BETWEEN NATURAL HISTORY AND EXPERIMENTAL METHOD. DESCARTES AND BOTANY

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Abstract. Botanical studies were slow to be influenced by experimental method, since the learned were immersed in the demanding work of collecting, observing, listing, and describing. The transition to 'modern science' was therefore delayed, for natural history prevailed at the expense of experimentation. Although Francis Bacon's (1561-1626) experimental method also concerned natural history and botany, his programmatic reformation of science was underdeveloped and incomplete. The other champion of early modern philosophy, René Descartes (1596-1650), rejected natural history and grounded his science on intellectual evidence, the converse of Bacon's natural philosophy. The object of this paper is to understand whether or not Descartes' science includes botany within the order of reason, reducing its variety into a grey ontology. Some pages of a lesser known manuscript where Descartes jotted down notes about plants, the *Excerpta Anatomica*, allow a reconstruction of his botanical work against the natural historical endeavours of his contemporaries. Do Descartes' botanical studies methodically include botany within science: handling botany beyond natural history, providing it with theoretical frame and direction, postulating causes and explaining effects, and eventually adhering to his physical laws of nature and to his mechanical physiology?

Keywords: Descartes, Method, Experience, Enumeration, Induction, Natural History, Botany, Mechanics, Physiology, Life Principle

Introduction

In the transition from natural history and natural magic to experimental science, botany represents a relevant and thought-provoking field, for it was lately shaped by the experimental method into modern natural philosophy. Botany especially lacked theoretical control and direction. The main topic of this article is to focus attention on Descartes' philosophy of science and on the way his method might solve botanical inconsistencies. In the first part of this article, I am going to show the deficiencies of botany, the predominance of natural historical endeavour, and Bacon's attempt to introduce his experimental method, lately put in practice during the second half of the seventeenth century. Then, I am going to focus Descartes' interest on

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botany through an exam of both the applicability of his method and the exercise of his experiences on this field. Within the second part, contrarily to the main accepted interpretations, I argued a theoretical relationship between method and experience, which reduced natural history by means of the order of reason. Nevertheless, to have a science of botany, which is absent within his major works, something else is required: a context of interest, which I reconstruct in the third part, where Descartes' relationship with his contemporaries are displayed; a methodical approach, which I investigate in the fourth part, through his explanation of the effect of a rare and strange plant, the *Mimosa pudica*; and, finally, a mechanical representation, which I study in the fifth part. The aim is to prove that, since Descartes' method is claimed to be able to introduce theoretical order and direction in natural philosophy, it would operate also on botany, acknowledging botanical progress toward experimental science.

Natural history and botany at the outset of modernity

The seventeenth century inherited natural history from the previous century as a safe way to lend stability to the exuberant and incoherent variety of nature, organizing it into logical patterns against the obscure or magical endeavours of the Renaissance.[1] Natural history developed as a collective enterprise of gathering objects and documenting facts involved in finding, collecting, describing, listing or mapping variety. The goal of natural history during the early modern period was either to update ancient works or to organize new items into logical arrangements. Since nature was losing its order, catalogues, anatomical theatres, *Wunderkammern* and cabinets provided a "safety anchor for order and knowledge within a collapse."[2] Natural history's incremental knowledge advanced thus as "an important arena in which new definitions of knowledge arose from an increased emphasis on experience,"[3] in that it "became possible for history […] to develop serious intellectual contacts with natural science."[4] Nevertheless, since histories were mostly *descriptiones sine demonstratione*[5] (i.e. collecting without experimental knowledge), something other than naïve experience was still required to achieve *scientia*.

In fact, natural history is often ambivalent and contradictory. The case of one of the most important collectors of the time, the Italian Ulisse Aldrovandi (1522-1605), is particularly salient.[6] His work developed some of the paradoxes of classification and resulted in a difficult relationship with experimental method. First, whereas travelling provided plentiful findings that once brought to cabinets – the space where collectors did their work – allowed nature to be observed, natural history lacked a new trustworthy method. Second, Aldrovandi's authoritative descriptions were offset by his cluttered research and his aimless and frivolous pursuits, making natural history appear unable to answer the questions of research. His work ran the risk of triviality and disconnectedness. From a historical point of view, these contradictions demonstrate the limited status of natural history, which aimed at advancing science while keeping it bound to certain epistemological limits, as Pomian notices.[7] Botany is a perfect case study in which these inconsistencies are displayed. Curiosity, commerce, gatherings, experiences, and aesthetics are the foremost domains that govern botany. Documenting natural history was its prevailing technique,

establishing its central feature and putting aside experimental knowledge: collecting constituted one of the most important repositories in botanical knowledge, without any alternative logic of discovery. This field had only recently been "influenced by the 'experimental philosophy'," [8] for it was immersed in the labour of listing and describing. As Morton notices, "in the early decades of the seventeenth century descriptive botany continued the process of collecting and recording plants," for it "had lost theoretical impetus and direction." [9]

Francis Bacon was one of the first philosophers who sanctioned a modern logic of collecting by means of experimental method.[10] He highlighted the role of natural history, which was an important step of his new method toward *scientia* as outlined in the *Novum Organum*, but he also understood science required something more than simply Renaissance natural history. As Malherbe shows, experience has a significant part of the interpretation of nature, giving order to human reasoning and eliciting it of both impetuousness and prematurity.[11] To Bacon natural history consisted of collecting experiments and facts whose "true order [is] to strike a light first and then use it to find the way, by starting from experience ordered and digested and not at all topsy-turvy or haphazard, and thence deducing axioms." [12] What emerges is a natural history based on observation and experiments. Bacon argued that the first step of science therefore consists in collecting experiments and observations to "prepare a sound and efficient *Natural* and *Experimental* History, for that is the very foundation of our work." [13] However, this "may […] bewilder and distract the intellect unless it be set down and presented in suitable order [through] *Tables* and *Structured Sets of Instances*." [14] Moreover, natural history shall be governed and guarded by making "use of the true and legitimate *Induction*." [15] To Bacon, natural history was a "set of *results* emerging from a process of observation and experimentation and containing descriptions of the individual facts and phenomena" [16] but it also included the processes of observation and experimentation. We can use natural history to correct errors and doubts about other natural histories; that is, to reject anything inconsistent with experimentally confirmed statements.[17] Bacon employed experiments to grasp scientific knowledge and prevent preoccupation about data gatherings, for "men have put a great deal of over-scrupulous effort into recording the variety of things and unfolding in meticulous detail the differences of animals, herbs, fossils, most of which are rather sports of nature than anything of serious utility for the sciences." [18] He argued that, then, "the work should change direction and investigate and record the resemblances and analogies of things […]. For these things unify nature, and start to set up the science." [19] In conclusion, Bacon's experimental method helps in identifying the connections in nature, solving natural history's contradictions and developing modern science by providing the theoretical justification for a practical method.

Within the fifth, sixth and part of the seventh 'Centuries' of his *Sylva sylvarum*, Bacon discussed plants, providing them with both his empirical method and explanations. Contrary to his sources, Bacon elevated botany above "a mere natural historical [enterprise] and took it towards the level of natural philosophy." [20] He changed the logic of his sources, directing his studies towards the knowledge of 'material processes'. Nevertheless, his botanical studies appear limited regarding theoretical considerations, as "history and experiment take the first place above all"

and "speculations, and […] imperfect attempts at the interpretation of causes," are put forward by Bacon, "more to hint at what might be the case than to present it cut and dried."[21] Bacon's great attention to experiments and observations provided natural history and botany with a process of scientific transformation, which was to become more complete during the second half of the seventeenth century.

Descartes' method and (natural) history

Let's now turn to René Descartes, whose method grounded on the order of reason may be helpful against the disorder of natural history. Firstly, I will shed light on the relationship between method and experience in general; secondly, I will analyse some details of Descartes' interest in plants; thirdly, I will study the applicability of his method on plants and his science of botany. Unlike Bacon, Descartes banned history from his science for its uncertainty and confusion.[22] He argued that no history of nature can be comparable to, or part of, natural philosophy, which shall be ruled by his method. Whilst Descartes identified knowledge by the ability to produce appropriate judgments upon things, he thought history inhibited the freedom of these judgments, preventing *scientia*, that is certain and evident cognition.[23] Hence, true knowledge was achieved by means of intuition and deduction, for it was grounded in intellectual evidence, i.e. the clearness and distinctness of ideas. Experience seems excluded or limited to secondary questions.[24]

Despite both Descartes' refusal of history and circumspect attitude toward experience (either for its connection with sensory perception, for epistemological reasons or for the difficulties involved in collaborations), observations are required to complete science.[25] In the sixth part of the *Discours*, in fact, *expériences* are claimed to be necessary for making "most of these effects quite certain,"[26] and a theory on the use of experiment and scientific collaborations within his method is provided.[27] In his correspondence, Descartes' experiences are held to be a useful tools in difficult fields, albeit with one constraint: in order to avoid futile curiosity, theoretical frameworks must be defined before every experience.[28] His method builds the correct order for things, either correctly applying intellectual order to different fields, defining theoretical frameworks which align every phenomenon to the standard of reason, or reducing things to order and measure by means of experiences and observations, organizing spontaneous experiences into experiments by means of the methodical procedures.[29] Within this order, every experience, as well as natural history, can be scientifically fruitful.[30]

Upsetting Aristotelian features, Descartes builds his philosophy on the order of reason, and through his method he is able to complete science by means of experiments, explaining the effects from the causes, proving the cause through the effects, or following different lines of deduction.[31] When Descartes' natural philosophy begins with hypotheses, conjectures, observations, experiences and, eventually, natural history (therefore complicating the definition put forward by Daniel Garber of a two-step method),[32] all of these work "*ex arbitrio*"[33]: according to the order of the intellect and by means of methodical procedures.

Descartes' botany versus natural history

In a letter to Mersenne written in October 1639, Descartes accepted the seeds of the Sensitive herb, "for in that moment a part of [his] surveys concerns plants."[34] Although natural history alone was partly rejected and partly absorbed to the order of Descartes' method, botany is latent within his major works[35]: one major question therefore arises: did Descartes' research give credit to botany as a science or did natural historical endeavour prevail over Descartes' order? In fact, besides his interest, nothing assures us of his scientific results, for nothing on botany was published within his natural philosophy. Questions arise concerning whether botany is subject of Descartes' science, ordering phenomena within physical rules, and how the explanation of botanical phenomena involves specifying both correct causes and mechanical representations that conform to the laws of nature.[36]

But first, let's turn to Descartes' correspondence to discover whether he shared the same approach and interest of the scientists of the United Provinces (or Dutch Republic, the name of the Netherlands in that period). Botanical inquiries and experiments were spreading throughout the country, along with gatherings, collections, and botanical gardens. Descartes was able to profit from them. Behaving Dutch among the Dutch, Descartes frequented the men of science of these Provinces and made the most of the great vitality of this new State, whose prosperous vessels brought back goods produced all across the world, satisfying the leisure of all and the curiosity of naturalists.[37] After his (second) arrival in 1628, he enrolled at the Leiden University, where he could visit the famous *Hortus Botanicus*.[38] Thanks to Henricus Reneri (1593-1639), with whom he worked on botany at the end of 1637, Descartes was admitted in Hooft's circle, whose patron, Pieter Cornelisz. Hooft (1581-1647), poet and historian, belonged to a merchant family; in this literary circle, Descartes could have discussions with botanists, apothecaries and naturalists.[39] His friendship with Constantijn Huygens, secretary to Frederick Henry, the 'stadtholder' of the Republic, and patron of many scientific circles, put Descartes in contact with many naturalists who were interested in botany. In those years, he gained a certain familiarity with Adolphus Vorstius,[40] professor of medicine in Leiden, but also director of the botanical garden.

His correspondence reflects the familiarity with naturalists and catalogues. For example, when Descartes asked Mersenne to send him the catalogue of the Parisian *Jardin des plantes*, he promised to exchange the favour with the catalogue of Leiden's *Hortus Botanicus*, which he could easily obtain.[41] Additionally, during the discussion of the *Mimosa pudica*, whose seeds failed to grow in Descartes' garden, he mentioned that the same failure had occurred at the Leiden botanical garden.[42]

Loci amœni of beauty and recreation, botanical gardens also served a didactic function in the seventeenth century due to their accumulation and representation of plants by means of catalogues. His judgment on catalogues is expressed in a letter to Mersenne: they are "useless for my scopes, because [they] contain only names, whereas I am looking for things."[43] While he was studying plants, Descartes reduced collecting to mere name-gathering, worthless to his scientific effort; words only abstractly display the vastness of nature, whereas he intended to study nature as a material thing. Revealing the "distance that separated names and things,"[44] he

deprived catalogues (and therefore natural history) of their scientific fruitfulness, but he recognized them a convenience under certain conditions, dictated by his method. Firstly, surmounting the abstract nature of catalogues, he required a material study of things based on physics which makes further knowledge available. Secondly, he thought objects could be usefully catalogued only when theoretically framed and enumerated. Enumeration was not simply the exhibition of things, but one of the methodical operations which supported intuition in the steps involved in deduction, and one of the rules of the method within the *Discours*.[45] In this case, enumeration helped in making ideas evident about plants, providing objects for botanical studies and aligning them to the order of reason. Traditional natural history looks scientifically inoperative, and Descartes, while rejecting its role, grounds a way of cataloguing on the order of reason, through methodical procedures. His studies on botany may pass through catalogues and natural history only when these are governed by reason.

Although natural history seems to have found a theoretical order, neither a list of plants nor their explanations are found in Descartes' main works however. This absence is not due to methodological deficiencies, but only to "certain circumstances," namely the difficulty in carrying out "all the experiences [he] should need in order to back up and justify [his] arguments [*raisonemment*]."[46] Hence, questions remained as to whether Descartes' method was actually able to order botanical phenomena, both connecting these to theoretical frameworks and explaining them within the mechanical laws of nature.

The *Mimosa pudica*. Descartes' methodical order

The discussion on the *Mimosa pudica* contained in his correspondence with Mersenne is a convenient example of Descartes' implementation of method in his botanical studies. Historically, the shrinking response of the Sensitive herb, lately called *Mimosa pudica*, represented an inexplicable phenomenon that undermined any system of nature. Its leaves fold inward and droop at the slightest contact with fingers. This movement casted serious doubts on the Aristotelian tripartite division of the soul, for this plant appeared endowed with the animal soul, defying the traditional view of the sensory system and opening to a vitalistic conception, as though it was permanently inhabited by spirits.[47] No definitive explanation for this behaviour had been provided, and this plant found difficult location within natural history. Descartes was asked to give his own account, bringing the phenomenon of the moving leaves from the condition of inexplicability to the order of reason.

Since he was to reject both Aristotelianism and vitalism in favour of a mechanical conception of nature composed of a mechanically ruled inert and extended matter, Descartes' answer proved to be revealing in order to illustrate sensibility and automatism in non-human beings.[48] He wrote:

> Concerning the Sensitive Plant that you wrote me having seen in Mr. de La Brosse garden, I do not find anything curious except its rarity; for, after having explained the heart movement in a way which may suit both plants and animals, if the same organs are to be found within this plant, I will have no difficulty in conceiving how it moves; I would

> undertake this explanation only after having seen and examined it, though.[49]

What Descartes suggests to Mersenne consists of no more than a hypothesis and a few methodological steps, which confirm that inert matter may display sensations (and life) following from the disposition of parts [*pièces*],[50] their mechanical organization and their 'interdependency'.[51] Neither vegetative nor sensitive souls are allowed in the explanation, for these Scholastics terms mean nothing else than the disposition of parts and the locomotive power, according to Descartes.[52] Movement is always a mode of extended matter and, being a response to a sentient condition, this movement comes from the disposition of matter and parts. In fact, besides consciousness, belonging to mind alone, sensation reveals a mechanics of sentience within animal body. Descartes would account about this movement from the analogy between animal and plant functions, confirming both his laws of nature and his physiology of complex bodies.[53] Despite being no more than a supposition, this reveals the theoretical framework underpinning his explanation for the phenomenon. Moreover, Descartes ensures that, within his explanation of the heart-beat, movement, sensation and a process that was to be traditionally conceived as goal-directed may be subordinated to structure and explained mechanically.[54]

Nonetheless, my focus on this letter concerns Descartes' methodical definition of this object within his natural philosophy, rather than the features of this phenomenon. By the means of his method, the *Mimosa* is inserted in Descartes' grey ontology, as a theoretically framed object of his *scientia*, therefore different from items arranged within natural history. This letter displays Descartes' application of methodical procedures to achieve a theoretical framework and, subsequently, a possible science of vegetation. He follows the procedures of comparison[55] and induction: he has compared plants and animals starting from a singular shared feature (movement), which means that he has enumerated their qualities, discovering those in common. Subsequently, from common characteristics he has induced a common cause: since the deductive line is inoperative, he follows different lines, applying methodical induction.[56] Although these methodical procedures guarantee the theoretical framework, observations and experiments (different from ordinary experience, as put forward by Armogathe[57]) are required to complete the science, as Daniel Garber notices,[58] and to prove whether his supposition is correct. Descartes would prefer personal experiments. Two methodological reasons explain why: first, since truth is fundamentally subjective according to Descartes, a claim must be understood to be true by the scientist, therefore experiment must be done by him and not simply accepted on the authority of an institution or of tradition; consequently, to believe the results of experiments made by others one must have good reasons and share the same theoretical framework. Second, experiments made by others are therefore useless if they do not utilise 'the same scale', i.e. if they do not look for the same things.[59]

Accordingly, reason provides experiments with truth, and methodical procedures indicate the truth on every subject under examination. A visual exam is hence required.[60] Unexpectedly, what has been ejected from true knowledge,

sensation, is methodically restored. Although sensory impressions occur in the body, "the soul [alone] has sensory perceptions,"[61] and sensations are still governed by reason. Thus, they may be trusted as they prove the existence the mind-body relationship and confirm the existence of external bodies: everyone "can be affected by the various beneficial or harmful bodies"[62] by means of sensations, expressing a judgement upon them. Sensation both provides reasoning with objects and orders experiences within reason. Therefore, the visual exam required is intellectually ordered. For example, visual exams are suggested at the end of the *Dioptrique*, where Descartes planned on using microscopes in natural science and botany.[63] The plant he cultivated, however, did not bloom; he could not examine it and his methodological steps remained merely theoretical.

Two major consequences result, confirming the role of method within botany, as I argued. The first is that Descartes' method is operative in botany. The methodical procedures of comparison and induction operate in this field, accounting for both a connection between the visible and the invisible and a reduction to a single cause. Hence, these procedures methodically determine the order of natural variety without following the aesthetic order of natural history, but only the evidence of reason. The second consequence is scientific: the laws of nature hold everywhere, reducing botanical phenomena to mechanical physics[64] and to biomechanics.[65] Descartes rejects sensitive qualities, spiritual evidences and odd phenomena contrary to nature as impossible, we have some good examples of these curiosities within his correspondence.[66] In summary, from this phenomenon, method rules over botanical knowledge as it works on nature in general, providing vegetation with causal accounts and reducing natural and botanical variety to the clearness and distinctness of ideas. The *Mimosa pudica* is an object of his *scientia*, which does not start from the object itself, but from the methodical features of reasoning. In conclusion, the *Mimosa* shows the possibility of a science of botany within Descartes' method, but, given its particularity, nothing assures us that Descartes made of plants a subject of his *scientia.*

The *Excerpta Anatomica*: Descartes' experiments on botany

What stands out with the example of the *Mimosa*, the practice of experiments that will spread the theoretical frameworks on the entire field of botany, making it as a science within Descartes' physics and not merely an object of temporary curiosity, is still under question and it is object of this part. In fact, the notes of the *Anatomica* reveal a number of experiments concerning the functions of plants (their growth, differentiation, nutrition, flowering and fructifying). Within them, Descartes carefully examines plants, looking for a confirmation of his theoretical frameworks and providing it with a mechanical representation.

The first important thing to note is that these pages begin with Descartes' practice on animals, to which some references to botany are mixed, revealing a similar investigation on plants. The first botanical observation appears in what has been named Part IV. Descartes inscribed a few notes about how bodies (either plants or animals) are mechanically formed by a whirling movement of matter, activated by heat [*vi caloris*]. Despite the uniformity of nature posited in the *Discours*,[67] in which matter is undifferentiated and behaves mechanically, he brings out a differentiation between

animals and plants regarding the way in which they are generated. On the one hand, the uniformity of bodies is confirmed in that they share the same natural laws and mechanical constructions; but on the other, Descartes establishes an experimentally elaborated mechanical differentiation. The main difference consists in the fact that the particles of matter revolve spherically for animals [*volvantur sphærice in omnes partes*], but only circularly for flora [*volvantur tantum in orbem circulariter*]. Although in both cases formation is mechanically governed and caused by heat and the movement of particles that make up bodies from the seed, this slight diversity of movement differentiates animals from plants. The latter develop adhering to the earth [*adhærere terræ*], whereas the matter of animals produces a round membrane which wraps the foetus [*tunicam rotundam efficient, quæ totum fœtum involvit*].[68] As Descartes puts forward, plants need to be linked to the earth, and therefore their movement must leave space for this connection; while animals have no need of this. It thus becomes clear that the generation of bodies is mechanically processed. Moreover, I argue that the spherical movement is provoked by the mixing up of the two seeds from which animals originate, as Descartes already described,[69] whilst the circular movement from the part of a singular seed, by which plants come up.

A second and crucial set of notes dated from November 1637 is entitled *De Accretione et Nutritione*.[70] This date confirms the temporal limits of Descartes' interest in botany, which is confined to the period after the publication of the *Discours*, when Reneri was involved in studying botany in Santpoort. Whilst in the first note he discusses generation, in this note he studies nutrition, distinguishing between the growth by accretion of dead bodies (minerals and stones) and the growth by nutrition of living bodies (animals and plants). Although both of them are reduced to the mechanical modes of extended matter, Descartes highlights one major difference: growth is a mere juxtaposition or addition of parts [*partium appositionem, sine ulla earum immutatione*] for stones and metals, but a mutation [*cum aliqua partium immutatione*] for animals. Dead bodies [*mortuorum*] like metals in mines or honey in hives grow by accretion. An example is particularly interesting. During fossilization, wrote Descartes, stone particles penetrate the pores of wood transforming it by adding their parts to the wood [*transmutation ligni … in lapidem*].[71] This was subject of Mersenne's curiosity, who asked Descartes about the transformation of certain stones in something like wood.[72] Within these notes, a different explanation of this phenomenon emerges: the stones which transform in wood were wood whose fossilization is mechanically incomplete. Moreover, Descartes' notes show the analogy between inert matter and dead bodies: when wood stops its accretion and the plant dies, the wood becomes a dead body which can be transformed in a stone by simply mechanical operations. He elaborated this conception of natural bodies, for in a letter to the Marquis of Newcastle dated November 1646, Descartes repeats this explanation, adding a distinction between stones and metals.[73]

These notes continue analysing the accretion of living bodies [*viventium sive eorum quæ nutriuntur*], underlining the distinction between dead or inert matter and living bodies. Although Descartes does not explicitly refer to fermentation ruling digestion, in those notes he adds meaningful aspects of nutrition which cannot be found elsewhere in his writings. Growth concerns nutrition. Living beings' growth

depends on a mixture of small parts [*partes variæ variarum figurarum sibi mutuo occurrentes miscentur*], which act on the other parts [*se muto agunt*] and acquire a certain figure [*donec quasdam determinatas figuras acquirant*].These parts are transported through little rivulets and then sediment at precise places, according to their structure. Although in all of them there is a sort of material sedimentation and the modes of extension rule both nutrition and accretion, two major differences arise. First, within living bodies, particles are transported by rivulets which are part of the body, whilst for minerals the stream is not part of the body itself. Second, whilst stone accretion consists only of deposited particles, little parts mutate and blend themselves into living bodies, where they undergo a mechanical transformation.[74] Nutrition shows some physiological functions and the continual change of parts within the body, therefore ensuring a sort of individuation for organic bodies.[75]

Moreover, Descartes mechanically distinguishes between the mere assimilation of little parts, which is nutrition, and the growth of bodies, in which the particles construct new parts. This allows an explanation of aging in terms of movements and disposition of matter, linking aging with nutrition in an unexpected way.[76] Accordingly, life consists of both the rapid substitution of parts and the increase of rivulets, which facilitate nutrition [*crassiores partes illis rivulis content in locum circumjacentium paulatim succedunt, pulsæ a tenuioribus … vel rivulum unum in duos aut plure dividunt*], whilst aging occurs when this replacement slows down and the rivulets do not grow and join together [*rivuli … ex uno duo fiant*], and death occurs when parts are compressed [*compingantur*] and no substitution is therefore possible [*cessat etiam nutritio et vita*].[77]

Descartes then distinguishes between imperfect and perfect nutrition [*accretio sive nutritio vel imperfecta vel perfecta*]. Imperfect nutrition indicates that the little parts have already been mixed and ordered before filling up the ribbons [*aliunde advenit*], leaving sediment without creating new parts of the body, but nourishing fur, nails, horns, mushrooms, tubers parts of plants and animals. Perfect nutrition presumes the formation of seeds [*generationem sive seminis productionem*], i.e. the growth of the body. Both of them are part of living bodies' nutrition, while dead bodies only display the former without the mechanical operations of the latter. In fact, particles undergo the operations of blending, contributing to the construction of the body [*material rivos replens est talis, ut aliam advenientem … sibi possit omnino assimilare*]. Since those parts must have a similar shape [*non nimis contumacem et diversæ naturæ*], Descartes reduces them to three geometrical figures: prisms, conoids, and concaves [*perexiguis prismatibus, paulo majoribus conoidibus, et aliis certo modo ad has duas simul jungendas apto concavis*],[78] which also take part in composing seeds [*hæ tres solæ existentes semen component*]. The structure of plants develops from a seed and from the particles contained therein. In a piece of *La Description du corps humain*, where Descartes cannot study the composition of animal's seeds, he examines plant seeds,[79] taking them as a general example valid for living beings, passing from a visible case to an invisible one. Throughout this note Descartes insists that animals and plants share similar nutritive functions, and that define them as living beings.

Nutrition and other functions therefore confirm Descartes' theoretical framework: the modes of extended matter and biomechanics work for both plants and

animals. A further outstanding issue consists in the fact that, despite the uniformity of natural bodies, Descartes stresses a distinction between inert and living bodies, claiming a differentiation among minerals, plants and animals. On the one hand, the same mechanical laws govern natural bodies, reducing any and all principles to mechanics.[80] On the other hand, as I have shown, the examination of physiological functions within the *Anatomica* reveals a difference between dead and living bodies, confirming what Descartes wrote in a letter from 1632.[81] This differentiation is connected with a considerable historical problem, as we know, since the classification of natural bodies has always dealt with problems in distinguishing between reigns and establishing order. Although Descartes did not discuss this subject directly, I argue that within these pages mechanics plays a relevant role in indicating a way to discriminate among bodies: differences and affinities between plants and stones or plants and animals belong to the mechanics of their structures and functions, establishing a fixed order.[82] Moreover, Descartes provides an explanation of the relationship between inert matter on the one side and both dead and living bodies on the other. In other words, while he did not create a scale of beings, within these unpublished notes, his mechanics allowed a physical distinction between living and inert bodies.

In the following notes, Descartes expands the mechanics of growth and nutrition into an explanation of the outward differences founded between plants. Both the movement and disposition of particles, which are modes of extended matter, along with heat, a cause of physical phenomena, play an eminent role in botanical functioning as well as in plants' differentiation. Since bodies essence does not come from external characteristics, but from the shapes, disposition and movement of particles, plants' outward aspects also belong to their internal structure. Descartes applies his theoretical framework to the external quality of plants, object of natural history attention and now reduced to mechanics. While discussing why the strength of heat cannot extract salt from water, which depends on its dryness, Descartes reinforces his reasoning with the example of fruits.[83] Fruits are not salty [*nulli quod sciam fructus salsi proveniunt*]. They are formed by the fluid dynamics of particles (the movement of sap within the rivulets) and the action of the Sun, which heats the soil and activates the movement of particles. Salt, by contrast, is fixed and cannot be moved by heat, nor elevated amid the vapours fulfilling the rivulets [*sal esse valde fixum, nec a sole in plantas elevari*].[84] Before explaining the formation of fruit, Descartes sheds light on the way in which the components of concoction produce fruits with different features. Exhalations and vapours activated by heat play a role in forming the qualities of fruits, as sap is combined with them. In *The Meteors*[85] Descartes explains the physical status of vapours, whilst in the *Anatomica* he demonstrates their role within plants. Hence, depending on the characteristics of the vapours mixed with sap, fruits display different aspects.[86] Sometimes vapours contain black or opaque parts [*esse partes in fumum quidem ab initio a calore excitatas, ideoque opacas et nigras*], and when they are mixed within the rivulets [*postea vero in arbore a partibus fluidis celeriter motis paulatim secretas et simul constipatas*], they produce bitter fruits which purge bodies [*ideoque abstergit*].[87] Two further considerations were put forward by Descartes. The first was geographical: he argued that, since in hot regions the sun creates much more vapour,

their interaction with plants produces bitter fruit. The other was medical: since vapours are dry, bitter fruit are unhealthy to men and affect bodies.

Finally, Descartes mechanically expounds on the formation of fruits in a large note.[88] He explained that small parts arise from the earth and move within the trunk in a rectilinear motion [*emergent particulæ ex trunco recto motu*]; then, moving circularly and reaching the branches, they intersect another circular movement of particles [*motus cirularis decussatim*], which break and mix up the particles until fruits are created [*particulæ franguntur magis et magis, et ita fructus maturescit*]. Hoeing and grafting are useful farming operations to increase the production of fruit, since they help the movement of particles from the earth through the roots [*subtiliores partes attrahuntur*] and within the rivulets [*particulæ per duarum diversi generis arborum meatus evectæ magis interpolantur*]. Both of them are mechanically ruled, for they concern the disposition, movement and figure of parts.

Although fruits grow, flowers come out, leaves sprout, trees come up and seeds germinate in the same mechanical way, some differences appear within plants. Descartes mechanically explains them, for the parts of plants change according to the disposition and figure of particles, whose mutations depend on their movement. For example, since air resists the movement of these vapours, the movement of particles disposes the external fibres of plants diagonally [*in transversum volvuntur*]. Reversely, since within the trunk no air opposes the vapours, particles move rectilinearly and dispose the internal parts in a rectilinear fashion [*partes interiors habeant rectas*]. Nevertheless, since vapours do not arise following a straight line within the trunk [*non plane recta sursum*], but arise obliquely [*oblique*], the most solid particles among them go toward the bark [*solidiores versus corticem feruntur*], whilst the others stay in the middle. Thus, bark has diagonal fibres for both external and internal movements, whilst the internal part has rectilinear fibres. Leaves have the same diagonal texture of bark [*in transversum eorum figuram sumit, et formature in folia*], while fruits, whose parts come from the internal rivulets and from the circular movement of particles, have a circular figure [*rotundus*]. These figures do not belong to peculiar qualities of particles but the disposition, movement and figure of matter. In addition, the solidity of external fibres does not depend on some obscure end or quality, but only on their extension and figure.[89] Descartes puts forward another differentiation between water plants, which are more porous, and other plants: their dissimilarity is due to the disposition of parts and their interaction with vapours and exhalations.[90] All of these outward differences and these inward structures are mechanically ordered by Descartes' physics. In this way, Descartes' botanical variety is methodically framed.

Conclusions

Despite having been relegated to an unpublished work, botany proves to be a relevant field of Cartesian natural philosophy. I showed that Descartes' method provided botany with theoretical frames and direction, bestowing this field with a scientific status, different from the chaotic and uncertain condition displayed at the beginning of the seventeenth century. Therefore, botany passed from the predominance of natural historical techniques to a modern status, in which experiments and collecting are balanced together. Consequently, Descartes represents

an intriguing transition between natural history and the experimental practice. As I showed, within his method botany is therefore a field of modern science. First, I argued that Descartes' reduction of collecting to his methodology imposes limitations to the natural historical approach. By contrast, I showed that Descartes' method provides theoretical frameworks within which botanical variety is aligned to the order of reason. The *Mimosa pudica*'s case is historically salient, because Descartes embedded this strange phenomenon within his laws of nature and his physiology, ensuring its epistemological status and setting it free from the uncertain arrangement of natural history. Descartes orders its singularity within his methodical procedures, providing oddity with a scientific explanation. I used this strange case to see whether Descartes' method worked on vegetative studies and whether a botanical science would be possible within his physics. Second, I studied Descartes' *Anatomica*, a set of notes where he jotted down personal examinations on plants. These studies reveal the wide applicability of his laws of physics and of his mechanical physiology, making plants a suitable subject of his natural philosophy. Plants are therefore scientifically studied: their external variety and outward characteristics are reduced to their internal structures, which in turn are mechanically ruled. Finally, within the notes of the *Anatomica*, I underlined that botany is an interesting field both to study Descartes' experimentation and to set new philosophical considerations: the examination of plants explains their functions (generation, growth and nutrition), shedding light on some new aspects, and also reveals the nature of material bodies and an outstanding and totally new differentiation between living and dead bodies. Thanks to his botanical studies, Descartes' 'life principle' can be re-examined in detail by means of his biomechanics. In conclusion, his botanical studies disclose a progress within the science of vegetation, going beyond the natural historical endeavour. Botany is submitted to the order of reason, which provides it with theoretical control and direction. Although largely ignored, Descartes' botanical studies reveal a progress in natural science that opens to both a historical reconsideration of botany during the first half of the seventeenth century and a philosophical re-examination of some physical and physiological aspects of Cartesian philosophy. His method proves that his work on botany, avoiding the droughts of natural history and collecting, but reducing this chaotic field to the order of reason, can be considered a consistent part of modern *scientia*.

References

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[16] Jalobeanu, D., (2011): 89.
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[22] Cf. Descartes, R., *Regulæ ad directionem ingenii* III, in *Œuvres complètes* (hereafter AT), ed. Ch. Adam et P. Tannery (Paris, 1969-1978); vol. X, 367. For an interesting definition of Descartes' science, see Sorell, T., "*Scientia* and the Sciences in Descartes", in Scientia *in Early Modern*

Philosophy. Seventeenth-Century Thinkers on Demonstrative Knowledge from First Principles, ed. T. Sorell *et al.* (Dordrecht: Springer, 2010), 71-82.

[23] Descartes, R., *Regulæ ad directionem ingenii* II, AT X, 362.

[24] Experiences are secondary in temporary and theoretical terms. Descartes to Mersenne, 23 December 1630, AT I, 196. Descartes, R., *Regulæ ad directionem ingenii*, IV, AT X, 371. Descartes, R., *Primæ Cogitationes circa generationem animalium*, AT XI, 510.

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[26] Descartes, R., *Discours de la Méthode* VI, AT VI, 76.

[27] On the topic of both Descartes' experiments, see Buchwald, J., "Descartes's Experimental Journey Past the Prism and Through the Invisible World to the Rainbow", *Annals of Science* 65/1 (2008): 1-49. See, on the topic of Descartes' collaborations and observations, Bos, E.-J., Verbeek, Th., "Conceiving the Invisible. The Role of Observation and Experiment in Descartes's Correspondence, 1630-1650", in *Communicating Observations in Early Modern Letters (1500-1675). Epistolography and Epistemology in the Age of the Scientific Revolution*, ed. D. van Miert (London, Torino: The?Warburg Institute-Nino Aragno, 2013), 161-177.

[28] Descartes to Mersenne, 23 December 1630, AT I, 195-6: "sans être trop curieux à rechercher […], il faudrait principalement faire des Recueils généraux […], il est impossible qu'on n'en fasse beaucoup de superflues, et même de fausses, si on ne connaît la vérité des choses avant". See also, Descartes, R., *Regulæ ad directionem ingenii* IV, AT X, 371.

[29] The definition of methodical procedures has been well explained in Lojacono, E., "Epistémologie, méthode et procédés méthodiques dans la pensée de R. Descartes", *Nouvelles de la République des Lettres* I (1996): 39-105.

[30] Cf. Descartes to Mersenne, April 1632, AT I, 243.

[31] The difference between Descartes and Aristotle is a huge theme; it could be useful to give a glance at Jolley, N., "*Scientia* and Self-knowledge in Descartes", in Sorell, T., (2010), 83-98. For the structure of his method, see Descartes to Mersenne, 10 May 1632, AT I, 250-1. The third rule of the method makes clear that possibility; see Descartes, R., *Discours de la Méthode* II, AT VI, 18-19. Cf. *Ibid*., VI, AT VI, 76. Descartes to Morin, 13 July 1638, AT II, 198.

[32] Garber, D., "Descartes and Experiment in the *Discourse* and *Essays*", in Garber, D., *Descartes' Embodied. Reading Cartesian Philosophy through Cartesian Science* (Cambridge: Cambridge University Press, 2001), 85-110. And Garber, D., "Descartes and Method in 1637", in Garber, D., (2001), 33-51. As I argued, a relevant role should be conferred to the way Descartes started scientific explanation with a-posteriori stances: *The World* begins with a *fable* (AT XI, 31), *The Man* begins with a supposition (AT XI, 120), the *Discourse* is rather a fable, a history than a treatise (AT VI, 4), the *Optics* and the *Meteors* begin with suppositions. The third part of the *Principles of philosophy*, where a science of nature is provided, begins with a natural history (AT VIII-1, 81).

[33] Descartes, R., *Regulæ ad directionem ingenii* VII, AT X, 391.

[34] Descartes to Mersenne, 16 October 1639, AT II, 595.

[35] Descartes confirms their absence in the *Principia philosophiæ* IV, art. 188, AT VIII-1, 315: "duas adhuc alias, quintam scilicet de viventibus, sive de animalibus et plantis, ac sextam de homine essem scripturus". Descartes, R., *Lettre-Préface*, AT IX-2, 14-15.

[36] I consider useful the definition of Descartes' science in Clarke, D., *Descartes' Philosophy of Science* (The Pennsylvania State University Press, 1982), 108-132.

[37] Cf. Descartes to Balzac, 5 May 1631, AT I, 204.

[38] Cf. Gaukroger, S., *Descartes. An Intellectual Biography* (Oxford: Clarendon Press, 1995), 187, 210. Rodis-Lewis, G., *Descartes. Biographie* (Paris: Calmann-Lévi, 1995), 109.

[39] On Descartes' relationship with Reneri, see Reneri to Mersenne, March 1638, in *Correspondance Mersenne*, éd. C. de Waard Paris: Editions du Centre National de la Recherche Scientifique, 1962), vol. VII, 115. Reneri to de Wilhem, 28 February 1638, UBL, BPL 293A, in

Dibon, P., "Bacon en Hollande", in *Francis Bacon. Terminologia e fortuna nel XVII secolo*, ed. M. Fattori (Roma: Ed. dell'Ateneo, 1984), 216-218. I owe much of this to Buning, R., *Henricus Reneri (1593-1639). Descartes' Quartermaster in Aristotelian Territory* (Utrecht: Zeno, 2013, Ph.D. Thesis).

[40] Descartes to de Wihlem, 24 May 1647, AT V, 33. Descartes to Vorstius, 19 June 1643, AT III, 686-689.

[41] Descartes to Mersenne, 25 December 1639, AT II, 633.

[42] Descartes to Mersenne, 13 November 1639, AT II, 619. Descartes to Van Zurck, 26 November 1639, AT II, 713.

[43] Descartes to Mersenne, 11 June 1640, AT III, 73. Cf. Descartes to Mersenne, 1 April 1640, AT III, 50.

[44] Foucault, M., *Les mots et les choses* (Paris: Gallimard, 1967), 141-142, "l'histoire naturelle trouve son lieu dans cette distance maintenant ouverte entre les choses et les mots – distance silencieuse, pure de toute sédimentation verbale et pourtant articulée selon les éléments de la représentation, ceux-là même qui pourront plein droit être nommés".

[45] Descartes, R., *Regulæ ad directionem ingenii* VII, AT X, 387-382. Descartes, R., *Discours de la Méthode*, II, AT VI, 19.

[46] Descartes, R., *Lettre-Préface*, AT IX-2, 17.

[47] Paré, A., *Les Œuvres* (Paris: chez Gabriel Buon, 1585), IX, CCCCVI. Sanctorius, S., *Commentaria in primam fen, primi libri canonis Avicennæ* (Venetia, 1629), 692-693. For a clear historical reconstruction, see Des Chene, D., *Life's Form. Late Aristotelian Conception of The Soul* (Ithaca: Cornell University Press, 2000).

[48] For a fascinating reconstruction of Descartes' study on animals' sensation, see Marcialis, M.T., "Sensibilità e automatismo negli animali-macchina cartesiani", *Rivista di storia della filosofia* LXVI/4 (2011): 603-631.

[49] Descartes to Mersenne, 23 August 1638, AT II, 329: "Pour l'herbe sensitive que vous me mandez avoir vue chez Mr de La Brosse, je n'y trouve rien d'étrange que la rareté; car après avoir décrit le mouvement du cœur d'une façon qui pourrait aussi bien convenir à une plante qu'à un animal, si les organes s'y trouvaient de même, je n'ai aucune difficulté à concevoir comment le mouvement de cette plante se peut faire; mais je ne voudrais pas entreprendre de dire déterminément comment il se fait, si je ne l'avais vue et examinée auparavant."

[50] Descartes called them pieces, not just part as he did for inert bodies. See Descartes, R., *L'Homme* V, art. CV, "Reflexion sur tout ce qui a été dit de cette machine", AT XI, 201. For some works on Descartes' study on animals, see Harrison, P., "Descartes on Animals", *Philosophical Quarterly* 42 (1992): 219-227. Morris, K., "Bêtes-machine", in S. Gaukroger *et al.* (London-New York: Routledge, 2000), 401-419. Newman, L., "Unmasking Descartes' Case for the Bêtes machine Doctrine", *Canadian Journal of Philosophy* 31/3 (2001): 389-426. Des Chene, D., *Spirits & Clocks. Machine and Organism in Descartes* (Ithaca: Cornell University Press, 2001).

[51] Cf. Brown, D., "Cartesian Functional Analysis", *Australasian Journal of Philosophy* 90/4 (2012): 75-92.

[52] Descartes to Regius, May 1641, AT III, 371-372.

[53] For what concerns the analogy between bodies, see Descartes, R., *L'Homme* IV, art. LV, "Belle comparaison …", AT XI, 165-166. For Desccartes' laws of nature and mechanical physiology, see Descartes, R., *Le Monde* VII, AT XI, 38-44. *L'Homme* II, art. *XX*VI, "Comment elle est incitée par les objets extérieurs à se mouvoir en plusieurs manières", AT XI, 141-142. Gaukroger, S., *Descartes' System of Natural Philosophy* (Cambridge: Cambridge University Press, 2002), 187.

[54] Gaukroger, S., "The resources of a mechanist physiology and the problem of goal-directed processes", in *Descartes' Natural Philosophy*, ed. S. Gaukroger (London: Routledge, 2000), 383-

400. See also Garber, D., "Descartes and the Scientific Revolution: Some Kuhnian Reflections", *Perspectives on Science* 9/4 (2001): 405-422.

[55] On comparison, see Descartes, R., *Regulæ ad directionem ingenii* VI, AT X, 381-387. Marion, J.-L., "Ordre et relation. Sur la situation aristotélicienne des '*Regles V et VI*'", *Archives de Philosophie* 37/2 (1974): 243-274. And especially, Savini, M., "*Comparatio vel ratiocinatio*. Statuto e funzione del concetto di comparatio/comparaison nel pensiero di R. Descartes", in *desCartes et desLettres. Epistolari e filosofia nell'età cartesiana*, a c. di F. Marrone (Firenze: Le Monnier, 2008), 132-169.

[56] Descartes, R., *Regulæ ad directionem ingenii* VII, AT X, 387-392. As we can see, this is induction to ideas.

[57] Armogathe, J.-R., "Sémantèse d'*experientia/experimentum/expériences* dans le corpus cartésien", in *Experientia*, ed. M. Veneziani (Firenze: Olschki, 2002), 259-271.

[58] Garber, D., (2001), 93, 102.

[59] Cf. Descartes, R., *Discours de la Méthode* VI, AT VI, 72-73: "pour les expériences que les autres ont déjà faites, […] elles sont, pour la plupart, composées de tant de circonstances, ou d'ingrédients superflus, qu'il lui serait très malaisé d'en déchiffrer la vérité; outre qu'il le trouverait presque toutes si mal expliquées, ou même fausses, à cause que ceux qui les ont faites se sont efforcés de les faire paraître conformes à leur principes".

[60] On the role of vision in science, see *Regulæ ad directionem ingenii* IX, AT X, 400.

[61] Descartes, R., *La Dioptrique* IV, AT VI, 109.

[62] Descartes, R., *Meditationes de prima philosophia* VI, AT VII, 80.

[63] Descartes, R., *La Dioptrique* X, AT VI, 226-227. That expectation is seized by Henricus Reneri.

[64] Descartes qualifies his physics as mechanics in many places, for example in Descartes to Debaune, 30 April 1639, AT II, 542. Some interesting works on Descartes mechanics are Séris, J.-P., "Descartes et la mécanique", *Bulletin de la Société française de philosophie* 81/1 (1987): 31-66. Gabbey, A., "Descartes' Physics and Descartes' Mechanics: Chicken and Egg?", in *Essays on the Philosophy and Science of René Descartes*, ed. S. Voss (New York: Oxford University Press, 1993), 311-323. Roux, S., "Cartesian Mechanics", in *The Reception of the Galileian Science of Motion in Seventeenth-Century Europe*, ed. C.R. Palmerino, J.M.M.H. Thijssen (Dordrecht: Kluwer, 2004), 25-66.

[65] Cf. Des Chene, D., *Life and health in Cartesian natural philosophy*, in S. Gaukroger, (2000), 723-735.

[66] Answering about the strange case of the thorn blossoming in the body of a Spaniard, which explanation belongs to the fact that heat is a common principle of life: "la chaleur étant un principe commun pour les animaux, les plantes, et les autres corps, ce n'est pas merveille que la même serve à faire vivre un homme et une plante" (Descartes to Mersenne, 30 July 1640, AT III, 122).

[67] This uniformity was established mechanically in order to constitute a scientific object to which reduce each body, the continuity followed; cf. Descartes, R., *Discours de la Méthode* V, AT VI, 45.

[68] Descartes, R., *Excerpta Anatomica* IV, AT XI, 595. See also Descartes, R., *Primæ cogitations circa generationem animalium*, AT XI, 534-535.

[69] A meticulous description is provided within the Descartes, R., *Primæ cogitations circa generationem animalium*, AT XI, 506-507, where Descartes refers that the two seeds take diametrically opposite positions in the uterus, and then they blend together, facilitated by heat. See also Aucante, V., (ed.), *Ecrit physiologiques et médicaux* (Paris: PUF, 2000), 31.

[70] Descartes, R., *Excerpta Anatomica*, AT XI, 596.

[71] Descartes, R., *Exerpta Anatomica*, AT XI, 596.

[72] Descartes to Mersenne, 16 October 1639, AT II, 595.

[73] Descartes to the Marquis of Newcastle, 23 November 1646, AT IV, 570-571. Cf. Feingold, M., "Descartes and the English: the Cavendish Brothers", in *La biografia intellettuale di René Descartes attraverso la* Correspondance, a c. di J.-R. Armogathe e G. Belgioioso (Napoli: Vivarium, 1999), 697-711.
[74] Descartes, R., *Excerpta Anatomica*, AT XI, 596-597.
[75] Descartes, R., *L'Homme* I, art. III, "Comment les viandes se digèrent dans son estomac", AT XI, 120-123. Descartes, R., *La Description du corps humain* III, AT XI, 247.
[76] On the topic of aging, see Grmek, M.D., "On Ageing and Old Age", *Monographiæ Biologicæ* 5/2 (Den Haag: Junk, 1958) "Réflexions sur des interprétations mécanistes de la vie dans la physiologie du XVIIe siècle", *Episteme* 1 (1967): 17-30.
[77] Descartes, R., *Excerpta Anatomica*, AT XI, 597. See also Descartes, R., *La Description du corps humain* III, artt. XXI-XXIII, AT XI, 249-250.
[78] Cf. Descartes, R., *Excerpta Anatomica*, AT XI, 597.
[79] Descartes had studied the seed of plants, as testified in *La Description du corps humain* IV, AT XI, 253.
[80] Cf. Bitbol-Héspèries, A., *Le principe de vie chez Descartes* (Paris: Vrin, 1990).
[81] Cf. Descartes to Mersenne, November or December 1632, AT I, 263: "je parlerai de l'homme […], car j'entreprends d'expliquer toutes ses fonctions. J'ai déjà écrit celles qui appartiennent à la vie, comme la digestion des viandes, le battement du pouls, la distribution de l'aliment etc., et le cinq sens."
[82] Francis Bacon, for example, presented many pages on these differences and affinities within the seventh century of his *Sylva sylvarum*, in *Works of Francis Bacon* (hereafter SEH), ed. J. Spedding, R.L. Ellis, D.D. Heath, (London: Longman, 1859), vol. II, 528-550.
[83] Descartes, R., *Excerpta Anatomica*, Problemata, AT XI, 621. Similar problems are discussed within the Correspondence, but also in Descartes, R., *Les Météores* III, AT VI, 255-256; and in the Descartes, R., *Principia philosophiæ* I, art. XC, AT VIII-1, 255.
[84] Descartes, R., *Excerpta Anatomica*, AT XI, 622. Bacon, by contrast, had argued that salt is helpful in hasting the growth of plants (*Sylva sylvarum*, exp. 595-600, in SEH II, 525-527) and that some fruits are salty (exp. 645, *SEH* II, 539-540).
[85] Cf. Descartes, R., *Les Météores* II, AT VI, 239-248.
[86] Cf. Descartes, R., *Excerpta Anatomica*, AT XI, 622-623.
[87] Descartes, R., *Excerpata Anatomica,* 622.
[88] Descartes, R., *Exccerpta Anatomica,* 628-629.
[89] Descartes, R., *La description du corps humain* III, art. XXIV, AT XI, 250: "pour savoir […] en quelle sorte chaque portion de l'aliment se va rendre à l'endroit du Corps à la nourriture duquel elle est propre il faut considérer que le sang [or sap] n'est autre chose qu'un amas de plusieurs petites parcelles […]. Et je ne sache que deux raisons […]. La première est, la situation du lieu au regard du cours qu'elles suivent ; l'autre, la grandeur et la figure des pores où elles entrent". Descartes will explain both of them in the two following articles, *La description du corps humain*, artt. XXV-XXVI, AT XI, 251.
[90] Descartes, R., *Exccerpta Anatomica,* 629.