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From Food to Elements and Humors

Digestion in Late Renaissance Galenism

Abstract: In late Renaissance medicine, the example of digestion was frequently invoked to prove the elemental composition of the human body. Food was considered as being decomposed in its first elements by the stomach, and digested into a thick juice which is assimilated by the liver and the body parts. Such a process points to the structure of the human body into four elements that are transformed into different types of humors during several stages of “concoction”. This chapter examines the Galenic interpretation of digestion expounded by the French physician Jean Fernel (1497–1558) in his *Physiologia* (1567). In this treatise, Fernel states the body composition into elemental portions, while stressing the role of the “innate heat” as the physiological counterpart of the body’s essence or “substantial form”. He applies this view in his account of digestion, where he states that the conversion of food follows the rule of “mixture”. This chapter aims to explore how Fernel applies his interpretation of elements and innate heat to the process of digestion, as well as his sources in Galen’s *De facultatibus naturalibus*, Avicenna’s *Canon*, and Aristotle’s *Meteorologica*. It first examines the role of the natural soul and its “nourishing” faculties in nutrition as a physiological function. It then considers the role of elements, humors and innate heat during the “concoction” of food in the stomach, liver and veins.

1 Introduction

In the early modern period, the theme of nutrition pervaded all theoretical and practical branches of medicine. The functioning of the digestive system was studied in physiology, while its malfunctions and diseases were examined in pathology. Therapeutics prescribed numerous alimentary remedies to facilitate digestion and cure sicknesses, while dietetics advised the most adapted regimen to preserve health. Semiotics as the study of medical “signs” and symptoms considered urine as a major indication of a healthy or sick temperament. However, despite the wide scope of nutrition in the early modern medical disciplines, most of the historical surveys on this theme have been concentrated on dietetics and therapeutics, by exploring the various regimens and treatments based on herbs, spices and other food-based drugs (Gentilcore 2015; Albala 2002; Margolin

and Sauzet 1982; Giacomotto-Charra and Vons 2017). It is mostly from the viewpoint of alchemy and Paracelsianism that the recent research has examined nutrition as a process of food digestion and assimilation (Clericuzio 2012; McKee 1998; Temkin 2002, p. 180–194). In this perspective, early modern alchemists have been considered as putting forward the body's chemistry, in particular the processes of coagulation and fermentation as well as sensory qualities like colors and flavors. Although these themes emerged in early medical and natural philosophy, they have received little attention from the historians, except for the medieval period (Jacquart 2006; Lyndon Reynold 1999; Cadden 1980). This chapter aims to fill this gap by exploring the early modern reception of the Galenic theory of digestion in a major treatise on theoretical medicine: the *Physiologia* of the French physician Jean Fernel (c. 1497–1558). Centered on the structure and functioning of the healthy body, this treatise is part of a broader work, the *Universa medicina* (1567), which is divided in physiology, pathology, therapeutics, and the study of hidden or “occult” causes.¹ As a concise and systematic account of Galenic medicine in a humanist framework, it was widely read by early modern physicians and saw multiple re-editions throughout the seventeenth century (Kany-Turpin 2002; Henry and Forrester 2003 and 2005).

In his works, Fernel aims to combine Galenic medicine and Aristotelian physics with Platonic philosophy in order to enhance the divine origin of life and the soul. Such a framework has been explored in the history of medicine concerning Fernel's theory of seeds, “occult” qualities and diseases of the “total substance” in his treatise *On the Hidden Causes of Things* [*De abditis rerum causis*] (1546) (Hirai 2011, p. 46–79; Deer Richardson 1982; Blank 2010). Interestingly, Fernel's interpretation also applies to his account of physiological functions, above all nutrition. Along the lines of the Galenic and Aristotelian tradition, he considers nutrition as a vital function which is operated by the soul. The latter accomplishes the physiological functions by means of a vital principle that has a celestial origin: the body's “innate heat”. This principle thus points to the celestial facet of nutrition as a vital process connected to the soul.

While nutrition is a physiological function related to the soul and innate heat, it is also connected to the body composition in elements and humors. Fernel follows the medical tradition by stating that food is composed of the four elements (air, water, earth, fire) and that the digestion of food produces the four humors. During this process, the elements and their primary qualities within food are decomposed and assimilated into blood (hot–moist), yellow bile (hot–dry), phlegm (cold–moist), and black bile or “melancholia” (cold–dry).

1 Fernel, *Physiologia*. I am referring to the edition and translation by Forrester (2003).

As the balance or imbalance of these qualities and humors determine the state of health, the digestion of food is a key process in the body's physiology.

In this perspective, this chapter examines Fernel's explanation of digestion from two main angles. First, it looks at his application of the Aristotelian theory of elements to digestion as a transformation of nutrimental matter. Second, it appraises the influence of Platonic philosophy on his interpretation of nutrition as a vital function directed by the soul, in particular its relation to "occult" qualities and the body's "total substance". Third, this chapter explores the "concoction" of food as a process of coagulation and fermentation. As will be argued, Fernel develops these three themes by synthesizing the philosophy of Galen, Aristotle, and Avicenna. For his synthesis of medieval Latin-Arabic texts in the light of ancient sources, he proves to be emblematic of the current of Renaissance medical humanism (McVaugh and Siraisi 1990). His account of nutrition indeed aims to articulate Greek texts with medieval Arabic textbooks in order to develop medicine as a theoretical field of knowledge based on the Aristotelian natural philosophy.

In the following section, I examine Fernel's presentation of nutrition as a physiological function related to the faculties of the "natural" soul. The three next sections investigate the successive "concoctions" of food in the stomach, liver and veins, in particular the formation of the four humors. To this purpose, I consider the fifth and sixth book of the *Physiologia* dedicated to the faculties of the soul and to the functions and humors, respectively.

2 The "Nourishing" Faculties of the Natural Soul

In his *Physiologia*, Fernel presents a clear synthesis on the structure and functioning of the healthy body, from its anatomical body parts and first components – elements and humors – to its main physiological functions. In order to explain the latter, he adopts a Galenic framework, and first recalls the "tripartition" of the soul within the body (Galen, *De placitis Hippocratis et Platonis* VI,3, K. V,519–532; Arist. *de An.* II,2, 413b1–10). The "natural" (*naturalis*), "sentient" (*sentiens*) and "intelligent" (*intelligens*) souls each predominate in the three realms of living beings: vegetal, animal, and human, respectively.²

In accordance with Galen's *De facultatibus naturalibus*, Fernel explains that the natural soul is common to all living beings (Fernel, *Physiologia*, p. 310–321).

² Fernel, *Physiologia*, p. 304 : [...] *tres quoque animae species iisdem nominibus insignitas, quae sunt naturalis, sentiens, et intelligens: quibus haec respondent viventium genera, φυτόν, id est terra editum sive stirps, brutum, homo.*

Its faculties govern three main vital functions: reproduction, growth, and nutrition (Galen, *De fac. nat.*). During the embryonic development, the “procreative” (*procreatrix*) faculty overrides, followed by the “increasing” (*auctrix*) faculty until the mature age, while the “nourishing” (*altrix*) faculty predominates for the rest of life.³ The “nourishing” faculty converts food into the body substance, which needs a constant repair of what has been lost. This occurs within the digestive system, which includes the actual digestive tract and the venous system. In addition, Fernel points out that nutrition needs to be distinguished from another important vital function, reproduction. Though both faculties relate to the natural soul, nutrition aims to the conservation of individuals, while reproduction is about the conservation of the whole species.

Fernel continues his synthesis of the medical tradition by applying Galen’s account of the natural faculties to his explanation of nutrition. The “nourishing” faculty of the natural soul works by means of four “auxiliary” faculties. These are the “attracting” (*atrahens*), “expelling” (*expellens*), “retaining” (*continens*), and “concocting” (*concoquens*) faculties, which ensure the circulation of the ingested food within the digestive organs.⁴ The auxiliary faculties operate during three successive “concoctions” in the stomach, liver, and veins, which each produce a specific humor as well as a residue (*excrementum*).⁵ To do so, the attracting faculty in the stomach and liver draws the useful part of food. It works in concert with the retaining and concocting faculties to hold and “cook” the ingested food with the assistance of the body’s “innate heat”.

Along the lines of Galen’s theory of nutrition, Fernel explains that the three phases of digestion as “concoctions” aim to sort the nutrimental part of food from its residual waste, which is evacuated afterwards. At the beginning of this process, the gastric concoction transforms the ingested food into a creamy white substance: chyle. As a humor and “first nutriment”, chyle is sorted from its residual waste, the fecal matter that is produced in the intestines. Then, the hepatic concoction runs the conversion of chyle into blood (αἱμάτωσις). Chyle

3 Fernel, *Physiologia*, p. 312: [...] *opera autem sunt stirps surgens è semine, aut qui utero geritur foetus ac fingitur: augescens stirps aut animal: hoc saluum et vita conseruatum. Tres praesunt illis effectrices facultates, procreatrix, altrix et quae auctrix appellatur.*

4 Fernel, *Physiologia*, p. 320: *Facultatum naturalium numerus ut impleatur, ad altricem reversione facta, quae illi tanquam auxiliariae vel administrate parent, huc referendae videntur. Sunt autem hae atrahens, expellens, continens, et concoquens, quarum necessitate corpus alitur et sustinetur.*

5 Fernel, *Physiologia*, p. 438–441: *Hoc autem tribus tantummodo locis concessum videmus, è quibus etiam triplex existit concoctio, prima in ventriculo, secunda in iocinere, tertia in singulis particulis. Sua quanque antecedit praeparatio, suaque sequitur absolutio, suum cuiusque alimentum tanquam subiecta materia, suus genitus humor, suumque excrementum.*

takes the form of a red humor or “juice” (χυμός) which contains the four humors, and whose remainder is the urine that is secreted in the kidneys. Finally, the venous concoction in the body parts operates the assimilation of the “secondary humors” in the veins, whose residues are sweat and the “vapors” that are evacuated by the skin pores during perspiration. Throughout this process, the auxiliary faculties achieve the “juxtaposition”, “agglutination” and “assimilation” of the digested food into the body part following Galen’s exposition in *De fac. nat.* – see section 4.

Within his synthesis of the Galenic account of nutrition, Fernel further describes the treatment of foodstuff at the level of its substance, elements and qualities in each phase of digestion. The following sections move on to explore his explanation of the three “concoctions”, in particular the decomposition of food in elements and its transformation into humors in the stomach, liver and veins.

3 The Making of Chyle: Food Elements and the “Total Substance” of the Stomach

In the medical tradition, the first phase of digestion as a “concoction” in the stomach points to two important aspects for the understanding of nutrition. On the one hand, it raises the problem of the “attraction” of the ingested food by the stomach. Though Galen describes this process with the notion of “attracting faculty”, the phenomenon of attraction in natural philosophy is difficult to explain (Jacquart 2006). For this reason, physicians often relate it to the equally challenging notion of hidden or “occult” quality related to the body’s essence or “substantial form”. On the other hand, the gastric digestion puts forward the decomposition of foodstuff into its basic ingredients, the four elements. In the early medical philosophy, this aspect is mostly treated in the context of the Aristotelian natural philosophy in relation to the notion of elemental “mixture”, that is the union of elements through the moderation of their qualities.

Fernel, in turn, synthesizes the traditional account of the gastric digestion as a process of attraction and decomposition of food. He relates it as much to Galen’s explanation of concoction as to his own account of the “substantial form” and “mixture” of elements, which is expounded at the beginning of his *Physiologia* and in his treatise *On the Hidden Causes of Things* (Hirai 2011, p. 46–79; Moreau 2018). As Fernel explains, the “highest and greatest mission” of nutrition is the purgation and transformation of foodstuff before its diffusion through all

the body parts.⁶ This process starts with the preparation of the nutriment in the stomach. The masticated food is first treated by the heat and saliva of the mouth. Pushed by the gullet fibers, it moves towards the esophagus before being “drawn” by the stomach, which proceeds with the first concoction:

In the interval the concocting faculty changes and prepares all the food, without assistance from the fibers, by its own innate heat and spirit, and by the heat that, like a fire set around a great caldron, is contributed by the adjacent parts, the liver, spleen, heart, diaphragm, vena cava and intestines [...] Moreover, the particular substance of the stomach brings this concoction to completion, and not only by those generally known qualities, but also by a secret and hidden property [...] It comes about not just by the force and ardor of heat, but also by the total substance of the stomach, and the “inserted” property which we mentioned. (Fernel, *Physiologia*, p. 404–407; translation slightly modified).⁷

In this excerpt, Fernel states that the concocting faculty of the stomach transforms food thanks to the heat of the surrounding organs, which is coupled to the body’s “innate heat”. The latter is a vital principle related to the body’s “total” or “whole” substance (*tota substantia*), which is related to its essence, and endowed with specific powers (Deer Richardson 1982; Bianchi 1982; Temkin 1972). Fernel further describes the attraction exerted by the innate heat as a phenomenon acting by “similitude of substance” so that the effects of the gastric attraction are comparable to those of the magnet and purgative drugs.⁸ By way of illustration, he takes the example of the ostrich’s ability to digest iron thanks to the total substance of its stomach (Fernel, *Physiologia*, p. 406–407).⁹ The same

6 Fernel, *Physiologia*, p. 402: *Summum supremumque naturae munus est nutritio, quam ex alimento accepto illa perficit: hoc enim illius est tota materia, in quam penitus incumbit, quam variè tractans expurgat, convertit, propriisque ductibus in omnes extremasque corporis particulas diffundit atque confert.*

7 *Hoc interim spatio facultas concoquens, cibum omnem mutat et conficit, nullis quidem fibrarum adminiculis, sed tum proprio ingenitoque calore et spiritu, tum eo quem ut lebeti magno circumiectus ignis, ita et proximae partes illi inferunt, iecur, lienis, cor, diaphragma, vena caua, et omentum [...]. Caeterum propria ventriculi substantia concoctionis illius absolutionem perficit, idque non modo vulgatis et notis illis qualitativibus, verum etiam tacita et recondita proprietate. [...] Fit autem haec non modo vi et ardore caloris, sed etiam tota ventriculi substantia, et insita quam diximus proprietate.*

8 Fernel, *Physiologia*, p. 320–321: *Restat igitur ut sit sua cuiusque particulae vis attrahendi, quae quod illi familiare est et conveniens, ex sanguinis mole privata benignitate prolectet. [...] Sic stirpes e terra amoenum succum, sic lapis heracilius ferrum, sic et purgantia medicamenta unumquempiam è corpore humorem, naturarum substantiarumque similitudine trahunt.*

9 The wonderful ability of the ostrich to digest anything was stated in Pliny’s *Naturalis Historia* X,1, and further discussed in the medieval and early modern period about the digestion of stones, iron, and gold (Buquet 2013). In medieval medicine, the relation between the ostrich’s

idea is presented in Fernel's *On the Hidden Causes of Things*,¹⁰ where he explains that the concoction is operated by hidden or "occult" causes associated to the stomach's "total substance" (Fernel, *On the hidden causes*, p. 498–503).

Such a statement relies on Galen's analogy between the attracting faculty of the stomach and the force of the magnet, which are both related to the "total substance" (Galen, *De temperamentis* III,1, K. I,654–655; *De fac. nat.* II,7, K. II,106–107; *De elementis ex Hippocratis sententia* II,5, K. I,507–508). In turn, the "total substance" is a difficult concept in Galen's philosophy, which has been much theorized by medieval scholastic physicians (Gibbs 2013). Throughout his works, Galen sparsely mentions the body's total substance as the cause of a range of physiological, pathological and pharmacological phenomena (Galen, *De theriaca ad Pisonem* 3, K. XIV,224–225). They have the common feature of a great force of attraction which is attested by experience, but impossible to explain theoretically.

To Galen's account of the total substance, Fernel associates his own interpretation of the innate heat which is presented in the *Physiologia* and *On the Hidden Causes of Things*. As an instrument of the soul, the innate heat animates the body and presides over physiological functions such as reproduction, growth and nutrition. Because of its vital nature, it is not composed of the element fire but of aether. Aristotle establishes aether as a celestial entity which is additional to the four elements, and states that the stellar element enters in the composition of vital heat (Arist. *de Caelo* I,3, 270b20–25; *de Generatione Animalium* II,3, 736b34–737a2). According to Fernel, the celestial nature of the innate heat is due to its nature of instrument of the soul and its close connection to the body's essence or "substantial form" (Fernel, *Physiologia*, p. 256–263; *On the Hidden Causes*, p. 478–497). Recent studies have shown that his interpretation relies on the Platonic philosophy of Marsilio Ficino, which emphasizes the celestial origin of the form (Hirai 2011, p. 46–79; Walker 1958; Zanier 1957). In his medical philosophy, Fernel particularly insists that the living body has a substantial form of divine origin which comes from the world-soul as a cosmic "giver of forms".

Fernel's view on the attracting faculty of the stomach is also indebted to a major textbook of Galenic medicine in the late medieval and Renaissance period, the *Canon of Medicine* by the Persian physician Avicenna (Gibbs 2013; Copenhagen 1984). In his explanation of food concoction, Avicenna compares the force of

stomach and the total substance can be traced at least in Averroes about the virtues of food and drugs (Averroes, *Colliget libri VII* [Venice: Giunta, 1574], fol. 95vb).

¹⁰ Page numbers refer to the edition and translation of John M. Forrester (2005).

the substantial or “specific” form, which he associates to the Galenic notion of total substance, to the “attracting virtue” of the magnet (Gerard of Cremona, *Avicennae Arabum medicorum principis [Canon medicinae]*. Vol. I. [Venice: Giunta, 1595], p. 73a and 111b). Moreover, Avicenna establishes that such a specific form has a divine origin due to a celestial “giver of forms”, a notion rooted in his emanationist philosophy (Hasse 2012). In this perspective, Fernel’s approach to food concoction in the stomach is close to Avicenna’s interpretation of the same theme. His description of the gastric concoction in the *Physiologia* is to be understood upon a Galenic and Platonic interpretation of innate heat, total substance and the superior form. For Fernel, it is the substantial form of the stomach, which is related to the Galenic notion of total substance, that supervises the preparation of the ingested food by means of the innate heat and the attracting faculty.

Having expounded the attraction of food by the stomach, Fernel further describes the decomposition of food and its transformation into chyle:

And so, with the aid of all these, so to speak, assistants, [the stomach] starts by gathering the foods together, and mingles one with another, the dry with the moist. At the same time, it fragments and crushes up everything, so that all the portions can be seen to have taken on some uniformity of substance. While these [portions] are being thoroughly mixed in this way, they are inevitably softened, both by the rule of mixture and by the nature of the disposition. Having ceased fighting, all the outstanding qualities are brought into some middle range. The substance becomes of one and the same nature, reaching some likeness to cream. (Fernel, *Physiologia*, p. 404–407; translation slightly modified.)¹¹

According to Fernel, the decomposition of food and its transformation into chyle follow the “rule of mixture”. With these terms, Fernel refers to the Aristotelian theory of mixture which he develops in the *Physiologia* for his exposition of “temperament” (Fernel, *Physiologia*, p. 208–213; Moreau 2018). The latter is a fundamental concept in early medicine. It defines the state of health coming from the balance of the primary qualities (hot, cold, dry, and moist) that are related to the body’s elements. From the perspective of Aristotelian natural philosophy, the temperament comes from the union of elements as a “mixture” (*mistio*) (Arist. *de Generatione et Corruptione* I,10, 327a30–328b24). As Fernel explains,

11 *Itaque his omnibus tanquam ministris adiutus ventriculus primùm quidem alimenta in unum cogit, et alia cum aliis, arida cum humidis confundit, simul verò omnia frangit et exterendo comminuit, ut iam partes omnes quandam substantiae aequabilitatem adeptae videri possint. Quae dum ita exquisitè permiscetur, necessariò ex misionis lege, tum ex affectionis natura mitigantur, et deposita omnia qualitatum exuperantia in quendam mediocritatis ordinem adducuntur et recidunt, fitque uniusmodi eiusdèmodi naturae substantia, speciem quandam cremoris consequuta.*

the mixture of elements consists in the mingling of their qualities as a “battle” of opposites (hot/cold, dry/moist), which results in their common moderation. As the qualities reach a moderate state, the body’s elements arrange in minute parts or “portions”. Such a process is followed by the immediate introduction of the substantial form, which achieves the formation of a uniform and tempered substance.

Applied to the gastric concoction, Fernel’s explanation of mixture implies that foodstuff is broken down into its mere elements as minute parts or “fragmented portions”. At the same time, the elemental qualities “fight” and weaken to some “middle range” as a balanced disposition. The concocted foodstuff is then transformed into a new substance in the form of a “thick juice”: chyle. For his explanation of food concoction in the stomach, Fernel thus offers a remarkably consistent explanation with his theory of mixture.

4 The Hepatic and Venous Concoctions: From Minima to Coagulated Blood

According to the Galenic tradition, the digestion of chyle into blood in the liver and veins consists in successive steps of filtration (Jacquart 2006). In this case, the ability of digestive organs to process the concoction of humors is not explained by their substantial properties, but by the fineness of their conducts, in particular these of the veins. To develop this reasoning, Fernel goes on using the general framework provided by Galen along with later contributions to this subject by medieval Latin-Arabic physicians. The latter draw particular attention to the transformation and texture of the resulting juices.

As Fernel specifies, the making of chyle in the stomach is only a preparation to the second concoction in the liver, for which chyle is transformed into blood. After the gastric concoction, the pylorus opens up to evacuate chyle and the waste materials towards the intestines, with the assistance of the “expelling” faculty. Chyle is then prepared in the “minute channels” of the mesenteric veins. With the aid of the attracting faculty, it is sent to the hepatic vena cava and its minuscule branches, where it acquires the texture of white wine.¹² There, it

¹² Fernel, *Physiologia*, p. 414–415: *Ad hunc igitur modum alimentum in iecur perlabitur, trahentibus quidem tum mesenterii venis, tum vero iecore per venas. [...] Ex qualitatis quidem cognatione, vinum quàm aqua ocysus in corpus assumitur: at substantiae tenuitas et vis quaedam penetrandi, causa est ut vinum album promptius quam rubrum et austerum in iecur pervadat, id enim expeditius trahentis vim consequitur.*

undergoes a “complete” concoction before obtaining the form of blood in the liver:

The veins scattered throughout the liver are so very thin that all the juice closely approaches its flesh and particular substance, being all in contact with it on every side. Because of this prolonged stay, and the intimate contact in the liver, with the chyle dispersed by each of its *minima*, a more swift and unimpaired form of blood is acquired than if it were contained in a wide cavity, such as the heart or stomach. (Fernel, *Physiologia*, p. 420–421; translation slightly modified.)¹³

For Fernel, it is the fineness of the hepatic veins which achieves the concoction of chyle by contact with the liver wall as these veins process each of the smallest components (*minima*) of chyle. Such a “distribution” *per minima* denotes the elemental structure of chyle along the lines of the theory of elements and mixture which is presented in the *Physiologia* (Fernel, *Physiologia*, p. 210–212). Accordingly, elements are defined as minute, if not “minimal” parts in the compound. These terms mainly refer to Galen’s conception of the element as the smallest or “minimal” part in bodies in *De elem. ex Hipp. sent.* In this treatise, Galen also states that mixture is facilitated by the decomposition of the compound into *minima* in the same manner as the mixing of wine and water (Galen, *De elem. ex Hipp. sent.* I,1 and 9, K. I,413 and 489). Moreover, medieval physicians such as Gentile da Foligno in his commentary to Avicenna’s *Canon* raise the issue of the “quasi-minimal” diffusion of concocted blood by the tiny veins of the body parts during the third concoction (Jacquart 1998, p. 345–346; Gentile da Foligno, *Primus Avicennae Canonis [...] Liber* [Venice: Scotus, 1520] fol. 37v).

Fernel adds that after the hepatic concoction, chyle thickens, turns red, and reaches a certain moderation in order to become a mass of “natural blood” which contains the four humors – blood, yellow bile, phlegm and black bile or “melancholia”. By describing blood as a tempered and finely structured substance, Fernel’s again relates his theory of mixture to the way of producing humors and juices during digestion. The chyle is processed through its smallest elemental components, and transformed into the blood mass which has a balanced disposition.

After the hepatic concoction, the digested blood is subject to a third concoction in the veins of the body parts. In this regard, Fernel insists on the fineness of

¹³ *Quum igitur tanta sit venarum per iecur disiectarum exilitas, succus totus ad eius carnem propriamque substantiam proximè accedit, à qua universus usquequaque attingitur. Ob hanc vero moram diutinam, et ob exquisitam in iecore contagionem, chylo per minima quaeque distributo, tum celerior, tum integrior sanguinis asciscitur species, quam si ampla capacitate, qualis est aut cordis aut ventriculi, conciperetur.*

venous conducts which diffuse blood “vapor”, in reference to Aristotle’s *GA* (Fernel, *Physiologia*, p. 434–435; Arist. *GA* II,4, 738a35–38). He adds that chyle circulates not only through the orifices of the veins, but also through their pores, where it acquires the “highest degree of perfection”. During this process, blood as an “alimentary humor” undergoes several steps of transformation, which end in the assimilation of blood into the body part.¹⁴ Fernel here follows Galen’s description of the last concoction as a triple process of juxtaposition, agglutination and assimilation that is applied to the digested blood in *De fac. nat.* (I,11, K. II,24; Hp. *De alimento* 8).

These phases of transformation are identified as “secondary humors” in medieval Latin-Arabic medicine (McVaugh 1974; Reynolds 1999, p. 105–119; Jacquart 2006). In this respect, Avicenna develops the notion of fourfold secondary “moistures” (*humiditates*) (Gerard of Cremona, *Avicennae Canon*, p. 20b–21a). As he explains in the *Canon*, the first moisture is contained in the orifices of the small veins that are close to the members, while the second moisture passes like “dew” through these veins to nourish and moisten the members. The third moisture is a coagulated “nutriment” which has acquired the temperament of the body part, though it is not converted yet into its complete essence. Received from the sperm at birth, the fourth moisture is responsible for the replenishment of the body parts. Fernel shares the same explanation of four nameless “secondary humors”, although the scholastic tradition rather adopted the terminology of the *Pantegni*, one of the most important medieval textbooks of medicine along with Avicenna’s *Canon*. In this treatise, the last three humors are named “dew” (*ros*), “glue” (*gluten*) and “change” (*cambium*), in allusion to their respective texture (Isaac Israeli, fol. 88rb).¹⁵

Having examined the successive concoctions of food in the stomach, liver and body parts, I shall now further explore the composition and formation of the four humors.

¹⁴ Fernel, *Physiologia*, p. 442–443: *Tertiae concoctionis opus et utilis succus est universum eorum humorum genus, quos aliquando diximus secundarios appellari, in quorum ordine eum primum collocavimus, qui in exilibus est partium venis, secundum qui tanquam ros in partes influit eis que apponitur, tertium qui affigitur, quartum qui iam in partis substantiam concedit eique assimilatur.*

¹⁵ Isaac Israeli (1515): *Liber Pantegni*. In: *Omnia opera Ysaac*. Lyon: Bartholomeus Trot, fol. 1r–144r.

5 Digesting the Four Humors: Fermentation, Combustion and Putrefaction

Upon his approach to concoction as a mixture, Fernel links the properties of the four humors to their structure in four elements. Their elemental content comes from the balance of chyle's primary qualities which produces the blood "mass" including the four humors. In the medical tradition, the body's humoral composition is fundamental for the understanding of health and disease. The excess of one of the humors is considered as an affection which requires to be purged by pharmacological means through the ingestion of drugs or by surgical means such as bloodletting. In this perspective, Fernel's exposition of the humors attempts to provide a theoretical counterpart to the main activity of physicians: identifying the qualitative disposition and possibly the humoral affection of their patients. Moreover, the formation of humors points to the inner "kitchen" of the body which operates the "cooking" of food. In this context, Fernel's description is not only centered on their diverse textures and properties, either in their natural and pathological states, but also on the nature of their transformation. He explains their successive alterations in metaphorical and chemical terms coming from Aristotelian philosophy as well as medieval Latin-Arabic medicine.

Resulting from the concoction of chyle in the liver, natural blood is a "mass" composed of the four humors. As Fernel explains, these fluids are each characterized by two of the primary qualities (hot, cold, dry, moist) as well as "secondary" qualities such as texture, color, and flavor (Fernel, *Physiologia*, p. 444–447; Hp. *De natura hominis* 5, L. VI,40–44; Galen, *De elem. ex Hipp. sent.* II). These qualities come from the mixture of the elements and their primary qualities within chyle. Phlegm (cold–moist) comes from the cold and "raw" portion of chyle, bile (hot–dry) from its hot and fine portion, blood (hot–moist) from its moderate portion, and melancholia (cold–dry) from its cold and "earthy" portion.¹⁶ As Fernel underlines, the quantity of each humor depends on the constitution of the liver and on the composition of the ingested food. For this reason, each humor within blood has a certain "latitude" of temperament.¹⁷ Established by Galen, this concept, also known as "latitude of health", is a gradual range of

¹⁶ Fernel, *Physiologia*, p. 428–429: *Pituita enim ex frigida et cruda chyli fit portione, bilis ex calida atque tenui, sanguis ex mediocri, melancholicus humor ex frigida atque terrena.*

¹⁷ Fernel, *Physiologia*, p. 426–428: [...] *nam unusquisque humor certa temperamenti latitudine circumscribitur, per quam divagari potest. [...] neque suus cuique ad unguem definitus est gradus. Ex quo intelligitur [...] varietatis plurimum afferi, ex efficientis caloris vi et alimenti materia, quarum iusta comparatio gignendi humoris speciem definit.*

temperaments for each humor, from health to sickness, with a medium point as a “neutral” state (Ottosson 1984, p. 166–194; French 2001, p. 106–107; Galen, *Ars medica*, 4, K. I,316–317). This means that the proportion of qualities for each humor is variable and depends on the individual constitution. As a result, it can bring about a healthy (“natural”) or morbid (“preternatural”) variation of the humor.

Fernel adds that the humors are in a pure state only in their dedicated organ: phlegm in the brain, yellow bile in the gallbladder, and black bile or “melancholia” in the spleen. Consequently, they are not pure in the blood mass, otherwise the body would not be healthy.¹⁸ For instance, the presence of pure yellow bile within blood is symptomatic of jaundice. Fernel anchors this reasoning in the Hippocratic treatise *De nat. hom.*, which states that the four humors are mingled within the blood, and that purgative drugs should be used when a humor is in excess (Hp. *De nat. hom.* 6, L. VI,44–46).

Like many Renaissance physicians, Fernel describes the process of digestion along the lines of Aristotle’s *Meteorologica*. In this treatise, the notion of concoction (πέψις) is considered as a broad category which designates either ripening in the same way as fruits, boiling like the digestion of milk and food, or roasting (Arist. *Mete.* IV,3, 380a11–381b22). These models of cooking were used in a medical context to describe physiological processes such as the formation of blood and the seed (Martin 2002 and 2008). Following this framework, Fernel defines the gastric concoction as the boiling (ἔψησις or *elixatio*) of the moisture of ingested food by the innate heat (Fernel, *Physiologia*, p. 406–407). Concerning the digestion of chyle into the four humors, he refers to the Aristotelian definition of concoction as ripening and roasting. However, he extends it to an analogy with wine fermentation:

We see that the innate heat of fresh must, collected into vats, makes it effervesce, be changed, and be digested. From this surplus items are forthcoming that were previously indistinctly present, and then get extracted and isolated for the first time by the force of concoction: one quite heavy and more earthy, which falls to the bottom and is called the lees; the other lighter and more airy, which floats on the top and is usually called the flower. It is assuredly in a similar manner that chyle traversing the liver, and being a moist liquid, boils after a fashion and is concocted, and in the end something thick appears, corresponding to

¹⁸ Fernel, *Physiologia*, p. 454–455: *Ex quibus intelligitur quatuor humores, qui in sanorum sanguine continentur, synceros non esse, nec eorum naturam exprimere, qui in bilis folliculum atque in lienem coniecti sunt.*

the lees, and also something thin and light resembling the flower. (Fernel, *Physiologia*, p. 420–423; translation slightly modified.)¹⁹

As Fernel describes the chemical process of fermentation, he does not allude to the alchemical notions of *fermentum* or *fermentatio* (Clericuzio 2012; McKee 1998). In fact, the comparison of digestion to fermentation originates in ancient philosophy (Siraisi 1987, p. 36–40; Pagel 1982, p. 79–80). For instance, Hippocrates explains that the digestive organs are in a state of fermentation when they are processing food (Hp. *De prisca medicina* 11, L. I,594). Plato describes the decomposition of food within the small veins as a process of fermentation due to the movement of airy and earthy particles (Plat. *Timaeus* 66b). Aristotle includes the boiling of must (fresh grape juice) in the broader category of concoction (Arist. *Mete.* IV,3, 380b34). As for Fernel, he closely follows Galen's metaphor of vinification to describe the formation of the four humors (Galen, *De usu partium* IV,3, K. III,269–270). As parts of the concocted blood, the thin yellow bile and the thick melancholia (black bile) are analogous to the phases of fermenting grape juice, namely the scum or “flower” and the sediment or “lees”. Phlegm (*pituïta*) is presented as a nearly mature portion of blood that is dry and astringent in taste because of its composition in “raw” parts.²⁰ Pure blood, in turn, is the achieved result of concoction just like wine after a couple of years: “ripe, tasty, and full of heat and strength.”

Finally, Fernel characterizes the four humors with particular sensory qualities such as color, texture and taste. Following the medical tradition, he describes blood as red and tempered, yellow bile as yellow and fine, melancholia as black and thick, and phlegm as white and liquid. As Fernel has previously established, each humor has a wide range of healthy and morbid variations. The latter include “superfluous” (residual) and “preternatural” (pathological) humors, in accordance with Galen's *De fac. nat.* (Fernel, *Physiologia*, p. 458–459;

19 *Mustum recens ab uvis expressum coniectumque in dolia, cernimus ab innato sibi calore effervesce, mutari, et concoqui: hinc supervacanea comparere quae prius quidem confusa inerant, ac tum primùm concoctionis vi secernuntur atque secedunt, alterum quidem grauius magisque terrenum, quod in fundo subsidens fecem appellant: alterum leuius magisque aëreum, quod per summa innatat et flos vini dici solet. Simili profectò ratione chylus in iecur transfusus, cum humidus quidam liquor sit, quodammodo fervet et concoquitur, tandemque nonnihil crissum existit, feci respondens, nonnihil etiam tenue et leve flori consimile [...].*

20 Fernel, *Physiologia*, p. 424–425: *Quod bimestre adhuc est, quamvis à fecibus et spuma expurgatum, gustatu tamen subcrudum, austerum et astringens deprehenditur, quòd crudis partibus visum effugientibus perfusum est. Has dierum numero vini calor evincit et concoquit, indicio quod vinum annum aut bimum qui degustabit, iam maturatum id, suave, plenum caloris et roboris percipient.*

Galen, *De fac. nat.* II,9, K. II,135–140). To describe their formation, Fernel does not refer to vinification, but to other chemical phenomena such as combustion and putrefaction. For instance, the preternatural bile is subject to a progressive burning into yolk-colored or “vitelline” (λεκιθοειδής) bile, leek-green (πρασοειδής) bile, verdigris-colored (ιώδης) bile, woad-like or “cerulean” (ισατώδης) bile, and “black bile” (Galen, *De atra bile* I,1, K. V,104–148). The latter is distinct from the natural black bile or “melancholia”. Fernel compares the preternatural “black bile” to a ferment of acidic nature, which effervesces and corrodes the body parts.²¹ Such an “ashen” or “burnt” humor may also result from the putrefaction of the superfluous counterpart of black bile. It condenses into small lumps which decay afterwards.²²

In addition to the preternatural sorts of bile, Fernel recounts four kinds of preternatural and superfluous phlegm. These types of phlegm are developed by Avicenna on the basis of Galen’s distinction between acidic, salty and sweet phlegms, with liquid, thick, viscous and spreadable properties (Galen, *De alimentorum facultatibus* I,1, K. VI,463; Gerard of Cremona, *Avicennae Canon*, p. 21b). Among the preternatural phlegms, the “acidic” one, which is similar to fruit juice, results from an incomplete concoction in the liver, so that it effervesces but becomes sour due to the lack of innate heat. The “salty” phlegm arises from natural “sweet” phlegm, which is partly roasted by putrefaction.²³ In addition, the superfluous type of phlegm includes four possible varieties due to a gradual thickening: thin and aqueous, condensed and “mucilaginous”, “vitreous”, and “plastery”.²⁴ The latter, which stems from the solidification of “vitreous” phlegm, has the consistency of stones or gypsum.

21 Fernel, *Physiologia*, p. 462–463: *Altera species ex ea fit bile quam vitellinam dixerunt. Exustione enim haec primùm in porraceam, deinde in aeruginosam, post in ceruleam, novissimè in atram omnium perniciosissimam commigrat [...]. Ea enim est quae in terram impacta, fermenti more et quodam quasi aestu effervescens, hanc iactat et excutit [...].*

22 Fernel, *Physiologia*, p. 462–463: *Ex sanguine nulla proximè bilis atra profertur. Nam si sanguinem statuamus vel incendio vel putredine in venis torreri et conflagrare [...]. Quum autem sanguis à venis illapsus fuerit in ventrem, in intestina, aut in aliam interioremem capacitatem, illic quidem primùm concrescit in grumos, tandèmq̃ putrescit.*

23 Fernel, *Physiologia*, p. 464–465: *Una est quae acida vocatur, summè quidem cruda, et quae praeter primam ventriculi confectionem, vix ullam aut minimam in iecore atque venis accepit. [...] Altera pituitae species salsa appellatur, ex dulci haec putrescente nata [...].*

24 Fernel, *Physiologia*, p. 464–467: *Una est pituita tenuis et aquea [...]. Altera censetur muco similis [...]. Haec si caloris vi et impulsu tantam adipiscatur crassitudinem, ut iam partibus conclusa possit adhaerescere, vitrea tum appellabitur, quae tertium genus est. Ad extremum vero cum ex concretionem sic iam durescet, ut à lapidis aut gypsi duritia non procul absit, quarta tum emerget quam multi gypseam appellant [...].*

6 Conclusion

It is argued that Fernel applies the framework of the Aristotelian physics of elements to the Galenic account of digestion. He indeed considers the process of “concoction” as a process of “mixture” which involves the elements and the primary qualities of the digested food. Such a scheme, in turn, involves two entities constitutive of the body: its essence or “substantial form” and its matter.

As a vital function, digestion implies the body’s substantial form, which Fernel defines as a superior entity of celestial and divine origin. While this aspect of his philosophy relies on a Platonic cosmology, it also offers a physiological application. The body’s substantial form is associated to its total substance and innate heat. The latter plays the role of instrument of the soul to exercise the vital functions. During the concoction of food in the digestive organs, the innate heat operates through the attracting faculty by unfolding hidden properties connected to the total substance.

On the other hand, the digestive organs process the matter of ingested food, which is composed of the four elements. The nutrimental matter is broken up in elemental portions in the stomach, and then “concocted” upon each of its *minima* in the mesenteric and hepatic veins. Furthermore, Fernel’s view on the moderate constitution of chyle and blood, which consist in minute portions, follows his own interpretation of mixture that is expounded in the *Physiologia*. Accordingly, the four humors are described as composed of elemental portions endowed with a certain qualitative temperament.

Fernel’s articulation of the Galenic account of nutrition with Aristotelian physics is close to that of Avicenna. In his *Canon*, the latter stresses the role of the specific form and the total substance in operating digestion, as well as the mixture of elemental parts which produce the humors. In his turn, Fernel synthesizes Avicenna’s explanation in a fashionable Renaissance account that is based on Galenic medicine, Aristotelian physics and Platonic philosophy. This allows him to explain how the body’s matter and substantial form, through the elements and innate heat, work in the physiological operations.

Moreover, Fernel’s theory of nutrition gives an insight into the chemical nature of food digestion. Following the medical tradition, he adopts the Galenic metaphor of wine fermentation concerning the formation of the four humors. Also, Fernel expands on the different definitions of concoction as boiling, ripening and roasting which were developed in Aristotle’s *Meté*. The bodily fluids are subject to diverse processes of coagulation, combustion, and putrefaction in the digestive system. While characterized by the four primary qualities, they feature other sensory qualities such as taste, color and texture.

Interestingly, the Aristotelian and Galenic frameworks which Fernel uses are further developed by early modern physicians in the context of an alchemical understanding of digestion. This mainly occurs in light of the Paracelsian interpretation of digestion as the transmutation par excellence in the “stomach” as an athanor. On the one hand, the sorting of the humor from its residual waste is considered as an alchemical extraction or “separation” of the pure from the impure. On the other hand, the processes of fermentation, coagulation and putrefaction are revised through the prism of three alchemical principles (Salt, Sulfur, Mercury) in replacement of the four elements and their primary qualities. Although the three principles aim to debunk the four humors and their morbid variations, Paracelsian physicians at times maintain traditional topics such as the chromatic variations of humors as a sign of different phases of transmutation, the comparison between the formation of blood and vinification, and the production of corrosive substances due to a bad digestion. From the perspective of seventeenth-century alchemical reinterpretation of digestion, Fernel’s theory thus proves to be particularly valuable for tracing the ruptures and continuities of early modern innovations with the medical tradition.

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