needs further clarification, since one is said to see or hear both when asleep and when actually seeing or hearing. (For the sake of clarity, in what follows, Aristotle will purposely ignore the distinction between agents and patients.) An analogy with knowledge (*epistēmē*) should bring into sharper focus the contrast potentiality-actuality as applied to perception (and partly foreshadows Aristotle's discussion of reason in III 4 and 5). A person can be called a knower, *epistēmōn*, (1) in virtue of having a certain material constitution (that is: having the proximate matter that belongs to a species capable of acquiring knowledge) or (2) because that person already masters a certain field of knowledge (Aristotle gives the example of grammar, and, if we trust certain manuscripts, of arithmetic as well). The first 'knower' has knowledge potentially, because she / he has the right faculty for acquiring that knowledge and is still to go through a relatively lengthy process of learning; having acquired the knowledge of, say, grammar or arithmetic will constitute the corresponding actuality. In a way this actuality and the second type of potentiality are two aspects of the same state. Now, the person who already is in command of that field of knowledge is a *potential* knower because she / he is still to apply or manifest that knowledge (for instance, by recognizing the letter A). Such manifestation or application of her / his passive knowledge constitutes the actuality corresponding to the second type of potentiality. For a thorough analysis of *De Anima* II 5, see Gill 1989, Ch. 6. See also comments by Thomas Aquinas (trans. Foster and Humphries 1951, 233-251), Ross (1961, 233-38), Rodier (1964 repr., pp. 248-63), Hicks (1965, 349-60).

complex organs, and to artifacts (whose capacity to perform some function, when handled appropriately, depends on the dispositional qualities of their homoeomerous components).

The structure of Book IV, as I indicated in my preliminary notes, is not linear or easy to follow, and the rather sinuous trajectory it describes is more baffling than one might find it after a cursory reading. One way in which we can make sense substantially of the bulk of *Meteor*. IV is, as I have already implied, by considering it from the perspective of another text – the fifth chapter of *De Anima* II. There are several advantages to looking at *Meteor*. IV through the prism of the *De Anima* II 5 two-step or three-stage model. More light will be cast, I hope, on the structure of Book IV; besides, I hope that this section will further clarify why and in what sense material dispositional properties are *potencies* while also being *actual*. Most importantly, I would like to show that *Meteor*. IV, in addition to providing criteria for a generic division of the homeomers and revealing their chemical composition by the observation of their behavior (i.e. the manifestation of their dispositions), is also meant to connect two distinct orders of *dunameis*: material dispositions such as elasticity and friability, and capacities of organic homeomers to perform specific functions as parts of complex organic structures. The latter hinge upon the former (although the former seem to be for the sake of the latter, as it were), but these two orders of *dunameis* emerge simultaneously in the organic uniform stuffs, that is, in the homoeomerous parts of plants and animals. To set out the links between these two orders of *dunameis*, I will enlist Aristotle's own help and will essentially follow the distinction between two levels of potentiality and actuality (marked out in *De Anima* II 5), which accounts, on each of these two levels, for the emergence and for the manifestation of *dunameis*.[133] I will then propose that

[133]I should point out that, in *De Anima* II 5, Aristotle does not extrapolate that model from perception and knowledge to other contexts in any detailed or significant way. He does mention one material disposition there – combustibility – but only to underscore that sense perception exists in potentiality (*dēlon oun hoti to aisthētikon ouk*

conditional necessity is the principal key to integrating the two orders of *dunameis* ('simple' material dispositions and capacities of tissues to perform specific functions) into a unitary picture and possibly to acquiring more insight into the relationship between Aristotle's chemistry and his biology. In short, the following two subsections of this chapter are intended to clarify the way in which the material *dunameis* that claim Aristotle's attention in *Meteor*. IV 1-11 are to be connected with the significantly different type of *dunameis* discussed in Ch.12.

1. Emergence and manifestation of strictly material dispositions

In Ch. 1 of his *Meteorology* IV Aristotle concentrates his attention on the role of the active primary *dunameis*, hot and cold, in the generation[134] and destruction of uniform bodies. The chapter also includes references to organisms and contexts that admit of final causation; however, it is safe to affirm that Aristotle is concerned here chiefly with uniform bodies and that

---

estin energeiai, alla dunamei monon, 417a6-7), until some external stimulus acts upon it, just as fuel is burnable, but will not actually burn until an external agent, fire or some other source of heat, makes it burn. Both cases revolve mainly around first actuality / second potentiality – as it becomes clear from reading the rest of the chapter, since at issue here is an already acquired and functioning faculty of perceiving, and an already formed disposition to burn. I will not attempt to prove that every aspect of *De Anima* II 5 is faithfully mirrored by the structure and content of *Meteor*. IV. I readily admit that the *De Anima* model works best in a context that involves *erga* and final causation. Therefore, the notion that the transition from first potentiality to second potentiality/first actuality entails change proper, whereas the switch from second potentiality/first actuality to second actuality supposes the preservation of what is potential by the agency of what is actual (see, e.g., *De Anima* II 5.417b4) will not necessarily apply to all material dispositions (what I call the first order of *dunameis*), since the manifestation of a passive material disposition can sometimes amount to its suppression, when the body being affected is destroyed, e.g. in the case of burning. I consider this model, however, to be fundamentally relevant to *Meteor*. IV in its discussion the two steps that I have already mentioned: (a) the acquisition and (b) the (conditions governing the) manifestation of dispositions, and I will use this aspect of it as an explanatory device in my own discussion of the fourth book of the *Meteorology*.

[134] Although perhaps he anticipates the topic of the subsequent chapters when he mentions not only *haplē genesis* but also *phusikē metabolē* (e.g. 378b29).

Ch. 1 is meant as a preamble to a longer and more detailed discussion about the effects of the active *dunameis* on "already constituted natural bodies" (379b11). The emphasis is quite clearly placed on the realm of life (rather than on mineralogy etc.), as Aristotle adds at the beginning of his account on generation and destruction: "these processes occur both in plants and in animals *and their constituent parts*" (378b28 ff.). The section devoted to generation is, unlike the one on destruction, rather sketchy (378b32-379a2):

> Simple, natural generation is a change effected by these properties [i.e. hot and cold] when present in the right proportions, in the matter underlying a particular natural thing, this matter being the passive properties of which we have spoken.

To some extent, Ch. 1 is an unfulfilled promise:[135] in *Meteor*. IV we are not offered a detailed and sufficiently clear scenario concerning the coming about of the naturally constituted (uniform) bodies. One of the reasons for this fact may well be that Aristotle would have had to discuss notions like *genesis* and *mixis* at length; this would not have been a particularly economical solution within Book IV, especially given that *Meteor*. IV is partly a sequel to *Generation and Corruption*, where these concepts receive indeed a detailed and fully articulated treatment. Another reason for the absence of such a rigorous treatment of the *genesis*[136] of uniform bodies in Ch. 1 may be that, although not much is said about *mixis* in the other chapters either, nevertheless we get numerous hints about the emergence of derivative dispositional

[135] Hinted at in 378b26-31; cf. Ch. 12, 389b25-26: *dia tēs geneseōs.*

[136] Chapter 7 of *Metaph*. addresses the implications of this issue in greater detail than any other section of that book: "E.g. is earth potentially a man? No – but rather when it has already become seed, and perhaps not even then." (1049a1-2) Aristotle embarks then on a discussion of negative conditionals ("if nothing hinders…"). Later on he continues: "The seed is not yet potentially a man; for it must be deposited in something other than itself and undergo a change, But when through its own motive principle it has already got such and such attributes, in this state it is already potentially a man; while in the former state it needs another motive principle, just as earth is not yet potentially a statue (for it must first change in order to become brass)" (1049a14-18).

properties in Chs. 2-11; in other words, Aristotle preferred to postpone for a while such comments on the emergence of derivative dispositions, rather than concentrate them in Ch. 1.

Consequently, the story – rather alluded to than told in plain fashion – about the coming about of uniform natural bodies is intended to precede a discussion about various sorts of alteration in them (Ch. 2 and following). The sequence of thought behind Ch. 1 and the subsequent chapters is, then, that the operations of the active *dunameis* on the passive ones are responsible first for the *emergence and presence* of certain properties in the "naturally constituted (uniform) bodies" and then (in Chs. 2-3 and also 5-7) for various *alterations*.[137]

In the course of writing chapters 2-11, Aristotle seems to repeatedly shift the emphasis of his analysis from dispositional properties to processes (corresponding to those properties) and back to dispositions. I take such processes (like solidification and liquefaction in Chs. 5-7) to mark the final stage in the three-stage model, namely the transition from the disposition for e.g. getting / being melted (under the right thermic conditions) to the actual state of being melted.

In *De an*. II 5 Aristotle makes it clear that the transition from first level potentiality to second level potentiality-first level actuality (change proper - *kinēsis*) normally takes a certain amount of time, whereas the transition from second level potentiality-first level actuality to second level actuality occurs instantaneously. This seems also to reflect what happens in

[137] We are also told in Ch. 1 (378b33, 379a18 etc.) that what is responsible for the *persistence* of those properties, specific for a certain uniform body, is due to the natural, proper heat, a sort of dynamic equilibrium (this being the case mostly but not exclusively in organic stuffs, where internal heat is a principle of growth or development and of preservation); should it be modified or destroyed, the defining properties of the uniform body would also be modified or suppressed. In some basic sense, these dispositional properties along with the natural heat (in the right proportion – *logos*) seem to constitute the 'form' of the uniform body (more so than, for instance, the ratio between the original ingredients that, as a result of the effect of the active factors, formed a homogeneous mixture). I should add that the set of (defining) dispositional properties that characterize a particular uniform body can be conceived of as its 'form' only in a *non-teleological* context (i.e. if we do not seek the function of a uniform body within e.g. a plant or a living organism, in order to get to the *ti esti* – cf. *Meteor*. IV 12, *PA* II 5, 6 etc. – of that uniform body).

Aristotelian 'biochemistry' where the constitution of a body with a specific set of dispositions is a gradual process, whereas the actualization of a disposition (e.g. fragile > broken) occurs instantaneously (and, accordingly, it is not to be seen as *kinēsis* proper).

To sum up, the two-step model described in *De an*. II 5 seems to match the structure of *Meteor*. IV 1-11 largely, if we take Ch. 1 to refer, not only to the destruction of uniform bodies, but also, at least *per speculum et in aenigmate*, to their formation and to the emergence of dispositional properties as a result of generation or *genesis*, in the newly formed homeomers,[138] and if we consider much of Chs. 2-11 to be a discussion about dispositional properties and about processes that amount to the manifestation of those dispositions (as well as the emergence of additional dispositions in already constituted uniform bodies as a result of alterations).[139]

Thus the first part of the model illustrates the transition from first level potentiality, which I take to be the potentiality in the ingredients to acquire certain dispositional properties, if mixed in a certain ratio and if exposed to certain effects of the active *dunameis*, to the actual emergence of the dispositional properties. The second part of that model would be the switch from the latent presence of derivative *dunameis* – which I take to be second level potentiality or first level actuality – to second level actuality, namely the manifestation of those dispositional properties.

[138] First part of the *De an*. II 5 model: from first level potentiality to the actual emergence of the dispositional properties.

[139] Second part of the *De an*. II 5 model: from the presence of derivative *dunameis* – which I take to be second level potentiality or first level actuality – to second level actuality.

2. Emergence and manifestation of dispositions to fulfill specific functions

a) There is, I believe, a second (and more faithful) illustration of the three-stage model in *Meteor*. IV, which can be detected in the relationship between chapters 1-11 of Book IV and its final chapter, Ch. 12 (as well as *PA* II and other parts of Aristotle's biological corpus). The scope of the second application (II) is narrower than the first one (I), as it is confined to tissues and to uniform stuffs that constitute artifacts. The emergence of the powers / capacities (*dunameis*) to perform certain functions (*erga*) must, I believe, be regarded as simultaneous with the emergence of a specific set of derivative *material* dispositions from the original ingredients of a given uniform stuff. The first portion of the model (transition *from* first level potentiality *to* second level potentiality-first level actuality) corresponds in this context to the coming about of the capacity of some homogeneous stuff/tissue to perform a function in a living body (along with the emergence of the purely material *dunameis* discussed in much of Chs. 1-11).

The first step is a gradual one (from first potentiality to second potentiality / first actuality), both in the case of strictly material *dunameis* (I) and in that of *dunameis* that presuppose a teleological context (II): the development of an embryo into a real organism and the emergence of capacities to fulfill some *erga* is a gradual transformation, so it involves change proper. On the contrary, the second step of the model (from second potentiality / first actuality to second actuality) does not entail change or *kinēsis* proper, but rather a sort of switch or *exaiphnēs*, as I suggested before: there would be no gradual transition *from* my real but un-exerted capacity to see when I shut my eyes, say, to relieve them from too much strain, *to* seeing when I open my eyes, or (to give an even less problematic example) from the latent capacity for feeling (say, in the flesh of one's right hand, when one's right hand is poised to touch the keyboard of a computer) to actually feeling (when one strokes a key).

It is noteworthy that Aristotle rarely claims in Ch. 12 (e.g. 390a11) that the nature of something (such as a non-uniform part of a living body or some artifact) is essentially defined in virtue of its *function*. He more often says or suggests that, for instance, an organ is defined in virtue of its *ability to perform a function* (390a11, 12, 18).[140] Thus, the *form* of an eye or of flesh would not be reducible to actually performing its function (*ergon*) as such (seeing, feeling – in a tactile sense etc.), but to the *dunamis* for performing that *ergon*.

For the sake of clarity, I should point out that, just as a first-order disposition like fragility is a potency while also being an *actual* quality (i.e. a porcelain vase is *actually* fragile, when still intact), one can also say that the second-order disposition or ability of an organ or of a tissue (e.g., in the case of an eye and of flesh – to see, and to make tactile perception possible and to be constitutive part of complex organs, respectively) is not only a second level potentiality, but also a first level *actuality* (a healthy eye, in a living body, *actually* has the ability to see, even when it does not see – when the eye is shut or when one finds oneself in thorough darkness). In other words, when a healthy eye is shut, whether one is asleep or not, or if it is pitch dark, the eye does *not* lose its *eidos* even temporarily.[141]

b) The first step in the second application would follow *GA*, but we do not have such an account spelled out in *Meteor*. IV; it remains in the background and should be understood. The second step of the *De anima* II 5 model would be, as I have already suggested, the switch *from* the ability e.g. of flesh to feel *to* actually feeling – not a change proper (and so this is indeed in

[140] Somewhat similarly, within the first 11 chapters, a homoeomerous stuff or body is not defined in virtue of its e.g. being shattered at some point, but in virtue of its *dunamis* to be shattered, broken – fragility (despite the fact that *energeia* does have multifold priority with respect to *dunamis* in general, and that a particular *dunamis* hinges conceptually on, is to be understood with reference to, the corresponding *energeia*).

[141] This is one more reason for considering Aristotle's attack against the Megarians an important component of *Metaph*. □ (see Ch. 2 of this dissertation).

keeping with *De an.* II 5, where the transition from first level actuality to second level actuality is not a lengthy, gradual process).

C. CONCLUSIONS

Can I and II (the two applications of the model I have discussed in the second part of this chapter) be combined into a unitary account? I believe they can – and in a significant way, which also marks the logical and explanatory connection between the two orders of *dunameis* that I mentioned at the beginning of this section ('simple' material dispositions, such as flexibility or solidifiability, and a uniform material's *dunamis* for fulfilling a function). The unifying principle seems to be *conditional necessity*,[142] a fundamental concept in Aristotle's natural philosophy, at two levels or in two steps. For the sake of clarity, let me connect them in reverse order:

(II) If some 'simple part' (e.g. a particular bone) is to be able to perform some function (*ergon*), as part of a complex organ like a hand or a leg, it has to have such and such material dispositions, e.g. to be quite hard but slightly flexible.

(I) If a uniform stuff (e.g. bone) is to have certain material dispositions, say, if it is to be quite hard but also slightly flexible, it has to have this chemical composition and that physical structure.[143]

Let me add here that these two applications of the *De an*. II 5 model also appear to conform to *Metaph*. Θ 6. It seems to me that an organic uniform stuff (e.g. flesh) endowed with the ability to

[142] For a theoretical treatment of conditional / hypothetical necessity, see, e.g., *Ph*. II 9, *PA* I 1 (639b21 ff.).

[143] See also *PA* (e.g. at 642a10-13; cf. 646b17-19) for illustrations of cases of hypothetical or conditional necessity where dispositions play a crucial role. Also, Lennox's comments (ms. 3-4) are enlightening in this respect.

perform a function is, compared to itself at a strictly material level (e.g. flesh – if devoid of the ability to perform an *ergon* and seen as a mere collection of material dispositions) *what substance is to matter*. 'Mere flesh'[144] does not have the capacity for the *ergon* that defines the nature of flesh as a medium for touch, as Aristotle would put it(or as part of a complex part like a hand), and accordingly, mere flesh (in *Meteor*. IV, up to Ch. 11) can be regarded as matter *in relation to* flesh as a sense organ (or as a constituent part of some complex organ) that is more clearly a compound of matter and form in Ch. 12.[145]

Within the first application (I) too, one can point out that an already constituted uniform body (since its nature is defined – at this level – by a certain set of dispositional properties which constitute its 'form'), is *to* the original ingredients (that may acquire such dispositions if mixed in a certain ratio and exposed to certain operations of the active *dunameis*) *as substance* – in a rather rudimentary sense – *is to matter*.

The second illustration (II) of the *De An*. II 5 model in *Meteor*. IV is closer to the treatment given to that model in *Metaph*. Θ 6-8. The transition from second potentiality-first actuality to second actuality in the case of the uniform parts (e.g. ability to feel > feeling, in the case of flesh) resembles some of the examples listed in *Metaph*. Θ, as the tight connection between final causality and the capacity to fulfill a function figures prominently both in *Meteor*. IV and in *Metaph*. Θ (e.g. 1050a3 ff.).

---

[144] See on a similar distinction *GC* I 5.321b20 ff.

[145] I should assume a more cautious tone here, as I did earlier. The examples given in *Metaph*. 1048b2-3 – "… and that which has been shaped out of the matter [is] to the matter, and that which has been wrought up to the unwrought" (corresponding to: "and the others [are] as substance to some sort of matter") – do not perfectly square with what flesh as a sense organ is to flesh as a mere stuff. Probably the *Metaph*. 1048b 2ff. passage would better match, again, a scenario involving an embryo that develops into a full-fledged organism, that, among other things, has a part called flesh etc. In the same 'embryological' context, the various types of priority of actuality over potentiality become quite important, I think. At this point, however, I should not delve into this matter.

In the second half of this chapter I have attempted to make an addition to the growing literature on this book (by suggesting a new approach to reading *Meteor*. IV), rather than to dislodge some already established view. I hope that I have been able (a) to reemphasize that *Meteor*. IV is an inquiry not only into the nature of material dispositions, but also into their emergence *and* their manifestation, (b) to show that it distinguishes between two orders of dispositions and affords a plausible account linking them (an account that sheds light on the connection between Aristotle's science of homeomers and his biology, and between his science and his metaphysics and philosophy of science), and (c) that *Meteor*. IV offers illustrations for the implicit thesis that dispositions are *potencies* while also being *actual* properties (cf. second potentiality / fist actuality).

Aristotle's attempt to give a credible, by his time's standards, account of the formation and nature of homeomers, of the emergence and variety of their dispositional differentiae and of the connection between two significantly different types of dispositions (topics that I have explored in this chapter) would not have been possible without a perceptive inferential technique, without a clear method of conducting divisions and without his conviction that a material account should be accompanied and counterbalanced in science and natural philosophy by teleology. I will devote full attention to these last few topics in the fourth chapter of my dissertation.

V. SCIENTIFIC METHOD IN *METEOROLOGY* IV (MATERIAL DISPOSITIONS PUT TO WORK)

A. PRELIMINARIES

So far I have focused on the metaphysical condition of material dispositions and on their emergence in uniform bodies, as set out in *Meteor*. IV. Henceforth I will discuss the ways in which Aristotle actually makes use of dispositional differentiae in scientific explanations. Indeed, one of the most interesting aspects of *Meteor*. IV is the deployment of Aristotle's scientific method. Since I am not aware of any truly comprehensive study of Aristotle's wielding of scientific method in *Meteor*. IV, I will consider here some of its dominant aspects: observation and inference, division, balancing of material causation with teleology, and the relationship between *Meteor*. IV and Aristotle's biology. The nature and 'weight' of these aspects are determined in part by the main purposes of Book IV, for instance, by Aristotle's transparent intention to establish a generic division of *ta homoiomerē* that would benefit his biological research and the formulation of its results. I believe that such an analysis can prove particularly profitable for a thorough understanding of Aristotle's treatment and use of dispositions in this text.

Besides, a study of methodology in *Meteor*. IV can contribute significantly to settling important problems such as whether in his scientific treatises Aristotle is mindful of his own

prescriptions offered in the *APo.* and *PA* I. That is, I will try to show that, in addition to marking a (thematic) transition from works primarily concerned with inorganic materials to biological treatises, *Meteor*. IV functions as a preamble[146] to biological works (e.g. *PA*) in that it foreshadows the application of some of their methodological aspects (announced in the *APo.*). The relationship between *APo.* and, especially, Aristotle's biological corpus has been a vexed question. Scholars like Lloyd (1996, esp. 7-37) and Barnes[147] are rightly reluctant to accept that Aristotle's scientific treatises thoroughly faithfully and consistently follow the *APo.*, but they tend not to stress enough the links that do exist between theory and practice, as Lennox, Balme and Gotthelf do. Finally, I hope that this chapter will add fodder for thought to scholars interested in contemporary trends in the philosophy of dispositions, especially in their relevance to causality and scientific explanation.

Let me explain briefly why I have decided to start this investigation with sections dealing with 'Observation and Inference' and with 'Division'. Aristotle's attempt to outline a virtually new scientific domain, that up to him had a rather loose status at best, is an outstanding feat, comparable – at a more modest scale – with his effort to mark the boundaries of the science of animals,[148] with which his '(bio)chemistry' is tightly connected. The study of organic and inorganic uniform stuffs and of the processes that cause their constitution and their alterations

[146] 'Preamble' does not necessarily suggest a chronological order here; the chronology of Aristotle's extant works has been, of course, and will undoubtedly continue to be a matter of debate. Rather, *Meteor*. IV is to be taken as an antecedent for, e.g., *PA* in the sense in which the beginning of *Meteor*. I sketches an ample and sequential scientific program.

[147] 1982, p. 37: "Aristotle's scientific treatises are never presented in axiomatic fashion. The prescriptions of the *APo.* are not followed in, say, the *Meteorology* or the *PA*. These treatises do not lay down axioms and then proceed to deduce theorems; rather, they present, and attempt to answer, a connected series of problems."

[148] The problems pertaining to the unity and boundaries of science(s), especially with respect to Aristotle's biology, have been the object of several recent studies, notably by Lennox (2001d, 2001e).

finds its unifying and defining principles in Aristotle's sustained effort in *Meteor*. IV to demarcate its object, in his handling of scientific method and in his search for a distinct and acceptable technical terminology (covering *genē* of homeomers, the processes they undergo and the dispositions that differentiate them).[149] In Düring's words (16): "This treatise can be regarded as the first attempt to rope in a new province of science and to make it accessible to scientific research, a sequel to the efforts of the late Academy at classifying and charting the various kingdoms of nature." In order for Aristotle's science of uniform bodies to acquire a rather clear contour and identity and to become accessible to further scientific research, he had to organize its object in a sufficiently articulate fashion. This clarification and organization of the substance of *Meteor*. IV is achieved to a great extent by appeal to dispositions.

[149] As we have seen (e.g. in Ch. 3 in connection with kinds of *pepsis*), the technical jargon of Aristotle's 'chemistry' includes words like 'boiling' and 'roasting'. He puts up a vigorous struggle with his own language and, confessedly, does not always get the upper hand. As in his biological treatises, he is often forced to admit the limitations and unwieldiness of his mother tongue and either leaves blank spots, as it were, in his scientific discourse (i.e. when phenomena are described but are left nameless), or is constrained to resort to what I would call *scientific metaphors*. Close to the beginning of the second chapter he writes that "It must, however, be understood that these terms do not properly (*kuriōs*) describe the subject-matter under discussion, nor cover all the phenomena which should be classed together as similar: the terms just mentioned must therefore be interpreted to cover all phenomena which should be classed with them and not only those covered by their normal meanings" (379b14-17). And, speaking of ripening, he notes: "This, then, is what ripening is in the case of fruit, but many other things that have been concocted are said to be ripe; the process is specifically the same but the term used metaphorically [*metaphorais de*], since, as we remarked earlier, there are no specific names for each type of maturity that occurs when matter is determined by natural heat and cold." This is not the place to launch a detailed disquisition into his handling of metaphors (Lloyd 1996, 205-222 provides us with good guidance in this respect). Instead, I should only note that Aristotle's trailblazing efforts to establish an acceptable and practical – if sometimes ambiguous – terminology in the lecture that we call today Book IV of his *Meteorology* appears to contribute substantially to delineating this scientific domain (along with the methodological features that I will discuss in this chapter).

All four books of the *Meteorology*, along with other scientific treatises, circumscribe the realm of 'for the most part', eluding absolute necessity.[150] In such a world, dispositions are bound to thrive, so to speak, and to exhibit an enormous diversity. As I have already claimed (in the introduction to this dissertation), material dispositions fulfill *two chief functions* in *Meteor*. IV: (a) they play a crucial role in determining what the 'chemical' composition of a body is (although this may be already fairly clear from the examples I have quoted previously, it is time for me to back this claim with more vigorous arguments in the first section of this chapter), and, relatedly, (b) they are instrumental in Aristotle's division of the homeomerous bodies. These will be the topics of the next two sections.

B. OBSERVATION AND INFERENCE

The explanatory role of 'dispositional differentiae' is fully revealed in Aristotle's effort to progress from the visible to the invisible, that is, from the (possible) manifestation of dispositions[151] to the composition of homogeneous stuffs, and to determine causal differentiae

[150] The phrase "rather [or: more] disorderly nature" – *phusis ataktotera* (*Meteor*. I 1.338b2) – suggestively reflects the condition of the sublunary world. On the polarity 'always' (unfailingly necessary) – 'for the most part', see Sorabji 205-244 in Berti 1981, and *APo*. 96a8 ff. on middle terms and 'for the most part'.

[151] Dispositions themselves are, of course, 'invisible', while their manifestations can very well be perceptible; still, one does not have to contemplate the manifestation of a disposition (e.g. the melting of a meltable body) in order to become aware of that property; rather, one can be aware of a thing's dispositions by relying on one's past experiences or on someone else's reports; then, once we know that a certain body is, say, inflammable, brittle etc., we can go on to 'look into' the composition and texture of that body, as Aristotle believes.

(the ingredients and the ratio in which they are present in one body or another).[152] This is in keeping with *Ph.* I 1 (at 184a17 ff.) where Aristotle notes that, in the study of nature, we should start with what is clearer and more knowable to us and then proceed towards what is more knowable in nature, continuing: "The things which are in the first instance clear and plain to us are rather those which are compounded. It is only later, through an analysis of these, that we come to know elements and principles" (trans. Charlton).[153] Observation and inference become thus indissolubly combined in Aristotle's detection of the causal differentiae.[154]

Intriguingly, although the logical and investigative direction is from dispositions to composition, Aristotle uses dispositional properties and the material nature of various stuffs as starting points alternatively in his study. While (A) in Chs. 6-9 he starts with assumptions about

[152] The biological works, especially Chs. 1-9 of the second book of *PA*, devoted to the simple or homoeomerous parts of organisms, offer some unmistakable parallels. For instance, in his discussion of the material nature of blood in *PA* II 4, Aristotle explains the dispositions of various types of blood by dint of the 'chemical' composition of blood (its aqueous ingredient is liable to evaporate and implicitly blood is liable to coagulate easily etc.). In fact this must represent the final result of an investigation that started by focusing on the *behavior* of homeomers like blood, on the assumed or observed manifestation of its dispositions; through such observations and through assumptions about the presence of fibers or *ines* in blood Aristotle seems to be able to move from what is more easily accessible (the manifestation of dispositions) to the 'invisible' (the chemical composition and the microstructure of homeomers such as blood). Cf. *PA* II 5.651a27-30: "Among blooded animals the ones with bodily blood have harder fat. For hard fat is earthen, which is why it solidifies, just as both what is itself fibrous and broths of that sort do; for it has a small amount of water but a large amount of earth." (As in the previous example, Aristotle starts with the material composition of a uniform part, here – fat, since its material constitution explains the various dispositions of that part. But in order to get to the 'chemical' composition, he would first have to pay due attention to what is more easily accessible (i.e. the observed or assumed manifestation of the tendency to solidify etc.).

[153] Cf. *APo*. II 19.

[154] In keeping with *APo*. I 13, we can say that the observation of the manifestation of dispositions allows for a rather rudimentary (though not negligeable) grasp of what a uniform stuff is (i.e. we know *that* it tends to behave in this or that fashion if exposed to such and such conditions); the underlying cause of such dispositions, however, provides a deeper understanding of the nature of that uniform material (i.e. we know *why* it tends to exhibit such behavior). I will return to the distinction between knowing the fact (*hoti*) and knowing the reason why (*dioti*) later in this chapter.

the composition of uniform stuffs and seems to infer from it their behavior, (B) in Ch. 10 he changes the order (e.g., "Solids from which moisture has not wholly evaporated contain a preponderance of earth but can be softened by heat like iron or horn" – 388b30-31).[155]

A. In other words, in Chs. 6-9 he proceeds as follows:

composition (if something is mostly earth or water) or physical structure (*poroi*);[156] external action (and if cold or heat acts upon that stuff; if a certain physical force is applied, then…);

manifestation of dispositions (then it reacts like this or the effect is…).[157]

For instance: "Of the compounds of earth and water in which earth predominates and which are solidified by cold, those that solidify because the heat has left them melt when the heat returns to them again, like frozen mud" (383a27-30).

B. The typical stages of the analysis in Ch. 10, on the other hand, are:

---

[155] Then, in Ch. 11, after learning how to 'detect' earth and water in uniform stuffs, we also learn how to determine whether cold or heat predominates in each of them – 389a24 ff.: "…Those composed of water are, generally speaking, cold, unless they have some external source of heat…; those composed of earth are generally hot, having been manufactured by heat, like lime and ash... Things composed of more than one element contain heat, having most of them been formed by concoction by heat…" (see the account of brain in *PA*, on two ways of establishing that brain is cold).

[156] In a few sections of Chs. 8 and 9 (e.g. on elastic, malleable and compressible things) we are scarcely offered any causal explanations for the dispositions discussed there, but in most of the eighteen sections devoted to *dunameis* and *adunamiai* Aristotle is careful (1) to define or describe the disposition at hand, (2) to provide illustrations, and, most importantly, (3) to causally explain the disposition in terms of the material constitution of a *genos* of uniform bodies sharing that dispositions, by invoking thermic conditions, but mostly by utilizing the nature of the *poroi* presumably present in those bodies (and revealed by the dispositions or behavior of certain uniform bodies).

[157] Generally a particular chemical composition (and physical microstructure) is said to correspond to (and in fact is the cause of) a set of derivative or emergent dispositions. Chapter 11 may seem somewhat odd in that the material constitution of a certain uniform body is said to correspond to the predominance of heat or cold in it; in fact heat and cold, in that context, are not basic contraries but emergent properties, arising in the process of *mixis* and during instances of *pepsis* that produce or alter the aforementioned uniform body.

manifestation of dispositions – as a result of the action of cold or heat;

composition of the homoeomerous body displaying those dispositions.

For instance: liquids which evaporate (or whose density increases) / e.g., by cooling / are made of… Or: bodies which solidify / as an effect of cooling (heating) / are compounds of water (of earth).[158]

Given the alternation of these two directions (A and B), one should not be surprised that, in Aristotle's formulations, which I think are usually readily syllogizable,[159] sometimes the 'middles' (normally indicating causes, according to *APo*.)[160] are represented by the ingredients of the uniform stuffs, but often it is the dispositional properties that become the 'middles', as in the following example. In Ch. 10, at 388b32 ff., Aristotle notes that things that can be melted by fire, such as wax, are composed largely of water.[161] This is translatable into:

Wax can be melted by fire.

Things that can be melted by fire are composed mostly of water.

Wax is composed mostly of water.[162]

---

[158] In effect, Ch. 10 re-systematizes much of what was already said in Ch. 6 for instance, by focusing not on the processes of solidification and liquefaction as such, but rather on states of aggregation – liquid, etc.

[159] For theoretical implications, see *APo.* II 16-17.

[160] Not always, though; see *APo.* I 13.

[161] Let me also give an example of a quasi-syllogistic formulation involving a 'physical' disposition (based primarily not on the 'chemical' composition of the body but on the nature of its *poroi*) – 385b20 ff.:
Soda can be dissolved by water
Bodies that can be dissolved by water are porous throughout
Soda is porous throughout.

[162] In Ch. 7, at 383b18 ff., we read that "Compounds which contain more water than earth are only increased in density by fire, but those that contain more earth than water are solidified. Soda and salt, therefore (*dio*), contain more earth, and also stone and clay." Causal conjunctions like *dio* and *gar* deserve attention, given their frequent use. In Ch. 7, at 384b20, for instance, we are told that "Earthenware is composed of earth only, because (*gar*) [to

This sort of inference, where the middle represents a disposition, is exactly what will allow Aristotle to determine the composition of uniform bodies in *Parts of Animals* as well. Again, it should probably not be surprising that the middle is represented by dispositions more often than by ingredients; this fact emphasizes the illuminating[163] role of dispositions in *Meteor*. IV. In other words, while the composition and microstructure of a body, along with the thermic processes that contribute decisively to its generation or alteration, cause the coming about and the presence of certain dispositions in that body (and account for those dispositions in the order of nature, so to speak), in scientific investigations like the ones on which *Meteor*. IV seems to rely it is the *assumed* existence of those very dispositions that explains or points us to the composition and microstructure of uniform bodies.

Before assessing the role of postulates or 'indemonstrables', let me add a few words on observation, signs and experiments. That Aristotle's inquiry into the nature of uniform bodies is to a significant degree empirical is indubitable. 'Empirical' can cover several zones, of course, including observation and experiment. There is not too much room for experiment here, but some experiments do appear to be described in *Meteor*. IV. In Ch. 7, at 384a3-8. Aristotle attempts to gain insight into the chemical composition of must by observing its overt 'behavior'/manifestation of dispositions:

---

signal grounds for the claim made; here, one might translate: "evidence for this is that, when dried…"] when dried it solidifies gradually; neither can water gain entry through pores from which only vapour could escape, nor can fire, which was the solidifying agent." The logical sequence underlying this passage is in fact the reverse order: earthenware solidifies gradually (disposition) because it is composed of...; *gar* clearly marks the illuminating power of material dispositions in the scientific process of using the 'visible' (although, as I repeatedly stated before, dispositions as such are not perceptible, of course) in order to get insight into the 'invisible'.

[163] The meltability of wax is caused by its watery composition; but the explanatory priority of the latter does not amount to its being more obvious, of course. See also my notes on *hoti / dioti* in this chapter.

> Compounds of water and earth should be classified according to which predominates. For some kinds of wine, for example, must solidify when boiled. In all such cases it is the water that is driven off in the process of drying. This is signaled (*sēmeion d'hoti*) by the fact that if you collect the vapor it condenses into water: and so (*hōste*) where there is any sediment left it must be earthy (trans. Lee with slight modif.).[164]

Quite naturally, when operating with inferences, Aristotle pays close attention to signs;[165] his demonstrations are occasionally admirably ingenious, and, on rather rare occasions, they may not even appeal to dispositions, or moves them into the background:

> …amber appears to belong to this class [i.e., solids composed of earth;[166] see context], as the insects trapped in it show that it has formed by solidification (388b22).[167]

In this example, a disposition (solidifiable) of amber in its original state is a sign of the composition of that homeomer and is itself indicated by another sign, namely, the insects trapped there. Now, when bare observation or experiments are not sufficient, Aristotle readily appeals to comparison. A good illustration of this concerns the persistence of basic dispositions like lightness or the tendency to move upward (more precisely: towards the outer limits of the sublunary sphere) in compounds like oil:

---

[164] For a similar example in which the kitchen fulfills honorably the function of a chemistry laboratory, see *PA* II 7.653a20 ff.: "That the brain is a combination of water and earth is clear from the following fact about it: boiling it make it dry and hard, and with the evaporation of the water by heat the earthen material remains. It is just like what happens with boiled mashes produced from legumes and other fruits once the moisture mixed in them departs because they are, for the most part, constituted of earth; that is, these too become completely hard and earthen."

[165] See Freeland's (1990, 288) remarks on *Meteor*. I-III: "Aristotle uses signs and proofs in an inference pattern now termed 'abduction', to argue from explanatory success to the truth of his proposed analyses." The term *sēmeion* itself is more abundantly used in *Meteor*. I-III; for *Meteor*. IV, see: 380a1, 384a6, 31.

[166] It is clear that the compound was fluid when the insect got imbedded, but the implication seems to be that the water largely evaporated from it.

[167] Cf. also 380a1 ff.: *hugieias sēmeia, dēloi*.

> The nature of oil is the most difficult to determine. For if it contained more water, cold should solidify it, if more earth, fire should do so. In fact, however, its density is increased by both, while it is solidified by neither. The reason is that it is full of air [composition], which is why it floats on water [disposition], since air naturally moves upwards (383b21-26).

The reasoning is quite simple: air moves upward; olive oil is lighter than water and thus floats on it; in a way it shares the air's tendency to move upward; so, oil must contain air.[168] Again, the 'invisible' (i.e. the presence of air in the composition of olive oil) is unveiled by the disposition of oil to float on water; in doing so Aristotle explains a higher level dispositional property (of a compound like oil) through a lower level dispositional property (of air).[169] Important though observation may be in Aristotle's attempt to infer the chemical nature of a homogeneous body, this enterprise would be considerably more arduous without postulating additional factors. Let me spell out this point in the next segment.

To give a more solid theoretical foundation to this discussion, let me mention that in *APo*. I 13 Aristotle marks a distinction between understanding the fact (*hoti*) and understanding the reason why (*dioti*), (a) within the same science (78a23-78b34) or (b) in different sciences (that is, the fact being the object of a science, the reason why – the object of another science: 78b35-79a16). *Meteor*. IV is, I believe, a relatively good illustration of (a) but maybe not of (b).[170]

---

[168] One might wonder why fire was not proposed there instead of air, since both air and fire naturally tend to move upwards, and given that, e.g., at *PA* II 5.651a24-27, Aristotle notes that "…oil is one of the moist things which are a combination of air and fire." Aristotle speaks of other dispositional properties of oil, besides lightness (383b22 ff.) that presumably point to the presence of air in the composition of oil; cf. *GA* 735b13 ff.: "Oil… thickens when it gets mixed with *pneuma* [in *Meteor*. IV the word is: *aēr*]; and that is why <oil> when it becomes whiter is thickening, since the watery substance in it is separated out from it by the heat and becomes *pneuma*" (trans. Peck). See Düring's note on this – p. 85.

[169] I am thankful to Professor Gill for helping me to clarify this final distinction.

[170] See end of this chapter.

In what follows, I shall focus on the first case (a), which allows me to confine my analysis only to the scope of *Meteor*. IV and to some of its common points with *APo*. Aristotle starts, in *APo*. I 13, with a theoretical formulation of two ways in which the reason why can be handled:

Understanding the fact and the reason why differ, first in the same science – and in two ways. In one way, if the deduction does not proceed through immediates: in this case the primitive explanation is not assumed, but understanding the reason why occurs in virtue of the primitive explanation. In a second way, although the deduction does proceed through immediates, it proceeds not through the explanation but through the more familiar of the converting terms. For there is no reason why the non-explanatory counterpredicated term should not sometimes be more familiar, so that the demonstration will proceed through this term (78a23-29; trans. Barnes).

At least the first example he uses to clarify and illustrate this distinction is easily comparable with passages in *Meteor*. IV. Let me first sum up the first example offered in *APo*. I 13 (78a30-78b3). From the fact that planets are not twinkling, one can infer that planets are near (i.e., closer than the fixed stars) – provided one also posits that what does not twinkle is near. Aristotle says, in Barnes' translation:

> Let C be the planets, B not twinkling, A being near. It is true to say B of C: the planets do not twinkle. And also to say A of B: what does not twinkle is near. (Let this be assumed [*eilephtho*] through induction or through perception.) Thus it is necessary that A holds of C, and it has been demonstrated that the planets are near. Now this deduction gives not the reason why [*dioti*] but the fact [*hoti*]: it is not because the planets do not twinkle that they are near – rather, because they are near they do not twinkle.

In *Meteor*. IV what is generally more familiar (a thing's disposition, or rather its observed or anticipated manifestation) and easy to access by mere perception (the expected manifestation of that disposition) usually forms the middle term, although such middles are not 'causes' in any strong sense; e.g., in the example I gave before –

Wax [is something that] can be melted by fire

Things that can be melted by fire are composed mostly of water[171]

Wax is composed mostly of water

- being capable of getting melted by fire (the more obvious aspect, easy to ascertain empirically, corresponding to 'planets do not twinkle') is not the cause of being composed mostly of water; rather the other way around.

Conversely,

> It is also possible to prove the latter through the former, and then the demonstration will give the reason why (*dioti*). E.g., let C be the planets, B being near, A not twinkling. B holds of C and A of B: hence A holds of C. The deduction gives the reason why, since the primitive explanation has been assumed (78a39-38b3; trans. Barnes).

As for *Meteor*. IV, it is quite seldom, if at all, that Aristotle actually resorts to the real causal differentia (which is also what is less manifest) – the composition of some uniform stuff – in order to find out the dispositional differentiae characteristic for that stuff. Even when the progress seems to be from the 'invisible' ('chemical' composition) to the *phainomena* ([manifestation of] dispositions), as in Chs. 6-7, if one translates the text into syllogisms, the

[171] The second premise – things that can be melted by fire are composed mostly of water – is almost a law-like statement, which, in *Meteor*. IV, appears to function as a first principle. Similarly, in the *APo*. I 13 example too one needs to introduce a sort of (optical) law: what does not twinkle is near, which, Aristotle says, is assumed through induction or through perception.

middles seem to be constituted by the dispositional properties rather than by the 'chemical' composition (ingredients of the uniform mixtures and their ratio). To use an example that I cited before, Aristotle tells us (383b18 ff.) that compounds that contain more earth than water are solidified by fire, and goes on to say: "Soda and salt, therefore (*dio*), contain more earth, and also stone and clay." *Dio* seems to suggest that what reveals the composition of, say, salt, is the fact that it is solidified by fire; therefore, I take it that the corresponding syllogism should sound somewhat like this:

Salt can be solidified by fire

Being able to be solidified by fire is a property of compounds that contain more earth than water

---

Salt is a compound that contains more earth than water

As I implied earlier, Aristotle's preference for deductions that 'give the fact' is explained by the role of dispositional properties, as middles, in leading (along with law-like enunciations) to the insight into the composition of uniform bodies.

To sum up, although *Meteor*. IV does not display a formulaic language studded with symbols and neatly articulated syllogisms,[172] it seems to conform to the nature of a bipartite[173] science (incorporating understanding of the fact and understanding of the reason why), as described in the first part of *APo*. I 13.

[172] On this point see Gotthelf's 'First Principles in Aristotle's *Parts of Animals*', p. 194 ff.

[173] Kullmann's (1990) formula.

1. Indemonstrables

Let me turn my attention now to an aspect different from, but bound up with the inferences I discussed earlier: the appeal to statements on undemonstrated (and apparently indemonstrable) facts.[174] The first chapter of *Meteor*. IV, as I noted on several occasions, provides a rigorous set of principles pertaining to the combinatory rules that govern elemental transformation and to the essential nature of the four contraries.[175] Also, chapters 2 and 3 furnish the basic 'laws' determining the occurrence of concoction and insufficient concoction. The criteria whereby Aristotle discerns (*diagnōsometha*)[176] whether a thing is composed of earth or of water are based principally on chapters 6 and 7 (where first principles play a prominent role). Invoking

[174] One could consider this topic against a broader background. A parallel with the (end of fifth century?) treatise *On Ancient Medicine* may be opportune and suggestive here. The author of that treatise vigorously criticizes those who appeal to 'heat' and 'dry' in order to explain virtually every affection of human body (cf. *De natura hominis* - against the theory that the human body is made only of blood or only of another humor); as Cooper persuasively shows, in a paper presented at the Princeton Colloquium of Classical Philosophy, the author of *On Ancient Medicine* was not only an empiricist, but also deeply rationalist: he too was ready to make use of *hupotheseis* – underlying principles – not 'cold' or 'hot', but: 'astringent', 'bitter', 'acidity', 'saline character' etc. Aristotle seems to concur both with the author of *On Ancient Medicine* (since he based his investigation on a number of underlying principles, while at the same time relying heavily on observation) and, in a different respect, with those attacked by him (in so far as Aristotle assigned a crucial role to 'cold', 'hot', 'dry', 'moist'). An appropriate illustration of Aristotle's use of first principles is also his view, in this respect, in a medical context: "Aristotle reveals a far higher degree of empirical observation than does Plato, but he is fundamentally in agreement with him in that the first principles of medicine should be drawn from philosophy" (Longrigg 1993, 431; cf. *De respiratione* 480b23, *De sensu* 436a18). The importance of the rationalist vein in Greek natural philosophy (and beyond) was stressed (if somewhat too firmly) also by Popper: "I now come to my last and most central contention. It is this. The rationalist tradition, the tradition of critical discussion, represents the only practicable way of expanding our knowledge – conjectural or hypothetical knowledge, of course. There is no other way. More especially, there is no way that starts from observation or experiment. In the development of science observations and experiments play only the role of critical arguments" (in Furley and Allen eds., p. 151).

[175] For a more theoretical discussion, see *APo*. 71a17-71b33 (cf. *GC* II.1-5).

[176] Ch. 10, 389a5.

dispositions as well as hypothesizing plausible but indemonstrable facts seems to help one, according to Aristotle, to reveal the compositions of certain homogenous stuffs; e.g., if you know that some material is likely to melt when exposed to heat *and if you hypothesize* that what melts (e.g. silver) contains water, then you can conclude that that particular stuff contains water, which perhaps predominates in its composition.[177]

Meteor. IV too contains quite a number of aprioristic[178] sentences (e.g., compounds of earth and water are solidified both by fire and by cold; compounds which contain more water than earth are only increased in density by fire), in which Aristotle assigns a particular composition to bodies behaving in some way or another. But Aristotle does not find it necessary to thoroughly explain to his readers or listeners how he reached such law-like enunciations. Let me elaborate on this point.

---

[177] I should add that the most obvious instance of use of first principles in *Meteor*. IV appears to be the treatment of the four opposites / causes [*aitia*] (moist, dry, hot, cold) as well as of the so-called elements. Yet, their existence and nature were not simply assumed by Aristotle: he takes them as starting points in *Meteor*. IV – but not without arguing first for their existence in *GC* (II 1-8), of which *Meteor*. IV is in a way a sequel. *Meteor*. IV in fact begins with an allusion to that treatise: "We have distinguished in the elements four causal factors (*aitia*) whose combinations yield four elements: two of the factors are active…" (Somewhat similarly, in a biological context, in *PA* II 4 Aristotle seems to simply assume the existence of *ines* or fibers in blood, but in fact he had hinted at an experimental procedure that could reveal their existence, in *HA* III 6.515b32-33; on this see Lennox 2001c, 201.) Aristotle promptly adds, as if in order to draw our attention to the more 'applied' character of *Meteor*. IV (in comparison with *GC*): "this can be confirmed by considering some examples…" (*hē de pistis tuton ek tēs epagogēs: phainetai gar*…; cf.: 387b16 *tauta gar phainetai*…; 382a6 *dunamis …phainetai*…).

[178] Düring (1944, 12-13) cautions us that observation, although an important aspect, is not sufficient in this scientific demarche: "For the most striking feature in his scientific thinking is the way in which he always combines speculation and observation. This treatise is predominantly speculative: facts are collected and sifted, it is true, and there are many really interesting observations; but they are nearly always regarded from a strictly speculative point of view and are often forced to answer the theories made up beforehand. The treatise stands nearer to his speculative early work *On Heaven* and *GC* than to the biological writings; in points of style and general mode of reasoning it reminds us of the treatise *On Locomotion*."

Aristotle famously notes that, in natural philosophy, it would be superfluous to demonstrate that there is such a thing as nature; accordingly, the existence of nature is simply posited. But, whereas this may be taken to be a self-evident fact, it is not so self-evident that what is meltable (say, silver) contains water (though not only).[179] Where do such hypotheses stem from? Often Aristotle appears to tacitly ground his 'laws' on *analogies*, e.g., between an element and a state of aggregation: water and liquid, earth and solid, a type of 'confusion' that figures prominently in *Meteor*. IV; similarly, he posits the existence of *poroi*, based on an analogy of various bodies like sponge[180] (although possible influences from other authors are not to be discounted).[181] Nor does he deign to explain in *Meteor*. IV how *poroi* come about in various bodies, what determines the formation of distinct types of *poroi,* etc.[182] *Poroi* play an

[179] Undemonstrated first principles – i.e. *archai* that are not based merely on everyday experience or common-sense can also be found in books I-III of the *Meteor*., where the central concept is that of *anathumiaseis* – (dry or moist) exhalations (see e.g. the first few occurrences of the term: 340b27 ff.). The invocation of these exhalations does not seem comparable (function-wise) e.g. with the observation that there is change in the world (an obvious fact which renders a demonstration of the existence of *phusis* unnecessary). Nevertheless, Aristotle does not attempt to demonstrate the existence of the exhalations.

[180] 386a30.

[181] I have not found any occurrence of the term *poros* in the *Timaeus*, although Plato is certainly interested in the physical inner structure of various bodies and substances, this allowing him to explain phenomena such as increase / decrease in density; the interstices also account for the lightness, say, of bronze (59c). But, despite terminological differences (to *poros* Plato prefers: 59c2 *dialeimmata*; 60e4 *diakenōn*; 60e5 *euruchōrias*; 60e8 *diexodon*; 61a2 *eisodos*; 61a5, 61b1, 61b4 *diakena*), similarities with Aristotle's account are startling.

[182] As I mentioned before, *poroi* can display several characteristics; again Aristotle does not deem it necessary to offer a cogent demonstration of this fact. We learn from Aristotle that *poroi* can be distributed in the mass of a body in different ways – evenly, by fascicles etc. (e.g., at 385b25 – in earth the pores 'alternate' – cf. 386a16; 386b2 ff.); they can be arranged longitudinally, they can be 'hard' (385b21: [*porous*] *sklēroterous tou hudatos*) or they can have different diameters. This last point entails some puzzling issues. At 387a19 ff. we read that some bodies are combustible because their pores can be penetrated by fire (cf. 60e-61a in the *Timaeus*). But not all pores can be penetrated by water, for instance, or, as Aristotle puts it, by *ogkoi* of water (385a30 *hudatos ogkōn*) – which on Aristotle's non-atomistic account seems baffling, since in principle they are infinitely divisible); cf. Ch. 1 of this dissertation. Here are a few possible corresponding cases in the *Timaeus*: 59a3 (*ton hugron ogkon*); 59b7 (*gēs*

important explanatory role not only in elucidating how a certain stuff (usually some liquid) can penetrate and alter another body, but also in Aristotle's accounts of 'physical' dispositional differentiae such as fragility (386a9-17) and fissility (386b26-387a3).

One should not miss the fact that, when resorting to such principles, Aristotle scarcely betrays any hesitation.[183] This *attitude* is, I believe, worth almost as much attention as the various aspects of his scientific *method*. I would tentatively suggest that not betraying hesitation does not amount to Aristotle's conviction that he was in thorough command of the 'truth' (e.g., regarding the composition or the texture of a certain uniform body). Although there may be some risk involved in quoting a passage from a work in support of a passage in another work, I would quote a passage in the first book of *Meteor*., which I think is pertinent to my discussion about Aristotle's scientific attitude in book IV as well. Right before delving into the study of the nature of comets (I 7.344a5 ff.), Aristotle makes a rare confession:

> We consider that we have given a sufficiently rational explanation of things inaccessible to observation by our senses if we have produced a theory that is possible (*eis to dunaton*): and the following seems, on the evidence available, to be the explanation of the phenomena now under consideration.[184]

---

morion oligon); 60c3 (*tōi tēs gēs ogkōi*); 60e4 (*gēs ogkous* - *diexodon* - particles of air and fire are smaller than the interstices in a mass of earth and do not dissolve it, like the particles of water). Also: 385b20-21 *porous meizous tōn tou hudatos ogkōn.*

[183] In Freeland's opinion (in a paper devoted to the first three books of the *Meteorology* 1990, 308), "…This strategy involves arguing from explanatory success to the truth of a scientific theory. As a scientific realist Aristotle is committed to maintaining that it is in principle possible for a scientific theory to provide true and accurate accounts of the actual causes of the empirical phenomena it investigates. In the meteorology, for example, Aristotle would maintain that the exhalations which are fundamental principles of meteorology really do exist and do function in just the ways his theory describes. What evidence can be cited for this conviction? Abduction is a form of inference to the best explanation: the best explanation for a theory's predictive success is that it is true, i.e. that it describes the world as it really is."

[184] Cf. *Meteor*. I 1.339a2-3: "Of all these phenomena, some we find inexplicable, others we can to some extent understand." And Plato's *Tim*. 68d – on the impossibility of any experiment that would verify his 'likely story'.

Perhaps Aristotle is not far here from the rather cautious and modest tone assumed by Plato in his 'likely story'[185] in the *Timaeus* or even from Parmenides' attitude in his '*Doxa'*.[186]

2. Laws of nature

As we have seen, while the structure and language of *Meteor*. IV do not follow the quasi-mathematical model urged by the *Posterior Analytics*, the chemical treatise is nonetheless compatible with the spirit of Aristotle's philosophy of science; it is in fact not particularly challenging e.g. to reformulate entire passages from it in syllogistic fashion or to see how Aristotle makes use of principles. The very object of the *Meteorology* imposes the use of a somewhat different way of articulating the scientific demonstration than the more generic model afforded by *APo*, since a 'fuller' and more descriptive language is better suited for Aristotle's science of homeomers than an aridly formulaic and elliptic discourse (and the same goes, of course, for his biology).

The study of Aristotle's appeal to observation and inference in *Meteor*. IV (and its implications for his scientific discourse) would be incomplete without a synopsis on the role played by laws of nature.[187] The connections established by Aristotle between dispositional

[185] Cf. Xenophanes with respect to the 'invisible' and the acquisition of belief and knowledge: 21B34, 21A33, 21B29.

[186] A question worth pursuing, but which I cannot pursue here is: Does Aristotle make use of arguments from probability in his scientific treatises, comparable with the use of *enthumēma* in rhetoric?

[187] The notion of natural law in Aristotle's works may not be articulated in theoretical terms as neatly as it will be in later authors, but its importance is certainly hard to underestimate. A few things, however, are rather safe to affirm with respect to this topic: (a) It is clear, of course, that these are not 'natural' laws imposed un-naturally by a demiurge (see Lennox's illuminating chapter on Plato's *Timaeus* in *Aristotle's Philosophy of Biology*, 280-302); (b) Aristotle is not concerned by the possible 'failure' of the laws of nature and is rather immune to the kind of worries

differentiae[188] and the composition of uniform bodies are meant to cast light on crucial aspects of the material nature of the homeomers and to enable him subsequently to group homoeomerous stuffs not only according to their dispositions, but also according to their material constitution. In doing so, he often formulates laws governing the emergence and / or actualization of material *dunameis*, which emphasize his effort to organize the vast amount of information and empirical results available to him with respect to uniform stuffs. Most of these law-like statements are, as I have tried to show, quite easy to integrate into syllogistic structures. I should draw now attention to the *conditional* or *quasi-conditional* nature of many of those statements.

Conditional accounts usually take the following form in *Meteor*. IV: if a uniform body consists of certain ingredients (present in it *dunamei*) in a particular proportion and if the right external conditions obtain (e.g. if sufficient – dry or moist – heat is applied to it), then a certain disposition will emerge, or (if already existent) it will be manifested. Conversely, conditionals

---

that were formulated later on, in the Middle Ages, and remolded by the Humean tradition (in which induction plays a crucial role), given what Aristotle has to say about the ungenerated nature of the universe and its eternity in *De Caelo* etc.; (c) it is likely that, according to Aristotle, those laws are imbedded in nature, so to speak, rather than being *mere* reflections of regularities in our consciousness. Regarding this third aspect, Lenoble writes in his *Esquisse d'histoire de l'idée de nature* (77): "Le Cosmos se présente enfin comme un ensemble, sinon encore de phenomènes, du moins de qualitiés originales liées entre elles (et non par nous) dans un ensemble cohérent. Et ceci était absolument nouveau. Aristote n-a pas eu à créer l'idée de loi naturelle: nous savons que la pensée magique cherche (et 'trouve' hélas!) les lois de la Nature; mais il a conçu l'idée d'une Nature qui n'est plus un symbole humain et par conséquent de lois que nous avons à constater et non pas à imaginer suivant notre désir."

[188]Again, Aristotle does not initiate any theoretical discussion of the relationship between dispositions and laws of nature. I should mention briefly, however, that this topic has commanded the attention of quite a few contemporary thinkers. See Goodman 1955 passim and Mumford 1998 (who would like to "outlaw" the laws of nature and, instead, to rely more firmly on dispositional accounts: pp. 216-238) Let me also quote here Armstrong's view (17): "…One then owes an account of why we are (…) entitled to attribute unrealized powers, potentialities and dispositions to the objects. My suggestion is that we should do this by appealing to the laws of nature. The idea is this: given the state of the glass, including its microstructure, plus what is contrary to fact – that the glass is suitably struck – then, *given the laws of nature are as they are*, it follows that the glass shatters… One can identify laws of nature with relations between universals, in particular with relations between properties."

can be used at least theoretically to show that, if a body exhibits a certain behavior, under specific conditions (i.e. when affected by heat or cold in such and such a way), then it is bound to have this or that 'chemical' composition.

Thus, analyzing the frequently *conditional* nature of Aristotle's formulations can help us gain more insight into exactly[189] how secondary dispositions are supposed to emerge, according to Aristotle, but mostly into how, once they are present in an already constituted uniform body, they can be manifested or actualized.

On Aristotle's account (*Metaph*. Θ 1046b28 ff.), even the Megarians offer a sort of conditional model in order to give conceptual flesh to *dunameis*: something is capable of producing a certain action or is actually suffering a certain effect only *if* (or: when) it is in fact producing that action or suffering that effect. Aristotle himself gives much prominence to conditional patterns in treating both the emergence and the manifestation of dispositions, although in a decidedly non-Megarian vein (that is, according to him, capacities are *not* to be reduced, as in the Megarian scenario, to their own manifestations). This prominence is evident from a few passages in the theoretical texts devoted to the nature and typology of *dunameis* (esp. in *Metaph*. Θ 5), and transpires also in the more applied scientific works, notably in *Meteor*. IV. Although there are indeed quite a few conditionals in *Meteor*. IV, the reader should not expect to encounter there an unfailingly sustained enumeration of *dunameis* neatly formulated in conditional terms; but then, one should not expect the bulk of this work to be a list of technically

[189] My optimism in this respect, however, is somewhat contained by the worry that a *very* exact scenario (if exactness is indeed a product of quantifiability) is simply not formulable in Aristotelian terms, given the 'qualitative' nature of his scientific discourse. Thus, expressions like 'the more and the less', and the constant reminder of the fact that water and earth are mixed in (all or most) uniform bodies *in certain ratios*, are of utmost importance in understanding Aristotle's treatment of mixtures and of their differentiae in *Meteor*. IV, but such wording and notions are confined to a vague and general level.

formulated syllogisms either, although many of its claims and 'laws' are readily reformulable in strictly syllogistic fashion. In like manner, dispositions are often described in *Meteor*. IV in a conditional way only implicitly.

There is one basic aspect of Aristotelian powers that is worth mentioning at this point and in which the provision of certain conditions becomes crucial (beside the fact that, *if* an active power is to be realized, it has to interact with the right opposite, passive power). The way in which natural powers will be actualized, if at all, hinges on the conditions under which they may come to play out. In *Physics* VIII 1.251b1-3 Aristotle makes precisely this point:

> …All things that are capable respectively of affecting and being affected, or of causing motion and being moved, are capable of it not under all conditions, but only when they are in a particular condition and approach one another (trans. Hardie and Gaye).

Variations in temperature, volume, dynamics etc. will either prevent a *dunamis* from being manifested, or will determine its full or partial actualization. The first three chapters of *Meteor*. IV, although laying more emphasis on processes than dispositional properties as such, hints quite transparently and liberally at various conditions of this kind.[190] To fully understand that (and why) things tend to decay[191] more rapidly if some conditions rather than others obtain, it is important to be aware not only of the ingredients of a body already constituted and of whether it

[190] See, for instance, *Meteor*. IV 1: "…There is less decay in cold than in warm weather: for in winter the amount of heat in the surrounding air and water is so small as to be ineffective, while in summer it is greater. Again, what is frozen does not decay, as its cold is greater than the air's heat, and therefore is not mastered by it: but what causes change in a thing does master it. Nor does anything boiling or hot decay, because the heat in the surrounding air is less than that in the object, and so does not master it or cause any change. Similarly what is in motion or flowing decays less easily than what is static. For the motive force of the heat in the air is less than that of the heat residing in the object, and so causes no change. For the same reason large quantities decay less than small ones: for the larger quantity has too much native heat and cold in it for the properties of its environment to master" (379a26-379b4).

[191] This tendency, I take it, should be assimilated to the type of *dunamis* that is very close in meaning to *phusis* (X changing into Y, in virtue of its own, internal principles); see *Metaph*. □ 8.1049b5-11, cf. *Metaph*. Δ 12.1019b1-2.

is affected by heat or by cold, but also whether the heat is internal or in the environment, dry or moist (see his discussion of boiling in Ch. 3 of *Meteor*. IV), whether the volume of the uniform body is relatively small or is overwhelming, whether the body under discussion is static or mobile etc., since aspects like volume and mobility are among the factors – along with the nature of the ingredients and the agencies of cold and hot – that explain why a body possesses certain secondary dispositions (e.g. an enormous amount of water is less likely to 'decay' than a small amount of water etc.).[192]

This whole host of contributing factors can be converted into a list of conditionals: *if* the temperature is low enough, a body tends to decay at a slower pace or the process of decay can even cease altogether; *if* the volume of a thing is sufficiently great, it tends to decay less rapidly than a smaller volume of identical stuff exposed to a similar environment etc.[193] Also, in the subsequent discussion of types of concoction and inconcoction Aristotle goes on to list conditions that secure the normal course or the hindrance of an organic process; the right proportion between active *dunameis* (especially internal heat) and the passive contraries (or

[192] I should emphasize that a conditional analysis of properties and processes is not, in Aristotle in any case, an elegant strategy for doing away with dispositions. What I mean is that conditional analyses can serve various philosophical purposes and can be intended sometimes to weaken the status of dispositions. In assuming that 'if factors X_1, X_2… obtain, then result Y will be produced', one can bypass the ascription of dispositions to a certain thing; such a conditional account can be taken simply to (causally) link a set of categorical factors to an actual event. Aristotle, however, shuns such temptation. See Mumford (1998, 63), for a contemporary take on this matter: "What I suggest is the rejection of a solely conditional analysis of dispositions and that we treat them as real instantiations of properties which afford possibilities rather than just being shorthand ways of talking about certain combinations of events. The alternative view to the empiricist conditional analysis view is thus one of dispositions as instantiated properties."

[193] While these can be considered conditions *sine quibus non*, there are additional factors which are not necessary for the manifestation of some disposition and cannot prevent it, but do influence its character. Here is an example (tending to 'mature') from the same *Meteor*. IV: "And the maturing process is initiated by the thing's own heat, even though external aids may contribute to it: as, for instance, baths and the like may aid digestion, but it is initiated by the body's own heat" (379b21-25).

rather earth and water) affected by it (as well as the right ratio between 'dry' and 'moist' within that body) are the principal variables that come into play here:

> Concoction, in fact, is what happens to everything when [read: if] its constituent moisture is mastered; for this is the material that is determined by a thing's natural heat, and as long as the determining proportion holds [read: if it holds for a certain amount of time] a thing's nature is maintained (379b33-380a1).

In a similar manner, Aristotle notes with regard to 'rawness' or incomplete ripening (a species of *apepsia*, or incomplete concoction) that "immaturity results from a deficiency of natural heat and its lack of proportion to the moisture that is being ripened" (380a32-4). The one-way nature of the material powers ensures the *necessary* character of their manifestation, if, that is, certain conditions do hold.[194] This, however, could not be the case with *meta logou dunameis*.[195] I have used here only examples that concern material dispositions; but the structure of these conditionals would have to import additional qualifications – e.g. 'if one's will inclines this or that way' – when applied to human faculties, since they can lead to contrary outcomes. The most explicit and comprehensive statement of the *necessary* presence of the right conditions, if some *dunameis* are to actually lead to a change, comes in the first part of Ch. 5, in *Metaph*. Θ (1047b35-1048a8):

> Since that which is 'capable' is capable of something and at some time and in some way (with all the other qualifications which must be present in the definition), and since some things can produce change according to a rational formula and their potencies involve

[194] Conditionals can also assume a negative form especially if the focus is on conditions that might thwart the realization of a *dunamis*: "A thing is capable of doing something *if there will be nothing impossible in its having the actuality of that of which it is said to have the capacity*. I mean, for instance, if a thing is capable of sitting and it is open to it to sit, there will be nothing impossible in its actually sitting; and similarly if it is capable of being moved or moving, or of standing or making to stand, or of being or coming to be, or of not being or not coming to be" (*Metaph*. 1047a24-9; cf. 1048a16-21, *Physics* 255b4 and 24, *De Anima* 417a26-8).

[195] See on this Appendix I.

> such a formula, while other things are non-rational and their potencies are non-rational, and the former potencies must be in a living thing while the latter can be both in the living and in the lifeless; as regards potencies of the latter kind, when the agent and the patient meet in the way appropriate to the potency in question, the one must act and the other be acted on, but with the former kind of potency this is not necessary.

In this context, of the use of conditionals, I should add that Aristotle sometimes backs the validity of some of his laws (which, besides pointing to a certain regularity among natural phenomena, also shed light on the dependence of dispositions upon 'chemical' compositions and thermic processes) by bringing up *counterfactuals*. For example, olive oil is somewhat of a maverick among uniform bodies, so to speak, as it is not easily solidified by either cold or heat. Right before mentioning this peculiar behavior of olive oil, Aristotle notes:

> The nature of olive oil is the most difficult to determine. For *if it contained* more water, cold *should* [impf.: *edei*] solidify it, *if it contained* more earth, fire *should* do so (383b21-3; trans. Lee, with modif.).

Meteor. IV does not attempt, however (and expectedly so), a theoretical elaboration of the significance of such counterfactuals in the scientific discourse.

Besides their form, the *scope* of these laws should retain our attention. Some laws apply to very comprehensive kinds of phenomena, others to narrower ones. Here is an example of the former kind (a sort of umbrella-law covering many narrower and more specific laws): "Destruction takes place when what is being determined gets the better of what is determining it with the help of its environment…" (379a12-13) Most of the laws put forth in Book IV have, however, a more limited scope; for instance: "Compounds which contain more water than earth are only increased in density by fire, but those that contain more earth than water are solidified" (383b1820).

The generic content of such a law includes references to: (a) 'chemical' composition, (b) dispositions and, usually, (c) thermic (and mechanic in much of Chs. 8-9) conditions that would favor a change in the body having that composition (i.e. conditions that would allow the manifestation of those derivative passive dispositions).[196] Chapter 11 is rather an exception, since there the connection is primarily between the intrinsic heat or cold of uniform bodies and their composition. (Yet, as I have already mentioned, some of these laws place more emphasis on environmental factors or on parameters like dynamics, volume, etc.; see 379a30-b4.)[197]

---

[196] Such laws are sometimes formulated in the biological works as well, e.g. *PA* II 2.648b23-34, in the context of the polysemy of 'hot': "…Again, boiling water is hotter to the touch, but cools and solidifies more quickly than oil. And again, blood is hotter to the touch than water and oil, but solidifies more quickly. Again, stones, iron, and such things heat up more slowly than water, but once hot burn more intensely." In that particular passage, however, the material composition of homeomers is not spelled out, but it is to be understood, I think, as an important factor, especially given that a few lines further into Ch. 2, in a passage that clearly sends the reader to *Meteor*. IV, Aristotle overtly takes into account the 'chemical' composition of homeomers: "The hot seems both to solidify and to melt. Thus cold solidifies these things consisting only of water, while fire solidifies those consisting of earth; and among hot things, the more earthen solidify quickly by means of cold and are insoluble, while the watery ones are soluble. What sorts of things are capable of solidification, and the causes owing to which they are solidified, have been determined more clearly elsewhere" (649a29-34).

[197] Lennox (ms. 10) gives an inspiredly succinct and generic formula of most laws enunciated in *Meteor*. IV: "As many as are <K> undergo □ when <H,C>" and explains:

"The values for K are typically but not always) elemental dispositions - which Aristotle takes to denote their kinds – of the object, which I will below write as follows:

<E/W> = compound of earth and water

<E/w> = compound of earth and water, with earth predominant

<e/W> = compound of earth and water, with water predominant

<W> = of water, or 'form of water'

<E> = of earth, or form of earth

The values for □ are more or less lengthy descriptions of the changes undergone. These are all said to be due, in one way or another, to the actions of heating and cooling. For example:

I. As many as are <E/W> are solidified by fire and cold, and made dense by both.

II. As many as are <E/w> solidify when heat departs and melt when heat returns.

Let me also point out that, within this category of laws applicable at the material level, some may be centered on the processes set off by the active factors, heat and cold (Chs. 2-3), while others are concerned primarily with the affections (*pathē*) undergone by a material substratum (Chs. 5-7; 10).

We can also distinguish in Aristotle's science between laws that apply at a strictly material level and laws that transcend it; a (super-)law of the latter kind might be: "nature does nothing in vain" (although qualifications would apply).[198] Among the postulates at work in *Meteor*. IV is, in Ch. 12, the seminal idea that the realm of life is vastly governed by final causation, a topic that I dealt with briefly before and that I will take up again later in this chapter.

Finally, to return to Aristotle's laws pertaining to the material level, one might wonder how they can conceivably hold in the realm of "for the most part". Granted that phenomena in the sublunary sphere function with less regularity than the outer spheres and the celestial bodies,[199] necessity and 'for the most part' are not exactly mutually exclusive concepts: if/when the right conditions are in place, a particular effect will take place of necessity. It is just that the conditions for the emergence and then for the manifestation of a certain disposition are not present with unfailing regularity and sheer predictability (differing in this sense from the more 'perfect' sort of necessity governing the heavens – the realm of the *aithēr*).[200] Connectedly,

---

III. As many as are <E/w> as solidify by cooling when all their heat has left, cannot be dissolved but by excessive heat, but become malleable by heating.

One with a different form and content is:

IV. As many as are solidified by heat or cold are dissolved by the opposite."

[198] On this topic see the relevant chapter in Lennox, *Aristotle's Philosophy of Biology* 205-23.

[199] *Meteor*. I 1.383b1-2: "Its province is everything that happens naturally, but with a regularity less (*ataktoteran*) than that of the primary element (i.e. the *aithēr*)."

[200] This may not be the place for a lengthy excursus on the connections between the two realms making up the Aristotelian universe, but the reader of *Meteor*. IV should bear in mind that many of the operations of the elementary

Aristotle sometimes – rather rarely – is ready to accept that some of these laws are laws *sui generis* since they are not quite universal, but are based on a preponderance of cases; e.g. in Ch. 11, we read at 389a25-27 that the majority [*epi to polu*] of the things consisting of water are cold, unless they have some external source of heat. A clarification is important here: the fact that the sublunary world is not governed by the same type of necessity as the heavens and is characterized by a lower degree of regularity does *not* entail that a law can follow its course, as it were, on one occasion and can fail on another occasion, although on both occasions exactly the same type of uniform stuff was subjected to exactly the same conditions. What the example cited from Ch. 11 seems to intimate is that, among watery liquids there is a certain diversity (some consist strictly of water, while others include residues of earth etc.; perhaps some have come about as a result of processes that differ from those that prompted the production of other watery liquids etc.). In any case, beyond such hypotheses, one can say with confidence that the 'one-way' character of material *dunameis* ensures that, if certain conditions apply and given the nature of a certain uniform stuff, then (as a result of its being affected e.g. by heat or as a result of physical pressure etc.) there can be only one outcome, and that outcome will be replicated as often as a uniform body with the same constitution will be exposed to similar conditions.[201]

Laws of nature do not form the topic of a rigorous and explicitly articulated *theoretical* investigation in Aristotle, although his interest in the regularity of natural phenomena and of the predictable connections between certain sets of circumstances and categorical (chemical and physical) properties on the one hand and the possible manifestation of dispositions on the other

---

forces in the sublunary sphere are ultimately determined by the effect of the sun and, generally, of the heavens on the sublunary sphere.

[201] See, for instance, Ch. 6, 383a6-8: "Watery liquids… are not solidified by fire, for they are dissolved by fire, and the same cause operating on the same substance in the same way cannot produce opposite effects."

hand seems to foreshadow (and maybe in part to initiate) later discussions on this topic. (That later authors – e.g. various strands of Platonists – tackled it frontally and used the term *nomos* lavishly to refer to laws of nature may have been stimulated to some extent by their preference for a teleology marked by providential or quasi-providential nuances.) Still, the appeal to laws of nature in relatively applied scientific treatises like *Meteor*. IV may afford – implicitly – interesting theoretical points, if read with due attention and caution. Thus, it is reasonably clear, I hope, that the 'chemical treatise' points to a position closer to what we might call today dispositionalism than to actualism.[202] What I mean to say, beyond the apparent anachronism of the use of these terms in an Aristotelian context, is that Aristotle did not take laws of nature to be just summary descriptions of strictly actual events (an idea that the Megarians would have found perhaps palatable, just as the positivists would have found it so in more recent times), but he uses law-like formulations rather to ascribe *dispositions* (in this context – to organic and inorganic uniform materials).

My synopsis of the variety and of the place of laws of nature in *Meteor*. IV is meant to contribute to a fuller understanding of Aristotle's effort to find order, based on causal connections, in what might otherwise look like a variegated slew of phenomena. Aristotle's rather impressive scientific apparatus – including the appeal to dispositions in order to cast light on the otherwise imperceptible composition and microstructure of uniform bodies, and the formulation of natural laws – has its own worth, but it also avowedly (see Ch. 12 of *Meteor*. IV) serves the purpose of making a meaningful division of homeomers possible. Crucial aspects of that division would have been impossible, I would argue, without the information provided by the inference of chemical composition and of physical features (e.g. *poroi*, distribution of

[202] For an assessment of these various positions, see, e.g., Harré 1993, especially Ch. 2.

humidity etc.) from the observation of the behavior of uniform bodies (i.e. of the manifestation of their dispositions) and without the law-like statements that capture the regularity of the connections between the presence of certain dispositional differentiae and a specific sets of chemical and physical characteristics. It is high time for us to see just how such a division is managed by Aristotle within the confines of his 'chemistry'.

C. DIVISION

In the last chapter of *Meteor*. IV Aristotle surveys the accomplishments of the first eleven chapters as follows:

> We can tell from their generation what is the constitution of the homoeomerous bodies, what are the kinds (*ta genē*) into which they fall and to which kind each belongs (*tinos hekaston genous*); for the homoeomerous bodies are composed of the elements, and serve in turn as material for all the works of nature… Knowing, therefore, into which kind each of the homoeomerous bodies fall (*tinos genous hekaston*…), we should proceed to describe each of them… (389b25-28; 390b15-16; trans. Lee with modif.)

I have already suggested that one of the main achievements of *Meteor*. IV is providing criteria for a reliable and clearly articulated division[203] of the various homogeneous bodies into

[203] The technical term is *diairesis* – frequently used in the biological works. It does not occur, however, in *Meteor*. IV (the verb *diairein* is used eleven times there but with concrete meanings like 'to split' or 'to disperse'). Modern scholars have tried to suggest that Aristotle's method of *diairesis* aims in the biological works at a classification of animals, comparable with modern zoological classifications. David Balme has been the staunchest critic of such analogies. In several of his papers he points out convincingly that *Aristotle's divisions were meant not to classify but to define*, or, as Aristotle would put it, to "hunt" for the definiendum, to discover exactly what an animal species is. In Balme's words, "[Aristotle] does not carry the framework of division across the board as in a classification, nor

overlapping kinds or *genē*[204] – an enterprise that will turn out to be particularly profitable in later writings, like *Parts of Animals* II (especially Chs. 1-9) and various portions of *GA*.[205] In his 'chemical treatise', Aristotle distinguishes uniform materials with respect to the various types of processes they are *liable to* undergo (and, so, with respect to their dispositional properties),[206] as

---

does he create a terminology of orders, families, etc., as Linnaeus did to establish such a framework… Modern taxonomists have been mistaken in seeking a classificatory system here. For in biology Aristotle uses only two taxonomic concepts, the *genos* and the forms of a *genos*, and all attempts to find regular intermediate classes have notoriously failed" (1987, 72).

[204] The technical terminology itself (chiefly the use of 'kind' or *genos* and 'form' / 'species' or *eidos*) pertaining to division in *Meteor*. IV deserves attention. *Genos* occurs at: 388b22*;* cf. 390b15; *eidē / eidos*: 379b10, 17, 381b4, 23, 382b11, 13, 383b14, 388a26; 'the more and the less' / 'by degree', *mallon…hētton*: 382a17. *Genē* are analyzable into *eidē*, which are 'smaller' *genē*; the *eidē* themselves can be regarded as *genē* in respect to the *eidē* into which they are further analyzable. It is worth mentioning that many of these *genē* / *eidē* do not have proper names and, therefore, Aristotle uses a sort of technical nomenclature: 'the earthy ones', 'the easily liquefiables' etc. – a linguistic situation comparable with that in his biological writings ('the soft-shelled ones', 'the live-bearing four-footed animals' etc.); for more details, see Lennox's chapter 'Divide and explain' in *Aristotle's Philosophy of Biology*, 7-38.

[205] A qualification may be opportune here: not all aspects related to division in Aristotle's biology seem applicable to the topics considered in *Meteor*. IV – e.g. the use of analogy (in biology, in the comparison of quite different kinds or *genē* of animals: scales – feathers; gills – lungs etc.).

[206] A question one may raise in this context is whether all (detectable) material *dispositions* of a certain uniform body are to be considered on a par with each other qua differentiae (apart from categorical properties like composition and microstructure which determine the presence of such dispositions). It seems likely that we can discern some differential potentials as quasi-defining characteristics while others are accidental. Aristotle is less explicit about this in *Meteor*. IV than we might wish he were, but one could venture at least to suggest that 'defining' *material dispositions* are those that allow us to recognize a uniform stuff as what it is. In the case of, say, bronze, a 'defining' set of dispositional properties could include its hardness, its tendency to liquefy at very high temperatures and to be solidified by cold etc. (Some of these properties also presumably allow Aristotle to gain insight into the composition of the stuffs displaying those properties, the chemical composition and microstructure of a homoeomerous stuff being their truly causal differentiae.) I am considering in this note a sketchy hierarchy of a uniform stuff's dispositions at a purely material level; but even in a *teleological* context, some material dispositions may still have preeminence over others. In order for bone or flesh to fulfill their roles as constituents of a complex organ, like a hand, certain material dispositions such as hardness or elasticity may prove crucial – rather than other properties that they also happen to possess, such as a certain heaviness or color. This can be extended to artifacts,

well as by employing their 'chemical' composition and microstructure as (causal) differentiae. It appears, therefore, that what is at stake in an adequate investigation into the nature of Aristotle's method of division in *Meteor*. IV is, among other things, our ability to give a precise outline of the chief functions of this book.

Indeed, Aristotle is permanently preoccupied to make clear distinctions (some of which are part of elaborate divisions) throughout *Meteor*. IV:

- Ch. 1: basic powers (or causes) – elementary stuffs
  generation – destruction (including *sēpsis*)
- Ch. 2 and 3: action of heat and cold on already constituted homeomers:
  concoction – inconcoction
  ripening – rawness
  boiling – scalding
  roasting – scorching
- Ch. 4: hard – soft
- Ch. 5-7: solidification:
  by heating
  by cooling
  liquefaction:[207]
  by heating
  by cooling
  in watery liquids
  in compounds of water and earth:
  in which earth predominates
  in which water predominates
- Chs. 8-9: secondary dispositions of uniform bodies:
  sensible qualities
  intrinsic qualities
  eighteen pairs:
  dunameis – adunamiai
- Ch. 10: liquids:
  watery
  earthy

---

where, in virtue of the same sort of conditional necessity, if the bronze blade of an axe is to perform its specific function when handled properly (cutting, chopping), it has to have certain material properties (hardness etc.), while others (like, again, color) will remain irrelevant with regard to that *ergon*.

[207] Solidification and liquefaction being the basic, most important processes dealt with in *Meteor*. IV – from the point of view of the affections undergone by the dry and moist.

solids:
that solidify as a result of cold
that solidify as a result of heat etc.

- Ch. 11: hot and cold in:
  bodies composed of water
  bodies composed of earth
  bodies composed of more than one element
- Ch. 12 matter – form; material causation – teleology.

What becomes immediately clear after reading this book is that Aristotle frustrates the expectations of a modern reader; he does *not* classify homoeomerous bodies, for instance, into natural and artificial (alloys etc.); the natural ones into inorganic and organic; the inorganic ones into types of stones and metals; the organic ones into vegetal and animal tissues etc. Rather, he speaks of 'earthy' materials, or 'the earthy ones', of 'the predominantly watery ones', of the 'elastic ones', 'the ones giving off fumes', stuffs that have longitudinal pores, and so on. What may be the meaning and usefulness of a division into such kinds of homeomers?[208]

Throughout his scientific corpus, Aristotle's ambition in operating such generic divisions is chiefly to organize the facts (see *APo*. II 13), the upshot being his ability to draw attention to causal differentiae and to grasp 'problems'.[209] To quote Lennox (2001a, 35-6, n. 26), who wrote a number of authoritative papers on the topic,

[208] The role played by dispositions in divisions or (in a modern setting) in classifications still commands the attention of philosophers of sciences and is emphasized in several treatises written over the past fifty years or so (e.g. in Goddman's 1955, pp. 50-1: "…I suggest that two points be kept in mind for future reference: the formulation of the general problem, and the recognition that dispositional as well as manifest predicates are labels used in classifying *actual* things."

[209] On grasping problems through divisions, see *APo*. II 14: "In order to get to grips with problems, you should make excerpts from the anatomies and the divisions. Do this by supposing the kind common to all the items and excerpting – if, e.g., it is animals which are being studied – whatever holds of every animal. Having done this, next excerpt whatever follows every instance of the first of the remaining terms (if, e.g., it is a bird, whatever follows every bird)" (98a1-6; trans. Barnes).

> Division is a way of organizing information for the sake of explanation / definition,[210] not a method of discovering information.

This overall purpose of Aristotelian *diaireseis* is visible in *Meteor*. IV, just as it is in *HA* (and one could conceivably regard them as two distinct but concomitant prolegomena for *PA*). In *Meteor*. IV the term *dunamis* is occasionally used interchangeably with *diaphora* (difference, differentia),[211] in much the same way as, e.g., in *PA* II. I should mention that in *Meteor*. IV *secondary (derivative)* dispositions get the place of pride among the differential potentials of uniform bodies, although the relatively short Ch. 11 is devoted almost exclusively to two primary

[210]Producing increasingly complex and enlightening definitions allows us, according to Aristotle, to proceed from merely fumbling around (starting an inquiry with a limited degree of understanding or amount of knowledge: *APo*. II 10.93b32-6) to grasping what a thing really is (i.e. acquiring understanding and being able to formulate a *causal* account; see *APo*. 93a28; 93a17-21). When it comes to uniform stuffs and to fully defining their nature, *Meteor*. IV may seem at first to be just a source of nominal definitions. Compare a *Meteor*. IV(1-11)-like definition of flesh as 'a uniform stuff that is mostly earthy, is flexible etc.' with a functional account such as: 'flesh is the uniform stuff that makes tactile perception and movement possible'. Yet, at least with respect to material *dispositions*, *Meteor*. IV is meant to probe quite deeply and to seek more than just nominal definitions (which indicate for us the phenomenon that should be investigated; a real definition points us to the cause of the thing that we are attempting to define; see *APo*. II 7) of *dunameis* by revealing the underlying causes – chemical composition and microstructure – and conditions that lead both to the emergence and to the actualization of those *dunameis*; Chs. 8-9 of *Meteor*. IV, for instance, are replete with such rich definitions. As for uniform *stuffs* themselves – in order to get full definitions, we will have to look them up in the biological treatises (where they are defined by appeal to functions, *erga*). On the relation between division and definition, see also *APo*. II 13 e.g. 97b11-16.

[211] E.g. at 380b31. Charlton (1987, 283-4) notes that the fact that Aristotle uses *dunameis* as differentiae is no innovation (though he would certainly agree that Aristotle is innovative on several accounts in *how* he uses them). He even ventures to suggest that "Aristotle could have picked it up from his father the Macedonian court physician". Indeed, even at a cursory reading of most Hippocratic writings, one is bound to realize that *dunamis* is one of the central concepts in this heterogeneous collection. It is in CH that one can detect, for example, an extensive and systematic use of *dunameis* as differentiae (*idiai dunameis*) or5 distinctive properties and meant to mark important distinctions between tissues, drugs etc. See, for instance: *De vetere medicina* 16.2, 17.3, cf. 15.4 (*idiēn dunamin*); *De natura hominis* 42 (bis), *Regimen* 474; see also., in a non-CH context, Protagoras 330A (*dunamin…idian*); cf., in Aristotle, *PA* 646b17 (*dunameis anomoias*). See also von Staden 269.

contraries – hot and cold – as differentiae. Dispositions, however, are not the only differentiae: uniform bodies can also be distinguished from one another by their ingredients, principally by the ratio between dry and moist (or: earth and water).

Aristotle lays the theoretical foundation for division or *diairesis* in several texts, such as *APo.* II (esp. chapters 13-14) and *PA* I. In *PA* I, more than anywhere else, Aristotle is out to demolish the method of dichotomy he attributes to Plato and the Academy. Although Aristotle agreed with his former mentor that, in a division, one should not chop across the joints like a clumsy butcher, he abhorred the Platonic dichotomous division and offered a fundamentally new technique. Its main features are conveniently listed in a classic article by David Balme entitled 'Aristotle's use of division and differentiae' and also in a study by Lennox entitled 'Divide and Explain: the *Posterior Analytics* in Practice'; the current section of Ch. 4 of this dissertation bears their profound mark. Let me point out these various features of Aristotle's method of division and illustrate them by appealing not only to Aristotelian biology, but also and mainly by relying on *Meteorology* IV. One of my aims here, is, again, to strengthen the thesis that Aristotle did put some of his generic, theoretical precepts to work in the more particular contexts of the scientific treatises.

Successive differentiation. In the dialogue *The Statesman*, Plato divides animals into wild and tame, and then blithely divides tame animals into gregarious and solitary. No reason is offered for this order of the cuts, and characteristics like gregarious do not stem necessarily from tameness (since there are also wild gregarious animals), so this way of dividing seems to be arbitrary in several respects; implicitly, it cannot guarantee that one will end up with a complete set of defining characteristics of a certain animal species. As a remedy, Aristotle introduced a

requirement for successive differentiation, meant to ensure that the final differentia will entail its antecedents.[212]

To mention just one famous example, footed animals are divided by Aristotle into bipeds and quadrupeds; of course being quadruped or four-footed is a sort of footedness; if footed animals were divided into gregarious and solitary, it would be quite obvious that such attributes are not derived from 'footed'.[213]

Let me give an example of the use of division in *Meteor*. IV. In Chapters 6 and 7, for instance, there is a 'cut' or division between watery liquids and mixtures of earth and water. Such mixtures, in turn, are divided into compounds in which water is the prevailing ingredient and compounds in which earth predominates (384a3-4); at this stage the differentia is the chemical composition, or the primary material dispositions, given that the central criterion is the ratio between dry and moist or earth and water. These bodies are further divided according to their various reactions to heat (or its privation – cold); at this stage the differentiae consist of secondary material dispositional properties (such as [in]solubility – e.g. 383b11).[214]

Aristotle divides processes somewhat as he divides stuffs. After dividing basic powers or *dunameis* into active (hot, cold) and passive (moist, dry) in Ch. 1 of *Meteor*. IV, he shows in Chs. 2-3 that the action of the active powers on matter can be divided along the lines of

---

[212] Cf. *APo*. II 14.98a8-10: "It is plain that we shall now be in a position to state the reason why whatever follows the items falling under the common kind holds of them – e.g., why they hold of man or of horse."

[213] Cf. *Metaph*. Z 12.

[214] As I suggested earlier, some secondary properties seem to result from the 'chemical' composition of a body (the ratio between its original ingredients), e.g. 'solidifiability' and 'meltability', and the effect of heat or its absence on that mixture, whereas others seem to be caused primarily by the physical structure of a body: fragmentability and breakability due to many alternating pores or to long continuous pores respectively – 386a9-18 (physical structures which, although Aristotle is not clear on this point, can be assumed themselves to be due to a particular chemical composition and to a certain effect of heat / cold upon it).

concoction (*pepsis*) and inconcoction (*apepsia*); concoction is divisible into ripening, roasting, boiling, whereas inconcoction can be divided rather neatly into three opposite states and processes – rawness, scalding and scorching (which, in turn can be divided – we may assume – into further, more specific, types of processes).[215] This division into various types of *pepsis* and *apepsia* is in fact *also* a division of uniform mixtures,[216] just like the first one, since stuffs can be divided according to whether they have undergone concoction, or to whether they are boilable etc. This way of dividing by successive differentiation pervades indeed much of *Meteorology* IV.

Multiple differentiae. Division, Aristotle recommends, must be done by multiple differentiae. If footed is divided into two-footed and many-footed, and this category into four-footed and six-footed etc., this is a perfectly reasonable and legitimate division; nonetheless, it is glaringly insufficient. To say that humans are two-footed or are bipeds and to say that elephants and cats are four-footed or are quadrupeds scarcely gets us to the essence of what a human is or at what an elephant is. The solution is to operate with several divisions simultaneously. In *Meteor*. IV, Aristotle divides uniform mixtures according to three major criteria: (a) according to their 'chemical composition' (earthy and watery stuffs etc.), (b) according to physical characteristics (such as the presence of tiny pores or channels in a mass of, say, clay or salt); and, very importantly, (c) according to the various dispositional properties possessed by those uniform stuffs. In the end, if you want to know what the *material* nature of, say, wood is, you have to consider all of Aristotle's divisions and lists of dispositional properties and come up with

[215] Again, finding the right English correspondents for the Greek processes and states described by Aristotle has always been a considerable challenge for any translator of the *Meteorology* and Aristotle himself was avowedly not in a very enviable position himself, as he had to struggle with the lack of an adequate terminology or nomenclature and appealed to what I called earlier scientific metaphors quite often; see especially Chs. 2-3 of *Meteor*. IV on transfers of sense.

[216] Cf. note 219.

a jigsaw puzzle of sorts;[217] wood is a uniform mixture which contains mostly earth and air in a particular ratio, and which is combustible, fissile etc. This method of division is theoretically conducive to the formulation of definitions; however, one must add some qualifications here. Such a division can help us to outline the material nature of salt, iron or suet, but, at least when it comes to *organic* uniform bodies (root, bark, suet, blood, bone, etc.), *Meteor*. IV will not exactly get us to their essences, since a full account of their natures would require placing them in a teleological context and considering their respective functions (as suggested by Ch. 12 of *Meteor*. IV and as illustrated by *PA* II etc.).

The use of *negative differentiae*, while not prohibited, should be cautious and scanty. Negative differentiae, when relevant at all, do not allow for further division. For instance, if animals are divided into footed and footless, footed can be divided into, e.g. two-footed and four-footed, but a similar operation is meaningless in the case of footless. Now, both snakes and fishes happen to be footless, so, in order to define their natures properly, one has to make use again of multiple morphological as well as functional differentiae (and maybe to appeal to analogy), and to consider 'footless' as only one among many other differentiae. Similarly, in his 'chemical treatise' (esp. Chs. 6-7) Aristotle divides uniform compounds into 'meltables' and 'unmeltables', and further divides 'meltables' according to the conditions under which they melt, but he does not even attempt to subdivide 'unmeltables' *as such*. Similarly, some homeomers contain earth and water, while others appear to be devoid of one of them;[218] the latter would not

[217] See *PA* I, *APo.* II 13 ff. Locating wood in a variety of genera, is not a way of fully explaining the nature of wood; division should rather be seen (Lennox, 'Divide and Explain', 7-38) as a way of organizing information for the sake of explanation, a method for testing antecedently organized information for completeness; to take another example, we can locate 'blood' in various genera in *Meteor*. IV 1-11, but, as Ch. 12 warns us, it is only after becoming aware of its functions that we know what a tissue like blood, taken individually, really is.

[218] See the first chapter of this dissertation.

be divided, of course, into *eidē* in virtue of the absence of that ingredient. Instead, if their material natures are to be outlined properly, we have to ponder also other relevant divisions and differentiae.

Also, one should *divide only by opposite differentiae*. As Balme notes (1987, 75),

> Aristotle criticizes the kind of empirical division that would be made if in defining a colorless fish we were to divide animals into swimming and colored. This would produce a cross-division, since there may be animals that both swim and are colored.

In *Meteorology* IV Aristotle is consistently keen on dividing by opposites (at a dispositional level or at the level of material constitution): solidifiable stuffs can be divided into those that are solidified by cold and those that are solidified by heat; compounds can be divided into those in which earth predominates and compounds in which water predominates. Although it is preferable to divide by positive opposites (A and B, rather than A and non-A),[219] and this is relevant to the use of negative differentiae as well, Aristotle does not shun divisions where the presence of some *dunamis* is seemingly contrasted with its absence. One of the most obvious examples is his division of uniform mixtures, in chapters 8 and 9, into eighteen pairs of stuffs according to some of their dispositional properties: capable or incapable of solidification; meltable or unmeltable; softenable by heat or unsoftenable by heat etc.[220] Nonetheless, as I suggested in Ch. 2 of this dissertation, *adunamiai* like 'unmeltable' or 'unsoftenable by heat' are not mere instances of privation or *sterēsis*, but can be regarded as 'positive' states or properties, in so far as they are resistive powers – in these cases, the *dunamis* to resist some agency of heat.

Let me conclude this succinct enumeration of points of convergence between the use of *diairesis* in *Meteor*. IV and Aristotle's theoretical precepts regarding this method, by calling

[219] See Balme 1987, 76.

[220] See also his division of processes (*pepsis – apepsia*) in Chs. 2-3; on this cf. my notes in my Ch. 3.

attention to divisions made in terms of *'the more and the less'*.[221] Comparison between radically different kinds of animals can be facilitated by analogy (lungs – gills etc.); however, when marking distinctions between animals belonging to different species within the same kind (*heni genei*), Aristotle relies on degrees or 'the more and the less' (e.g. species of birds can be compared and contrasted by pointing out that one has a larger beak than some other species etc.).[222] Aristotle's 'chemistry' is not quantitative in any rigorous way, but he does attempt to differentiate between various degrees in the material composition of stuffs belonging to the same *genos*; in Ch. 6 of *Meteor*. IV, for instance, Aristotle distinguishes among compounds of earth and water between those in which earth predominates and those in which water predominates; furthermore, among the former, one can discern various degrees in the preponderance of earth (see, e.g., *pleon* at 383a27). Degrees in the predominance of some ingredient appear to correspond (along with differences in the configuration of the *poroi*) to different positions of *dunameis* along continua such as meltable–unmeltable or combustible–incombustible.

[221] See Ch. 7 in Lennox 2001a (pp. 160-181).

[222] Towards the end of *PA* I 4, at 644b7-14 Aristotle explains: "Roughly speaking, it is by the figures of the parts and of the whole body that kinds have been defined, when they bear a likeness – e.g. members of the bird kind are so related to each other, as are those of the fish kind, the soft-bodied animals, and the hard-shelled animals. For their parts differ not by analogous likeness, as bone in mankind is related to fish-spine in fish, but rather by bodily affections, e.g. by large/small, soft/hard, smooth/rough, and the like – speaking generally, by the more and the less."

Indeed, to re-emphasize a point that I have already made, divisions of processes[223] alternate with divisions of stuffs, and, as far as the latter are concerned, divisions centered on 'chemical' composition are virtually intertwined with divisions whose principal criteria are the dispositions or expected behavior of uniform stuffs.[224] Even in Chs. 8-9,[225] where the criterion

[223] That is, as I noted before rather fleetingly, even the division of *processes* (especially *pepsis* and *apepsia*, but also solidification – liquefaction etc.) usually presuppose divisions of *stuffs* according to their dispositions and constitution; to take an example, the section on boiling as a form of concoction, in Ch. 3 (380b13-381a12), is implicitly a section about the capacity or incapacity of various stuffs to undergo that particular process (see *hepsēton* at 380b25). I should point out that often in *Meteor*. IV, for instance in Ch. 10 (cf. Chs. 5-7), Aristotle appears to speak of *actual* reactions to heat or cold: given a certain composition of some uniform body and the presence of internal heat or its exposure to external heat/cold etc., that uniform body will react in this or that way, or will suffer such and such effects. Even in such contexts, where Aristotle's formulation may seem to focus on the *actual* manifestations of that body's dispositions, in fact the emphasis remains on the *possible* manifestations of such properties. E.g. in Ch. 10, at 388a30 ff.: "liquids which evaporate (*exatmizetai*) are made of water", "liquids whose density heat increases (*pachunetai*) are mixtures"; Aristotle's interest obviously goes here with the tendency or disposition of liquids to evaporate or become denser, rather than with actual instances of those dispositional properties.

[224] In this respect too the division operated at multiple levels in *Meteor*. IV may not be dissimilar from divisions made in the zoological works, where kinds of animals can be distinguished within the same chapter or paragraph both with respect to morphological (and physiological) differentiae and in so far as their temperament and characteristic habits are concerned (the former being in some cases responsible for the latter).

[225] The order of the dispositions listed in Chs. 8-9 does not appear to follow any strict criterion. The rather vague unifying principle seems to be that they are shared by the majority of uniform bodies (and maybe that they are explained more in terms of physical microstructure, *poroi* of a type or another, than of chemical composition). It starts with solidifiable and meltable (and their opposites) probably because these dispositions have already been treated in Chs. 5-7 and there, in Ch. 8, may be the right point for a brief recapitulation (this seems to be implied at 385a22-23). The third pair ('softenable or unsoftenable by heat') seems to be a natural sequel, since the emphasis is again on the effect of heat on uniform stuffs, and is followed by 'softenable by water'. Next, eleven of these eighteen pairs (5-14 and 16) are primarily concerned with derivative passive dispositions that correspond to *physical* processes – various types of pressure, impact etc. (flexible, breakable, fragmentable, capable of taking an impression, plastic, squeezable, ductile, malleable, fissile, cuttable, compressible). The fifteenth *dunamis* listed there is 'viscous' (contrasted to 'friable'); the last two are related to each other: 'combustible' and 'capable of producing smoke' (towards the end of Ch. 9 Aristotle adds another disposition, 'inflammable' – *phlogista*, i.e. 'capable of producing flame' – a species of 'combustible', which is defined as 'capable of dissolving into ashes). Each of these

for the division of uniform stuffs is clearly the expected behavior of uniform materials, i.e. their dispositions (since homeomers are divided into kinds like flexible – inflexible, squeezable – unsqueezable, compressible – incompressible), such kinds correspond to (overlapping)[226] *genē* of uniform stuffs, grouped according to their material constitution. Material dispositions appear to be causal consequences of other characteristics of homogeneous stuffs, like the ingredients constituting those stuffs and the physical features that belong to them (*poroi* of a sort or another), and implicitly emerge as a result of the thermic processes described in Chs. 2-3 and 5-7 of *Meteor*. IV. Still, dispositions are not demoted to the status of second-hand properties, so to speak, but are consistently given a great deal of attention, both as signs of the chemical composition and microstructure of the homeomers, and as differentiae in Aristotle's division. The prominent position of material dispositions will be maintained in much of *PA* II and in sections of *GA*, and expectedly so, since dispositional properties are more directly relevant to conditional necessity[227] than the *mere* mentioning of the original ingredients of some material.

By contrast with treatises like *PA* and *HA*, *Meteor*. IV does not seem to foster the ambition of supplying the reader with a quite exhaustive division. Thus, to take a glaring

---

pairs, of course, marks a continuum along which one can find, besides the resistive power (e.g. inflexible), numerous degrees of the corresponding passive power (e.g. flexible). I would not exclude entirely the possibility that a mnemonic scheme *also* underlies this list (e.g. 1-2 and 5-12: *pēkton, tēkton, kampton, katakton, thrauston, thlaston, plaston, pieston, helkton, elaton*), although the phonetic resemblance between *some* of these words is probably coincidental (e.g. *pēkton* and *tēkton; kampton* and *katakton* go together rather naturally as contrastive qualities).

[226] Meaning that the same chemical composition and physical structure can correspond to several of the 18 or rather 36 dispositions listed there; the same material, say wood, can be at the same time fissile (*schiston*), combustible (*kauston*), unmeltable (*atēkton*), capable of giving off fumes (*thumiaton*) etc. Conversely, the same type of disposition, e.g. meltable, can indeed be found in homoeomerous stuffs with distinct compositions (basically, different ratios between dry and moist or earth and water), but the disposition will be situated at different points on the unmeltable – very-easily-meltable continuum, for meltable stuffs as diverse as wax and silver.

[227] See the second segment of my Ch. 3.

example,[228] little is said in *Meteor*. IV (see the beginnings of Chs. 8 and 10) about *active* derivative dispositions. Yet, while Aristotle's overall purpose in *Meteorology* IV is, as far as we can tell, not to provide a complete and detailed classification of homogeneous compounds, he does offer a set of generic divisions (made in a spirit remarkably compatible with that of a number of theoretical texts) that are meant both to organize a vast amount of information and to bolster further investigation – especially though not exclusively – into the nature of organic uniform stuffs. These materials will become the object of renewed scrutiny in the biological works, where the study of various tissues (considered separately, *kath'hekaston*) will include an inquiry into their defining functions.[229]

D. ON TELEOLOGY AND CONDITIONAL NECESSITY IN *METEOROLOGY* IV

Aristotle's view on natural teleology is at the heart of several sections of this dissertation (e.g. on the emergence of derivative dispositions). Still, given the obvious importance of final causation in the shaping of Aristotle's scientific method, the topic of the current chapter, I think that a corollary on this topic may be appropriate here.

[228] See my note on this in Ch. 2 of this dissertation.

[229] It is unlikely that Aristotle also offered similar *kath'hekaston* accounts of inorganic stuffs like metals and stones (although *Meteor*. IV can plainly function as a prolegomenon to treatises on such topics as well, not only to zoological works). He probably preferred to assign this task to Theophrastus and maybe to others. (Had Aristotle given an account of metals considered separately, its guiding principle could not have been the appeal to defining *functions*, but possibly sets of defining – dispositional and categorical – properties.)

Like Plato,[230] Aristotle was not satisfied with the reductionist approach of the earlier natural philosophers (*hoi phusiologoi*).[231] The regularity observable within species, as well as the remarkable complexity displayed by most organisms, Aristotle thought, could not possibly be the result of haphazard conglomerations of elementary particles. Rather they have to be explained by reference to hierarchically organized final causes:[232] elements are for the sake of homogeneous stuffs, (organic) homogeneous stuffs are for the sake of the organs which are constituted of them; organs are for the sake of organisms in which they are functional parts. One should also note that ends or goals (*ta hou heneka*), according to Aristotle, do not appear to be mere explanatory tools, but are ontologically robust, so to speak, i.e., are things in the world. The manifestos of Aristotle's teleology are *Physics* II (especially Chs. 3, 7, 8) and *PA* I, although other texts are replete with explicit references or at least allusions to final causation.[233]

Chapter 12 of *Meteor*. IV tackles final causation frontally,[234] which at first sight may appear irreconcilable with the preceding eleven chapters – concerned largely but maybe not entirely with material causation. Several features of Aristotle's discussion of final causation and necessity in Ch. 12 are potentially puzzling and can be somewhat misleading at a cursory

---

[230] There are, however, important differences between Plato's and Aristotle's teleology; whereas in Plato 'nature' is a product of *technē*, being fashioned by the divine craftsmen and his aides, Aristotle, in his biology, is committed to a truly natural teleology (for a detailed account of final causation in Plato, see 'Plato's unnatural teleology' by Lennox 2002a, 280-302).

[231] See, among other relevant passages, Aristotle's attack on Democritus who had no use for final causation (in *GA* V 8).

[232] See, for example, *PA* 646b5 ff.

[233] *Metaph*. □, *APo.* (94b27 ff.) and many other texts.

[234] A certain material composition or a particular shape would not suffice for, say, a hand to actually be a hand. The hand of a dead man is a hand in name only (*homōnumōs* – 389b33, 390a1), a sculptured flute is a flute in name only. If a hand is to be really a hand, it has to have certain dispositional properties, but, more importantly, it has to be able to perform certain functions (*erga* – e.g. 390a11: seeing, the function of the eyes) and so, implicitly, it has to serve some goals. Significant in Ch. 12 is the recurrence of the formula *heneka tou* – 389b31, 390a4, 390a8.

reading. On one hand, Aristotle (390a3 ff.) transparently implies that final causation can be involved not only in the structure and functions of organs and organisms, but also in homoeomerous bodies and even in the nature of the four so-called elements (390a8). On the other hand, necessity alone seems to be responsible for the coming about of uniform stuffs (flesh, bronze, etc.), whereas it is certainly not sufficient to account for the structure of more complex things like a hand (its functional roles having to be accounted for with respect to some final causation) or a saw (which is the product of craftsmanship or 'art', *technē*).[235]

In fact, material causation (or: necessity) and teleology are meant to be two complementary aspects in the study of nature, according to the Stagirite. In other words, it is fundamental for Aristotle's approach to biology (and it is important to keep in mind that *Meteor*. IV is a sort of preamble to Aristotle's biological treatises, especially *PA* II) to balance his interest for the *material* nature of living things and their parts (and the material dispositions of some parts) with an examination of *final* causation in connection with organs and organisms. The point that the natural philosopher has to balance his interest in material accounts with an acute interest in formal accounts is made in no uncertain terms in the last chapter of *Meteor*. IV (at390b18-20):[236] "For we know the cause and nature of a thing when we understand either the material or formal factor in its generation and destruction, or best of all if we know both, and also its efficient cause." Hence it is clear that, while material accounts like those provided in chapters 1-11 are necessary, they are by no means sufficient to fully explain the nature, e.g., of uniform

[235] A pertinent question is: how much of the sublunary world involves teleological causation (besides artifacts)? Whether Aristotle envisaged an all-pervading teleology extending to the boundaries of the universe and presumably including all natural realms has been a matter of dispute. Let me just note here that, judging by the first three books of *Meteor*. IV, it appears that colossal chunks of the sublunary world – meteorological and geological phenomena – involve virtually no trace of final causation. To this one can add other aspects that eschew, as it were, final causation, like spontaneous generation, the color of the eye or whether one has curly or straight hair etc. (cf. *GA* V).

[236] Echoing other Aristotelian passages such as *Ph.* 194a22-28.

parts of organisms. Conversely, it is equally clear from *Meteor*. IV that Aristotle is sometimes willing to and perfectly able to conduct a 'bottom-up'-type research.

As both Gill (1997 and ms.) and Lennox (ms.) point out, things that answer *at the material level* of bone and flesh can be generated by heat and cold alone, i.e., by simple necessity.[237] However, heat and cold cannot bring about (through their effect on dry and moist) "flesh and bone complete with teleological purposes" (Lennox, ibid.; cf. Gill 1997, 160). Whereas the effect of heat and cold upon dry and moist can be said to determine (some of) the material dispositional properties of stuffs like flesh, it is by appeal both to material causation and to *logos* and teleological causation that we can give a full and adequate account of uniform materials as constituents of functional organs and living organisms.

To what extent and how are the two aspects meant to be brought together, that is – how do the two types of causation 'cooperate' according to *Meteor*. IV 12?[238] In this biological context, 'conditional' or 'hypothetical' necessity becomes a central factor. In *Ph*. II 199b34-35 Aristotle distinguishes between 'hypothetical' and 'simple' necessity. In a cognate passage, in *PA* II (642a8-13), he explicitly links dispositional properties (already discussed in *Meteor*. IV) to conditional necessity:

> …This is, as it were, conditionally necessary; for just as, since the axe must split, it is a necessity that it be hard, and if hard, then

[237] 'Democritean necessity' as John Cooper's puts it (1987); or: purely material causation.

[238] This problem is addressed in a manner that seems to echo *Meteor*. IV 12 in several passages in *GA*, e.g. in II 6, at 743a36 ff.: "Heat and cooling (which is deprivation of heat) are both employed by Nature. Each has the faculty (*dunamis*), grounded in *necessity*, of making one thing into this and another thing into that; but in the case of the forming of the embryo it is for a *purpose* that their power of heating and cooling is exerted and that each of the parts is formed, flesh being made soft (*malakēn*) – as heating and cooling make it such, partly owing to *necessity*, partly *for a purpose*, - sinew solid and elastic (*xēron kai helkton*), bone solid and brittle (*xēron kai thrauston*)… We are to say, then, as already stated, that all these things are formed partly as a result of *necessity*, partly also not of *necessity* but *for a purpose*" (trans. Peck). Cf. *GA* V 8.

> made of bronze or iron, so too since the body is an instrument (for each of the parts is for the sake of something, and likewise also the whole), it is therefore a necessity that it be of such a character and constituted from such things, if that is to be.

The passage includes an important and suggestive disjunction. Lennox (ms.) convincingly shows that material *dispositions* play a pivotal role in Aristotle's discussion of conditional necessity. Given that an ax can be made of bronze *or* of iron, what really counts is not that an ax be made of a particular stuff, if it is to be an ax and serve a certain purpose, such as chopping or splitting wood, but that its nature include a certain set of dispositions (like hardness or the capacity to be molded in a certain way when molten, and then to be honed etc.).

This brings me back to my previous comments on *Meteor*. IV 12 and especially to my analysis of the argumentation of this book in light of *De Anima* II 5.[239] Both orders of *dunameis* discussed in the 'chemical treatise' – material dispositions like hardness and elasticity and, in Ch. 12, the capacity to fulfill a specific *ergon* (e.g. of flesh to function as a medium for touch or to be a well functioning part of a complex organ, such as a hand) – are rallied in Aristotle's explanation of the workings of nature at the level of organic and inorganic uniform stuffs both in a strictly material context and *sub specie causae finalis*.[240]

---

[239] See Ch. 3 of this dissertation.

[240] I should add that, while final causation is paramount in the last chapter of Book IV, in my opinion it is not entirely absent in the main body of *Meteor*. IV – although this tends to be partly or entirely neglected in studies on this book. Let me quote some of the relevant passages here (see also my notes on these sections of *Meteor*. IV in my chapter 3): "…Since concoction is maturity, the process of ripening is complete when the seeds in the fruit are capable of producing another fruit of the same kind: for this is what we mean by mature in other cases also (380a12 ff.)." Also: "The end [although one should not assume that the presence of any reference to *telos* in a text automatically involves teleology] for which things are boiled or concocted is not the same in all cases; in some it is for eating, in others for drinking, in others, again, for some other purpose, as, for instance, we speak of drugs being boiled (381a2 ff.)." The notion of fruition, for instance, may foreshadow Ch. 12 and points to the fact that Aristotle is concerned in some of these passages with substances (like plants) rather than merely with uniform stuffs. Such

E. CONCLUDING NOTES ON THE RELATION OF *METEOROLOGY* IV WITH ARISTOTE'S BIOLOGY

Let me return now, towards the end of my study of Aristotle's 'chemistry' and his appeal to dispositions, to the very starting point of this dissertation: the place of the chemical treatise in the Aristotelian corpus.

After surveying the roles of observation and inference, of division and of material and final causation in Aristotle's 'chemistry', I should reassert my belief that a comprehensive analysis of Aristotle's scientific method in *Meteor*. IV can help us acquire an adequate and nuanced understanding of the status and role of material dispositions in this treatise. Furthermore, such a study is worth pursuing in its own right, I think, and can contribute to a more vigorous grasp of Aristotle's multifaceted scientific method in general and to settling

---

examples support, I think, the view that Aristotelian natural teleology is confined to the realm of life (and excludes mineralogy, meteorology). Similarly, at 379b25-33 we read that "In some cases the end (*telos*) of the process is a thing's nature, in the sense of its form and essence (*eidos kai ousian*). In others the end of concoction is the realization of some latent form (*hupokeimenēn tina morphēn*), as when moisture takes on a certain quality and quantity when cooked or boiled or rotted or otherwise heated; for then it is useful (*chrēsimon*) for something and we say it has been concocted. Examples are must, the pus that gathers in boils, and tears when they become rheum; and so on." This last passage seems to resemble *Tim*. 83de; cf. *De vetere medicina* 19; *Peri pathōn* 246; *Anonymus Londinensis* XI 43. For passages outside Ch. 12 of *Meteor*. IV that deal with or allude to final causation, see also Ch. 5 (at 382a28 ff.) and Ch. 10 (at 388a20-25), where there is a hint to final causation, although it is imbedded in a reference to non-uniform or instrumental parts (organs etc.): "The non-homoeomerous bodies owe their constitution *to another cause*; the material cause (*hulē*) of the homoeomerous bodies which make them up is dry and moist, that is, water and earth, which display most clearly these two characteristics (*dunamin*); their efficient causes (*ta poiounta*) are heat and cold" (trans. Lee, with modif.).

debates around the connections between theoretical / programmatic texts and texts where methodological precepts are put to work.

But what about the relation between *Meteor*. IV and other 'applied' scientific treatises like *PA* II? One thing that is worth being mindful of, I believe, is that, although *Meteor*. IV can be regarded as a prolegomenon to Aristotle's biology, especially to those sections of his biological corpus that deal with simple or uniform parts, the chemical treatise is not simply parasitic upon works like *PA* II, but has very much its own worth. It sheds light on phenomena which may be less majestic than the movements of the stars and less fascinating than the morphology and habits of exotic and not so exotic animals, but which are pervasively part of our lives; after all, knowing how things tend to behave[241] determines to some extent our own behavior and expectations (to echo Goodman's words again: things are full of threats and promises). *Meteor*. IV, however, goes far beyond organizing uniform stuffs according to material dispositions and glimpses, as it were, at what some of those dispositions are signs of: the chemical and physical constitution of uniform materials.

This being said, we should not exaggerate the 'autonomy' of the chemical treatise either, as there is no denying that the scientific enterprise achieved by *Meteor*. IV rests on the foundation prepared in *GC* and, in a smaller measure, in *Meteor*. I-III,[242] and in a way finds its

[241] In Ch. 8 of *Meteor*. IV Aristotle notes that his ambition is to deal with some of the most common material dispositions, that would allow us to differentiate "the great majority of bodies" (*ta…pleista schedon tōn sōmatōn*).

[242] Especially if the two sorts of exhalations responsible for a plethora of meteorological phenomena and for the coming about of various minerals are not to be excluded from the picture outlined in *Meteor*. IV but should be supposed in the background.

fulfillment in works like *PA* II and *GA* V.[243] Exactly how is this fulfillment supposed to be realized?[244]

In the section on 'Division' I tried to convey how Aristotle articulates part of the material that he will deal with again in *PA*.[245] Apparently, in comparison with *PA* II, *Meteor*. IV is centered around the 'what', *ti*,[246] and is concerned with collecting and organizing facts in a generic fashion, whereas *PA* (esp. II 1-9) will account for what uniform stuffs are separately (*kath' hekaston*) by providing the reason why, *dioti*, based, in addition to the analysis of the

[243] Writing about Aristotle's study of the *pathēmata* by which the animals differ (*GA* 77816-18), Lennox (ms. 15) notes that "Perhaps the most sustained and extensive use of explanatory patterns of *Meteor*. IV to be found in the biology is in *GA* V."

[244] Given the overall topic of my dissertation, I have chosen to focus in what follows on *dispositions* as differentiae (in Aristotle's divisions of homeomers) and as signs (of the composition and microstructure of homeomers). Yet, as I noted in Ch. 3, the links with the biological corpus, where we learn quite a bit about concoction (the concoction of blood into other tissues etc.), also include the generic treatment of thermic processes like *pepsis* and *apepsia* in *Meteor*. IV (esp. the second and the third chapters). As Lloyd (in 'The master cook', 83) notes, "'Concoction' (*pepsis*) is used in an amazing variety of contexts throughout Aristotle's natural science and most especially in his zoology, where it must rank as one of his key concepts." The generic discussion in *Meteor*. IV, comprising definitions and examples as well as a division into three species of concoction and three species of incomplete concoction, seems intended to put some order in that "amazing variety".

[245] Düring (1955) and, recently, Lennox (ms.) have made – from different perspectives – groundbreaking contributions to our understanding of how 'indebted' *PA* is to *Meteor*. IV, so I should not attempt to emulate them here. Instead, let me list a few pertinent references to Aristotle's biology, conveniently enumerated by Düring and Lennox: *PA* II: 64620-27; 649a30-34; 650b14-18 (on the material nature of blood and its earthen fibers; we learn from *PA* that, when lacking them, blood does not solidify); 653a22-26 (a passage – dealing with the brain – where the "theories of *Meteor*. IV are used to determine the nature of a uniform part which is never explicitly discussed there", to quote from Lennox). Let me just add a few references to passages in *GA* that are or seem reminiscent of *Meteor*. IV: *GA* II 1.734b25 ff. (on heat and cold as being capable of producing uniform parts with their dispositional differentiae, but not instrumental parts etc.); II 6.743a4 ff., 743a18 ff. (on the agency of cooling and heat); 743a36 ff (same topic, connected with the notion that both material necessity and final causation are at work in the generation of organic homeomers); III 2.753a25 ff. (on the earthy nature of yolk).

[246] Although, *within* Book IV of the *Meteorology*, chemical composition and physical microstructure (along with a host of external and internal factors – thermodynamic and not only) can supply 'the reason why' for the presence and manifestation of dispositional properties.

material constitution of the homeomers, on functional accounts and, implicitly, on final causation (flesh or blood etc. is essentially what it is because it has a *dunamis* oriented towards this or that *ergon*).[247] The text of *Meteor*. IV seems to include important indices in this respect, which evoke the terminology of *APo*. In *Meteor*. IV, for instance at 381b21-23,[248] Aristotle concludes his discussion of concoction and inconcoction by saying: "Then, what concoction is (*ti…esti*) and what inconcoction, and ripeness and boiling and roasting and their opposites [are], has been said." Accordingly, the fourth book of *Meteor*. along with parts of *PA*, may seem to reflect the relationship circumscribed in *APo*. I 13 (*hoti / dioti* in different sciences). In *APo*. I 13, at 78b36 ff., Aristotle points out that, in the case of sciences devoted either to the study of the fact or to the study of the reason why, the former are subordinated to the latter (*thateron hupo thateron*): this is the relationship between optics and geometry, mechanics and solid geometry, harmonics and arithmetic, observation of heavenly bodies and astronomy. Thus, one might assume that 'biochemistry' is subordinated to 'zoology' (or biology), to use two useful anachronisms.

Yet this, I would argue, cannot be so – not in a way that would closely reflect the *APo*. I 13 account in any case. Subordinate sciences, according to *APo*., have a more empirical / less theoretical[249] nature than the corresponding 'supraordinate' ones:[250]

---

[247] See, e.g., the end of *PA* II 5: "We have stated, regarding blood, serum, and soft and hard fat, both what each of them is (*ti*), and owing to what causes (*dia ti*) each of them is." (A passage sounding remarkably like the end of *Meteor*. IV 12.390b15 ff.: *lēpteon kath' hekaston ti estin, hoion ti haima*…)

[248] I am thankful to Professor Lennox for drawing my attention to this passage.

[249] The contrastive pair of terms is: *aisthētikon – mathēmatikon*.

[250] On the priority of some sciences with respect to others, see also *APo*. I 27.87a31-35: "One science is more exact (*akribestera*) than another and prior to it (*protera*) if it is concerned both with the facts (*hoti*) and with the reason why (*dioti*) and not with the facts separately from the science of the reason why; or if it is not said of an underlying subject and the other is said of an underlying subject (as, e.g., arithmetic is more exact than harmonics); or if it proceeds from fewer items and the other from some additional posit (as e.g. arithmetic is more exact than geometry)." For the place of *eidē* in the 'supraordinate' sciences, see *APo*. I 13.

> They possess demonstrations which give the explanations, and often they [i.e. the mathematical scientists] do not know the fact – just as people who study universals do not know some of the particulars through lack of observation.

PA II 1-9 relies massively, for example, on the observation of various types of blood, fat etc., which allows the discernment of their dispositions and, by appeal to *Meteor*. IV, the insight into their material composition, so *PA* II does not appear to be any less empirical than *Meteor*. IV. In fact, *generic* divisions like the ones made in *Meteor*. IV would have to be preceded by and would be perhaps 'more theoretical' or abstract than minute and individual observations made in the course of some biological investigations.

Yet, the one very important respect in which *Meteor*. IV does find itself in a position of subordination with respect to treatises like *PA* II is that *Meteor*. IV speaks at length about the potentials and constitution of uniform stuffs, without, however, giving a full account of their natures. In other words, the material accounts presented in *Meteor*. IV 1-11 provides only a partial grasp of the nature of the homoeomerous bodies, whereas *PA* II significantly completes these accounts by refocusing our attention on the functions fulfilled by the organic homeomers within the more complex structures of which they are constitutive parts. This view is supported, I think, by the passage opening the final chapter of *Meteor*. IV, where Aristotle announces: "Having dealt with these matters, let us proceed to give separate accounts of flesh and bone and the other homoeomerous bodies (*kath' hekaston legōmen ti sarx…*)" (389b23-25). Also, towards the end of the same Ch. 12, where Aristotle anticipates more advanced stages (covering biology) of his overall scientific project, he reasserts a point that he made earlier:

> Knowing, therefore, into which kind each of the homoeomerous bodies fall, we should proceed to describe each of them (*leptēon kath' hekaston ti estin*), giving the definition of blood, flesh, semen and all the rest (*hoion ti haima ē sarx…*). For we know the cause (*dia ti*) and nature (*ti*) of [each] thing when we understand either

> the material (*hulēn*) or formal factor (orig.: *logon*) in its generation and destruction, or best of all if we know both, and also its efficient cause. When we have thus explained the homoeomerous bodies we must similarly examine the anhomoeomerous, and finally the bodies composed from them, such as men, plants and the like (trans. Lee, with slight modif.).

Even if Book IV of the *Meteorology* is subordinate *in this way* to sections of Aristotle's biological works, I hope that my examination of a few prominent topics in the 'chemical treatise' can assure its reader that it should not be relegated anymore to the category of *opera minima*. Had a less propitious tradition handed down to us nothing of Aristotle's 'akroamatic' notes but this treatise on homoeomers, he would still be no negligible figure in the history of Greek science.

VI. FINAL CONCLUSIONS

This brings my account to its final conclusions. My purpose has been twofold throughout this dissertation: to contribute to a better understanding of Aristotle's book on the homeomers (line of argumentation, structure, main functions, methodology, and its main tenets), especially from the perspective of its treatment of *dunameis*, and to offer some new insight into Aristotle's theory of material *dunameis* in general. Let me briefly remind my readers – in more specific terms – what I have tried to achieve in this study.

An investigation of this type should start with some cautious preliminaries. The prolegomena to the main body of my dissertation are clustered around the authorship of *Meteor*. IV. In the course of dealing with this rather elusive issue, I pointed out the somewhat fractured line of argumentation that we can find in that treatise (especially but not only with respect to the place and content of Chs. 8 and 9), the odd ring of certain aspects of the scientific discourse there (e.g. the quasi-absence of an overt scrutiny of reputable opinions), and the definition of the homeomers, which are often taken unqualifiedly to be mixtures, although the text of *Meteor*. IV allows for the thesis that some, in fact quite a few, uniform bodies consist of only one element (likely as a result of some drastic process of separation). My conclusion regarding its Aristotelian authenticity (to which all of these issues are related in evident or indirect ways) is that the text of *Meteor*. IV, and especially the ideas conveyed by it, can be assigned to Aristotle himself. These

preliminaries are crucial in shaping and directing my inquiry into the nature of material dispositions in the chemical treatise and their relevance to other Aristotelian texts.

Unlike, e.g., Charlton, I take the powers of uniform bodies to be properties (rather than simply equating them with matter), a point supported in my view by theoretical Aristotelian texts as well by applied scientific treatises like *Meteor*. IV. The handling of *dunameis* is in keeping there with the *Metaphysics* and *Physics* accounts, although *Meteor*. IV considerably clarifies aspects that, expectedly, were left almost untouched in those more theoretical contexts. I find the relationship between dispositions and categorical properties of special interest; Aristotle is less transparent on this point than one might hope, but we can still tease out from his numerous examples the idea that material dispositions are not coextensive with chemical composition or physical structure. Besides, dispositions are not reducible to their own manifestations either. These two points may appear to be imperiled by the fact that *dunamis* and *pathos* (a term that can refer to actualizations of material dispositions and to categorical features) are sometimes used quasi-synonymously; I have argued that, in fact, *dunamis* and *pathos* stand in such situations for the two complementary facets of the same state (in a relationship similar to that between second potentiality and first actuality). Finally, I have suggested that the manifestations of dispositions can function as *signs* for the natures of homoeomerous bodies, whereas dispositions are *part* of their natures, with the important qualification that the bulk of *Meteor*. IV draws only an incomplete contour of the nature of the organic homeomers (a more complete picture being afforded by some of Aristotle's biological works, where functional / teleological accounts play a dominant role).

My inquiry into what dispositions are is followed by a study of the emergence of dispositional properties, distinct from the qualities of the original ingredients of some uniform

stuff. My emphasis is firmly placed there on the telling limitations of Aristotle's implicit and explicit explanations. I take those limitations (e.g. with respect to the coming about of *poroi* of a particular type, diameter, arranged in a specific way etc.) to be an important aspect of Aristotle's scientific *attitude* (rather than method), as he often settles for probability (according to an overt and generally ignored confession made in the first book of the *Meteorologica*) but is reluctant to push his investigation into the territory of pure and tenuous speculation. My next step was to place the discussion about the emergence of dispositions in a theoretical context. The model offered by *De anima* II 5 (first potentiality // second potentiality/first actuality // second actuality) helped me to give a more precise outline of the program lying at the heart of *Meteor*. IV, which is not concerned only with the division of homeomers, but also, to some extent, with their generation and with their manifestation. I distinguished between first-order *dunameis* (e.g. the disposition of a tissue or an inorganic material to melt or to be solidified under suitable conditions, the kind of *dunameis* dealt with in most of *Meteor*. IV) and second-order *dunameis* (the capacities of the simple parts of an organism to perform specific functions – referred to in the last chapter of *Meteor*. IV), i.e. between a purely material and a chiefly teleological level. The two orders of *dunameis* are intriguingly connected through Aristotle's notion of conditional necessity, I think, in a way that foreshadows passages in his biological works. Yet this is only one of the functions fulfilled by *Meteor*. IV; some of the other functions are captured in my final chapter, on the relevance of dispositions to the scientific method deployed in *Meteor*. IV.

I have claimed that *Meteor*. IV bolsters the position of those scholars who find that there are robust connections between Aristotle's philosophy of science and his more applied scientific treatises. After outlining some of the challenges that Aristotle had to overcome in delineating a virtually new province of science, I tried to demonstrate that observation and inference are put to

work in order to get us from the expected or actual manifestation of material dispositions to the 'invisible', i.e. the composition and structure of uniform stuffs (in a manner that makes Aristotle's formulations easily syllogizable, and that fully reveals the revelatory value of the dispositions, implicitly used as 'middles'). The regular character of the connections between chemical composition or physical structure and corresponding dispositional qualities gave me the opportunity to assess Aristotle's treatment of laws of nature, and to study their types, recurrent structure(s) and scope. Besides the author's lavish use of law-like statements, his method of division contributed to organizing this new field of scientific investigation in a way that would make it profitable for his research in biology (and conceivably forms a significant tool for research in other areas as well, such as mineralogy). The criteria used by Aristotle in his division of homeomers conform (especially with regard to the use of multiple differentiae) to the precepts included in parts of *APo.* and *PA* I. This division is intertwined with and dependent on Aristotle's strategy to take dispositions as points of departure in revealing the composition and structure of uniform materials (since the three chief criteria for division in *Meteor*. IV are: dispositional differentiae, the ratio between the ingredients that formed a particular homeomer through *mixis* etc., and physical peculiarities, such as the presence of a certain type of capillaries or *poroi*). I concluded my fourth chapter with corollaries on two topics that are tackled at earlier points in my dissertation and are directly relevant to Aristotle's scientific method: teleology (which, I argue, may not be *wholly* neglected in Chs. 1-11) and the relationship between *Meteor*. IV and treatises such as *PA* II (this, I claim, is not a relationship of subordination in the strict sense that we find in *APo.*, but a looser sort of subordination, given, among other things, that *PA* II 1-9 provides a firmer grasp on the nature of uniform stuffs, which are considered there from a teleological perspective).

The treatise known today as the fourth book of the *Meteorologica* should be regarded as a remarkable feat by its time's standards and as a privileged vantage point that allows us to contemplate and reevaluate important tenets of Aristotle's natural philosophy, metaphysics and philosophy of science. The long tradition of commentaries on *Meteor*. IV was replaced in modern times by persistent silence. I hope that this research, along with a number of recent studies that inspired it, will signal the revival of a keen interest in the 'chemical treatise.' The growing interest of contemporary philosophers of science in the nature of dispositions can only strengthen this revival.

APPENDIX A

THREE QUALIFICATIONS

These notes are meant to be an addition to my outline, in Ch. 2, of the nature of dispositions in *Meteor*. IV. As I suggested there, among other things, pointing out what material dispositions *are not* can help us see, by contrast, what they *are* (e.g. they are not reducible to categorical properties or to their own manifestations). I would like to continue roughly in the same vein here. I hope it is reasonably clear from my second chapter that the similarities between the *Metaph*. sections on the meanings and aspects of *dunameis* most relevant to change and the status of *dunameis* in *Meteor*. IV are quite substantial. Yet, there are at least three aspects pertaining to the *Metaphysics* theory of *dunameis* that are more difficult to detect in *Meteor*. IV, although they are probably not wholly absent there.

I. *Hēi allo.* Active powers and passive powers can reflect the relationship between completely distinct entities (agents and patients) or they can be sources of change in the same thing *qua other*, and sources of a thing's being changed by itself *qua other*. The notion of a patient and an agent located, so to speak, in the same entity seems applicable chiefly to living beings, most clearly to humans (e.g. an ailing person that heals himself qua doctor). There does not seem to be any place for such duality in the realm of the uniform materials, whether organic

or inorganic, described in *Meteor*. IV. Aristotle makes it clear that "…In so far as a thing is a natural unity (*sumpephukēn*), it cannot be acted on by itself; for it is one and not another [than itself]" (1046a28-9). In another passage in *Metaph*. Θ (5.1048a8-10) he remarks that non-rational potencies[251] produce only one effect each, whereas the rational potencies can produce opposite effects (although not simultaneously, with regard to the same object, and in the same respect).

In such cases, i.e. when taking into account a uniform body in itself, not in its (possible) interactions with other things, the analysis into active and passive could be irrelevant. Therefore, it could not be the case, for instance, even that the natural heat present in uniform bodies – an important explanatory factor in *Meteor*. IV – could act upon them as an active *dunamis* (especially if they happen to be organic and are likely to grow and naturally acquire new properties) somewhat like the doctor's medical skill mustered in the healing of his own ailment.[252]

II. *Meta logou* vs. *alogoi dunameis*. In addition to his tripartite distinction (active powers, passive powers, resistive powers), Aristotle suggests another level of division, according to whether the principles (*archai*) of change are situated in the soul (a topic more amply developed in *De Anima* and in the ethical treatises) and are, more specifically, associated with its reasoning faculty, or whether they are non-rational. (In short: *dunameis meta logou* vs. *alogoi*

[251] See also the next section, on *alogoi dunameis*.

[252] This point can be further illustrated also with a passage in the first part of *De anima* II 5, where Aristotle speaks of the necessity that there be external stimuli, if perception is to occur at all: "It is clear that what is sensitive is so only potentially, not actually. The power of sense is parallel to what is combustible, for that never ignites itself spontaneously, but requires an agent which has the power of starting ignition; otherwise it could have set itself on fire, and would not have needed actual fire to set it ablaze" (417a6-9; trans. Smith).

dunameis).[253] The former type (*meta logou*) is given only short shrift in Δ 12 (esp. 1019a23-6), but Aristotle devotes to it two chapters in Θ (2 and much of 5).

This distinction is only implicit in the substance of *Meteor*. IV, as that text ignores *dunameis* that have to do with intentionality. In Θ 1046a36 ff. material dispositions are regarded as 'unidirectional' (one-way abilities, to borrow a formula from McGuire 1985, 243): the wholesome can only produce health; the hot can only heat, says Aristotle (or, if one is to delve into the more 'specialized' effects of the hot, one might add: it can only dry/solidify this particular stuff, or it can only melt/liquefy that particular stuff; given that opposite effects take place in different bodies, with different sets of passive *dunameis*, this, of course, constitutes no breach of the law of non-contradiction). In short, material dispositions can produce only one effect each, in the right circumstances, whereas each *dunamis* pertaining to the (overarching *dunamis* of) reasoning or to intentionality is equally capable of opposite effects – although not simultaneously or in the same patient. The medical *technē*, for example, can cure and harm,[254] albeit a qualification is necessary here, as it appears: healing and harming, to take the case of the medical art, are not on a par with each other from a conceptual point a view. The priority of the former term (healing) is revealed in the following passage (1046b10-13):

> …Such sciences must deal with contraries, but with one in virtue of their own nature and with the other not in virtue of their nature; for the rational formula (*logos*) applies to one object in virtue of that object's nature, and to the other, in a sense, accidentally.

[253] *Dunameis* pertaining to living beings, especially to humans, can be divided into innate (e.g. senses) and acquired (rational ones), as stated at the beginning of Ch. 5 of □. It might be added that – somewhat similarly – among material *dunameis*, some are a result of the generation of a particular stuff, while others are consequences of various alterations of that body (see esp. Chs. 1-3 of *Meteor*. IV).

[254] It is not always fully clear how comprehensive an area the *dunameis meta logou* are supposed to map (for a detailed and insightful analysis of this issue, see Freeland 1979, esp. section 3 of the first chapter of her dissertation).

Aristotle mentions a basic *dunamis* in the passage that I summarized earlier (Θ 1046a36 ff.) – the hot – but the 'one-way' character of its (possible) effect is also patent in the nature of the *derivative* material dispositions, like solubility: if put in water, salt can only dissolve, rather than explode or change color; by contrast, dispositions involving deliberation are bi-directional: a human being can decide to follow her / his desires or to stem them. Since *Meteor*. IV is strictly the territory of *alogoi dunameis* I have confined my analysis to this class of properties.

III. *Kalōs.* There is also a more special sense in which active and passive *dunameis* can be referred to: in addition to indicating simply powers to act or be acted on, they can signify powers to act or be acted on *well* or in the right way (*kalōs*). The context (*Metaph*. Δ 12.1019a23-26) implies that the scope of this application of *dunamis* is limited to human action or intentionality.

There is, however, a second possible application of 'value-adverbs' ('well', 'badly' etc.)[255] to *dunameis*, that can, as it seems, be extended to powers and processes that do not necessarily involve consciously oriented actions. At 1019a21-23 Aristotle notes that we can call some things capable of undergoing a change, in virtue of their passive powers "and this we do sometimes if it suffers anything at all, sometimes not in respect of everything it suffers, but only if it suffers a change for better (*epi to beltion*)."[256] A few lines further, we are told with regard to *adunamiai* that "the states in virtue of which things are absolutely impassive or unchangeable, or not easily changed for the worse, are called potencies." It seems to me that changes for the better or for the worse can occur in a realm dominated by *alogoi dunameis*, like the ones studied in the

[255] For other instances of use (different from the one discussed here) of such terms in connection with *dunameis / hexeis*, cf. *Metaph*. 9 (actualized good is better than potential good) and the Ethics thesis according to which the instantiation of some virtue is better than a corresponding latent virtuous disposition.

[256] Cf. 1019b1-3, in the discussion of the various senses of *dunaton*: "…and in one sense that which has a potency of changing into something, whether for the worse or for the better…"

Meteorology, for instance, but only if final causation is not entirely removed from the picture. If a vase or a bone (as part of a living organism) is broken, I assume that Aristotle will admit that there is an immediate change for the worse, since the function so far fulfilled / expected to be fulfilled by the vase or the bone is suppressed. If, to consider a few cases where there is virtually no room for teleology (stuffs considered in themselves), a shard of earthenware or a bone (taken separately, not as part of a living organism) is shattered by the impact with a harder object, or an amorphous piece of wax not yet put to any use is melted, that shard or bone or piece of wax will *not* be said to suffer a change for the worse: at issue is not a thing whose *dunamis* to perform some characteristic function would be suppressed or debilitated by that melting or impact.

Aristotle also appears to consider warm 'better' than cold and moist 'better' than dry, maybe because life is associated with the presence of warmth and moisture – in the right proportion.[257] More to the point, however, would be complex *dunameis* corresponding to more complex processes like *pepsis* and its subtypes. *Pepsis* – crucial to the normal development of tissues, for digestion, metabolism and generally for healthy life – has a positive connotation, whereas *apepsia* has an implicit negative one in the first chapters of *Meteor*. IV, as it is an insufficient *pepsis* (and corresponds to absent or insufficient passive powers to be 'ripened', 'boiled' or 'roasted'). Some part of a plant can turn into a fruit and can form seeds (see *Meteor*. IV 3), or can wither or remain atrophied, depending on conditions that might favor or hamper *pepsis*.

[257] For the this 'privileged' condition of hot, moist, cf. *GA* 732b32-34 and *On Length and Shortness of Life* 466a18 ff.

APPENDIX B

ON TWO DISTINCTIONS PERTAINING TO THE TYPOLOGY OF DISPOSITIONS IN *METEOROLOGY* IV

In Ch. 2 I drew attention to the various distinctions that are made or can be made with respect to material dispositions in *Meteor*. IV. Let me add here a few observations on two of those distinctions, which have not received sufficient attention in recent scholarship.

Essentially perceptible dispositions vs. 'more intrinsic' dispositions. The distinction is between dispositions that should be defined essentially by appeal to sense-perception (that is, whose actualization depends on perception; cf. *De anima* III 2.426a15-26) and dispositions whose ontological status does not hinge on perception. Among the latter, in *Meteor*. IV, one can cite squeezability and fragmentability. Of course, we experience them through our senses, but they (and their actualization) are quite independent of our sense-perception. Among the former are hard and soft, which, rather surprisingly[258] are not defined simply as (in)compressibility or 'resistence to disintegration':

> Degrees of hardness and softness are indefinable with relation to each other; but since we judge all sensible qualities by sensation, it is clear that both hard and soft are defined absolutely with reference to touch, which we use as a mean [*mesotēs*] saying that

[258] Since in *Categories* 8.9a25-28 Aristotle adopted a different take on this than in *Meteor*. IV: "We predicate hardness of that which resists disintegration and softness of that which does not."

> what exceeds it is hard and what falls short of it is soft (*Meteor*. IV 4.382a16-21).

The *Categories* may come in contrast to *Meteor*. IV on this point, but Plato's *Timaeus* 62c ff., for instance, is in agreement with the 'chemical treatise': "Soft is whatever yields to our body, hard whatever does not" – and the same goes there for: heat / cold; heavy / light; smooth / rough (very briefly). This, by the way, seems to be a sort of standard list of dispositional qualities in Plato's *Timaeus*, Aristotle's *GC* etc.

Aristotle quite transparently makes this distinction (namely: between dispositions whose condition depends on our sense-perception and those that do not) in a passage where he fleetingly mentions senses other than touch (along with touch):

> …All these bodies differ from each other, firstly, in the particular ways in which they can act on the senses (for a thing is white, fragrant, resonant, sweet, hot or cold in virtue of the way it acts on sensation), and, secondly, in other, more intrinsic [*oikeioterois pathesin*] qualities commonly classed as passive [*tōi paschein*] – I mean soluble, solidifiable, flexible and the like, all of which, like moist and dry, are passive qualities [*pathētika*] (*Meteor*. IV 8.385a, 1-11; trans. Lee with modifications; cf. 388a10).

On the notion of 'mean' in connection with perception, see *De Anima* II 11.424a2-8:

> …What we perceive must have a degree of the sensible quality lying beyond the neutral point. This implies that the sense itself is a 'mean' between any two opposite qualities which determine the field of that sense. It is to this that it owes its power of discerning the objects in that field. What is 'in the middle' is fitted to discern…

As for *oikeioterois*, "more intrinsic", in Ch. 8 of *Meteor*. IV, it signals that perception is less important in those cases (like the list of eighteen *dunameis* and their corresponding incapacities, in Chs. 8-9) and the emphasis is moved onto the properties that bodies have *in natura* and are not to be defined in terms of perception. Conversely, as I have already noted, perception plays a

crucial role when it comes to hard / soft (the 'first' among secondary properties) as well as colors, tastes, fragrance, and the four basic *dunameis*. Finally, let me note the 'supremacy' of touch among senses in *Meteor*. IV, in a way that is somewhat comparable with *GC* (see Joachim 204, on *GC* 329b18-20: "All qualities defined in this chapter… are defined by reference to perception. Thus, e.g., hard and soft are the incompressible and compressible estimated by our sense of touch, not the absolutely impenetrable and its contrary." Cf. *GC* 329b17: *prōtai diaphorai – haphē*).

'Chemical' vs. 'physical' dispositions. This distinction is indeed possible sometimes for readers of *Meteor*. IV, but should be made with due caution. By chemical dispositional properties I mean properties that can be accounted for in terms of the effect of heat and cold upon the 'chemical' composition of some homogeneous stuff and the ratio between its ingredients (example of 'chemical' property: meltable / non-meltable; e.g., stuffs that do not contain water or contain very little water, like salt or earthenware, are not meltable). By 'physical' dispositional properties, like fissile or splittable etc. (usually involving mechanical action / tension / pressure) I mean properties that can be explained primarily (but probably not exclusively) by recourse to the physical structure of solids, such as the diameter of the *poroi*,[259] the grouping and distribution of the *poroi* (uniformly or by fascicles) and their position (longitudinal, etc.), or their degree of hardness – many of the examples offered in Chs. 8 and 9 being good illustrations of such features. I should note, however, that properties like 'displaying a certain type of *poroi'* depend ultimately on the genesis and 'chemical' composition of uniform

[259] Of course, Aristotle does not offer any measurements or calculation, but is content to note that the *poroi* of a particular sort of uniform body is sufficiently small to prevent water from penetrating it, or is sufficiently large to allow this to happen etc.; see Chs. 8 and 9.

stuffs – so this distinction can appear quite blurred in the end. To take an example, in his brief section on 'softenable by water', at 385b20 ff., Aristotle notes that: "Anything which is earthy ['chemical aspect] and has pores larger than the particles of water and harder than water ['physical' aspect] can be softened by water. But bodies that can be dissolved by water are porous throughout."[260]

[260] See also Düring, p. 16, on this distinction.

APPENDIX C

ACTIVE DERIVATIVE DISPOSITIONS

The corresponding distinction between active and passive at the level of derivative dispositional properties has, somewhat surprisingly, far less weight in the economy of *Meteor*. IV. Surprisingly because *Meteor*. IV is supposed to embrace a huge array of dispositions that, according to Ch. 8, are shared by the great majority of homeomers. Yet, virtually all derivative material dispositions discussed at any significant length are passive (soft, meltable, boilable etc.). It is only at the beginning of Ch. 10 and, more notably, in the first part of Ch. 8 (385a1-4) that we find mentions of perceptible qualities, which, although often called *pathētikai dunameis* in Aristotle's works (somewhat curiously because they induce *pathē*, i.e. our senses 'suffer' some effect as a result of those stimuli), are of course active.[261] The catalogue of eighteen properties and their opposites discussed in Chs. 8 and 9 pose peculiar problems[262] and it is not entirely clear whether they are a revision maybe of another list that initially gave more emphasis to active,

[261] "All these bodies differ from each other, firstly, in the particular ways in which they can act on the senses (for a thing is white, fragrant, resonant, sweet, hot or cold in virtue of the way it acts on sensation), and, secondly, in other more intrinsic qualities commonly classed as passive – I mean solubility, solidification, flexibility and the like, all of which, like moist and dry, are passive qualities" (385a1-8).

[262] See my chapter (I) on the structure and authorship of *Meteor*. IV.

perceptible qualities (this would make the first part of Ch. 8 and, even more, the beginning of Ch. 10 more meaningful).[263]

Still, as things are in the extant text of *Meteor*. IV, very little is said about *active derivative* dispositions. I would explain this by drawing attention to the overarching purpose of this book. One of the main achievements of Aristotle in *Meteor*. IV is a generic division of *ta homoiomerē* focusing on causal differentiae. In such a division, to say that uniform bodies are divisible into red, yellow, white ones etc., or into stuffs that taste bitter and stuffs that taste sweet would have been of little use. Such distinctions, however, can prove important in a very detailed division of a particular class of *homoiomerē*, for example in a discussion about blood – which is not red in some species. Also, in a treatise on mineralogy dealing, say, only with rocks or only with metals, one might want to provide more complete lists of specific active dispositions, like the power of certain stones to attract pieces of metals – and Theophrastus, for instance, does mention this in his *De lapidibus*. *Meteor*. IV, however, is not concerned in detail with just one type of uniform bodies. Finally, Aristotle could have mentioned some of the active 'powers' of milk or honey or of other stuffs that can play, for instance, a therapeutic role (in the Hippocratic treatises[264] there is no shortage of such examples),[265] but, again, *Meteor.* IV is not the place for illustrations of this kind.

[263] There is at least one important passage elsewhere, in Ch. 4 (382a16-21) brings up the connection between a pair of material dispositional properties (hardness – softness) and touch, but the emphasis is *not* on the fact that soft and hard bodies alike can affect our senses; rather it is on the fact that certain bodies can be compressed or can resist compression and the only way of establishing their degree of 'compressibility' is by using our tactile capacity. The passage, nonetheless, is rather baffling, as Aristotle could have just dealt with hard and soft purely in terms of compressibility as he seems to do in *Categ*. 8.

[264] See, among other passages, *On Ancient Medicine* 22: "…salty and bitter, sweet and acid, astringent and insipid…". Cf., for a partial parallel, Plato's *Timaeus* 61d-62b.

Besides, I think one can also account for the fact that *derivative* active powers are upstaged by the passive ones in *Meteor*. IV for the following reason. We have seen from the *Metaphysics* that any passive power entails the thought of a corresponding active power (which has thus intuitive and conceptual priority over the passive one). Naturally, the list of eighteen passive *dunameis* in Chs. 8-9 (as well as in other chapters, e.g. *hepsēton*, "boilable") evoke the thought of corresponding active powers. Aristotle does mention the (basic) active power of heat to liquefy or to combine or to lead to various types of concoction and partial concoction in other chapters (e.g. 1, 2-3, 5-7). Yet, in Ch. 9, in the section on "combustible / incombustible" (*kauston / akauston*), a derivative disposition, not much is said about the corresponding active power (*to kaustikon*, I take it). The same goes for the other passive powers listed there (the sections on breakable, malleable, squeezable etc. do not include clearly delimited segments devoted to the corresponding active powers and examples of materials or things that may exhibit such active powers – whereas the passive powers are accompanied sometimes by lavish illustrations). One of the reasons for this imbalance must be that the 'mechanics' of the passive powers can be easily converted into descriptions (albeit maybe incomplete ones) of the corresponding active powers. If combustibility is a disposition accompanying and emerging from a certain 'chemical composition' (predominance of earth) and physical structure (longitudinal *poroi* pervading a body in its entirety – *Meteor*. IV.9, 387a18 ff.), the active power of setting ablaze can be described as the power to penetrate the longitudinal *poroi* of a body that consists mostly of earth etc. Now, one should acknowledge, nonetheless, the insufficiency of such an implicit definition (easy though it might be to reconstruct, based on the description of an opposite, passive power): we do not learn, in the course of such a reconstruction, just what leads to the instantiation of that

[265] Aristotle mentions the effect of warm baths on digestion in Ch. 1, but there it is a basic, not a derivative *dunamis*, heat, that is at issue.

active power in a certain body in the first place. Even so, Aristotle may have felt that enough was said about derivative active powers in the course of his dealing with derivative passive powers there and that, accordingly, there was no need to treat the former in a similar list. Finally, it is also *possible* (one should not look for a definitive proof in this regard) that some of the corresponding active powers (e.g. corresponding to malleable – *elaton* and fissile – *schiston*) can be found not simply in the nature of uniform stuffs, but in how they are handled in contexts involving *technē*.

APPENDIX D

RESISTIVE POWERS IN *METEOROLOGY* IV

Understanding the philosophical importance of the notion of resistive powers can be hampered, I think, by a certain linguistic ambiguity. In what follows I will attempt to prevent such confusion. From *Metaph*. Θ (1, 1046a13-14) we learn that *dunamis* can be sometimes equated with persistence, endurance (or impassibility: *apatheia*), "a state of insusceptibility to change for the worse and to destruction by another thing or by the thing itself qua other by virtue of an *archē* of change."[266] In *Metaph*. Δ (12.1019a26-32) Aristotle writes similarly that

> The states (*hexeis*) in virtue of which things are absolutely impassive (*apathē*) or unchangeable (*ametablēta*), or not easily changed for the worse, are called potencies; for things are broken or crushed and bent and in general destroyed not by having a potency but by not having one and by lacking something, and things are impassive with respect to such processes if they are scarcely and slightly affected by them, because of a 'potency' and because they 'can' do something and are in some positive state.[267]

Numerous examples of 'resistive' powers are invoked in *Meteor*. IV, especially in Chs. 8 and 9 (uncuttable, unmeltable, uninflammable etc.); these powers are called collectively *adunamiai* rather than *dunameis*. What may complicate a discussion about the status of resistive powers in

[266] In *Categ*. 8, *adunamiai* are more simply defined as the lack of corresponding *dunameis*.

[267] Cf. *Metaph*. 1046a29-35.

Meteor. IV is that they are referred to as *adunamiai*, rather than *dunameis*, and *adunamiai* might seem to point to the sheer lack of some power rather than to the presence of a resistive power, especially given passages such as this one, in *Metaph*. Δ 12.1019b15-21:

> Incapacity is privation of capacity (*adunamia de esti sterēsis dunameōs*) – i.e. of such a principle as has been described – either in general or in the case of something that would naturally have the capacity, or even at the time when it would naturally already have it; for the senses in which we should call a boy and a man and an eunuch 'incapable of begetting' are distinct.[268] – Again, to either kind of capacity there is an opposite incapacity – both to that which only can produce movement and to that which can produce it well.

Despite that definition of *adunamia* as privation of a *dunamis*, and despite the fact that eighteen properties are called *adunamiai* in *Meteor*. IV, I would argue that what Aristotle calls *adunamia*[269] in Book IV of the 'chemical treatise' is occasionally much the same as the third type of *dunamis* ('resistive power') in *Metaph*. Δ and Θ, rather than *simply* sheer lack of a certain quality, as in this passage. Chapters 8 and 9 of *Meteor*. IV abundantly exemplify this sense of *adunamia*. As I have already pointed out, Ch. 8 lists eighteen (passive) derivative dispositional properties: solidifiable, meltable, softenable, flexible, breakable, fragmentable etc. accompanied by their opposites: unsolidifiable, unmeltable, unsoftenable etc. For example, *adunamia* can sometimes be rather than, say, fragility, as in the *Metaph*. Δ passage, the very opposite of fragility, namely resistance to breaking.[270] In other words, *adunamia* (or *apatheia* – in the technical sense of 'insusceptibility to change') can sometimes denote the third major type of

[268] It seems to me that *adunamia* can be conceived of in different ways not only in the case of substances (see Aristotle's example in my quote from Δ 12), but also in connection with uniform stuffs; steel and certain stones are unfragmentable, but then so is water or milk, for different reasons, however.

[269] The term occurs at 385a11.

[270] See *Meteor*. IV 9.386a9-17 on *katakton / akatakton, thrauston / athrauston*.

dunamis (resistive power) as well, although, of course, one can also say that 'unbreakable' marks the opposite of and the absence of a passive *dunamis* like 'breakability' or 'fragility'. However, such an absence is not comparable to a pure and simple *sterēsis*,[271] as in the case of an unmusical man (and the dissimilarity goes farther: while an unmusical man can under normal circumstances become musical, a body that has one of the *adunamiai* listed in Ch. 8 is not normally expected to assume the corresponding *dunamis*, given various material, 'categorical' constraints). His unmusicality simply amounts to the lack of a certain quality, whereas an *adunamia* like unfragmentability is at the same time an *absence* (of the opposite of that *dunamis*) and the *presence* of a *dunamis* (resistance to a particular type of physical shock). True enough, such an *adunamia* does reflect, at a 'categorical' level, the absence of certain features (a particular type of *poroi* disposed in this or that fashion and distributed through a body in a certain way – see, e.g., 386a15-17), but that absence is offset by the *presence* of other physical features that account for that unfragmentability or whatever may be the *adunamia* at issue.

Let me add that, unlike the actualization of a passive power, that of a resistive power is not accompanied by its suppression. Thus in *De an*. II 5 Aristotle elaborates his thought that the realization of a potentiality can mean not only e.g. the gradual transition from one's being potentially in good command of grammar (when he is not yet, but has the right nature to become so) to being actually in good command of grammar, but also from his being a potential user of that knowledge to actually using it. He goes on to note that:

[271] On the various semantic values of *sterēsis* in Aristotle, see the *Metaph*. at1046a31-5: "Privation has several senses; for it means (1) that which has not a certain quality and (2) that which you might naturally have it but has not it, either (a) in general or (b) when it might naturally have it, and either (A) in some particular way, e.g., when it has not it completely, or (B) when it has not it at all. And in certain cases if things which naturally have a quality lose it by violence, we say they have suffered privation."

> …The expression 'to be acted upon' has more than one meaning; it may mean either the extinction of one of two contraries by the other, or the maintenance of what is potential by the agency of what is actual and already like what is acted upon, with such likeness as is compatible with one's being actual and the other potential (417b3-7).

The point made here is that the latter actualization is not an alteration (like the former), just as when we attempt to break a diamond with something that happens to be less hard than a diamond and do not succeed in our attempt, and no alteration ensues, but rather the diamond has in a way (instantaneously) actualized its unbreakability during that impact.

In my opinion, from studying the list in Ch. 8 of *Meteor*. IV, one of the reasons for Aristotle's calling the eighteen opposites *adunamiai* may be of linguistic nature. Elsewhere (e.g. *Metaph*. Z 7.1033a13-14) he repeatedly complains about the sheer lack of names for certain stuffs, processes, species. In the case of the eighteen opposites, he forges the appropriate names by attaching privative suffixes to verbal adjectives. Unsolidifiable, *apēkton* (e.g., oil, quicksilver, pitch – 385b4-5), is maybe an awkward but convenient and necessary choice of a name for the opposite of solidifiable, *pēkton*. It was only fitting that the heading itself for these eighteen resistive powers, *a-dunamiai*, contained that privative suffix. Had there been specific names for the eighteen opposites, it is likely that he would have called them *dunameis* as well (perhaps *antikeimenai dunameis*).

BIBLIOGRAPHY

Ackrill, JL. 1978 repr. trans. notes. *Aristotle's Categories and De Interpretatione*. Oxford.

Armstrong, D. M., Martin, C. B. and Place, U. T. 1996. *Dispositions – A Debate*. Ed. Tim Crane. London and New York.

Balashov, Y. and Rosenberg, A. eds. 2002. *Philosophy of Science. Contemporary Readings*. London and New York.

Balme, D. M. 1965. *Aristotle's Use of Teleological Explanation*. London.

Balme, D. M. 1972 *De Partibus Animalium I and De Generatione Animalium I (with passages from II. 1-3)*. Trans. and notes. Oxford.

Balme, D. M. 1987b. 'Aristotle's use of division and differentiae', in Gotthelf and Lennox eds. 1987, pp. 69-89.

Balme, D. M. 1991. *Aristotle – Historia Animalium*. Books VII-X. ed. trans. (prepared for publication by A. Gotthelf) Cambridge, MA and London.

Balme, D. M 2002. Aristotle – *Historia Animalium*. Vol. I – Books I-X: Text. (prepared for publication by A. Gotthelf). Cambridge.

Barnes, J. trans., comm. 1982 (1999, 2nd ed.). *Aristotle. Posterior Analytics*. Oxford.

Berti, E. ed. 1981. *Aristotle on Science: The Posterior Analytics*. Padova.

Bogen, J. and McGuire, J. E. 1986-7. 'Aristotle's Great Clock: necessity, possibility and the motion of the cosmos in *De Caelo* I.12', in the *Philosophy Research Archives*, Vol. XII, pp. 387-448. .

Bolton, R. 1976. 'Essentialism and semantic theory in Aristotle: *Posterior Analytics*, II, 7-10', in *The Philosophical Review*, LXXXV, 4, pp. 514-44.

Bolton, R. 1991. 'Aristotle's method in natural science: *Physics* I', in Judson, 1991, pp. 1-30.

Bonitz, H. 1955 (repr.). *Index Aristotelicus*. Graz.

Boudouris, K. J. ed. 1999. *Philosophy and Medicine*. Vol. II. Alimos.

Broadie, S. 1990. 'Nature and art in Aristotelian teleology', in Devreux and Pellegrin eds. 1990, pp. 389-404.

Busse, A. ed. 1902. *Olympiodori In Aristotelis Meteora Commentaria*. *Commentaria in Aristotelem Graeca*, Vol. XII. Berlin.

Carroll, J. W. ed. 2004. *Readings on Laws of Nature*. Pittsburgh.

Charlton, W. 1987. 'Aristotelian powers', in *Phronesis* XXXII, 277-89.

Claghorn, G. S. 1954. *Aristotle's Criticism of Plato's Timaeus*. The Hague.

Cleary, J. J. and Shartin, D. C. eds. 1989. *Proceedings of the Boston Area Colloquium in Ancient Philosophy* – Vol. IV. New York and London.

Cohen, S. M. 1996. *Aristotle on Nature and Incomplete Substance*. Cambridge.

Collingwood, R. G. 1964 (repr.). *The Idea of Nature*. Oxford.

Cooper, J. M. 1987. 'Hypothetical necessity and natural teleology', in Gotthelf and Lennox 1987, pp. 243-74.

Cooper, J. M. manuscript: 'Method and Science in *On Ancient Medicine*', prepared for the Princeton Classical Philosophy Colloquium.

Coutant, V. C. B. (Ph.D. Dissertation) 1936. *Alexander of Aphrodisias: Commentary on Book IV of Aristotle's* Meteorologica. (Columbia University).

Devereux, D. T. and Pellegrin, P. eds. 1990. *Biologie, logique et métaphysique chez Aristote.* Paris.

Düring, I. trans. and comm.1980 (repr.). *Aristotle's Chemical Treatise* Meteorologica*, Book IV*. New York and London.

Eicholz, D.E. 1965. *Theophrastus – De lapidibus*. Oxford.

Fobes, F. H. ed. 1967. *Aristotelis Meteorologicorum libri quattuor*. Hildesheim.

Foster, K. and Humphries, S. 1951. *De anima, in the version of William of Moerbeke; and The commentary of St. Thomas Aquinas***.** New Haven.

Freeland, C. A. (Ph.D. Dissertation) 1979. *Aristotle's Theory of Actuality and Potentiality*. University of Pittsburgh.

Freeland, C. A. 1987. 'Aristotle on bodies, matter, and potentiality', in Gotthelf and Lennox, pp. 392-407.

Freeland, C. A. 1990. 'Scientific explanation and empirical data in Aristotle's *Meteorology'*, in Devreux and Pellegrin, pp. 287-320.

Freudenthal, G. 1995 (repr. 1999). *Aristotle's Theory of Material Substance – Heat and Pneuma*. Form and Soul. Oxford.

Furley, D. 1989a. *Cosmic Problems: Essays on Greek and Roman Philosophy of Nature*. Cambridge.

Furley, D. 1989b. 'The mechanics of Meteorologica IV: a prolegomenon to biology', in Furley 1989a, pp. 132-48.

Furley, D.J. and Allen, R.E. 1970, 1975. *Studies in Presocratic Philosophy*. London and New York. Vols 1-2.

Furth, M. 1988. *Substance, Form and Psyche – An Aristotelian Metaphysics*. Cambridge.

Gassendi, P. 1959. *Dissertations en forme de paradoxes contre les aristotéliciens*. (Rochot, B. Ed. Trans). Paris. 1959.

Gill, M. L. 1989. *Aristotle on Substance: The Paradox of Unity*. Princeton.

Gill, M. L. 1991. 'Aristotle on self-motion', in Judson 1991, pp. 243-65.

Gill, M. L. 1997. 'Material necessity and *Meteorology* IV 12', in Kullmann and Föllinger eds. 1997, 145-62.

Gill, M. L. manuscript: 'The limits of teleology – Aristotle's *Meteorology* IV. 12'.

Gill, M. L. 2003. 'Aristotle's Distinction between Change and Activity'. In J. Seibt (ed.), 3-22.

Gill, M. L. manuscript: 'The theory of the elements in *De Caelo* III and IV'

Goodman, N. 1955. *Fact, Fiction and Forecast*. Cambridge, MA.

Gotthelf, A. 1987a. 'First Principles in Aristotle's *Parts of Animals*', in Gotthelf and Lennox eds. 1987, pp. 167-98.

Gotthelf, A. 1987b. 'Aristotle's Conception of Final Causality', in Gotthelf and Lennox eds. 1987, pp. 204-239.

Gotthelf, A. and Lennox, J. G. eds. 1987. *Philosophical Issues in Aristotle's Biology*. Cambridge.

Gotthelf, A. 1987. 'Aristotle's conception of final causality', in Gotthelf and Lennox eds., 204-242.

Gottschalk, H. B. 1961. 'The authorship of *Meteorologica*, Book IV', *The Classical Quarterly*, 67-79.

Hamlyn, D.W. trans. notes. *Aristotle's De Anima, Books II and III (with certain passages from Book I).* Oxford.

Harré, R. 1993. *Laws of Nature*. London.

Hicks, R.D. 1965. trans. notes. *Aristotle – De anima*. Amsterdam.

Horne, R. A. 1966. 'Aristotelian chemistry', *Chymia* XI, 21-7 (repr. in Seeck 1975, pp. 339-47).

Joachim, H. H. 1904. 'Aristotle's conception of chemical combination', Journal of Philosophy XXIX, 72-86.

Joachim, H. H. 1926 (ed. comm., repr. 1999). *Aristotle on Coming-to-Be and Passing-Away*. Oxford.

Johansen, T. K. 2004. *Plato's Natural Philosophy – A Study of the Timaeus – Critias*. Cambridge.

Jouanna, J. 1999. *Hippocrates*. Baltimore and London.

Judson, L. ed. 1991a. *Aristotle's Physics. A Collection of Essays*. Oxford.

Kuehlewein, H. ed. 1894 sqq. *Hippocrates – Opera omnia*. Leipzig.

Kullmann, W. 1990. 'Bipartite science in Aristotle's biology', in Pellegrin and Devereux eds., pp. 335-47.

Kullmann, W. and Föllinger S. eds. 1997. *Aristotelische Biologie*. Stuttgart.

Lee, H. D. P. ed. and trans. 1952. *Aristotle – Meteorologica*. Cambridge, MA and London.

Lennox, J. G. 1989. 'Commentary on Sorabji's "The Greek Origin of the Idea of Chemical Combination"', in Cleary and Shartin, pp. 64-75.

Lennox, J. G. 2001a. *Aristotle's Philosophy of Biology – Studies in the Origins of Life Sciences*. Cambridge.

Lennox, J. G. 2001b (repr.) 'Divide and explain: The *Posterior Analytics* in Practice', in Lennox 2001a, 7-38.

Lennox, J. G. 2001c (trans. comm.). *Aristotle – On the Parts of Animals*. Oxford.

Lennox, J. G. 2001d. 'The place of biology in Aristotle's natural philosophy', prepared for the Princeton Classical Philosophy Colloquium.

Lennox, J. G. 2001e. 'Aristotle on the unity and disunity of science', in *International Studies in the Philosophy of Science*, Vol. 15, no. 2, pp. 134-144.

Lennox, J. G. manuscript: 'Aristotle on the emergence of material complexity: *Meteorology* IV, 1-11' 1-20 ms.

Lenoble, R. 1969. *Esquisse d'une histoire de l'idée de nature*. Paris.

Lewis, E. trans. 1996. Alexander of Aphrodisias: On Aristotle's *Meteorology* IV. Ithaca and London.

Lindberg, D. C. ed. 1978. *Science in the Middle Ages*. Chicago.

Lloyd, G. E. R. 1970. *Early Greek Science: Thales to Aristotle*. New York, London.

Lloyd, G. E. R. 1996. *Aristotelian Explorations*. Cambridge.

Longrigg, J. 1993. *Greek Rational Medicine: Philosophy and Medicine from Alcmaeon to the Alexandrians*. London.

Martin, C. (Ph.D. Dissertation) 2002. *Interpretation and Utility: The Renaissance Commentary Tradition on Aristotle's Meteorologica IV*. Harvard.

McKeon, R. ed. 1966. *The Basic Works of Aristotle*. New York.

McGuire, J. 1985. 'Philoponus on Physics ii 1: Φυσις, Δυναμις, and the motion of the simple bodies', *Ancient Philosophy* V 2, 241-67.

Multhauf, R. P. 1978. 'The Science of Matter', in Lindberg, ed., pp. 369-90.

Mumford, S. 1998. *Dispositions*. Oxford.

Peck, A.L. trans. 1963. *Aristotle – Generation of Animals*. Cambridge, MA and London.

Pepe, L. 1979. 'A proposito del quarto libro dei Meteorologica di Aristotele', in Atti di Scienze Morali e Politiche. LXXXIX, pp 503-523. Napoli.

Pepe, L. 1982. *Meteorologica*.Trans. notes. Napoli

Pepe, L. 2002. 'Motivi centrali del IV libro dei Meteorologica e differenze rispetto ad altre opera aristoteliche', in Cristina Viano ed., pp. 59-79.

Plamböck, G. 1964. *Dynamis im Corpus Hippocraticum*. Mainz.

Popper, K. 1970. 'Back to the Presocratics', in Furley and Allen eds. (vol. I), pp. 130-53.

Reeve, C.D.C. 2000. *Substantial Knowledge*. Indianapolis and Cambridge.

Rodier, G. trans. notes. 1964 repr. *Aristote: traité de l'âme*. Dubuque, IA.

Ross, W. D. ed. comm. 1924 (repr. 1997). *Aristotle's Metaphysics*. Vols. I-II. Oxford.

Ross, W D. ed. comm. 1936 (repr. 1998). *Aristotle's Physics*. Oxford.

Ross, W. D. ed. comm.. 1961 (repr. 1999). *Aristotle – De Anima*. Oxford.

Ross, W D. trans. (1966 repr.). Aristotle's *Metaphysics*, in McKeon ed. 1966.

Sarton, G. 1960. *A History of* Science. Vol. I: Ancient Science through the Golden Age of Greece. Cambridge, MA.

Seeck, G. A. ed. 1975. *Die Naturphilosophie des Aristoteles*. Darmstadt.

Seibt, J. (ed.) 2003. *Process Theories: Crossdisciplinary Studies in Dynamic Categories*. The Netherlands.

Smet, A. J. ed. 1968. *Alexandre d'Aphrodisias – Commentaire sur les Météors d'Aristote*. Traduction par Guillaume de Moerbeke. Louvain and Paris.

Solmsen, F. 1960. *Aristotle's System of the Physical World – A Comparison with His Predecessors*. Ithaca, NY.

Sorabji, R. 1981. 'Definitions: why necessary and in what way?'. In Berti ed. 205-244.

Souilhé, J. 1919 (repr. 1987). *Étude sur le terme δυναμις dans les dialogues de Platon*. New York and London.

Staden, H. von, 1999. 'Dynamis: the Hippocratics and Plato', in Boudouris 1999, pp. 262-79.

Taub, L. 2003. *Ancient Meteorology*. London and New York.

Thom, R. 1990. 'Homéomères et anhoméomères en théorie biologique d'Aristote à aujourd'hui', in Devereux and Pellegrin eds., 490-511.

Tuomela, R. ed. 1978. *Dispositions*. Dordrecht and Boston.

Viano, C. ed. 2002. Il quarto libro dei 'Meteorologica' nella tradizione antica e medievale. Sankt Augustin.