SPONTANEOUS GENERATION IN THE CONTEXT OF EIGHTEENTH-CENTURY LIFE SCIENCES

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Abstract

This project is dedicated to the study of the relations between eighteenth-century life sciences and ideas of spontaneous generation. During this period of time, microscopic research brought up the issues of life and generation of small creatures that were unknown or neglected in the preceding era. This enquiry also helped the naturalists to learn about the details of generation of already known living beings. Asexual generation got a special place among these discoveries since it challenged the existing beliefs about nature. The naturalists who worked on the theories of generation adopted the discourse of spontaneous generation as a model for their theories. This invasion caused dramatic shifts in understanding the mechanisms of reproduction, the relation between the body and the soul, and agency of nature. In this thesis, I reconstruct the relations between the naturalist enquiry and the attempts to create a unifying metaphysical basis for unconventional generation.

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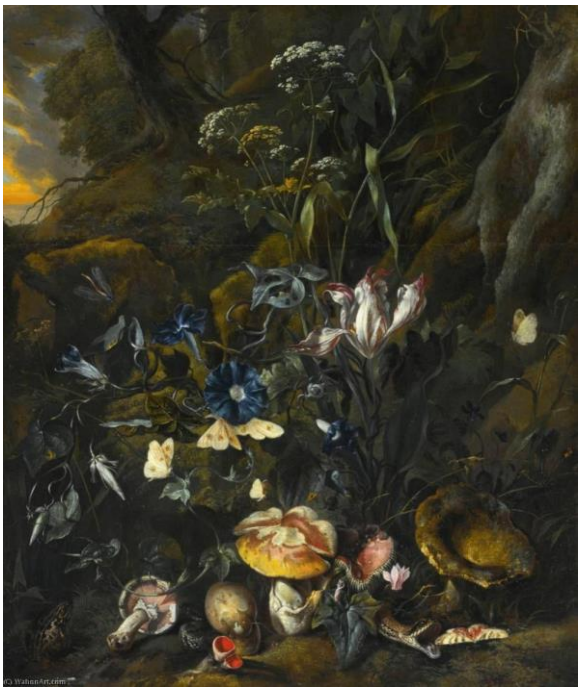
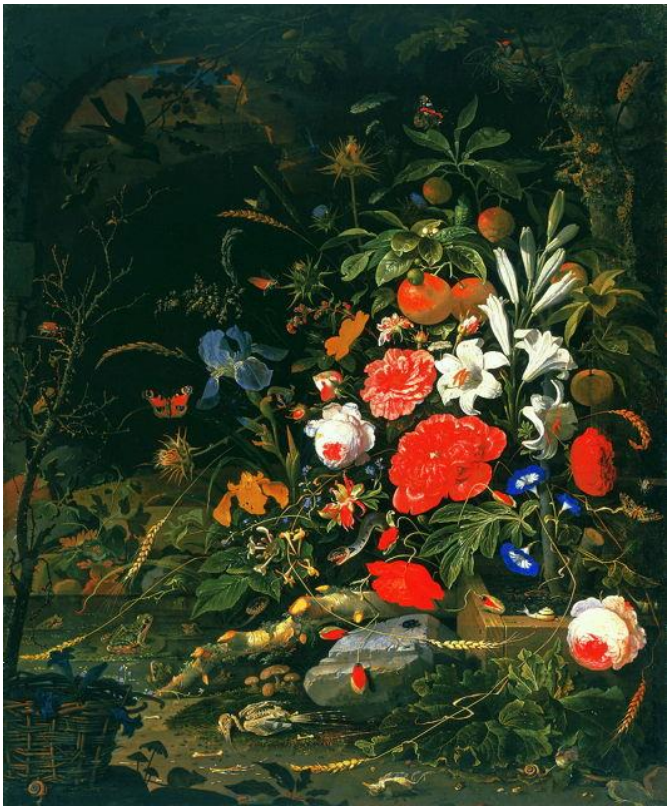
Preface

Four years ago I encountered the article of Karin Leonhard about the Dutch artist Otto Marseus van Schrieck who created numerous paintings of the forest floor. He put the inhabitants of dark grottos – toads and lizards – together with the common inhabitants of Dutch still-lifes – butterflies and moths among forest and garden flowers (Pic.1). Leonhard uses the Italian term *sottobosco* [low forest] to define this type of images that combine features both of still-life and landscape. The dark and vibrant atmosphere of these pictures is enforced with the density of the composition and common theme of the cycle of life and death. This is represented in the painting by Abraham Mignon where the bush of fruits and flowers is accompanied by the detail of a putrefying bird on the ground (Pic.2). From my perspective, at that point in time, almost four years ago, all these images looked like a strange representation of living matter itself or maybe dead matter producing living beings spontaneously. Leonhard interpreted these works in the context of seventeenth-century science and the revival of Aristotelian knowledge in Europe.[1] Nevertheless, despite the fact that the founder of the genre, Schrieck was an amateur naturalist himself, these pictures do not depict nature in its real state. However, it was a mystery for me why these early modern people were so obsessed with the life of these tiny creatures and why they were presenting this topic in such a cryptic way. These simple questions about rather humble seventeen-century Dutch painters led me to the history of the debates and unanswered questions on animal and human asexual generation in the eighteenth century.

[1] See Karin Leonhard, "Pictura's fertile field: Otto Marseus van Schrieck and the genre of sottobosco painting," *Simiolus: Netherlands Quarterly for the History of Art* 34, no. 2 (2009).



Pic. 1. Otto Marseus van Schrieck.,*Forest* floor, circa 1660-1670.



Pic. 2. Abraham Mignon, *Composition with a Dead Bird*, circa 1660-1670.

Introduction

And (3) soul is better than body, and living, having soul,
is thereby better than the lifeless which has none,
and being is better than not being, living than not living.
These, then, are the reasons of the generation of animals.
Aristotle. *On the Generation of Animals.* Book II

Eels are born from river mud and white butterflies are born from cabbage leaves. If you lost all the hives of bees, follow Virgil's advice and restore an entire population from the putrefying blood of cows.[2] Such assumptions lasted longer than we think they should and had more variations and nuances than we expect. In this introduction, I want to highlight the diversity of objects and phenomena in the natural world that could fall under this notion: the theory of spontaneous generation based on the belief that life can be produced from dead inanimate matter. It had a strong relation to the semi-imaginary phenomenon of the case of something being born out of nothing without time or space regularity. Spontaneous generation in its simplest understanding is the idea that sometimes (but not necessarily always) a mouse, a butterfly, a tapeworm, or a mollusk could arise not from a couple of parents but from the environment; but it is also the belief that a living creature could produce an offspring without another parent. Spontaneous generation could be applied not only to the tiny spores, insects and mushrooms but also to the emergence of a new organism inside a body without mating or predictable by chance. Spontaneous generation is not a unified notion. Nevertheless, in different contexts it was always related to themes of the relation between life and non-life: the decay of the flesh and the emergence of life from this dead matter, the emergence of life out of something never living, and

[2] Virgil, *Georgics*, trans. James Rhoades (1881), https://www.gutenberg.org/files/232/232-h/232-h.htm (accessed April 30, 2020).

asexual birth. Spontaneous generation was always related to uncertainty and mutability in nature, the propensity of nature for change.

I argue that spontaneous generation was the turning point for the important changes of the crucial aspects of generation theories. It provoked the reevaluation of the ideas about mechanics of generation, role of the matter and soul in this phenomenon, and the variety of ways of propagation in nature. During the late seventeenth and early eighteenth century asexual generation of the 'lower' creatures was legitimized as a possible way of reproduction due to the discoveries that took place in the field of the microscopic research. At the same time, spontaneous generation was not perceived as a phenomenon separate from the sexual generation of 'higher' beings. It provoked significant reevaluations of some aspects of theories of generation existing during this time. Most importantly, spontaneous or asexual generation pointed to the agency of nature in the reproductive mechanisms, which caused legitimate anxieties among the scholars who needed to respond to it with a new metaphysical explanation for the fundamental laws of generation. I argue that the seemingly marginal idea of spontaneous generation was the cause of the shifts in the understanding of generation on the fundamental level. Moreover, these epistemological changes could not remain in the domain of natural history and they influenced the perception of life, order of nature, and the human.

This project is focused on the tensions between new discoveries and observations and questions of natural history that addressed philosophy and religion. How to define the variety of terms used to describe spontaneous generation? Where do the boundaries of spontaneous generation lay? How this issue was used in structuring nature? The issue of structures and taxonomies leads to the question of categories used in early natural knowledge. Did this ability bring the distinctions between simple and complex organisms? What influence did the concept of spontaneous generation have over the definition of a

living being? In the context of animal souls, did it mean that the soul could arise spontaneously? What ideas about human's spontaneous generation existed and in what form?

The issues of spontaneous generation ran across various fields of natural knowledge that are usually studied separately – early embryology, anatomy, botany, epidemiology, and other parts of intellectual history that are not seen as "science" nowadays. I believe that analyzing the life of the concept of spontaneous generation on different examples will be fruitful to see the borders of this phenomenon and changes in its understanding and attitude to it.

Terminology. The first important issue is the absence of a general unified notion of spontaneous generation. There is a great deal of uncertainty and a variety of terms used for the references to this phenomenon in the Early Modern period. Spontaneous generation could be called *equivocal generation*, *biogenesis*, and expressed just in descriptions without actual naming. At the same time, all of these terms and patterns of descriptions could be used interchangeably or be strictly separated.[3] It is important to not that the scholars of the eighteenth century rarely used the term 'spontaneous generation' even if they described a phenomenon fitting this notion, but for the purpose of the thesis I use this term to make the delivery of the text clearer.

This problem of naming the phenomenon is deeply rooted in the history of the concept. Once articulated by Aristotle as a special way of generation of animals, insects, and plants, spontaneous generation could be applied to any phenomenon resembling the appearance of something living in the natural world without a visible act of mating of non-viviparous species. Some insects and plants (and other creatures) being born from tiny eggs and seed, or mushrooms rising from spores, were seen as springing from nowhere. This

[3] Peter McLaughlin, "Spontaneous versus equivocal generation in early modern science," *Annals of the History and Philosophy of Biology* 10 (2005): 79-88.

process included a special relation of matter and heat, and also (more) importantly the presence of *anima* – soul, that animated and gave the form to the unorganized and *nonliving matter*. At the same time, spontaneous generation could be applied to the formation of things that we do not consider living now – like regenerated parts of some creatures, tumors, and other unexpected formations in the bodies, minerals, and even diseases.

Another important aspect is the fact that the term reproduction was not spread in the early eighteenth century and instead of it the word 'generation' was used.[4] Generation was more universal, but also more obscure term that reflected the problem of understanding of the mechanics of this phenomenon.

Theology vs. Nature. As a further aspect, the question of birth or the formation of something new *ex nihilo* was an important philosophical and theological problem. This ideological clash was as important in the critique of this concept as the rise of empiricism in early modernity. On the one hand, spontaneous generation was ascribed to the tiniest organisms, many of which were perceived as low and "unclean" creatures. On the other hand, the perception of generation without mating in Christian civilization could not be seen without attachment to the Virgin Mary, her own birth, and the birth of Jesus Christ. It is possible to find this relation in visual arts: the bee, which was supposed to generate spontaneously, was one of the symbols of Mary. Another one, more rarely found, was the snail, believed to be impregnated with water (Pic.3).[5] The ideas about semi-miraculous births were traveling from text to text and appear in various realms of culture. Nevertheless, the influence of the ideas about "innocent" births and pregnancies was strong and provoked more and more discussions. The most important one for the eighteenth century was the issue of soul, its properties, divisibility, and generation.

[4] See Nick Hopwood, "Key words 'Generation' and 'Reproduction'," in *Reproduction* ed. Nick Hopwoon, Rebecca Flemming, Lauren Kassel (Cambridge: Cambridge University Press, 2018), 287-304.
[5] See Helen S. Ettlinger, "The virgin snail," *Journal of the Warburg and Courtauld Institute London* 41 (1978).

Pic. 3. Francesco del Cossa. Annunciation. 1470.

Against Spontaneous Generation. In historiography spontaneous generation is usually seen as a controversy, although the scale of the struggle is quite exaggerated. In the eighteenth-century life sciences, the main debate was held between supporters of preformism and epigenesis. Preformism was the dominating idea that was based upon the belief of pre-existing germs, eggs, or seeds that encapsulate the future organism with all its properties. This theory had a strong religious component in it. Naturalists derived some crucial concepts of natural knowledge from the biblical *Genesis* and its idea of simultaneous creation of everything in the world at a single point in time. That meant that there was no change and noteworthy mutability of nature. The world was stable and it was running according the divine design without essential changes. Preformists believed that the human kind (as well as other living creatures) was predesigned in the day of Creation. From this idea developed the concept of the fixity of species, the idea that the specimens were unchangeable and no creature could cross the limits of three natural kingdoms. This theory

resolved an important problem of generation and transmission of the soul. In other words, if a human being was encapsulated in a spermatozoid or an ovary it pre-existed there as a solid unity with the body and soul. Epigenesist argued that the life was generated gradually from unorganized particles of living matter. For example, in the case of humans and brute animals a fetus was formed from the bodily liquids of male and female parents and in the case of spontaneous generation a new organism emerged due to the activity of the unorganized matter. The debate between these two theories could not be resolved just in the area of natural knowledge due to the lack of information on embryogenesis that was hidden from a human eye. The studies of the 'low' organisms' generation played an important role in this debate serving as an argument for one of the views. Scrutinizing asexual generation, defining patterns and regularities in these cases was used as a model for understanding of the fundamental laws of reproduction. The studies of 'lower' beings' generation helped to normalize the phenomenon of spontaneous generation and apply it to the larger schemes of generation in general.

Spontaneous generation is often seen as a controversy with its own history. The beginning of the open attack on spontaneous generation with the usage of empiricist tools dates back to 1668 when *Experiments on the Generation of Insects* was published by an Italian naturalist Francesco Redi. This text established the foundations for the research of the generation of insects and, at the same time, left some space for a possibility for speculations on spontaneous generation. In the eighteenth-century, spontaneous generation problem from an empiricist perspective was brought up by John Tuberville Needham (1713-1781) and was developed in his correspondence with Charles Bonnet (1720-1793) and Voltaire (1694-1778). In 1786 was published another crucial text by an Italian naturalist Lazzaro Spallanzani (1729-1799) – *Experiences to Serve to the History of the Generation of Animals and Plants.* This is usually seen as a ground-breaking document of enlightened

science, although it was created in the context of a very cautious scientific community. At the same time, I have to note that the tendency to represent the research on spontaneous generation as a debate between the supporters and adherents of this idea is inaccurate. The naturalists who accepted unconventional generation rarely would call it spontaneous generation. The naturalists who wanted to attack their opponents used the notion as an accusation in superstitious archaic beliefs. In overall, the history of spontaneous generation was mutable and nonlinear just as the phenomenon itself.

Timeline. In the current historiography, the middle of the eighteenth century is seen as a time of a significant shift in natural history related to the publication of *Encyclopédie*, experiments of Lazzaro Spallanzani (1729-1799), works of Albrecht von Haller (1708-1777), and theories of Pierre-Louis Maupertuis (1698-1759). In this project, I work on the period that preceded these changes to show how the ground fo this work was provided. I start with the last quarter of the seventeenth century that Jacques Roger (1990-1920) called the 'revival of natural history'.[6] The enquiry on generation was an essential part of natural history as a phenomenon that challenged the perspective of physics on nature. As was stated even by the Cartesian thinker Bernard de Fontenelle (1657-1757), "machines cannot built machines" and the case on spontaneously generating organisms could illustrate the meaning of this quote.[7] I believe that the generation of the 'low' creatures played a crucial role in the understanding of the mechanics of generation on the fundamental level. In the end of seventeenth century the scholars started to realize the inadequacy of the rationalization of nature by mechanical philosophy, especially in the field of sciences of generation.[8]

During the first half of the eighteenth century, naturalists learned more about the formation of the fetus in human and animal bodies, and they studied reproductive systems of

[6] Jacques Roger, "The living world," in *The ferment of knowledge: Studies in the historiography of eighteenth-century science* ed. George S. Rousseau, and Roy Porter (New York: Cambridge University Press, 1980), 271.
[7] Ibid., 272.
[8] Ibid., 271.

different species, including humans. Charles Bonnet (1720-1793) in his early years discovered parthenogenesis – asexual reproduction of lice – while in 1742 Abraham Trembley (1710-1784) observed the reproduction of the *hydra* by cutting, and also discovered its regenerative abilities that were unknown before. This interest in the problems of generation during this period was different from the times before. These shifting tendencies were expressed in the search for unified patterns of reproduction, the testing of older beliefs about generation, and the development of ideas about the agency of nature in the formation of new organisms. The question of the agency of nature had a special significance for eighteenth-century thought due to its tensions between the idea of divine design and independent living force of nature – *vis vita*. These ideas were not necessarily atheistic or proto-atheistic, but they showed a shift in the definition of divine agency in the natural world that influenced the state of contemporary natural theology. I believe that studies of these ideas are important due to their genealogical importance for later biological and natural philosophical thought.

Jean-Baptiste Lamarck (1744-1829) and Charles Darwin (1809-1882) paid attention to the concept of spontaneous generation from different aspects, but the role of this idea was generally forgotten on a larger scale. Analyzing the metamorphosis of the idea of spontaneous generation on different materials of the first half of the eighteenth century makes is possible to show the tendencies in the understanding of origins of life in nature (from the birth of lice to speculations about the origins of life). The specific perception of asexual generation and attitude to it allows scholars to ask questions irrelevant to more visible and conventional issues of sexual procreation.

The State of the Art. The literature on the topic is both broad and quite narrow since that the problem of spontaneous generation lacks terminological consistency and represented in various fields of early natural knowledge that differ from each other quite

dramatically. Scholars from different fields – history of science, medicine, philosophy, and even literature touched upon the theme of spontaneous generation. I could identify two main approaches to the topic, one that is more general and contextual and another devoted to particular extraordinary cases. Some of these texts cover major problems of the topic and explain different nuances of the theory at a certain period and devoted to works of groups of thinkers. Sometimes in this type of scholarship authors trace the influence of the theory of spontaneous generation on other concepts – most notably evolution.[9] Another type of texts is focused on single-standing cases such as motives in fiction and poetry (and visual arts),[10] esoteric texts,[11] spontaneous generation in works of unknown amateurs and naturalists. The only monograph covering the eighteenth-century thought on spontaneous generation is John Farley's *The spontaneous generation controversy from Descartes to Oparin* (1977) and its first chapter being dedicated to the material of the seventeenth and eighteenth centuries. Farley represented spontaneous generation as an independent continuous debate going over centuries and analyzed it separately from other controversies of the early modern life sciences. 'Controversy' is a strong word regarding spontaneous generation since it would be hard to find a notable scholar of the time who used the term and observed or believed everything that this notion contained. We have to admit that the pathos of the passionate

[9] The studies of the impact of spontaneous generation on the evolutionary thought started in the second half of the eighteenth century.

[10] Gilberto Sacerdoti, "Spontaneous Generation and New Astronomy in Shakespeare's Antony and Cleopatra'," in *Questioning Bodies in Shakespeare's Rome*, ed. Nancy Isenberg (Göttingen: V&R University Press, 2010), 327-339.

[11] Paola Zambelli's review on Carlo Ginzburg's *Cheese and Worms* also addresses the dissemination of theories about spontaneous in Italy. Hiro Hirai worked with traces of this idea during the Renaissance and seventeenth century. See Hiroshi Hirai, "Athanasius Kircher's chymical interpretation of the creation and spontaneous generation," in *Chymists and chymistry: Studies in the history of alchemy and early modern chemistry*, ed. Lawrence Principle (Philadelphia: Science History Publications, 2007), 77-87; Hiro Hirai, "Earth's soul and spontaneous generation: Fortunio Liceti's criticism of Ficino's ideas on the origin of life," in *Laus Platonici Philosophi: Marcilio Ficino and His Influence*, ed. Stephen Clucas (Brill, 2011), 273-299; Hiro Hirai, "Living Atoms, Hylomorphism and Spontaneous Generation in Daniel Sennert," in *Matter and Form in Early Modern Science and Philosophy*, ed. Gideon Manning (Brill, 2012), 77-98.

fight of experimentalists against 'superstitions' about spontaneous generation[12] was not that heated and was not motivated by modern views on convincing scientific evidence.

Although the history of spontaneous generation is a part of the history of life sciences, a rare textbook on the history of biology ignores the issue of spontaneous generation. The classic book by Jacques Roger *Les sciences de la vie dans la pensée française du XVIIIe siècle: La génération des animaux de Descartes à l'Encyclopédie* (1963) translated into English in 1997 by Robert Ellrich and edited by Kaith R. Benson, does not contain a separate chapter on the question but spontaneous generation is built into the context of the complex debates of the time. Roger provided us with a greatly nuanced picture of the development of life sciences in the eighteenth century from leading thinkers to completely forgotten naturalists from the periphery. Although spontaneous generation is under-represented in this monumental work, it is never separated from other generation theories or archaized as an unimportant old belief. A more recent encyclopedic book devoted to the history of life sciences by Louis Magner covers almost the same timeline and also touches upon the issue of spontaneous generation.[13] Magner starts the chapter on seventeenth-century research by addressing the Aristotelian roots of the concept and later draws attention to experiments of Francesco Redi. Although spontaneous generation is not well-represented in this text, the author acknowledges the awareness and preoccupation of early life scientists with the relations of sexual and asexual reproduction.

I argue that spontaneous generation is a legitimate part of early life sciences and that this phenomenon is inseparable from questions of mainstream natural history. Even though the concept of spontaneous generation is usually perceived as a pseudo-scientific belief or a unique example of asexual reproduction, this idea was not less sophisticated than more conventional ones. We should keep in mind that during this time people primarily relied on

[12] This pathos is brightly expressed in the article by Wolfgang E. Krumbein, "Gone with the wind—a second blow against spontaneous generation," *Aerobiologia* 11, no. 3 (1995): 205-211.
[13] Lois N. Magner, *A history of the life sciences, revised and expanded* (New York: M. Dekker, 2002), 153.

the theory of preformism, had no explanation for mechanisms of inheritance, and, in the end, had not discovered gametes and gonads yet. We should always remember the different logic behind the motivation of critics and adherents of theories of asexual reproduction. Relying on these points, I am planning to analyze the case of spontaneous generation in three essays devoted to quite distant topics: the generation of insects and parasites, the generation and taxonomy of zoophytes, and the artificial generation of human beings.

Thesis Outline. The thesis contains three chapters that are devoted to the specific aspects of enquiry on unconventional generation. I chose the examples of the texts that reflected the studies and discoveries that were taken as challenging for the established theories of life and doctrines like the fixity of species or ideas about the nature of the soul. To illustrate the importance of this enquiry, I address the texts outside 'pure' natural knowledge that combined natural history topics with philosophy, polite conversation, and satire. As was pointed out earlier, the naturalists almost did not use the term 'spontaneous generation', but the discoveries of various creatures procreating asexually evoked the same questions as spontaneous generation – non-parental, non-parent-like, and unpredictable. I intend to show how the question of asexual reproduction of 'lower' creatures like worms and the microorganisms like fresh-water *hydra* (polyp) shifted to the issues of generation on the fundamental level.

The first chapter is devoted to the questions of the generation of worms that were studied in the end of seventeenth and early eighteenth century. I focus on how the studies of worms were brought to the area of natural history from the domain of medicine and how the hypotheses about their generation influenced the perception of asexual generation.

The second chapter is dedicated to the discovery of the polyp by Abraham Trembley in the early 1740s and the further reception of this case. I analyze the discovery of the polyp

in the context of modern taxonomy and how the regenerative abilities of this creature challenged the established theories of generation.

In the third chapter I analyze the conjunctions between the findings of John Needham's research on the generation of microorganisms and the issues of artificial fertilization. I intend to show how the enquiry into generation influenced the idea of controlled reproduction in the middle of the eighteenth century.

Chapter I

Animals Found in Animal Bodies. The Discussion on Spontaneous Generation in the Late Seventeenth and the Early Eighteenth Century

But yet in Nature, and her Operations, they are far more than merely Mechanical;
and the same is not a mere Organical Body,
like a Clock, wherein there is not a vital Principle of Motion;
but a living Body, having Life and Sense,
which Body is far more sublime than a mere Mechanism,
or Mechanical Motion. (Anne Conway, *The Principles of the Most Ancient and Modern Philosophy* London 1692 Chapter IX 2)

In this chapter, I analyze strategies of legitimizing asexual generation in examples of late seventeenth-century helminthology. With the invention of the microscope, a new world was discovered. Tiny creatures inhabited every surface, waters, air, and humans themselves. The naturalists saw this microscopic world constantly changing and rapidly growing and breeding in the ways different from the already known creatures. The metaphysics of this period were oriented on physical laws that were seen as universal. The life and generation of these small creatures challenged these beliefs in physical laws and brought up the problems resembling the discourse on spontaneous generation. In other words, the generation of these living beings was seen as non-parent-like and non-parental generation with obscure patterns and regularities that had to be studied and explained. The problem of the generation of worms inside an organism encouraged naturalists to study the causes of this phenomenon and link them to the problems of divisibility of matter and natural forces.

In current historiography on the subject of spontaneous generation, the topics of parasites and diseases occupy a significant place.[14] The studies of the phenomenon of

[14] The historian of the spontaneous generation controversy of the nineteenth century addressed the earlier discussions in the context of studies of parasites. See John Farley, "The spontaneous generation controversy (1700-1860): the origin of parasitic worms," *Journal of the History of Biology* (1972): 95-125; John Farley, "Parasites and the germ theory of disease," *The Milbank Quarterly* (1989): 50-68.

parasites in animal and human bodies were strongly tied to the discussion about spontaneous generation due to its relation to the questions of transformation and chance in nature. In this chapter, I will analyze the ways of explanation for the generation of microscopic organisms on the examples from the texts on the formation of worms in animal, plant, and human organisms. The first part of the chapter is dedicated to the controversial text *Osservazioni Intorno Agli Animali Viventi Che Si Trovano Negli Animali Viventi (Observations on Living Animals, that are in Living Animals) (*1684) by Francesco Redi which preceded the eighteenth-century ideas about the practice of experiment. In the second part, I will discuss *A Theologico-Philosophical Dissertation Concerning Worms in all Parts of Human Bodies* (1727) by William Ramesey published under the name G. de Gols. This work articulated not only modern research on worm-like microorganisms and their ominous presence in the world, but also philosophical and theological questions about these creatures. These two texts belonged to the area of helminthology that preceded the discipline of parasitology, but not resembled it. The Early Modern study of worms explored the generation of worms to answer the moralistic and theological questions.

In the eighteenth century, the issues of spontaneous generation appeared to the level of the microscopic organism's life that were invisible to a bare human eye. Various organisms, but mainly parasites found in the bodies of animals, humans, and even plants were often seen as a result of spontaneous generation. The essential problem of helminthology was the opposition of views on internal and external causes of parasites. It is also important to note that not only microorganisms, but the growth of various tumors inside and outside a body could be seen as a kind of generation similar to the one that parasites have. The fact that the generation and development of a tapeworm or a gall were hidden from observation, led to various ideas about their origins. Epigenesis and preformism

influenced the hypotheses about the generation of worms as well as the beliefs about death, putrefaction, and disease.

This context encouraged the naturalists to study worms by combining the earthly issues of worms' lifecycles with the subject of natural theology, philosophy, and superstitions. Why do only some organisms produce worms? Do parasites gradually emerge from the body itself or do they develop from an egg that a human or animals got from their environment – through food, water, or air? If the parasitic worms emerge internally by means of a body, does it correlate with the moral state of a person? Although these questions resemble those discussed in the central debate of the early life sciences between preformists and epigenesists, the subject of animals found in other animal bodies provoked its own questions regarding the interaction of microorganisms with humans, animals, and plants. How did discussions in the field of proto-parasitology affect the perception of spontaneous generation? Since the issue of parasitic worms was related to death and disease, could it influence the understanding of the limits and features of the notion of life? Was it understood as the simplest form of life? Was it seen as an advanced form of life (since a parasite could kill a 'higher' being like human or brute animal)? In the same context, was it possible to predict and regulate the emergence of these creatures or were they believed to be spread everywhere?

According to the existing historiography, the acceptance of spontaneous generation as an actual way of reproduction was an archaic belief that naturalists had to fight. Nevertheless, the notion of spontaneous/equivocal generation covered cases of asexual generation that were impossible to deny. Non-parental and non-parent-like births existed as well as the propagating activity of matter that was caused by microorganisms and these ways of reproduction needed to be built in the frame of conventional sexual generation. First, I argue that the scholars of the time actually observed the difference between various

ways of procreation, mainly between sexual (viviparity and oviparity) and asexual (spontaneous generation/equivocal generation).[15] The naturalists had to explain this difference, however the process of spontaneous generation (as well as generation in general) remained a mystery. Secondly, I argue that spontaneous generation was a model for the demonstration of the mechanics of generation. The naturalists showed that the simple process (which omits the long process of conception and prenatal growth) runs according the same laws of nature as a more complex one. To demonstrate this, the naturalists of the late seventeenth and early eighteenth centuries who analyzed the phenomenon of spontaneous generation, or any case of asexual reproduction, went in two directions. These directions were framed by two poles: preformism and epigenesis. In general, prefomists argued that spontaneous generation was nothing more than the growth of a pre-existing seed in a comfortable environment. Epigenesists wrote that the moving particles of the living or non-living matter could form a new organism.

At the same time, cases of spontaneous generation were paradoxical – new creatures were produced from both living and non-living matter without a parent organism. Another, more important paradox was the fact that, as scholars observed, organisms of different kinds could be produced (non-parent-like generation) in the bodies of living creatures The parasites were the most striking example of this phenomenon since the worms did not resemble humans or animals, but human and animal bodies produced them. Although, spontaneous/equivocal generation was criticized as a concept, cases of the generation of worms were impossible to reject. These phenomena needed names and terms that could help to communicate the specifics of the subject.

Equivocal and Spontaneous Generation. In both the sources and in the secondary literature, there is a general ambiguity between the terms of spontaneous generation and

[15] McLaughlin, "Spontaneous versus equivocal generation in early modern science," 81.

equivocal generation both. Both of these notions refer to the way of reproduction when a living organism is born asexually. Both of them could be used interchangeably, although the term equivocal generation was more frequent. In the original Aristotelian definition, spontaneous generation is a process when a living creature arises from a *non-living* matter. By the eighteenth century, spontaneous generation could be accepted as a asexual generation if there was a regular natural logic can be discovered in it. In the eighteenth century, spontaneous generation was mainly discussed in the context of micro-organisms and the mechanics of their life and their origins.

Equivocal generation, however, is a type of generation in which a couple of parents produce offspring of a kind different from themselves. In one of the few works dealing with this epistemological problem, Peter McLaughlin highlights that equivocal generation is primarily characterized by irregularity and the possibility of changes in nature by chance.[16] He also claims that, by the middle of seventeenth century, scholars did not believe in equivocal generation, but accepted the cases of spontaneous generation.[17] For him, the distinction between terms is in the juxtaposition of regularity and irregularity. He writes: "…spontaneous generation could be unequivocal. For instance, if the same solutions, the same ingredients, always give rise to the same species of infusoria, and different solutions give rise to a different kind of infusoria, there seems to be nothing equivocal about this sort of generation".[18] Nevertheless, the term equivocal generation implies the ability of a specimen to reproduce sexually as well as asexually and such cases were discovered by the late seventeenth and the early eighteenth century. Unconventional births were observed among animals and humans, and new species with unfamiliar reproductive properties were brought to laboratories from overseas. These factors produced debates about breeding, and the reasons for the formation of monstrous or non-parent-like offspring.

[16] Ibid., 81.
[17] Ibid., 80-81.
[18] Ibid., 81.

Equivocal generation was a broad umbrella term for various cases of asexual reproduction or phenomena considered as such. The idea of equivocal generation pointed out the cases of changes in nature by chance, fall-shorts, and hybrids that were challenging the idea of the fixity of species that was at the core of the eighteenth-century natural knowledge. The concept of the fixity of species is the belief that the natural world emerged in the moment of the Divine creation with all its variety.[19] This concept rejected the possibility of the appearance of new species as well as their extinction.[20] Nevertheless, the natural world demonstrated hybrids, new specimens, and fossils. The question of the origins of fossils was also in the spectrum of spontaneous/equivocal generation issues, and the idea that fossils spontaneously generate was acceptable.[21] I believe that the degree of the acceptance of mutability in nature lays deeply in philosophical views on nature and it affected the attitudes to alternative ways of generation that were discovered throughout the century.

Death and Putrefaction People associated the phenomenon of the corruption of the body with spontaneous generation since ancient times. The popular understanding of ideas about spontaneous generation was tied to the imagery of decay and the life of 'low' creatures.[22] Parasites troubled humankind throughout its history, and in the eighteenth century this remained a problem that required various medical and cosmetic solutions.[23] Worms devour a body after its death, which means that the death of a living being does not end the cycle of life in that body. The general explanation for this phenomenon was the idea that the process of putrefaction is constantly present in a human body due to the abdomen

[19] Jennifer Trusted, *Beliefs and Biology: Theories of life and living* (Springer, 1996), 87.
[20] Ibid., 87.
[21] See Evelyn Stokes, "The six days and the deluge: some ideas on earth history in the Royal Society of London 1660-1775," *Earth Science Journal* 3, no 1 (1969): 13-39.
[22] See Edward J. Geisweidt, "'The Nobleness of Life": Spontaneous Generation and Excremental Life in Antony and Cleopatra," In *Ecocritical Shakespeare* (Routledge, 2016): 113-128.
[23] Lianne McTavish, "Intestinal Chaos: Tapeworms, Dead Flesh, and Reproduction during the Eighteenth Century," in *The Secrets of Generation: Reproduction in the Long Eighteenth Century*, ed. Raymond Stephanson, and Darren N. Wagner (University of Toronto Press, 2015), 373.

activity, and after death this process continues.[24] There were different ideas about death in the Early Modern times. The natural philosopher Anne Conway (1631-1679), arguing against Cartesian doctrine, used the phenomenon of death in her pre-vitalist writings. For her, the dead matter did not exist since 'souls love bodies as widely known, the souls of certain people remain with their bodies and in their power after the death of the body and until it decomposes to dust."[25] In the eighteenth century, Buffon continued Descartes' idea of death as a process of drying out with final ossification.[26] This theory could be seen as opposed to the phenomenon of corruption. Nevertheless, in this theory the emphasis was put on the understanding of death as an extremely gradual process that starts long before the very moment of death.[27] The presence of parasitic insects and worms was not challenging this concept, but rather supporting this vitalist understanding of mortality.

The presence of parasitic worms in animals, but more importantly on the human body, provided a specific picture of the natural world filled with omnipresent worms not just dispersed across the world, but also living inside and on the surface of other creatures. It seems that this important, but quite a specific issue could challenge the Cartesian views on nature and life. Instead of divine machines operating according to the laws of nature, everything in the world could be seen as micro-biomes that are inhabited by invisible creatures. This corresponded with the work of microscopists and fit into the context of questions about the generation of this type of organism.

Bodies inside a Body. The phenomenon of the formation of bodies or living creatures within a body was an important issue for the history of life sciences. It must be noted that this phenomenon was not exclusively related to parasites, but also to the

[24] Ibid., 373.
[25] Deborah Boyle, "Spontaneous and Sexual Generation in Conway's Principles," in *The Problem Of Animal Generation in Early Modern Philosophy*, ed. Justin E. H. Smith (Cambridge:Cambridge University Press, 2009), 181.
[26] Joanna Stalnaker, "Buffon on Death and Fossils," *Representations* 115, no. 1 (2011): 26.
[27] Ibid., 22.

encounters of tumors of various forms, tissue formations, and embryo's pathologies like lithopedion or other rare phenomena.[28] Parasites could also influence the development of a fetus and such cases were known in early modern times.[29] In the late seventeenth and early eighteenth centuries the beliefs about animal births among human parents remained relatively popular (at least, as a moralist story in the midwife's literature).[30] An example of such a belief was the *sooterkin*, a mouse-like creature that was believed to be found together with a child after giving birth. Midwives thought that these creatures conceived independently from sexual intercourse and the theoretical explanation for these strange births was the corruption of the womb or the degeneration of the seed.[31] This provoked questions about the internal and external reasons for such fall-shorts. At the same time, such cases were quite rare and in this context the problem of chance, the possibility of an unpredictable shift in the development evoked the issue of spontaneous or equivocal generation. *Sooterkins* were identified as animal births and if a human gave birth to a creature considered an animal, it would be an example of equivocal generation.

However, this part of my thesis is dedicated to the tiny animals known during this time as worms and their generation, although the main poles of the discussion are split between epigenetic and preformist views on generation. Depending on the views of a certain naturalist, the case of a tumor, a monstrous embryo, or the emergence of a parasite inside a body could be interpreted in line with preformist or epigenetic theories. Tapeworms could be believed to emerge from the matter of a living or a dead body itself or to grow from a seed that was either transmitted to a host or pre-exist in the organism of a living being. The

[28] Lithopedion is a pathology when a fetus dies during the abdominal pregnancy and calcifies inside the body of a woman for long period of time. Such cases were rare, but some of them were reported about during the eighteenth century.
[29] McTavish, "Intestinal Chaos: Tapeworms, Dead Flesh, and Reproduction during the Eighteenth Century," 368.
[30] Alan W. Bates, "The sooterkin dissected: the theoretical basis of animal births to human mothers in early modern Europe," *Vesalius* 9 (2003): 6.
[31] Ibid., 9.

points of tensions were the question of natural laws that could be observed, identified, and predicted by a naturalist.

The texts of Redi and Ramesey addressed the mechanism of the generation of worms in plant, animal, and human bodies. These texts have a lot of differences from each other – Redi wrote about the experiments and laws of non-parental generation, and Ramesey worked with the philosophical framework for the discovered variety of worm-like creatures in the world. Nevertheless, these texts both engaged the specific way of generation and addressed this issue as one of the main features of the world of small creatures.

Francesco Redi's Views on the Generation of Galls

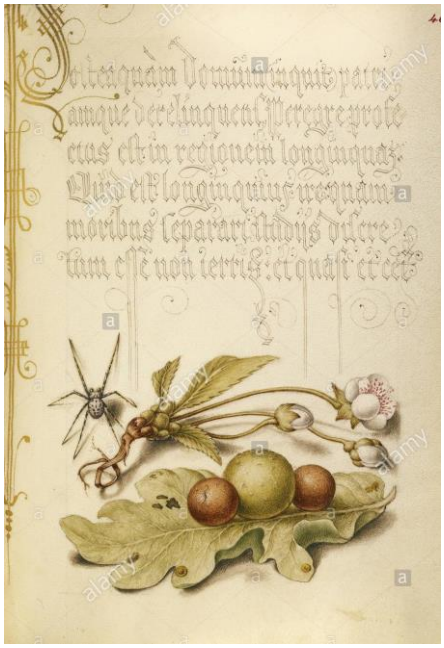
Francesco Redi was a key figure of the historiography of the spontaneous generation controversy. Redi is remembered as the naturalist who disproved the belief that flies were born from rotting meat using his observations and experiments. Although Redi is situated quite far from the main narrative of my thesis, his contribution to the life sciences was significant. He worked during the period, when the borders between various types of 'low' creatures were not established, and the cause of their generation remained largely unknown. I this section, I will analyze some passages from the treatise *Observations on Living Animals, that are in Living Animal* (*Osservazioni Intorno Agli Animali Viventi Che Si Trovano Negli Animali Viventi*) published in 1684 that is often neglected by researchers. This text contains information on snakes, insects, and plants and organisms found in them or produced by them. In this chapter, I will focus on Redi's account on the reproduction of *galls* (Pic. 3). Galls (in Redi's understanding) are round growths on different parts of plants that serve as a nest for the formation of various insects. Redi believed that the galls were produced by the plant and not by the parent-insect. This belief in the asexual inner

generation of galls provoked some critique of his views as an experimentalist and led to accusations in support of spontaneous generation.

The criticism towards Redi was related to the philosophical commitment and credibility of his observations and experiments. The topic of parasites or bodies that emerged in other bodies was mainly related to the field of early modern helminthology. The naturalists of the time did not know precisely if the causes of worms were internal or external. On the one hand, both internal and external causes could be explained by the preformist theory as generation from pre-existing eggs that either existed inside the living beings or brought from the outside. On the other hand, if there was no convincing information for external causes of the bodies generated inside the living beings that would point out that these worms were produced by the body itself. By the experiments with the flies, Redi proved that the emergence of flies in the corrupt flesh was caused directly by insects, but in the case of galls he took the opposite side in the debate. In both cases, Redi trusted his observations and experience, but how could he hold two seemingly opposite views as a naturalist and a man of letters?

Redi's experiments on galls provoked the same problems as spontaneous generation. The galls were an example of the living/nonliving dichotomy in early naturalist thought. In other words, the naturalists defined galls as an object dramatically different from an insect that it supposedly produced. The early naturalists saw the insects emerging from the formations on leaves as a metamorphosis from the stagnant nature of a tree to a vivid nature of an insect. Plants and insects belonged to the distinct natural kingdoms, had different reactions to the environment, ways of nutrition, and abilities to move. In the end, this type of generation was asexual and non-parental since a fly was born by a tree that conventionally produced life by vegetation.

The results of Redi's experiments seemed to contradict his own views on spontaneous generation. He saw that galls were formed by the inner processes of a tree without a parent insect, but he did not call this phenomenon spontaneous generation or equivocal generation. Why did Redi not consider the generation of galls as spontaneous generation? Did Redi treat this phenomenon as simple curiosity of nature? Did he acknowledge the difference between generation and vegetation? Focus on the answers to these questions will help to grasp the nature of the controversy about spontaneous generation and equivocal generation some decades later.



Pic. 3. Joris Hoefnagel (Flemish / Hungarian, 1542 - 1600), and Georg Bocskay (Hungarian, died 1575). *Spider, Cherry Blossom, and Oak Leaf with Galls*. 1591-1596.

Osservazioni Intorno started with the descriptions of different creatures obtaining various extra tissue formations – limbs and galls. In this context, galls meant any formation inside or outside a body of various shapes. In the beginning, Redi was focused on the subject of two-headed worm-like species, ones obtaining tumors, peculiar physical features or, most importantly, found in other living creatures and causing these tumor-like formations.

The topic of galls is not surprising in the context of Redi's research of worms. The notion of worm could be applied to any 'low' creature.[32] At the same time, the Redi's conclusions seem to be alienated from the main topic of the treatise. Nowadays galls are known as signs of disease on plants that can be caused by insects, parasites, fungi, bacteria, and viruses. In the late seventeenth century, galls were not perceived just as a disease of a vegetable organism, but as the birthplace of various insects. Not just naturalists, but also any curious person could observe this phenomenon and assure themselves of its reality.

Redi repeatedly made his observations on many plants, insects, and galls and concluded that galls were the source of an insect's life. This statement was harshly criticized by contemporaries and significantly affected the appreciation of Redi by historians of science and culture. At first glance, the fact of acceptance of the generation of galls from trees without an insect-parent seems dramatically conflicting with the results of previous experiments performed by Redi against the idea of the production of life by non-living matter. Nevertheless, the case of plant galls in this treatise was different from the experiments on flies and meat in *Esperienze Intorno alla Generazione degl'Insetti*. Redi saw this process as a phenomenon of a living plant producing other living creatures by law-like patterns. In the case of dead flesh, the flesh served as a breeding bed for flies and worms and it happened only in the case of access to the surrounding environment. The crucial aspect here was in the level of regularity – not every corrupted meat produced the same type of flies, but, according Redi's observations, galls on specific trees produce types of insects specific to them and this phenomenon takes place during a specific season.

The scholar Emily C. Parke defended Redi from the accusation of "epistemological sin" and analyzed his experiment in the light of the difference between spontaneous generation and equivocal generation. She highlights the fact that Redi argued against the

[32] Janelle A. Schwartz, *Worm Work: Recasting Romanticism* (University of Minnesota Press, 2012): 17.

idea of the rise of living creatures from non-living matter or from non-parents *by chance* but accepted cases of a similar type if they happened in nature regularly.[33] Redi believed that if a body (plant or animal) is alive it can produce a small maggot inside that grows into an adult specimen over time.[34] These were the core conclusions made by Redi after his observations on galls. This case made the picture of Redi's views on generation clearer and shows the strategies that Early Modern naturalist used for unconventional cases of generation. He thought that there was no contradiction if living matter produced a living organism if it happened in a consistent pattern. Nature was full of secrets and the generation of life remained a mystery at this point of time. The plant producing an insect or a human body generating a worm was possible because all the actors in this chain were possessing life. A more fundamental explanation of it belongs to preformist thought – any living creature contains a preformed seed eventually developing in a new organism. Parke puts an emphasis on this thesis to defend Redi from accusations of epistemological sin. Nevertheless, I think that Redi's points still legitimately opened themselves to the criticism from his contemporaries due to the fact that it contradicted the leading theory of preformism and represented the cross-species reproduction that was a bold idea for this time.

Generation involving creatures from different natural kingdoms as well as hybrids contradicted the concept of the fixity of the species that was an essential part of natural history. Although the asexual generation of insect through galls seemed ordinary, the fact that insects and plants belong to different natural kingdoms makes this claim uncomfortable for Early Modern naturalist thought. The concept of the fixity of species was dominant during the seventeenth and eighteenth centuries and was deeply rooted in the Christian perception of nature. The plant cannot be a parent of an insect or an animal, otherwise both

[33] Emily C. Parke, "Flies from meat and wasps from trees: Reevaluating Francesco Redi's spontaneous generation experiments," *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 45 (2014): 38-39.
[34] Francesco Redi, *Osservazioni Intorno Agli Animali Viventi Che Si Trovano Negli Animali Viventi* (Firenze, 1684): 63.

of them belong to the same species. According to the doctrine of the fixity of species, everything in the natural world was created in the moment of Genesis. The specimens could change in appearance and some properties due to the climatic environment or other external causes, but their nature remained the unchangeable. In the case of galls, the generation mechanism was presented as going across natural kingdoms because of the difference between generation and vegetation. The problem with Redi's inconsistency arose from his claim that he did not notice any insect laying eggs on the trees that he observed. Nevertheless, Redi believed that natural phenomenon was credible until it happens repetitively and a naturalist could predict it. For Redi, the core problem of spontaneous generation consisted not in the contradiction to the concept of the fixity of species or the relation to the metamorphosis of matter, but in its unpredictable behavior.

Osservazioni Intorno was not a theoretical treatise, but rather a compendium of the various observations on various kinds of bodies found inside and outside living beings. At the same time, it received criticism on the theoretical grounds from the scholars who rejected epigenesis. They used the term 'spontaneous generation' as a weapon against Redi's enquiry on the asexual generation of parasites. The practicing naturalists treated encounters with various living organisms in animals, humans, and even plants as a demonstration of the universal principle of generation that they pursued to discover. Redi's treatise showed that the naturalists of the late seventeenth century did not necessarily pick a side in the debate between preformists and epigenesists. In the sphere of science of worms, the investigation of internal and external causes was more dramatic. The naturalist had to divide the rare cases from regularities and on this basis make their conclusions. Redi was following this practice working with phenomena that were believed to be examples of spontaneous generation and divided the exceptional cases from regular patterns.

Nevertheless, the question of the limits of generation and vegetation and similarities and differences between them potentially provoked discussion about the universal law of generation that could be applied to every single living being. I believe that the naturalists took the 'low' creatures as the model for their theories since the generation of humans and animals was too complex and the details of it remained invisible. Remembering the Great Chain of Being, a worm must be a reflection of a 'higher' being like human or animal on the fundamental level. Moreover, a 'low' worm could destroy and corrupt any 'higher' being and the study of its internal and external origins led to the questions of medicine, morality, and theology. In the next chapter, I will show how this issue was radically approached in *A theologico-philosophical dissertation concerning worms in all parts of human bodies: containing several most curious and uncommon observations* ... by William Ramesey who published it under a pseudonym G. de Gols.

The Problem of Worms in Human Bodies

William Ramesey created probably the most radical treatise of his time on worms and their role in the natural world. He radically joined the topics of natural history and theology to the example of worms inhabiting a human body. From the religious perspective, the parasitic worms were related to the human morality – sins and punishment for them. This perspective was largely based on the absence of the information on worm's generation and the common popular belief in their internal causes. Ramesey went further then speculations about dangerous helminthes. He argued that the world that is filled with various worms – large and tiny, harmful and benevolent. Going through the text, a modern reader realizes that Ramesey wrote about microorganisms in general, but why did he call them 'worms'?

The notion ‘worm’ included a wide range of creatures in early modern natural knowledge. A worm could mean a serpent, slug, lizard, or any other ‘low’ being.[35] When naturalists observed tiny creatures with a microscope, they also frequently called them worms. The morphological properties of micro-organisms made the seventeenth-century naturalists think about similar animals that they were familiar with. William Ramesey in his dissertation on worms in human bodies used the vocabulary of his time, although he was aware of the diversity implied in this notion. Ramesey wrote not just about helminthes, but about micro-biomes existing all over the human body. At the end of the text, the author started to postulate about the ominous presence of worms in the natural world. This text is an outstanding example of the literature on worms that combined the features of a medical treatise, a natural history, and a philosophical essay. This complex of topics appeared due to the place that worms occupied in Early Modern natural knowledge. Although these ‘low’ creatures stood at the bottom of the Great Chain of Being, they were central to the life of humans. Many of them caused diseases and disgust, and signified the approximation of death. Other worms seemed marvelous and provoked curiosity.

In the eighteenth century, most works on worms in human and animal bodies were written by physicians. The study of helminths belonged to the area of medicine and had a utilitarian goal. At the same time, in the general texts on the topic medicine and natural history were going together during the late seventeenth and eighteenth centuries.[36] Natural history was important for physicians since it combined studies of the morphology and properties of plants, animals, and minerals with the philosophical framework applied to the natural world.[37] Moreover, the inclusion of the topic of worms into the general natural history legitimized this material as worth studying. An important strategy in this enterprise

[35] Schwartz, *Worm Work: Recasting Romanticism*, 17.
[36] Julie Grissom, "Parasitic Worms in Early Modern Science and Medicine, 1650-1810," (PhD diss., University of Oklahoma, 2014): 54.
[37] Harold J. Cook, “Physicians and natural history,” in Cultures of Natural History, ed. N. Jardine, J.A. Secord and E.C. Spary (Cambridge: Cambridge University Press, 1996), 91.

was the representation of worms as peculiar natural objects in morphology and properties.[38] The spontaneous generation of worms in this context proved their exclusive place in nature and drew attention to a strange phenomenon. At the same time, if worms were seen as something trivial and the preformist explanation for their asexual generation helped to represent the worms as a part of the whole system running according to universal laws.

In natural theology, the problem of worms was stated in a paradox. If God created a harmonious world, why did he create animals that can destroy the peak of his creative act – humans? On the one hand, the harmful nature of worms represented divine punishment for the sins of humankind. On the other hand, microscopic discoveries changed the image of the worm into a unit of the invisible and harmonious world. This tiny world impressed the early modern philosophers who interpreted these creatures as the postulation of the all-embracing divine design. Cartesian philosophy understood the natural world as a perfect mechanical system running according to the plan of the Divine clock-maker. The concept of multiple worlds occupied an important place in Cartesian thought, and especially in the works of Leibniz. The work of Anton van Leeuwenhoek and Robert Hooke in the field of microscopy influenced Leibniz and encouraged him to formulate the doctrine of 'worlds-within-worlds'.[39] The discovery of tiny organisms meant that there were no invisible parts in the world and everything works according to the divine design even on the lowest level. Nevertheless, this scheme was not self-evident in the eighteenth century and naturalists had to identify, study, and systematize these universal natural laws. The text of William Ramesey was an example of this tradition where nature was the revelation of God even in its humblest parts.

Generation was the question of natural theology and natural philosophy as much as the aspects of animal behavior and plant morphology. Early modern scholars analyzed these

[38] Grissom, "Parasitic Worms in Early Modern Science and Medicine, 1650-1810," 56-57.
[39] Justin E. H. Smith, *Divine Machines: Leibniz and the Sciences of Life* (Princeton: Princeton University Press, 2011), 144.

features to find similarities and finally justify the present order of society and nature. The question of generation and the variety of ways of generation had a special place in this context. Taxonomists and philosophers treated viviparous and oviparous creatures in different ways arranging them hierarchically, although the morphological features were more important for classification. Spontaneous generation was an anomalous way of generation, and the creatures that reproduced in this way were separated from others.

The study of worm's generation was supposed to answer naturalistic and theological questions. To answer both of them, the fundamental mechanics of generation must be the same both for sexual and asexual generation. Some naturalists saw spontaneous generation as a way of reproduction that was different from 'higher' creatures, but the same in mechanics – growth from pre-existing germs. Other scholars treated spontaneous generation as a thing in itself that genuinely differed from viviparity or oviparity. Spontaneous generation of worms in the context of naturalist thought proved either the universality of the natural laws or the exceptionality of worms. Ramesey's text is special for this project because it used the arguments of both approaches to support his natural theology views.

In his text, Ramesey concludes with the new vision of a human being as a biological entity. He wrote: "A mass full of worms, a walking Corps".[40] Ramesey declared that the presence of worms in a human body was a natural state ordered by God. Spontaneous generation is essential in this concept. In the eighteenth century, ideas about spontaneous generation of parasites remained strong due to the lack of information on their life cycles and transmission strategies.[41] The question whether worms were generated from within or

[40] William Ramesey, *A Theologico-Philosophical Dissertation concerning Worms in All Parts of Human Bodies Containing Several Most Curious and Uncommon Observations of Natural Productions. In a Letter to a Friend* (London: Printed for A. Bettesworth at the Red Lion; J. Osborn and T. Longman at the Ship in Pater-Noster-Row; and J. Silver bookseller in Sandwich, 1727): 6.
[41] Emilie Taylor-Brown, "Miasmas, Mosquitoes, and Microscopes," (PhD diss., University of Warwick, 2016): 48-49.

transmitted to a host from the external world was challenging for the early modern naturalists. The correlations with food, water, hygiene, and insect activity and the emergence of parasites were not precisely studied yet.[42] In addition, Early Modern physicians treated the discovery of worms in human bodies as the symptoms of disease, and Ramesey followed this tradition.

At the same time, the spontaneous generation of worms could be interpreted either in preformist or epigenetic fashion. In the case of Ramesey, his account on the generation of worms largely follows the preformist idea of pre-existing eggs. Addressing the origins of worms in human bodies, he gave two opinions on the issue. The first one was the idea that worms were created by God in the human body as a primordial natural part of it.[43] Ramesey cites the letter of Nicolaas Hartsoeker (1656-1725) in which he argues for the pre-existence of worms in human bodies.[44] Ramesey also listed evidence from ancient and modern naturalists that the propagators of this view used to support their opinions, like Pliny and Hippocrates, Johann Dolaeus (1651-1707) and Antonio Vallisneri (1661-1730).[45] These naturalists reported that worms were found in the bodies of new-born children and some of them were unique to the human kind.[46] The second opinion was the hypothesis that worms enter the human body from the environment as seeds of vermin.[47] Ramesey referred to the Genevan naturalist Daniel le Clerc (1652-1728) who wrote seminal works in the area of medicine and history of medicine. Le Clec proposed that worms are not unique to humans, that worms are various (harmful and not), and can be transmitted. Ramesey left the decision about the origins of worms in humans to readers, but sympathized with Le Clerc's

[42] Ibid., 56.
[43] Ramesey, *A Theologico-Philosophical Dissertation concerning Worms in All Parts of Human Bodies Containing Several Most Curious and Uncommon Observations of Natural Productions. In a Letter to a Friend*, 67.
[44] Ibid., 67.
[45] Ibid., 68.
[46] Ibid., 67-68.
[47] Ibid., 69.

concept.[48] Moreover, Ramesey made his idea more radical and devoted the rest of the dissertation to the assertion that worms inhabit the whole world – not just living beings, but water, biological liquids, and air.

Ramesey gave a complex account on the precise places where the worms were found, but he was not precise about the exact information on them. From habitual information on tapeworms and similar helminths inhabiting humans and animals, he went to curious cases like lizards and rats emerging in human bodies.[49] He named them "worms of strange figures brought up from human bodies".[50] A noteworthy part of this account is the proposal that any disease that manifested itself in a tumor or visible changes of tissues are nothing else than an activity of worms. He described leprosy, cancer, smallpox, and many other diseases or symptoms as the worms.[51] For Ramesey the worms did not only cause the disease, but also were the diseases themselves. For Ramesey, rush, tumors, and leprosy were actual worms, that were growing inside and on the surface of a body. At the same time, Ramesey rarely described the causes of this phenomenon. By the end of the book, he claimed that worms breed inside humans by laying eggs that are infinite in the worm's body.[52] He also admits that the sex of these creatures is not defined, as in snails and slugs.[53] Although Ramesey was not very precise on the exact origin of these seeds and mechanisms of the reproduction of these infinite seeds in a new worm, we see that his views were preformist. At the same time, it was much more important for the author to demonstrate the unity of the whole world inhabited by an uncountable number of tiny creatures where a human 'higher' being is always occupied by the 'lower' creatures like worms. However, it is important to clarify how the issue of infinite seeds could be solved.

[48] Ibid., 70.
[49] Ibid., 46.
[50] Ibid., 44.
[51] Ibid., 48-50.
[52] Ibid., 110.
[53] Ibid., 111.

On the one hand, the question of spontaneous generation was related to cases of unconventional generation that included not just the generation from non-living matter or creature, but also asexual and cross-specific births. Some naturalists could accept that a creature spontaneously generates a similar organism, but not into another specimen. On the fundamental level, the question of spontaneous generation was about the matter and its properties. Regarding the phenomenon of generation, the concept of the infinite divisibility of matter was essential. This idea was derived from mathematics and the infinite divisibility of numbers. In the case of physical substances, it was possible to imagine an infinite hierarchy of particles and even organisms that contain smaller and smaller versions of themselves *ad infinitum*. This concept would be used both by preformists and epigenesists, but with radical differences. The historian of science John Farley connected the acceptance of spontaneous generation on the level of divisibility of matter to the influence of Newtonianism and its competition with Cartesian thought.[54] The general understanding of generation for Cartesians was the phenomenon of the pre-existence of miniature versions of living creatures (seeds, germs, eggs, etc). *Embointenment* was an imagined phenomenon when this pre-existing seed simply unfolds and grows into a sufficient specimen and the number of these pre-existing seeds was infinite.

In Newton's thought, an important place was occupied by matter and motion guided by attractive forces as opposed to Cartesian distinct atoms in constant motion. Another feature of Newtonianinsm was the infinite divisibility of space.[55] The question of the infinite divisibility of matter was an important issue in the seventeenth and the eighteenth centuries and separated the Cartesians (who rejected the divisibility of atoms that composed the universe) from other divisions of thought. The idea of infinite divisibility existed since the

[54] Farley, "The spontaneous generation controversy (1700-1860): the origin of parasitic worms," 101.
[55] Although in the *Principia* and *Optics* he claims that this principle needs to be proved by experiment. See Carla Rita Palmerino, "The composition of space, time and matter according to Isaac Newton and John Keill," in *The Mechanization of Natural Philosophy*, ed. Sophie Roux, Dan Garber (Dordrecht: Springer, 2011), 117-142.

ancient times mainly in the context of mathematics and geometry. It was approved as an abstract model, but in the realm of the physical world it was treated as a speculative model. Although, in Newton's writings, these ideas were mostly related to astronomy and the composition of the universe, the naturalists were influenced by these concepts and could introduce them to their own models of the natural world. Farley connects the notion of infinite divisibility with some forms of preformism, however, it was much more strictly related to the epigenesis.[56]

If we judge Ramesey's text, it appears to be paradoxical. It was not enough to be just a preformist in order to distance yourself from spontaneous generation or equivocal generation. Ramesey united under his notion of 'worm' a diverse variety of creatures including insects and even mice. This almost Aristotelian imagery of spontaneous generation accepted that a human body can produce or be the suitable host of a non-human like creature. The issue of a body producing or bearing a creature of a different kind, like amphibians and rats found inside humans belonged to the cases of equivocal generation that could not be solved just by fitting them into a simple unfolding of strange seeds entering a human body. Ramesey overviewed cases similar to equivocal generation but gave them an interpretation that corresponded with Cartesian fashions of the time. His parasitic generation is asexual, cross-specific, and unpredictable. Nevertheless, the uncertainty about the actual origin of parasitic worms was strong during the eighteenth century and Ramesey left this issue open for the reader. Generally, the author intended to propose his theological concept of nature that was intertwined by the transmission of worms that connect the natural world with a human.

[56] Farley, "The spontaneous generation controversy (1700-1860): the origin of parasitic worms," 99.

The issue of worms in human bodies was at an intersection of various questions of the Early Modern life sciences. The naturalists had to work with an issue that was essential to the public health and, at the same time, emerged by almost unknown causes. The problem of the generation of worms overlapped with the problem of naming the issue since the notion of the worm could include a wide range of creatures among them some caused harm and others not, some were trivial and others extremely were extremely rare. The idea that worms were generated internally by the body of the host brought up the problem of infinite divisibility that the microscopic creatures seemed to illustrate. At the same time, the belief in the spontaneous generation of parasites called for the explanation of the causes of this generation which was much more problematic to explain. The spontaneous generation of worms contradicted the concept of the fixity of species and challenged the dominant theory of preformism and the mechanical perception of nature.

The cases of bodies emerged in other bodies started to be treated as a way of generation caused by the activity of matter both dead and alive. The naturalists of the time tried to frame asexual reproduction in the larger picture of natural knowledge and theories of generation which justified these cases as rare, but regular phenomena. Redi described the generation of insects through galls as a consistent pattern of non-parental and non-parent-like generation. Ramesey, on his part, represented the worms as omnipresent creatures disseminated all over the world that linked all the natural kingdoms. For Ramesey, the worms were the manifestation of the divine design of the harmonious world. This harmony could be reached only through the infinite divisibility of matter and infinite *emboitenment*. At the same time, neither Redi, nor Ramesey gave suggestions on the causes of such phenomena. Both of them followed the principles of mechanical philosophy and both of them interpreted generation in a preformist fashion. However, the peculiarity of cases – a tree giving birth to a wasp, a human body to a mouse – were taken for granted, although

such cases conflicted with the early modern practice of systematizing nature and the concept of the fixity of species. Another equivocal issue was the infinite divisibility of matter and the question of the physical or natural power that sets on the process of reproduction. I will work with this in the next chapter on the materials of the 1740s when this paradox became crucial for natural history due to the discovery of polyp that was also known under the name ‘hydra’.

Chapter II

"Concerning a Water Insect, which, being Cut into Several Pieces, Becomes so many Perfect Animals"

The Polyp: Generation and Taxonomy

In the 1740s, Swiss naturalist Abraham Trembley (1710-1784) made a sensational discovery of the freshwater polyp – an aquatic creature that was able to reproduce by division and regenerate its lost parts. Trembley described it as a tiny animal with a tubular body ending with relatively long tentacles. Due to these tentacles, it was also called hydra – the mythical monster with many heads. Similar creatures were known earlier, but Trembley was the first scholar who successfully proved the ability of the polyp to regenerate its lost parts and replicate new organisms, and he communicated this research to the scientific community and the wider audience. The polyp became an important phenomenon for two main reasons: the unique way of reproduction and the combination of features that obstructed the classification of it. During this period, the practice of ordering nature that manifested itself in the creation of new taxonomies was extremely important, and creatures that were the 'lowest' in the Great Chain of Being had to be taken into consideration. The eighteenth-century naturalists saw the polyp as a creature that had properties of both plants and animals and this observation challenged the concept of the three natural kingdoms – animal, vegetable, mineral. However, the naturalists struggled with traditional schemes of classification before. The creatures combining the features of a plant and animal were called zoophytes, and this name gradually became common. Regeneration was more challenging because it was a question for both natural history and philosophy. It evoked the problem of

the infinite divisibility of matter, the divisibility of the soul, and escalated the debate between prefomists and epigenesists. At the same time, the discovery of the phenomenon of regeneration took place in the context of multiple discoveries of cases of asexual reproduction that influenced the discussions about life theories.

Despite the peculiar features and way of the polyp's reproduction, the phenomenon of regeneration was not perceived as a curiosity of nature or a shortcoming of nature. Because of its relevance to the problem of regeneration, the case of the polyp obtained a metaphysical basis. The naturalists also managed to interpret it on the grounds of the theories of life: preformism and epigenesis. Nevertheless, the polyp's regeneration became a legitimate way of reproduction. After the discovery, naturalists and men of letters continued to treat it as something dramatically different, especially in comparison to human anatomy and reproduction. I argue that the polyp's unconventional way of the generation was a crucial factor in its perception among naturalists and philosophers. The polyp evoked the same questions as spontaneous generation: the generation of the polyp was impossible to predict, it blurred the line between dead and living organisms, the creature was neither male nor female, and it ultimately belonged to the class of the 'low' beings. The issues of unconventional generations (that were easy to claim as spontaneous or equivocal generation) were so important because they tested the established understanding of life. Since both the epigenesists and preformists looked for the universal laws of generation, the mechanics of generation in the simplest creatures, like worms and zoophytes, could be used as a strong argument in support of their views. The polyp was a perfect model for this debate: it was a perfect[57] animal able to reproduce itself by means of regeneration. At the same time, the case of the polyp as an asexually procreating creature brought up

[57] Perfect animal was a term for a living being that was able to give viable offspring.

controversial issues in the theory of epigenesis: the origins of the soul and the problem of material/immaterial nature of the soul.

In this chapter, I analyze how the discovery of the polyp's generation affected the development of theories of generation on the fundamental level of soul and matter. I work with the shift that happened after the work of Redi, Ramesey, Le Clerc, and other helminthologists (discussed in the previous chapter) when micro-organisms could not be studied just as 'lower' beings and required systematization. The distinctions between them became more striking due to the discoveries made by René Antoine Ferchault de Réaumur, Charles Bonnet, and other naturalists in their reproduction during the first twenty years of the eighteenth century. Early Modern taxonomies were based upon the morphological features of specimens and it put them within the strict limits of the three kingdoms of nature – animal, vegetable, and mineral. The concept of the fixity of species was in the core of these distinctions. Ordering nature was not just a question of natural history or philosophy, it was a theological question since the fixity of species was a religious idea: all living beings were created during Genesis and have not changed – neither degenerated, nor evolved. This concept also rejected the possibility of hybridization and the existence of creatures that could not fit into just one natural kingdom. The discovery of the polyp (as well as other peculiar organisms which had properties assigned to different natural kingdoms – sea sponges, corals, Venus flytrap, and others) provoked the reevaluation of taxonomical methods. Naturalists started to accept the ways of reproduction as not just a feature of an organism, but as a way to classify them and genealogically relate them to each other. Besides the necessity to navigate the diversity of nature, the naturalists looked for the fundamental laws of generation that they could use in support of their theoretical approach.

In this chapter, I argue that the discovery of budding and the regeneration of the polyp reinforced epigenetic theories which caused a reevaluation of the relationship between

matter and the soul. Does the polyp have a soul? Do animals have souls? During the early modern period, animal and human souls were seen as radically different substances.[58] Animal souls had a material nature, plants had vegetative souls and human souls had a spiritual nature. According to the idea of the Great Chain of Being, there was a hierarchy where souls were ranked from humans to brute animals, plants, and 'lower' beings. When the naturalists started to study these 'lower beings', they started to distinguish them and identify them as tiny animals, plants, and as the creatures that did not fit any category. The polyp had properties of both aquatic, plant, and animal specimens and the nature of its soul was an open question. At the same time, the soul was not just an intellective invisible substance. Some scholars also denied the Aristotelian orthodoxy of the distinctions between animal, vegetable, and human souls and they claimed that all souls operate by the same principle.[59] In the context of early modern natural knowledge, the soul was inseparable from physical issues and especially the principle of generation. Both preformists and epigenesists considered the soul to be an organizing principle of life. However, in the eighteenth century, this idea underwent radical changes and led to the emergence of materialist, and then vitalist philosophy of nature. It is also important to note that the idea of the materiality of the soul was rooted in antiquity, precisely in the Epicurean tradition. This materiality appeared in different contexts (medicine, philosophy, and natural knowledge) throughout the early modern period.[60]

In the context of this project, I am mainly focused on aspects of the asexual generation of the polyp which resembled the issues connected to spontaneous generation – the divisibility of matter, problems of taxonomy, and the role of the soul in reproduction. In

[58] Richard T. W. Arthur, "Animal Generation and Substance in Sennert and Leibniz," in *The Problem of Animal Generation in Early Modern Philosophy* ed. Justin E.H. Smith (Cambridge: Cambridge University Press, 2006), 149.
[59] Ibid., 152.
[60] Charles T. Wolf, and Michaella van Esveld, "The Material Soul: Strategies for Naturalizing the Soul in an Early Modern Epicurean Context," in *Conjunctions of Mind, Soul and Body from Plato to the Enlightenment* ed. Danijela Kambaskovic (Springer, 2014), 371.

earlier times, spontaneous generation was controversial because it was seen as a process of something living being produced from something non-living, or dramatically different in kind (bees being born from trees). Another problem was its unpredictability, the generation of the polyp was possible to control and it was a living being that produced its perfect copies. Nevertheless, it provoked anxieties similar to concerns about spontaneous generation. I believe that this contradiction was rooted in the unclassifiable nature of the polyp and its way of generation that challenged the preformist doctrine on the fundamental level. At the same time, it left open questions about the generation of the soul, the limits of life, and agency. I ask questions that combine the taxonomical approach to the polyp and the perception of its reproduction as a fundamental model of generation. What aspects of the regeneration elicited the debate between preformists and epigenesists? What features of the polyp's generation were useful for epigenesists to argue for their views? How did the case of the polyp contribute to the understanding of life in natural history?

In this chapter, I address reports from the *Philosophical Transactions of the Royal Society* in the early 1740s, including Henry Baker's *An Attempt Towards a Natural History of the Polyp* that was also published in the *Philosophical Transactions* in 1743, and finish with a famous text by Denis Diderot, *D'Alembert's Dream* (*Le Rêve de d'Alembert*) written in 1769. Texts devoted to issues of unconventional or spontaneous generation published in the *Philosophical Transactions* are not numerous, but most of them (even the shortest ones) contained suggestions about the main tensions in the debates about the polyp. Before an analysis of the sources, it is necessary to describe the context of the discovery and the issues that the phenomenon of regeneration raised between preformists and epigenesists.

The Context of the Discovery

The discovery of the polyp was sensational, but it did not occur on unprepared ground. Throughout the eighteenth century, there were many discussions about creatures with ambiguous properties. Morphological features played an important role, but in the case of the polyp, scholars paid attention to its regenerative abilities and behavior. This interest was related to the tendency that existed in the numerous studies of insects during the second quarter of the eighteenth century.[61] Almost every prominent naturalist of the time scrutinized the 'low' creatures. Bonnet, who became a prominent natural philosopher with his own metaphysical system of nature, started with the studies of insects and gained recognition after his discovery of the parthenogenesis of the tree-lice in 1740.[62] Bonnet worked with Réaumur, the creator of the fundamental *History of Insects* (1734-1742). Réaumur was very attentive to insects' behavior, anatomy, and generation. These features were essential since they were working with very diverse and small creatures. It is also important to note that these creatures inhabited very different areas. In this context, the naturalists struggled to distinguish if a creature was a plant or an animal, an insect, or fungi. Their reference points in making these distinctions were observations of movement that could be spontaneous or conscious, the presence of a nutrition system, and sexual generation (as opposed to budding and other cases).

When Trembley picked up a tubular aquatic creature in the ponds of Sorgvliet, he was concerned with its classification as a plant or an animal. He bisected it in order to study the polyp's ways of nutrition and more detailed morphology. After Trembley had observed the regeneration phenomenon of the polyp, he decided to communicate his discovery to the

[61] See Lorraine Daston, "Attention and the Values of Nature in the Enlightenment" in *The Moral Authority of Nature*, ed. Lorraine Daston, Fernando Vidal (Chicago: University of Chicago Press, 2010), 103-130.
[62] Elizabeth Gasking, *Investigations into Generation* 1651-1828 (Baltimore, MD: Johns Hopkins Press, 1967), 64.

leading scholars in this field. In late 1740, he started a correspondence with Réaumur and in January he sent Réaumur the first batch of species for the his experiments.[63] Unfortunately, the organisms were already dead when Réaumur received them. Nevertheless, Réaumur asked Trembley for permission to share his letters with the Academy. Afterwards, Trembley experimented with providing oxygen to the organisms and finally succeeded in the transportation of alive polyps in March of 1742.[64] Trembley chose to work with Réaumur because Réaumur had worked with cases of regeneration before, such as his research on lobster, crab, and crayfish claws in 1712.[65] Réaumur repeated Trembley's experiments on the specimens that he received and demonstrated regeneration to the "entire academy" and "the court and the city".[66] This demonstration was essential because the audience wanted empirical evidence. After the bisection of the polyp performed in London and Paris, naturalists of different backgrounds attempted to repeat the experiment with the aquatic creatures and worms that they could find in their local areas and exchanged information about their findings.

After Trembley's discovery, reports started to appear in the *Philosophical Transactions* about attempts to repeat the experiments on regeneration. These texts were descriptive, skeptical, or were written in the form of a report about some curious subjects. On January 1, 1743, a whole issue was devoted to the subject of the polyp, which included a translation of Trembley's original text into English, an abstract of a part of a letter from William Bentinck to the president of the Royal Society Martin Folkes (1690-1754), and the abstract of the preface to the sixth volume of Réaumur's *History of Insects.* The demonstrative evidence of regeneration needed to be communicated to the English public.

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[63] Marc J. Ratcliff, "Abraham Trembley's Strategy of Generosity and the Scope of Celebrity in the Mid-eighteenth Century." *Isis* 95, no. 4 (2004): 561.
[64] Ibid., 562.
[65] Melinda Cooper, "Rediscovering the immortal hydra: stem cells and the question of epigenesist," *Configurations* 11, no. 1 (2003): 5.
[66] Ratcliff, "Abraham Trembley's Strategy of Generosity and the Scope of Celebrity in the Mid-eighteenth Century," 562.

Folkes was personally informed about the discovered phenomenon of regeneration by Buffon. The general attitude towards the polyp was quite skeptical until March of 1743, when polyp's regeneration was demonstrated for the wide audience.[67]

In the translation of Trembley's letter, three main peculiarities of the polyp are discussed: the uncertainty of its belonging to animals or plants, its ability to reproduce without mating by budding and division, and its ability to live after being turned inside out. Trembley started with an anatomical description of the polyp. The naturalist described – the "body" of the polyp and its size; he identified the tentacles as "legs or arms"; "mouth" – all features that were analyzed on the first pages.[68] The polyp is definitely a living being because it moves in its ambiance to find a place to live and hunt.[69]

A special place in the letter is occupied by a description of its reproduction. The polyp reproduces by budding without mating, and this process is dependent on the organism's nutrition. Its second method of reproduction is the regeneration that happened after the bisection. It is important to note that Trembley was interested in both ways of procreation, in contrast to the scholars of the Royal Society, who were only focused on regeneration. Looking for aspects of the polyp's nutrition, Trembley dissected the polyp to examine its stomach. The naturalist then turned the tubular body of the polyp inside out and realized that the creature did not die and preserved all of its abilities.[70]

The regeneration needed not just to be proved, but to be translated into the language of philosophy and the theories of generation – epigenesis and preformism. The cases of regeneration were known before the eighteenth century. Throughout the centuries, people observed the common phenomenon of the regeneration of the lizard's tail. In 1686,

[67] Ibid., 562.
[68] Abraham Trembley, "Observations and Experiments upon the Fresh-Water Polypus, by Monsieur Trembley at the Hague. Translated from the French by P. H. Z. F. R. S," *Philosophical Transactions of the Royal Society of London*, 1742, 42(467): 3-5.
[69] Ibid., 5.
[70] Ibid., 9.

Melchisédech Thévenot (1620-1692) demonstrated this phenomenon in front of the Paris Academy of Sciences.[71] The naturalists of the seventeenth century who studied insects were aware that an insect could regenerate a lost limb. Nevertheless, these cases did not provoke a discussion similar to the scale of the case of the polyp. The polyp did not just regenerate its lost parts, but used its ability to regenerate to reproduce a new organism. The naturalist noticed this connection between regeneration and reproduction and this fact introduced it to the theories of life.

The generation of the polyp challenged the dominant theory of prefomism. The phenomenon of reproduction by cuttings literally illustrated the ability of matter to organize on its own. The theory of preformism was based on the model of pre-existing particles (eggs, seeds, germs) that grow according to divine design. In the case of the polyp, the reason for the regeneration comes from the interior environment. A naturalist bisects the polyp and the process starts. It is important to note that the ways of regulating reproduction were not yet invented and the ability to successfully multiply a living being was quite new. The preformists analyzed regeneration similarly to reproduction. For example, for Réaumur the only acceptable explanation that was consistent with prefomism was the idea that tissues contained the invisible 'germ', and the amputation of any part provided a stimulus for the growth of the lost parts.[72] Bonnet, as a passionate preformist, devoted a great part of his natural philosophy to the regeneration of the polyp. He kept a correspondence with Trembley and instructed him on the interpretation of the regenerative phenomenon.[73] Bonnet's views on the polyp's regeneration became more nuanced over time. In the end, he interpreted it on the grounds of his concept of *emboitement* – the idea that all organisms

[71] Charles E. Dinsmore, "Animal regeneration: from fact to concept," *Bioscience* 45, no. 7 (1995): 484.
[72] Keith R. Benson, "Observation versus philosophical commitment in eighteenth-century ideas of regeneration and generation," in *A History of Regeneration Research. Milestones in the Evolution of a Science* ed. Charles E. Dinsmore (Cambridge: Cambridge University Press,1991), 95.
[73] Dinsmore, "Animal regeneration: from fact to concept," 486-487.

were structurally complete during Genesis and enclosed in tiny germs.[74] The key aspect of *emboitement* was the stability of a single specimen as a unit with the entirety of its features. During regeneration, a specimen followed the goal of becoming complete in its appearance and anatomy. Nevertheless, the case of the polyp itself caused great anxiety amongst preformists because their models were more speculative then following the results of the observations.

From the side of epigenesis, regeneration happened due to the natural forces that help the tiny particles of matter organize and form a lost limb, or in the case of the polyp, an entirely new organism. The leading advocates of these views – Buffon, Needham, and Maupertuis – appeared sometime later. Earlier on, although not immediately after Trembley's discovery, a bright propagator of epigenetic views was the physician Julien Offray de la Mettrie. In his most important work *Man – Machine* (1747), La Mettrie proposed a ground-breaking idea that both humans and animals consisted of matter organized through the soul. La Mettrie's argument for the material started from a reference to Genesis – the first human was made from clay – "the miserable origin".[75] The concept of the soul was complex and included, at least, the intellectual and spiritual activity of a human being, and La Mettrie criticized the spirituality and immateriality of the soul as a vague idea depending on faith. To support his argument for the material nature of the soul, the philosopher pointed to the weaknesses of human reason and sensibility. In his view, the senses and the mind were deceiving and dependant on the state of the body.[76] This inseparable nature of the mental and physical state of every living being was a principal novelty of La Mettrie.

[74] Ibid., 487.
[75] Julien Offray de la Mettrie, *Machine-man and Other Writings*, trans. Ann Thomson (Cambridge: Cambridge University Press, 1996), 4.
[76] Ibid., 22-23.

Since matter and soul were inseparable for La Mettrie, matter contained the causes of its activity and organization of an organism as a solid unity.[77] This statement provoked harsh critiques, especially from the religious Bonnet who worked on his life theory with strong religious implications. Bonnet saw La Mettrie's ideas atheistic, because La Mettre rejected the spirituality of the human soul.[78] Moreover, La Mettrie saw human and animal souls as the same, distinguishing them by the level of intelligence. Human, animal, and vegetable souls operated by the same principle because they followed the agency of matter and the structure of the body defined everything.[79] The machine-man for La Mettrie was not clockwork endowed with divine spirit, but rather a mechanism that worked according to the state of its details.

Since La Mettrie claimed that human and animal were the same in their core, the polyp became an important argument in his writings. In *Machine – Man*, the author pointed to Trembley's polyp as an example of a creature that contains future creatures in all of its parts.[80] La Mettrie also addressed the regeneration of the polyp in his correspondence with Diderot who later wrote *D'Alembert's Dream* using the reproduction of the polyp as a metaphor for the generation of the inhabitants of other planets.[81] These parallels between a human being and a polyp were not unique for La Mettrie or Diderot. The phenomenon of the generation of the polyp concerned the naturalists who worked on theories of generation for a similar reason. The quest for the universal law of generation which included the relations between soul and matter could potentially affect the perception of human nature and its value.

[77] Aram Vartanian, "Trembley's polyp, La Mettrie, and eighteenth-century French materialism," *Journal of the History of Ideas* (1950): 270.
[78] Ibid., 261.
[79] La Mettrie, *Machine-man and Other Writings*, 27.
[80] Ibid., 27.
[81] Vartanian, "Trembley's Polyp, La Mettrie, and eighteenth-century French materialism," 269-270.

The Language of Credibility

In *Man – Machine,* La Mettrie was sarcastic about the naturalists who valued their theories of generation more than nature.[82] The practice of theorizing generation served the tendency to universalize nature, as was noted before. Nevertheless, this tendency was not homogenous and some naturalists did not follow it. In the first half of the eighteenth century, the variety of species in nature seemed infinite and the studies of 'lower' beings helped to recognize this infinity. This infinity needed to be recorded and structured, but the older idea of the three fixed kingdoms could no longer serve it. The classification of it was challenging for the naturalists of the time because the polyp combined the features of animals and plants in its appearance, physiology, and behavior. In the early stages of the research on this creature, the strategy was to create a profile that communicated basic information about the subject. To communicate successfully, the naturalists had to elaborate standards of this communication and use shared terminology in order to create a substantial record of a living being that was not classified yet. This was a collective work – to gather, test, and describe creatures similar to the polyp and analyze relations between them and this work could not be done without an intelligible language of communication.

The early account of the polyp can be divided into two categories – the reports about the experiments and the texts of the authors who mainly worked outside the scientific community and analyzed the discovered phenomenon on philosophical grounds in a speculative. This division was studied by Marc Ratcliff, who argued that this distinction signified a shift that happened in natural history and separated the naturalists from philosophers.[83] By the 1740s, it is hard to speak about a homogenous scientific community:

[82] La Mettrie, *Machine-man and Other Writings*, 27.
[83] Ratcliff, "Abraham Trembley's Strategy of Generosity and the Scope of Celebrity in the Mid-Eighteenth Century," 570.

among the studied texts, there were many amateur naturalists. Nevertheless, these texts explicitly demonstrated the changes that took place during this period: the establishment of a new scientific language and form of reporting.

This new language was a result of the development of microscopy, the culture of experiment, and the education of the time. Microscopy and experimentation were inseparable and the understanding of the experiment in the eighteenth century was rooted in Cartesian thought. With the help of the experiment, a scholar learns the phenomena of the world that provoke questions for science.[84] Then, the metaphysics, on its part, served to explain the fundamental principles of natural phenomenon. In the case of the polyp, the necessity to communicate the results of these observations to the interested community became an important strategy. Studying unconventional generations like the divisibility of polyp or the parthenogenesis of tree-lice, the naturalists had to justify their work in a credible way (it is important to remember that such finding could be rejected by some members of the naturalist community). This new strategy encouraged practitioners to focus communicating of the visible specifics of an analyzed organism, instead of speculations about the inner laws of nature that could stand behind any curios case. Due to these presuppositions, in the analyzed sources we can see a certain extent of skepticism towards the debates between epigenesists and preformists because they were deeply rooted in the obscure metaphysics of nature. At the same time, the naturalists had to consider metaphysical discourse because they could justify the reality of their findings through it. Both of these issues influenced the development of new linguistic standards in the literature on natural knowledge.

At the same time, this problem had geographical and cultural dimensions that were especially important in the case of the polyp and studies of various microorganisms. In the

[84] Howard Stein, "Newton's Metaphysics," in *The Cambridge Companion to Newton*, ed. Rob Ilffe (Cambridge:Cambridge University Press, 2016), 325.

context of the discovery of the polyp, a special role belongs to Geneva as an educational center and we have already seen that many of the heroes of the history of life sciences were Swiss. Another important factor were the educational relations between England and Geneva. These relations were established not only upon the dissemination of English philosophy (Locke's works especially), but also upon the import of freemasonry from England to Geneva.[85] Such international scholars as Bonnet and Trembley came from the same background that combined theological views with a specific scholarly approach. Geneva was a multilingual city with a history as an independent republic that had strong cultural ties with France. In the universities of Geneva, the spirit of freedom was intertwined with the authority of Calvinist theology. Liberal Calvinist theologians introduced Cartesian philosophy and the new science arrived at the Genevan universities relatively late, which led to a unique complex of Calvinist theology and modern scientific methods.[86] Reformed Calvinism taught followers to read nature as the revelation of God and nature had to be communicated to the audience by an objective language distanced from the author's personal perspective. Geneva had a strong connection with British Protestant thought, especially in the questions of natural theology.[87] These relations helped the discovery of the polyp quickly reach the Royal Society of London and receive the attention of a wider audience.

On the part of microscopy, the language of description was challenged by the discovery of microorganisms. The naturalists saw the world that was invisible before, but they had no tools for its description. In the earliest texts, naturalists called the creatures that they observed by the name of familiar animals. An early eighteenth-century microscopist Louis Joblot (1645-1723) described the creatures that he found as "swan", "the silver

[85] Nicholas Hans, "Educational relations between Geneva and England in the Eighteenth Century," *British Journal of Educational Studies* 15, no 3 (1957): 263-264.
[86] Virginia P. Dawson, *Nature's enigma: the problem of the polyp in the letters of Bonnet, Trembley and Réaumur* (Philadelphia: American Philosophical Society, 1987), 62-63.
[87] Ibid., 70.

bagpipe", "the glutton", "fishes", and "insects".[88] The necessity to classify these protozoa was essential and the elaboration of the conventional language was the first step in this process.

In this part of the chapter, I work with reports on the polyp from the early 1740s that generally demonstrated the features of the 'language of credibility' – descriptive narratives with focus on the morphological features, generation, and the behavior of a studied organism. At the same time, attempts to comprehend the observations were also present in these documents, mainly in the area of taxonomy. I analyze the notions that they used in their reports and attempts to classify the polyp or raise other issues related to the subject.

"The animal in question is an aquatic insect" – the first words of Trembley's letter that gave a class definition for the polyp, but, nevertheless, it is a convention. The nature of the polyp remained under examination. Before the publication of this letter, there was a letter published in November 1742 written by a botanist Jan Frederik Gronovius (1690-1762) who reacted to the news about the new species and its regenerative abilities. Suffering from a lack of information about the anatomy of the polyp, he skeptically assumed that this specimen was already known under the names *Uvae marinae*, *Holothuria*, and *Zoophyta* and belonged to the plant kingdom.[89] In the account given by Trembley, the polyp's animal nature was not explicitly argued, but properly animal features are highlighted – non-spontaneous movements, behavior, and anatomy.

In this context, an anonymous letter from November 1742 analyzes the problems of the polyp's classification. The author argued that the peculiarities of nature should not be seen as rare exceptions, but admitted as part of the natural order. He highlighted the

[88] Lorande Loss Woodroof, "Louis Joblot and the protozoa," *The Scientific Monthly* 44, no. 1 (1937): 43.
[89] Johann Friedrich Gronovius, "Concerning a Water Insect, Which, Being Cut into Several Pieces, Becomes So Many Perfect Animals," Philosophical Transactions of the Royal Society of London, 42(466), (1742): 220.

resemblance of regeneration to vegetable abilities and, at the same time, the similarity of regeneration to asexual ways of reproduction.[90]

In June 1743, *Philosophical Transactions* published two reports about further investigations on the polyp. The first one was written by the Duke of Richmond, Lennox and Aubigne after seeing Trembley's latest experiments at Sorgvliet. The author described the process of cutting and conjoining parts of a single polyp and obtaining a living being after that.[91] Lennox did not give any explanations or hypothesis and the tone of the report leaves the reader with the impression of the author's excitement and amazement about a natural phenomenon.

The next letter, by Thomas Lord, contained a description of his quest for insects with similar abilities. Naturalists collected more than 30 kinds of different water specimens but all of them died after cutting in approximately 48 hours.[92] After this, Lord recalled the account by a doctor Cromwell Mortimer (1693-1752) (also published in the *Philosophical Transactions*) about the regenerative abilities of water worms, fond them, and succeeded in his experiment.[93] Both of these letters were communicated to the Royal Society almost simultaneously and they are written in a similar descriptive language, although the authors treat the issue differently. The authors do not give any further thoughts on regeneration, budding, nutrition, or the general meaning of these experiments. Nevertheless, the epistemological and metaphysical discussion on the topic was happening, and Trembley himself participated in them.

[90] Anonymous, " Part of a Letter from – of Cambridge, to a Friend of the Royal Society, occasioned by what has lately been reported concerning the Insect mentioned in Page 218 of this Transaction," *Philosophical Transactions of the Royal Society of London*, 42(466), (1742): 229.
[91]Charles Lennox, "Part of a Letter from his Grace the Duke of Richmond, Lennox and Aubigne, F.R.S. To M. Folkes, Esq; Pr. R. S" *Philosophical Transactions of the Royal Society of London*, 42 (470): 510-513. P. 510-512.
[92] Thomas Lord, "Part of the Letter from the Mr. Thomas Lord to William Folkes, Esq. F. R. S. concerning some Worms whose Parts live after they have been cut asunder," *Philosophical Transactions of the Royal Society of London*, 42 (470), (1742): 522.
[93] Ibid., 522.

I argue that the establishment of a neutral descriptive style of reports was a necessity for the communication of the research to the community of naturalists. Another aspect of the texts was a certain consistency in naming the issue. Describing the polyp or other creatures that could regenerate, the naturalists used similar terms of description. The used notions mainly referred to the morphological features of the polyp – its anatomy and appearance. This way of communication was necessary since the issue of the polyp touched upon two main issues – generation, and taxonomy. The naturalists could be preoccupied with their own questions, but they could navigate through this information and recognize the necessary subject.

For example, Trembley was not preoccupied with regeneration, but with budding and its relation to the nutrition system, while most of the scholars worked with the phenomenon of regeneration and looked for its presence in other creatures. After the scholars' acceptance of the polyp's reproduction by cuttings, the ability of regeneration became an important question of the theories of life. The polyp's regeneration could be interpreted as growth from pre-existent germs as in the theory of preformation. On the other hand, it could be used as strong support for the theory of epigenesist because it could be seen as the polyp growing its own tissues when necessary due to the environment, or even as forming a new functioning organism from several polyps. The appearance of the polyp did not provide sufficient information for its classification, and due to this problem, the naturalists had to look for alternative ways to build it in the order of nature.

In the end, the tendency to describe the polyp in the form of a short entry was established and the naturalists started to use it as a form of communication about their finding. As was shown, the polyps were relatively rare and the naturalists had to look for worms and other living beings with regenerative abilities in order to convince themselves of the credibility of Trembley's discovery or to find resemblances among other 'low' beings.

Regeneration was the link between these reports and the record of an experiment was a significant part of it. On the part of taxonomy, the analyzed reports showed that the naturalists were inclined to animalize the polyp, although they were uncertain about its belonging to the animal or vegetable kingdom. Despite the distance taken from the quick conclusions about the classification of this creature, the naturalists wrote about the polyp as a creature with limbs and ability to move by its will like an animal. The regeneration of the polyp was seen as a possible link to the plant kingdom because it resembled the vegetation. These early texts do not show certainty about the greater picture of morphology and taxonomy of zoophytes, but rather prepared the ground for such text.

Natural History of the Polyp: An Attempt towards an Independent Classification

The reception of the polyp went quickly. The naturalists started to look for similar specimens with the ability of regeneration in their local areas. As was shown earlier, British naturalists of different backgrounds experimented on worms and various aquatic creatures to find similarities with the polyp. As a result of this endeavor, scholars collected information about different kinds of this creature, its features, diet, and behavior. All this information had to be structured by the tools of modern taxonomy. *An Attempt Towards a Natural History of the Polype* appeared relatively early and was published in *Philosophical Transactions* in 1743. The author of this systematic text was Henry Baker (1698-1774), a notable naturalist and a microscopist. He devoted a large part of his work to micro-organisms, especially to the descriptions of their anatomical features and behavior. I chose this text not only because it was the first attempt towards a separate taxonomy of this creature, but also because it illustrates a reflexive morphological approach to the eighteenth-

century practice of taxonomy. Baker classified the polyp as a morphologist, not because he was a conservative in natural history, but due to his skepticism about the tendency to universalize nature. For him, writing the natural history of the polyp meant a creation of an account on a specific object – anatomy, behavior, way of reproduction, and etc.

Henry Baker started *An Attempt Towards a Natural History of the Polype* with a general introduction to the history of the discovery. He mentioned the work of Leuwenhoek who described similar creatures in the seventeenth century as well as Trembley's discovery and searches for similar specimens on the British islands.[94] Then, the author moved to the general information on the behavior and anatomy of the polyps. He used the language that the naturalists elaborated in the *Philosophical Transactions* that tended to humanize the polyp. Baker's polyp had head, arms, and a stomach. Although the author acknowledged the plant-animal nature of the studied creature, he tended to describe it as an animal, especially in its behavior. He considered the polyp a perfect living being because it did not move spontaneously, but moved to reach and catch its prey.

Two chapters of the treatise were devoted to the reproduction and the regeneration of the polyp. Baker started, "Polypes produce their Young Ones in a Manner very different from the common Way of all other Creatures yet known. There is no Appearance of Copulation, nor any Distinction of Sex amongst them."[95] This new way was budding, which was a more natural way of polyp's reproduction. The author mentioned that the generation is extremely fast, "those others [offspring] sometimes push out a third and fourth Generation before the first falls off the original Parent."[96] This phenomenon excited the naturalist. Baker compared the peculiarity of the polyp's budding to the reproduction of the common

[94] Henry Baker, "An Attempt towards a Natural History of the Polype: in a Letter to Martin Folkes, Esq; President of the Royal Society," (London: Printed for R. Dodsley, at Tully's Head in Pall-Mall, and sold by M. Cooper in Pater-Noster-Row, and J. Cuff, Optician, in Fleetstreet, 1743): 4-5.
[95] Ibid., 49.
[96] Ibid., 49.

Suriname toad.[97] This toad carries its offspring inside its spine. In the eighteenth century, the naturalists did not know how the mating of these exotic specimens occurred, so Baker thought that there was a probability that the offspring arose from the parent's spine-tissues.[98] At the same time, Baker refused to make a strong claim of any real similarities between the polyp's budding and the Suriname toad's way of procreation.[99]

Describing the regeneration of the polyp, Baker focused on the details of the process of bisection – instruments and necessary manipulation. Then he described the process of regeneration and gave details of various ways to cut the polyp and the time for reparation.[100] By the end of the chapter, the author gave a list of other creatures that were able to replicate by regeneration with references to the notable naturalists of the time: Réaumur, Bonnet, and Needham. The conclusion of this chapter was curious. Baker reported that regeneration could be a crucial aspect in ascribing the polyp to the animal or human kingdom. If the movements that the polyp made during the cutting signified pain, the polyp was a sensible being that made it belong to animals. Nevertheless, Baker abandoned this thought and claimed that naturalists had not yet learned the proper limits of the animal and plant kingdoms, and the speculation about the issue was a waste of time.[101]

Baker's skepticism about the general tendency to look for universal laws of nature and create a universal taxonomy became evident in the conclusion. Baker concluded his treatise by summing up the views on the nature of the generation of the polyp. He mentions that some naturalists rejected the discovery of the polyp since it contradicted the theory of generation of life that they followed.[102] Others who witnessed the phenomenon of regeneration themselves approved this unknown way of reproduction, but struggled with the

[97] Ibid., 58-60.
[98] Ibid., 60.
[99] Ibid., 60.
[100] Ibid., 91-93.
[101] Ibid., 98.
[102] Ibid., 204.

explanation.[103] Baker confessed that he was unable to resolve this problem for the moment, although humankind learns all the creatures and their features.[104] Moreover, Baker was generally skeptical about the project of defining universal laws, which he called a "kind of Madness, or best mis-spending Time."[105] In support of his skepticism towards the pursuit of the universal laws of nature, the author brought up a quote from one of the Robert Boyle's *Essays*.[106] According to Baker's understanding of Boyle, the naturalist should follow the empirical results of his experiments and not fall into speculations that may obscure the portions of truth that science could derive from nature.

This approach had deep roots in the values of British society, as Steven Shapin showed in his seminal book *A Social History of Truth: Civility and Science in the Seventeenth-century England* (1994). The dry language of the reports as well as a skeptical bias towards speculations about the metaphysics of the newly discovered specimens was largely derived from the seventeenth-century tradition. At the same time, the discovery and study of the polyp was an international case that tied together the scientific approach of France, Britain, the Dutch Republic, and Geneva. Baker's text showed that the polyp challenged not only the order of nature manifested in the three fixed kingdoms, but also the tendency for scholar credibility and the empirical standards of scientific work. The naturalists had to communicate their findings in an objective way and distance themselves from holding a position limited just to preformism or epigenesist. Baker criticized naturalists that rejected the truth of nature because of their theoretical beliefs, who speculate about natural phenomena without sufficient empirical evidence. At the same time, the whole debate between preformists and epigenesists was speculative, and the core mechanics of generation remained a mystery by the 1740s.

[103] Ibid., 204.
[104] Ibid., 205.
[105] Ibid., 205.
[106] Ibid., 206.

The authors of the *Philosophical Transactions* distanced themselves from the conclusions on the issues of regeneration, although they were aware of it. This desire to separate the work of the observer from the position of the theorist was understandable. The naturalists discovered an unprecedented phenomenon that could be rejected on metaphysical grounds and lost in history. In the end, Baker's work is an attempt at an independent classification that took into account the incomplete information about nature's works and human's limited ability to perceive the world. In his view, a scholar needed exhaustive information on everything in nature to construct a theory and before this knowledge had been acquired, any theoretical dogma created obstacles for learning. Remembering Baker's mention of the scholars who rejected the results of Trembley's discovery, we can address the issues of the first chapter and the criticism that Redi received for his description of the generation of galls from trees. Both of these cases represented the concern and distrust towards unconventional ways of regeneration that could break the grounds of preformism and epigenesis. However, as was shown earlier, both preformists and epigenesists managed to create a theoretical ground for regeneration. It was not asexual generation that contradicted the fundamental principle of generation, but the issues that it raised. The regeneration of the polyp opened up more fundamental questions like causes of organization of matter, its divisibility, and the role of the soul in this process. More importantly, it was the question of agency that stood behind the causes of generation. The natural philosophers of the eighteenth century started to wonder if agency in generation belongs to God? Does it belong to Nature? Does it belong to matter itself?

D'Alembert's Dream

The polyp could not be closed in the laboratories of the naturalists. People wrote plays, poems and epigrams about the genderless creature stuck between animals and plants. The philosophers who studied natural history and created literary works played with the topic in various ways. First of all, they were attracted to the polyp because of its peculiarity. More importantly, the regeneration of the polyp through both budding and bisection by the hand of the naturalist evoked more fundamental issues like the agency of matter in generation. This issue pushed two tendencies: it fed the development of the epigenetic theory of generation and contributed to the foundation of materialism in the Enlightenment. The historian of science Shirley Roe studied the link between these two issues in detail. For her, the rise of epigenesis was strongly tied to the materialism of French naturalists that manifested themselves in the *Encyclopédie*.[107] In the context of natural history, the main argument of materialism was the idea of the material nature of the soul. In this case, the cause of generation belonged not to divine agency, but to the properties of matter. This concept corresponded to the epigenetic theory of the stadial development of an embryo that emerged from the equal physical contribution of both parents, the body of one parent (in the case of non-parental generation), or just unorganized matter. This concept evoked problematic questions similarly to spontaneous generation – the limits of the divisibility of matter and soul, agency, and chance. I believe that the question of chance is not simple because it did not only cover unpredictable generation, but also generation that could be caused artificially. In the case of artificial generation, the problem of chance and agency worked together. The discovery of the reproduction of the polyp by bisection performed by

[107] See Shirley A. Roe, "Radical nature in the Encyclopédie." In *Science, History and Social Activism* (Dordrecht: Springer, 2001), 37-59.

a naturalist showed that generation could be guided by a naturalist and this issue provoked anxiety even among materialist thinkers.

In this section, I analyze how the understanding of the soul as an organizing principle of life was influenced by the aspects which were brought up with the discovery of the polyp. In the eighteenth century, thinkers explored the relations between the body and the soul. Part of this discussion was rooted in the Cartesian dualism that postulated the strict distinction between physical and material substances that interact on the spiritual level. This concept experienced multiple changes, and by the 1740s the reception of the mind-body problem touched upon the questions of medicine and natural history. One of the central concepts of the Enlightenment was sensibility that not only dealt with human mental activity, but also senses in general – senses of touch, smell, taste, hearing, and vision. The new understanding of mind-body relations was manifested in the scandalous work by La Mettrie, *Man a Machine*, published in 1747. La Mettrie, who was a physician, argued that the mind and body are inseparable and the mental and spiritual state of a living being depended upon the physical state of a body. It is important to note that La Mettrie understood the human and animal souls as similar entities on the basis of their material nature. This statement escalated the degree of criticism from the Church and philosophers opposed to materialism since it challenged the spiritual nature of the soul. This rejection of spirituality was worrisome for the materialist thinkers as well. In *D'Alembert's Dream*, this concern was present in the example of polyp-people inhabiting the distant planets.

Denis Diderot was a thinker of many talents. He was a significant contributor to the project of *Encyclopédie*, philosopher, art critic, writer, but he was not a naturalist. Nevertheless, he was interested in the issue of natural philosophy, as his above-mentioned correspondence with la Mettrie shows. *D'Alembert's Dream* was a literary work where the author brought together fashionable topics about the polyp, extraterrestrial life, and

frivolous sexuality. These three issues were connected by the core questions of theories of generation and the metaphysical basis of asexual generation brought up with the discovery of the polyp. The participants of the imagined discussion were based on the real people. Mademoiselle de l'Espinasse (1732-1776) held a famous salon in Paris where the writers of *Encyclopédie* gathered, including Diderot himself and D'Alembert.

The text opened with the late-night discussion about the properties of non-living matter between d'Alambert and Diderot. Diderot claimed that the soul and the Creator were not a principle and justification for human consciousness, human and animal sensibility, and matter in motion. After this discussion, mademoiselle de l'Espinasse told the physician Bordeu[108] about the disturbing dream that d'Alambert had after this talk. De l'Espinasse communicated the thoughts of d'Alambert as if they were ravings of a sick man. She told the doctor about d'Alambert's rambling about the matter and the particles connecting with each other and the physician responded by addressing the case of bees emerging from trees.[109] Bordeu brought it up not just to address a strange phenomenon of nature, but also to illustrate the general law of nature. Bordeu argued that a swarm of bees and a tree are a single organism since everything in the world was matter producing matter as the epigenesist theory argued. More curious was a reference to the polyp, namely, its regenerative and budding reproduction that was implied to humans in d'Alambert's imagination,

> In Jupiter or in Saturn, human polyps! The males resolve themselves into males, females into females—that's an amusing thought . . ." (At that point he began to burst out laughing so hard I was frightened) "Man splitting himself up into an infinity of atomized men which we could keep between sheets of paper like eggs from insects which spin their cocoons, remain for a certain period in the chrysalis state, pierce through their cocoons, and escape as butterflies—a human society formed and an entire region populated by the

[108] Théophile de Bordeu (1722-76) was a quite renowned member of the famous „vitalist" medical school of Monpellier.
[109] Denis Diderot, *Rameau's Nephew and D'Alembert's Dream*, trans. *L. Tancock* (Harmondsworth and New York: Penguin, 1966), 111.

fragments of a single individual—all that is very pleasant to imagine. . . ." (Then the bursts of laughter started again) "If there's a place where the human being divides itself into an infinity of human animalcules, people there should be less reluctant to die. It's so easy to make up for the loss of a person that death should cause little regret".[110]

The asexual generation of human-polyps was an escalation of epigenesis in this text. The idea of active matter bringing together living particles was represented as legitimate and supported by respectable naturalists and natural phenomena. Nevertheless, asexual generation stands out as a controversial issue. The crucial aspect of Diderot's conjunction of topics of asexual generation and humanity was in the reevaluation of human identity in the case of the immaterial origin of the soul. The scholar Franc Palmeri explored the metamorphosis of matter represented in human and animal individuals in literary and visual imagination. He argued that Diderot wrote about the plural identity that human beings posses due to their asexual reproduction.[111] In other words, as a result of the generative activity of matter, humans did not matter as individuals, but were valuable as a collective unit. Diderot could take the idea of the infinite generative power of matter from la Mettrie who used the case of the polyp's generation as an illustration for his views.[112]

Both La Mettrie and Denis Diderot, borrowing heavily from Leibniz's monadology, used the hydra to argue against the notion of the soul as an organizing principle or the universal criterion of life.[113] At the same time, in *D'Alambert's Dream* Diderot was preoccupied not just with the metaphysics of matter, but about the issues of human identity that could be revised if the soul had material nature. In other words, if the soul had a material nature, it could not be the basis for the dignity of man. Diderot speculated on the outcome of the theories of generation and drew parallels between animal and human

[110] Ibid., 115.
[111] Frank Palmeri, "" Martinus Scriblerus", Diderot's" Dream", and Tiepolo's" Divertimento": Eighteenth-Century Representations of Aggregate Identity," *Comparative Literature Studies* 38, no. 4 (2001): 330-354.
[112] Mary Efrosini Gregory, *Diderot and the Metamorphosis of Species* (Taylor & Francis, 2007), 84.
[113] Benson, "Observation versus philosophical commitment in eighteenth-century ideas of regeneration and generation," 95.

generation; mentioned the cases of monstrosity and heredity. In the end, he looked for new principles of the organization and definition of life, and, for this reason, he evoked the cases of spontaneous generation in the animal and mineral world.

For him, asexual generation was proof of the agency of matter in organizing a new organism, but the origin of the soul became unexplainable. Diderot assumed that asexually generated humans (although he just speculates about their existence) did not have souls at all. But did it matter? Through the implied character, Diderot argued that soulless, asexual generation happening in abundance made the life of an individual worthless. The polyp that occupied the lowest step of the eighteenth-century Great Chain of Being that was supposed to be bounded with the highest creatures, including humans, challenged the dignity of the 'higher' beings.

Chapter III

Spontaneous Generation, Artificial Fertilization, and the Re-evaluation of Life

The debate between preformists and epigenesists may seem to happen in the realm of theories and speculations. In the previous chapter, I mentioned the skeptical attitude of the practicing naturalists towards the thinkers who valued their theories above new information about nature. The philosopher La Mettrie and the experimentalist Baker criticized the preformists who would rather reject the discovery of polyp, than reevaluate or elaborate the theory that they support. It is important to note that the development of the research on asexual generation challenged both theories of generation. The empirically derived data seemed bigger than the complex speculations about the pre-existing germs or matter forming a new organism. How could you win this debate? A successful experiment on artificial fertilization with a proper theoretical framework would help to resolve this controversy.

How was this problem related to spontaneous generation? It is essential to remember that in the eighteenth century embryogeny[114] was unconceivable. Although naturalists and physicians knew the details about the prenatal development of a fetus, the genesis of a new organism was unknown. To understand the conception, they had to know the generation of semen or ovaries as well as the other elements of gestation. What brings together the elements for the formation of a new organism? In the Early Modern times, the belief that sexual intercourse was essential in conception was strong, and an experiment on successful artificial insemination and further birth-giving would change the perception of this issue.

[114] Embryogeny is the formation and development of a fetus.

The theoretical basis for this experiment could either be preformist or epigenetic. Nevertheless, even in the case of a successful experiment, the space for speculation would remain in the question of am attractive force that induces the process of conception and the role of the soul in it. I will talk about the hypothesis of natural attractive forces proposed by Buffon and his colleague and ally in the theory of life, John Needham, later in this chapter. For now, it is important to state that on the micro level the mechanics of generation resembled spontaneous generation, and experiments on artificial fertilization played a crucial role in this problem. In the case of the generation of humans, the issue of the soul was extremely important and experiments on artificial fertilization (although they were not performed on humans) caused changes in the perception of human life, and even its value. In this chapter, I analyze how some aspects of the research on the generation of microorganisms resulted in attempts towards artificial fertilization and the further reception of the topic beyond the area of 'pure' natural knowledge.

In his fundamental work on life sciences, Jacques Roger gives a curious quote in the context of the development of ovism – the theory that generation is dependant on a female organism that contains preformed miniatures of future fetuses. This is what one of the critics of ovism wrote:

> …venerable antiquity…accepted that corruption and decay produce insects and several other animals! And, to line up against you more authentic and more trustworthy authorities than the authority of Monsieur de Redi, will you believe in this matter Basil the Great… and Hannibal Rosselius…? If you want others, read John Chrysostom and Saint Augustine.[115]

The anonymous author of the *Réponse à la lettre de M. Guillaume de Houppeville* accused the physician Houppeville (16..-1726) of advocating for spontaneous generation

[115] Jacques Roger, *The life sciences in eighteenth-century French thought*, trans. Robert Ellrich (California: Stanford University Press, 1997), 214.

since the work presented an argument for the reproduction of humans by means of eggs.[116] The fact that the female organism produced things that were widely identified as eggs and were presumed to largely contribute to reproduction provoked associations with spontaneous generation due to the obscurity of the process. Although these texts belong to the last decades of the seventeenth century, the conflict among various theories of generation, ideas about the formation of procreative organs, and asexual generation remained important into the middle of the eighteenth century.

In the previous chapters, specific cases of generation were analyzed – experiments on galls by Francesco Redi, tapeworms, and reproduction by the division of the polyp. These cases were challenging for practitioners and philosophers, but the mechanism of regular human reproduction was not more intelligible. The phenomenon of conception was hidden, especially among viviparous animals and humans, and this fact provoked numerous hypotheses about reproduction that were mainly based on analogy and results of dissections. By the middle of the eighteenth century, the oviparous[117] species were studied and experiments on their reproductive abilities were performed. In the case of viviparous animals and humans, finding a way to understand artificial fertilization could resolve the debate between preformists and epigenesists and clarify if 'higher' beings could produce in alternative ways – asexual or non-parental. This issue was also related to the question of the origins of life on Earth and the creation of the first humans.

The biblical account of Creation was the core idea of the origins of life on Earth. An important component of views on the origin of life was the authority of ancients. Aristotle devoted a large part of his *Generation of Animals* to spontaneous generation, but he did not include any information as regards this phenomenon and human beings. This problem was also discussed in *De Rerum Natura* by Lucretius, which was quite popular in the second half

[116] Ibid., 214.
[117] Oviparity is the way of reproduction of an organism by egg-laying.

of the seventeenth century. According to Lucretius, an infinite and eternal number of atoms are moving in the void and colliding with each other to form objects. He argued that the first creatures were formed without parents in the wombs of the Earth, nourished by liquids produced by the soil, and when an advantageous environment had been established over the planet, these first creatures emerged from the ground.[118] Lucretius' works were popular in the second half of the seventeenth century (it was translated into English in the middle of the century and then underwent many reprints) and made an impact on the development of corpuscular theory.[119] Lucretius' atomism was favored by mechanical philosophy, although the idea of the origins of the first humans was criticized from Christian and philosophical positions.[120] Lucretius' reconstruction of the process of the creation of life was controversial, then the controvery faded away. In the eighteenth century, his text lost its authority. Nevertheless, these ideas and expressions like "wombs of the Earth", nourishment through the soil, and a picture of the birth of humans without parents became strongly embedded in naturalist language. In the eighteenth century, such tropes started to appear in texts that were not strictly scholarly, but rather were texts reflecting on the focus points of natural knowledge in their time.

As was pointed out earlier, this chapter is devoted to the assumption that the nature of the generation of life was spontaneous at its fundamental core, on the "micro" level, and how this idea proceeded to the idea of the artificial or asexual generation of human beings. The problem of natural versus supernatural formation in the living matter that constitutes actual living creatures gave an impulse to some questions that were extremely challenging for Enlightenment thought. How does the mechanism of fertilization work? What attracts

[118] Lucretius, *On the Nature of Things*, trans. William Ellery Leonard (1916), http://www.gutenberg.org/files/785/785-h/785-h.htm#link2H_4_0028 (accessed May 1, 2020).
[119] Matthew R. Goodrum, "Atomism, atheism, and the spontaneous generation of human beings: The debate over a natural origin of the first humans in seventeenth-century Britain," *Journal of the History of Ideas* 63, no. 2 (2002): 207-210.
[120] Ibid., 210.

the particles that form a future organism to each other? These two questions addressed the largely unknown mechanics of generation. The main reactions to this question were plastic natures, and various natural forces generally expressed in the term *vis viva*. However, these ideas were philosophical constructs for the explanation of a physical phenomenon.

Another important part of this context was the applied usage of the knowledge about generation. Besides the interests of naturalists, the motivation for learning about the reproduction of various species was also coming from the area of agriculture and stock raising that also corresponded with the strategy of 'improving' nature that appeared during the eighteenth century. The ambitions of taking generation out of the hands on nature and applying it for the economic benefit manifested themselves were, on the first part, in the practice of collecting the specimens and learning their properties for future benefit. The peak example of this practice was the Linnaean theory of acclimatization of exotic specimens in Sweden.[121] Nevertheless, these acclimatized specimens as well as local specimens needed to be used profitably and the knowledge of the faster generation of vegetables, proper nutrition, and prevention of diseases was provided by the enquiry of natural history. In the first half of the eighteenth century, the most successful enterprise in this area occurred in agriculture with the invention of greenhouses. The treatises on this issue appeared in the first quater of the eighteenth century. The anonymous *Artificial Gardiner: Being, a Discovery of a New Invention for the Sudden Growth of all Sorts of Trees and Plants* (London, 1717) described the chemical paste, liquids and method by which a remarkably accelerated growth could be achieved.[122] Probably the most significant texts in this area belonged to the botanist and gardener Richard Bradley (1688-1732) *The Artificial Gardiner. The Second and Last Part* which contained the texts – *The Nature of the Hot-Bed, and its Use in Gardening* and *Some Farther Remarks Concerning Vegetation …*

[121] See Lisbet Koerner, *Linnaeus: Nature and nation* (Harvard University Press, 2009).
[122] Raymond Stephanson, "Fictional Science and Genre: Ectogenesis and Parthenogenesis at Mid - Century," *Journal for Eighteenth - Century Studies* 42, no. 4 (2019): 476.

(1717). Richard Bradley's various descriptions of greenhouse construction and management in *The Gentleman and Gardeners Kalendar* (1718) and especially in *New Improvements of Planting and Gardening* (1717-18). The last one was extremely popular and was reprinted in more than half a dozen editions which helped to spread knowledge about these practical matters.[123]

In this context, naturalistic speculations about alternative ways of reproducing humans appeared. Many such texts were anonymous or published under a pseudonym and contained satire where natural history topics were intertwined with the social issues of the time. *On the Inhabitants and Riches of Ireland, and Propagating of Mankind by Incubation* (1747) published under the name of Martinus Scriblerus in the *Philosophical Transactions*. This text played with modern ideas about the generation of humans and the ideas of benefits from the increasing population. This text was rather a pamphlet in its form that could make us think that such writings occupied the margins of the actual intellectual process. At the same time, this way of communication was used by such thinkers as Denis Diderot, Pierre Louis Moreau de Maupertuis, Buffon, amongst others. All of them worked in the field of life sciences and were deeply concerned with contemporary theories of generation. However, all of them produced several texts that are quite different in form from their main scholarship and these texts touch upon the topic of humans reproducing in alternative ways. Diderot fantasized about lunar humans dividing like polyps, and Maupertuis put his generation theory in a highly eroticized context with his *Venus Physique* (The Earthly Venus) published in 1745.

These subjects did not receive significant scholarly attention. Most of the authors working on the issue came from the field of literary studies. The same lack of studies on these materials was noticed by Stephanson who recently published an article on four British

[123] Ibid., 476.

texts from the middle of the century about artificial reproduction.[124] Probably the only one in this group that received a comprehensive analysis was *Lucina Sine Concubitu* (1750) by John Hill (published under the pseudonym of Abraham Johnson). George Rousseau analyzed the topic in his *Sexual Underworlds of the Enlightenment* (1978) and in a more recent article "Sexual Knowledge: Panspermist Jokes, Reproductive Technologies, and Virgin Births" (2015).[125] Rousseau's text was also addressed in general works on the history of medicine and midwifery, but more as a literary artifact. Stephanson put the texts in the context of assisted reproduction (greenhouses, chick incubators, other novelties in the sphere of agriculture).[126] I believe that it could be fruitful to apply the context of the theories of generation and examine the component of asexual generation in them.

I want to ask questions that address the relations between the eighteenth-century theories of the origins of life, theories of generation, experiments of artificial insemination, and cases of asexual generation. What was the motivation behind the introduction of these ideas to those texts? Were they based on the philosophical commitment of the authors or the efficiency of this imagined assisted reproduction? I believe that it is necessary to introduce spontaneous generation into this picture. As it was shown in the previous chapters, scholars addressed spontaneous (or equivocal) generation when they met specimens with unknown or unobvious ways of reproduction and especially cases of asexual generation (parthenogenesis of aphids). Spontaneous generation was applied to explain the mechanism of tissue formation including the growth of tumors, regeneration of organs, and various processes inside a pregnant body.

We saw that almost every phenomenon that could fit the limits of asexual generation was named or explained as spontaneous generation in either a positive or negative way. At

[124]Stephanson, "Fictional Science and Genre: Ectogenesis and Parthenogenesis at Mid-Century," 471-486.
[125] Raymond Stephanson, and Darren N. Wagner, eds. *The Secrets of Generation: Reproduction in the Long Eighteenth Century* (University of Toronto Press, 2015), 7.
[126] Stephanson, "Fictional Science and Genre: Ectogenesis and Parthenogenesis at Mid - Century," 474.

the same time, I showed that the attitude towards the concept of spontaneous generation changed over time. In this chapter, I will show how the most important component of the notion – conception without mating – was excluded from the picture when applied to the case of artificial reproduction of humankind.

Spontaneous Generation within the Limits of Corpuscular Theory

In the Cartesian model, the world is composed of inert matter and motion. This view logically gave birth to the Newtonian physics that influenced the life sciences to the same extent as other fields of knowledge. Physics is a part of nature and nature also operates by its own laws. The eighteenth-century naturalists were aware of it and they looked for the forces alternative to the Cartesian understanding of it that were guiding the mechanisms of reproduction. Spontaneous generation occupied a special, but not a central place in this picture. I will show how spontaneous generation was introduced into the natural knowledge of mechanical philosophy. It was largely reconsidered as a natural process of the development of an organism from pre-existing seeds, or a transformation from non-living matter into a living being. In previous chapters we saw that attacks against spontaneous generation were mainly motivated against "spontaneity", but not against asexuality and the mutability of the phenomenon of generation of life.

The work of a French philosopher Pierre Gassendi (1592-1655) precipitated a revival of atomism. The main source for his views of life on Earth is *Syntagma Philosophicum* (1658). In this treatise, Gassendi explains the core points of classical Epicurean atomism and offers his reformed version of the philosophy. Matthew R. Goodrum highlights that Gassendi took a lot from Lucretius for his explanation of biological phenomena, but he

faced problems that arose in the Early Modern philosophical and Christian context.[127] Gassendi introduced God as the creator of atoms and he endowed them with the motion to collide in the void and form complex structures. From this it might be inferred that these collisions happen without an order, which in turn leads to the highly unaccepted image of spontaneous generation as an unregulated process going against the laws of nature. Spontaneous generation was a significant problem for Gassendi, but he wrote about it in some brief paragraphs. Goodrum reconstructs the argument of Gassendi as his proposition of a system where God, as a creator of atoms, programmed them to act according to fixed patterns in order to form regular organisms.[128] Although the new atomism received criticism, many leading scholars of the time embraced it with enthusiasm and its component of natural theology largely contributed to its success.

Gassendi's works provided grounds for the justification of spontaneous generation even in the limits of mechanical philosophy. In his account, it remained a phenomenon that describes procreation without mating occurring on the level of creatures placed on the low levels of the Great Chain of Being. He proposed a resolution to the problem of spontaneous generation that resembles the later responses on the issue. The Lucretian image of the first humans emerging from the soil that nourished them with earthly milk was too pagan for seventeenth-century society. It was also considered nonsense by the most materialist thinkers of the time. In the *Syntagma Philosophicum*, the first part of the book on the generation of animals was devoted to spontaneous generation. Gassendi was not alone in his organizational principle of the hierarchy of generation. Nathaniel Highmore and René Descartes also started with the case of spontaneous generation because this issue was directly related to the questions of matter, organization, motion, and transformation. Gassendi was especially interested in fitting these categories into his atomist system. As was

[127] Goodrum, "Atomism, atheism, and the spontaneous generation of human beings: The debate over a natural origin of the first humans in seventeenth-century Britain," 211.
[128] Ibid., 211.

noted before, God was the creator of atoms in Gassendi's system and the process of the generation that is nothing else but a collision of atoms was also guided by God. Spontaneous generation for him is growth from pre-existing seeds, which makes it not very different from regular generation.[129] A similar understanding of the formation of matter was expressed by many philosophers of the time like Descartes, Boyle, Locke, and others. At the same time, the problem of the initial creation remained, and the thinkers of the time were quite humble in addressing this question. Moreover, the idea of the natural world as a system of constantly moving tiny particles forming living creatures was very tenacious and flourished in an altered form in the writings of Buffon and his colleague John Needham.

The Epigenesis of John Turberville Needham and the Problem of Equivocal Generation

The development of life sciences in the eighteenth century was usually seen as a debate between prefomists and epigenesists. However, Roger, and then Bowler proved that maintaining such dichotomy is not an easy task.[130] Albrecht von Haller (1708-1777), famous for his ovist views, changed from animaculist theory to epigenesis and then returned to preformism, but from the ovist's angle.[131] John Needham who developed the concept of epigenesis kept correspondence with the founder of the theory of preexistent germs, Charles Bonnet. These connections blurred borders among concepts and provided the ground for the emergence of specific theories. One of them was the equivocal generation of life by Needham that was taken as a matter of controversy. This concept was an important turning

[129] Ibid., 210.
[130] Peter Bowler, "Evolutionism in the Enlightenment," *History of science* 12, no. 3 (1974): 162.
[131] Shirley A. Roe, "The development of Albrecht von Haller's views on embryology," *Journal of the History of Biology* (1975): 167-190.

point in the history of vitalizing nature and assigning agency to nature. Before addressing the nuances of Needham's theory, it is necessary to clarify the two poles of the debate.

As was already mentioned, preformism was the idea that organisms grow from preformed micro-versions of themselves (seed, eggs, or germs), and was widely accepted in the seventeenth and eighteenth centuries. This process was also often called *emboitenment* or encapsulation. It worked perfectly on all levels of the Great Chain of Being and accepted the figure of the divine creator in its system. According to this view, spontaneous generation happened due to invisible preformed seeds disseminated all over the world and growing in comfortable conditions. Higher beings like brute animals and humans were also preformed in either male or female seed. Of course, this system was more detailed, but the principle was the same for most proponents of preexistence – a preformed miniature growing into an adult. Nevertheless, this concept did not explain the fact of monstrous births and heredity. Why does the offspring take traits of its parents? Although preformists had their answers, epigenesis as a concept was dealing with these exact issues. William Harvey was the creator of Early Modern epigenesis who recalled the Galenic notions of male and female seeds that combine together to form a new organism.[132] In the eighteenth century, the main figures of epigenesis were Maupertuis, Buffon, and Needham. The essential part of that concept was the introduction of a natural force operating by its own will and independent from the intervention of God.[133] Harvey's theory was not widely accepted for two reasons. First, his concept was broad and speculative due to the lack of empirical information on the process of conceiving. The second reason was the materialism of it that assigned the agency of generation to the forces of nature and not to God.

[132] Magner, *A history of the life sciences, revised and expanded*, 78.
[133] Charles T. Wolfe, "Endowed molecules and emergent organization: the Maupertuis-Diderot debate," in *Transitions and Borders between Animals, Humans and Machines 1600-1800*, ed. Tobias Cheung (Brill, 2010), 61.

John Needham is frequently believed to be an advocate of spontaneous generation, partly because of myths that were spread by Voltaire who went against his ideas about generation.[134] At the same time, Needham did not reject most of the preformist notions and shared the religious concerns of Charles Bonnet, a propagator of preexisting germs.[135] Needham was a faithful Catholic who was deeply engaged in natural theology and his concept of epigenesis contained a religious component. He argued for the universal vegetative force that brings tiny particles together and endows them with life in the case of the both 'low' and 'high' creatures. This epigenetic idea may seem to assign the agency of generation to nature and devaluate the role of God in this issue. In fact, Needham argued for that divine agency was behind this vegetative force and, since it was occurring by a regular pattern, the naturalist saw a divine design in the phenomenon of generation. However, he had to defend himself from accusations of materialism as his letters to Haller and Spallanzani showed.[136] More importantly, Needham himself was against the equivocal generation that he understood as 'spontaneous' generation – non-regular generation by chance.

The story started with Needham's experiments on the growth of microorganisms in sealed flasks that were heated up. After this, he examined the flasks with a microscope and observed a multitude of tiny organisms that appeared there. This experiment was rooted in recent years when Needham worked in Paris with Buffon on observations of infusions made with seeds and grains.[137] They observed tiny organisms floating in the infusions which led Buffon to his theory of constantly moving organic particles joining by chance. Buffon distinguished these creatures from 'true animals'. Needham, on his part, was concerned with

[134] Shirley A. Roe, "Voltaire versus Needham: atheism, materialism, and the generation of life," *Journal of the History of Ideas* 46, no. 1 (1985): 65-87.
[135] See Renato Giuseppe Mazzolini, and Shirley A. Roe, *Science against the unbelievers: the correspondence of Bonnet and Needham, 1760-1780* (Voltaire Foundation at Taylor's Institution, 1986).
[136] Ibid., 72.
[137] Shirley A. Roe, "John Turberville Needham and the generation of living organisms." *Isis* 74, no. 2 (1983): 159-162.

the origins of these organisms. Some of the results of these experiments were published in *Philosophical Transactions* in 1748-1750.

The observations of the generation of these microorganisms led Needham to the theory of epigenesis based on 'vegetative force' – the universal principle that assembles parts of matter into a new living being. This concept was expressed on the last pages of *Observations upon the Generation, Composition, and Decomposition of Animal and Vegetable Substances* published in the *Philosophical Transactions* in 1748. The great part of this text was devoted to discoveries in microscopy and unusual ways of generation (Needham mentioned polyps and corals). He carefully described the findings of preformists in studies of the semen. Nevertheless, Needham concludes with the following:

> It seems plain therefore, that there is a vegetative Force in every microscopical Point of Matter, , and every visible Filament of which the whole animal or vegetable Texture consists: And probably this Force extends much farther; for not only in my Observations, the whole Substance, after a certain Separation of Salts and volatile Parts, divided into Filaments, and vegetated into numberless Zoophytes, which yielded all the several Species of common microscopical Animals, but these very Animals also, after a certain time, subsided to the Bottom, became motionless, resolved again into a gelatinous filamentous Substance, and gave Zoophytes and Animals of a lesser Species.[138]

For Needham, the 'vegetative force' is a divine universal principle that was designed by him to fill the gap in the theories of life. Neither preformists nor epigenesists knew what set the mechanism of reproducing life in motion. Needham created this notion to resolve this problem, but since this idea was going against established discourse in life sciences, he received a lot of criticism. The accusations of advocating spontaneous generation are especially notable. Although the cited passage described the metamorphosis of dead bodies into a substance and in living animals and zoophytes, Needham many times repeated that he rejects the idea of equivocal generation, although he never uses the term 'spontaneous

[138] John Needham, "Observations upon the Generation, Composition, and Decomposition of Animal and Vegetable Substances," *Philosophical Transactions* 45, no. 490 (1748): 654.

generation'. Nevertheless, he accepted a non-parental way of reproduction if it occurs in a regular manner, and his earlier accounts on microscopic experiments support it. Two letters to Albrecht von Haller show that equivocal generation for him is a materialist idea that assigns agency of generation to nature and not to God and this idea he could not accept.[139] These two letters were written in 1760 and they show that Needham became more assured in his divine epigenesis. For him, equivocal generation, as a term for generation by chance, was a feature of materialism that Needham saw as a threat to his religious views. At the same time, the asexual generation of lower forms of life (that Needham observed in his flask) was accepted by him because he saw a regular pattern in these phenomena. He saw these tiny creatures as born out of nothing, without a parent, or the seeds from the outside. Needham interpreted his observations as the generation of life out of nothing just like in the case of spontaneous generation. As in the case of Redi and the generation of galls and the of studies of Trembley's polyp, the naturalists had to take into account the diversity of nature that showed unknown phenomena and they had to trust their empirical work. Although the generation of microorganisms in presumably sterile flasks looked like spontaneous generation, Needham rigorously argued that this phenomenon was a law of nature that could be proved by an experiment and there was no spontaneity in it. Needham had to defend himself against accusations of superstitious beliefs and spontaneous generation during his whole life. He wrote to Haller,

> In both cases, the divinity equally presides over the powers of generation, and it governs by infallible laws, absolutely exclusive of equivocal generation; the difference at most is but in the manner, and in the time, for either an omnipotent, instantaneous, direct production of everything at one at the beginning of time, or an indirect slow procreation in process of time conducted by infallible laws, and predetermined with certainty by he limited action of secondary causes, and foreseen circumstances, both equally presuppose the

[139] Renato G. Mazzolini, "Two Letters on Epigenesis from John Turberville Needham to Albrecht von Haller," *Journal of the history of medicine and allied sciences* 31, no. 1 (1976): 69-70.

wisdom, and power of the divinity, without which neither cause or effect could proceed in their present order not of operation only, but even existence.[140]

During the first half of eighteenth-century life sciences developed significantly and no longer resembled their seventeenth-century foundations. However, many of the ideas were inherited from these times. In Buffon's writings, it is possible to see the shadows of corpuscular theory or even the Lucretian "wombs" of the Earth. In Needham's view, spontaneous generation becomes a model process existing on the simplest, but the most fundamental level of life due to "vegetative force." The controversy that the new epigenesist provoked helped them to agree on the leading role of the interaction of both parents biological materials and not the sexual intercourse itself. Moreover, Needham and his opponents more or less accepted parentless generation. These delicate matters provoked much speculation about the asexual generation of humans. If earlier the conception of a child without coitus was considered to be a miracle, it was now a possible natural phenomenon. Nevertheless, it would be strange to call the artificial fertilization of humans 'spontaneous generation,' although it occurred without the intercourse of the parents. It was also important to note that artificial fertilization was rather a fantasy than reality. At the same time, these texts show the tensions between ideas about the generation of humans and things that humans use as resources – plants and animals. In these texts, they were brought to the same level and asexual generation helped to breed them in a regular way.

Artificial Fertilization

The issue of immaculate conception evokes two subjects. Of course, the first case is the story of the Virgin Mary giving birth to Jesus Christ. On the contrary, the second case

[140] Ibid., 72.

will be less sublime – the controlled breeding in farms and greenhouses. The issue of infertility was always concerning humankind. The multiple treatises on family life contained information about the actions that should influence the chance of conceiving and the health and appearance of a future child.[141] Another side of this issue is the quest for ways of controlled breeding in the animal and plant world for profit. The research on animal generation involved speculation and even experiments on artificial insemination. Nevertheless, the higher register of these ideas also existed in the culture surrounding early natural knowledge. To create a universal image of nature, scholars introduced figures of divine virgins – Diana of Ephesus and Lucina. If Diana was a common emblem of a treatise on nature, Lucina (the Roman goddess of pregnancy and birth-giving) was recalled on the pages of texts on midwifery and the generation of humans. The combination of virginity and fecundity was very attractive for naturalists of the time and it is possible to show that this interest was going beyond a cultural reminiscent.

Artificial insemination and assisted pregnancy in the animal world was known for a long time and used by bird-keepers, fishermen, and others. At the same time, folk knowledge seems to be different from the theoretical basis of artificial fertilization created by the naturalists of the early modern era. In the eighteenth century, ideas of hybridization and the controlled propagation of animals and plants were quite challenging questions. The religion-based idea of the fixity of the species made the scholars invent narratives about hybrids that were not conflicting with it. Nevertheless, experiments were performed in the field of artificial fertilization even during this time. The goal was not to reach artificial insemination resembling modern invitro, but to fertilize the embryo outside the body (in an egg), or by transmitting the semen into the body. Nature contains a great variety in it and in the seventeenth and eighteenth centuries naturalists were aware that the frogs and toads

[141] Roe, "Voltaire versus Needham: atheism, materialism, and the generation of life," 65-87.

inseminate eggs when they are laid.[142] Many of the first experiments were made on frogs and toads, but they were not successful. Réaumur collected the seminal fluid in frog breeches or dissected them to collect the semen.[143] Then he washed it and heated it up to apply on eggs to see if this method could prove the possibility of artificial insemination.[144] Unfortunately, he did not succeed in this research, but the fact of it inspired the scholar who is now known to be the founder of assisted fertilization – Lazzaro Spallanzani.

Spallanzani held epigenetic views and repeated the experiment of Needham with sterile flasks but received the opposite results with no microorganisms inside a flask after heating. Performing his new series of experiments of artificial insemination, he also followed his belief in preexisting seeds. In this picture, non-mating propagation could not be even close to spontaneous generation since it was the interaction of the male and female contribution to the conception and it could be performed in an assisted way. Spallanzani's first experiments were undertaken on the frogs. He observed the formation of tadpoles in frogs' eggs before and after the insemination. This led him to the discovery of the unfecundated egg that he defined as a preexisting fetus that was possible to inseminate in the laboratory.[145] After experiments on amphibians, Spallanzani decided to make an experiment on a viviparous animal. He chose a female spaniel that he managed to inject with the semen of a dog of the same breed. The results of his successful combination of careful observations with detailed experiments were published in the article *Fecondazione artificiale* (1779) and the dissertation *Dissertazioni di fisica animale e vegetabile* (1780). After these experiments, Spallanzani was reassured in both his ovist preformist views and universality of his method of artificial insemination. Now specialists in the field of AF praise him as the father of their practice. Nevertheless, the historian of artificial fertilization

[142] Barbara Orland, "The invention of artificial fertilization in the eighteenth and nineteenth century," *History and philosophy of the life sciences* 39, no. 2 (2017): 11.
[143] Ibid. 11.
[144] Ibid. 13.
[145] Ibid. 16.

Barbara Orland argued that the results of Spallanzani's work were based on methods and discussions that existed prior to his experiments.[146] In the next section, I will analyze two texts that were published around 1750, more than a decade before the discussed research that deals with the artificial breeding of humans.

An Essay on Increasing Inhabitants and Riches of Ireland and Propagating Mankind by Incubation

Martinus Scriblerus was a pseudonym of James-Brown Ashton that was taken after the group 'Scriblerus Club' that existed in London in the beginning of the eighteenth century. Originally, under this persona published such authors like Alexander Pope, Jonathan Swift, Thomas Parnell, and a number of other prominent thinkers of the time. Mainly the texts published under this name were satirical and *An Essay on Increasing Inhabitants and Riches of Ireland and Propagating Mankind by Incubation* (1747) continued this tradition. In this harsh satire, Ashton argues against the fundamental theory of political arithmetic– that a greater population equals greater national wealth – in order to satirize 'the general Depravity and Degeneracy of Human Nature' caused by fashionable immorality and a decline of healthy reproduction.[147] Stephanson described this treatise as an unserious mocking text based upon Swift's *A Modest Proposal*.[148] Stephanson highlights the main metaphor of the text – Harvey's 'omnia ex ovum' turned into phantasmagoria where women lay eggs as chicks and incubate their children with no emotional relations with them.[149] At the same time, Stephanson did not acknowledge the 'science' component of it, although it is fully present in the text.

[146] Ibid. 16.
[147] Stephanson, "Fictional Science and Genre: Ectogenesis and Parthenogenesis at Mid-Century," 472.
[148] Ibid., 472.
[149] Ibid., 472.

An Essay starts with a hyperbolical description of the phenomenon of decreasing population in the world. In order to prevent the extinction of the human race, the author offered to maintain the propagation in a new "fashion".[150] The author describes the process of giving birth as an ugly and painful process that women would be glad to get rid of.[151] He also added that humankind is degenerating and ordinary propagation is a danger.

> But since these remarkable changes are wrought in the Animal Oeconomy, that no well bred Woman can compliment her Sovereign Lord and Husband, even with a Heir, without the Perils and Dangers before recited, and since the Milk of such Ladies generally proves poisonous a Juice to a Human Infant, as that of Hemlock or Hebenon, Conception becomes a Crime, bordering upon, nay, almost equal to Suicide…[152]

To resolve the problem of maintaining the propagation of humankind, the author addressed modern natural knowledge or rather a parody of it. He described how the anatomy of humans changed over time – the first humans probably did not have navels, their heart and liver moved to other parts of their body, and other changes also took place.[153] The most impressive and frightening innovation was the discovery of nerves (that are apparently found in a more significant number in French people than British).[154] In the case of generation, the author shortly addresses the ovist prefomist theory – "all the things are produced from eggs".[155] In other words, although human nature was decaying, humankind had always been finding the way for the improvement of itself in order to pass through unfavorable circumstances. The author called to a major change in the way of human reproduction – to learn to lay eggs and give them to men to incubate. In this text, this task belongs to, apart from ordinary men, court pensioners, clergy, and members of the

[150] Martinus Scriblerus, *An Essay on Increasing Inhabitants and Riches of Ireland and Propagating Mankind by Incubation* (London, 1747), 6.
[151] Ibid., 6-7.
[152] Ibid., 7.
[153] Ibid., 8.
[154] Ibid., 8.
[155] Ibid., 9.

Parliament who are useful both "in Talking, as in Hatching".[156] The physiological part is omitted from this project, but the agency for this change was addressed to the humans who possess political power. "The most mighty Powers on Earth" should make a *fiat* that could reverse "the whole Course and Order of Nature".[157]

The idea of the artificial incubation of humans is framed as unnatural in this text. To highlight it, Ashton finished his text with the suggestion that the humans born this way are less valuable and can be cannibalized.[158] It is not easy to say if the author criticizes the ovist preformationism that was gaining more followers during this time. At the same time, this text does not contain any references to the epigenesis theory. Nevertheless, in this satirical text, the weaknesses of preformist doctrine were pointed out. The author did not explain how women should change the course of the pregnancy and how the fetus in the egg should survive. He implied that the egg is performed completely in the first three days which could point out the rhetorical weakness of preformism that represented the generation of animals and humans as identical processes. Both epigenesis and preformism had no answer to what power induces the formation of fetus or growth of it and often the agency for it was ascribed to God or Nature. The divine laws that were in the center of epigenesist views of Needham or the preformist doctrine of Haller are replaced with the power of government decree in this *Essay*.

Lucina Sine Concubitu

The essay *Lunina Sine Concubitu* was published in 1750 in form of a letter to Royal Society. The naturalist John Hill, signed as Abraham Johnson, hid his personality to speak about natural knowledge in a specific form. It is not a 'serious' text, but it touched upon

[156] Ibid., 11.
[157] Ibid., 10.
[158] Ibid., 12.

naturalist topics in the context of delicate cases. The author started the letter describing the case of pregnancy of a young woman who claimed that she never had intercourse with a man.[159] The doctor thought that the woman probably lied trying to save her reputation since she was unmarried. Nevertheless, after the examination, he read some contemporary texts on the issue of generation and realized some aspect of preformist theory that could justify this peculiar case. He addressed the philosophical text by William Woolaston (1659-1742) *The Religion of Nature Delineated* that was first published in 1722. This natural theological text approached the problem of the formation or transmission of a soul to a baby. Woolaston was a preformist who believed in the universal preexistence of seeds dispersed all over the world that will grow in a benevolent environment. Hill cites Woolaston's work to explain the nature of generation within the terms of preformism.[160]

> … that if such little Embryos or Animacula are so dispersed about, and taken in at the Mouth with Air or Aliment; and if nothing more is required than a certain hot Bed for them to dilate and expand themselves, till they grow too big to be longer confined, after the Manner of Seeds in a Cucumber-Frame: I say, this be the whole Mystery of Generation (and Experiment has since fully convinced me that it is so) I began to question, why might not the Foetus be as completely hatched in the seminal Vessels of the Woman, as when it passes through the Organs of both Sexes?[161]

Then Hill told a reader that his doubts were dispelled by Virgil's *Georgics*. He addressed the passage on the impregnation of mares by "parent wind."[162] Inspired by the authority of both a modern and an ancient natural philosopher, the author starts his own experiments. At first, he successfully exercised on silkworms with "a wonderful cylindrical, catoptrical, rotundo-concavo-convex Machine" and then started to collect "human insects" – preformed tiny humans spread in the air which he claimed to observe through the

[159] Abraham Johnson, *Lucina Sine Concubitu* (London: Globe, 1750), 1-3.
[160] Ibid., 8-10.
[161] Ibid., 9.
[162] Ibid., 10.

microscope.[163] Hill embraced the Virgilian idea of "parent wind" that brings tiny humans from the west and the naturalist easily collects them.[164] After collecting his materials, Hill claims that he performed an experiment on a woman who had no intercourse with a man for a long time and chose his chambermaid.[165] Nevertheless, the author did not tell how exactly the woman was impregnated, he just reported that he "mixed some Animacula in a Chemical Preparation, I administered them to her in a Doze of Physick".[166] Hill finished his essay with an account on mythical cases of the ancient times on births without coitus.[167]

George Rousseau identified this text as a panspermist joke where the author plays with myths and suspicious beliefs that existed in the popular imagination.[168] Rousseau points out that the idea of asexual reproduction was a result of confusion in the debates about generation and the tendency to devalue the role of the female organism in reproduction. Rousseau also highlighted that Hill's assisted generation is not fully asexual due to the fact of conception through the introduction of animacule into the body of the chambermaid.[169] At the same time, Rousseau did not outline that the understanding of asexuality in the eighteenth century was not dependant on the relations between sex cells. The idea of non-parental birth was more important for this time and since the animacule in Hill's imagined experiment was taken from the air and not from the other man, this case fits the idea of non-parental birth.

In both texts, it is not really panspermism (that is not even mentioned in the *Essay on Increasing...*), but preformism that was represented as an asexual procreation that received an attack. The first text looks like a caricature of ovist preformism. This motif had historical

[163] Ibid., 12.
[164] Ibid., 12.
[165] Ibid., 13-14.
[166] Ibid., 15.
[167] Ibid. 20-30.
[168] George Rousseau, "Sexual Knowledge: Panspermist Jokes, Reproductive Technologies, and Virgin Births," in *The Secrets of Generation: Reproduction in the Long Eighteenth Century*, ed. Raymond Stephanson, and Darren N. Wagner (University of Toronto Press, 2015), 502.
[169] Ibid., 506.

roots. Roger wrote in the chapter about seventeenth-century life sciences that ovism was often seen as immoral, contrary to faith, and even offensive for women.[170] In the *Essay on Increasing…* making no difference between a chicken egg and a human fetus is represented as going against the natural laws. *Lucina* was a satire on the encapsulation model of preformism. The author of *Lucina* described the tiny humans disseminated in the air which wait only for suitable circumstances to grow. The obscurity of an imagined experiment showed that the preformist theory and its universalism were not sufficient for the understanding of the generation of humans. The success of the imagined experiment was another way to show the weakness of the preformist doctrine. Things that could be proved on amphibians could not be performed on humans by this time. Although both texts do not address the epigenetic theory of generation, there was no other alternative to preformism. In the context of such texts, the insufficiency of the universal theory of generation is in the focus. Asexual generation – parthenogenesis, non-parental birth, and virgin births could exist in nature, represented here as opposed to the nature of the human generation. The *Essay on Increasing…* was even more detailed on the issue of humanity – incubated people are not fully people and could be eaten.[171] These short texts touched upon the striking issue of a human generation that could no longer be paralleled with generation occurring in the natural world and the case of an asexual generation helped to indicate that.

The essential component of both texts was the possibility of losing the value of human life if the generation of humankind could be controlled. In the *Essay,* the author gave this straightforward conclusion about the fast and efficient generation of humans through incubation. Hill did not raise this issue, but his representation of the experiment was quite utilitarian. Imagining the seeds that encapsulate the potential members of the society, he saw men and women that possessed predesigned properties and even professions. Although

[170] Roger, *The life sciences in eighteenth-century French thought*, 214.
[171] Scriblerus, *An Essay on Increasing Inhabitants and Riches of Ireland and Propagating Mankind by Incubation*, 12-13.

neither of the authors touched upon the issue of the soul, I believe that the materialist understanding of generation (that came with the development of research on the issue) influenced both epigenesists and preformists. In the previous chapter, I brought up La Mettrie's understanding of the relations between the soul and the body. His materialist concept of the dominating agency of matter in generation and the material nature of soul not only preceded the rise of epigenesis in the second half of the eighteenth century, but also induced shifts in the perception of humans as a creature with a dual nature – physical and spiritual. Preformism heavily relied upon the idea of the pre-existence of not only a body, but also a soul and it experienced significant changes due to new data on asexual generation. Needham justified his epigenesis by the divine agency behind it and, on this part, his strategy resembled the preformist argument for the cause of generation on a fundamental level. These mutual influences were going together with the growing knowledge about generation that gave this specific result due to the tendency to universalize the laws of nature. The generation of 'low' organisms that occurred fast, non-parental, and non-parent-like still resembled spontaneous generation even in these times. Spontaneous generation was now scrutinized as a case of asexual generation and was accepted by scholars on this basis. In this case, it may seem that thankfully these studies lost the matter of 'spontaneity' and the unpredictable chance in it. On contrary, spontaneous generation, being as a model for reproduction in general, kept this dangerous uncertainty about the agency in generation that could belong to God, Nature, or matter itself.

Conclusion

At the beginning of the eighteenth century, the naturalists thought about God and Nature inseparably. The works of the almost unknown scholar Ramesey was not much different in its motivation from the great naturalists Bonnet and Needham. All of them perceived nature as the revelation and created their works remembering the divine agency behind any natural phenomenon and the order of nature itself. This religious background did not define the exact views of these scholars. Bonnet was a persuaded preformist and Needham consistently argued for the epigenist theory even if epigenesis manifested itself in the spontaneous generation of microorganisms. This religious commitment also did not mean that eighteenth-century naturalists falsified their observations to keep the theological and metaphysical basis of natural laws unchanged. In this thesis, I tried to show how the unconventional spontaneous generation was introduced to natural history as a legitimate way of procreation and how it challenged the essential aspects of theories of generation. Preformists and epigenists had to modify and reevaluate their theoretical schemes according to the new data and new standards of empirical research. Nevertheless, these shifts and changes did not displace the religious component in natural history. The problems of generation theories addressed the issues of the soul and agency in nature which were directly related to the questions outside the area of natural knowledge. The study showed that these relations were complex and interdependent: natural knowledge took into account the religious and philosophical preconceptions, and philosophy and theology on its part internalized scientific reasoning. The understanding of these relations is essential to understand further trajectories of natural knowledge. The inquiry on the generation of microorganisms not only provided the grounds for the research on reproduction in general but also stated the essential philosophical and even moral questions.

Spontaneous generation played such an important role due to its relations to the problem of mutability in nature, activity of matter, and asexual generation. The generation of the 'low' organisms became a model for the general understanding of the mechanisms of reproduction – conception, formation, and development of a new organism. Before the moment when spontaneous generation gained this importance, this concept had to be brought from the field of unconventional ideas about nature and framed within the limits of natural history. This process started with the studies of parasitic worms in human bodies due to their obscure origins. In helminthology two views existed on the generation of worms in a human body. Some physicians argued that worms were brought from the environment with food, water, and air. Others claimed that the worms were generated by the body itself either by the activity of matter, or pre-formed eggs existing in the body of the host. The latter theory had more supporters due to the lack of information on the lifecycles of parasites and there was no reliable proof that the worms could be transmitted from the outside.

Spontaneous generation was a problematic concept for the preformist theory since it assigned the agency of generation to matter, and because of the religious background to preformation. During the second half of the seventeenth century, the experiments of Francesco Redi on flies and rotten meat seemed to defeat the idea of the inner causes of the generation of the 'low' beings and strenghtened the preformists' positions. Nevertheless, the hypothesis of spontaneous generation of parasites was dominating, but it needed to be justified either by a more elaborated model of preformism or by a study of the mechanisms of this type of generation. This inquiry was undertaken by Redi himself who defined regular patterns in the asexual generation of galls. He stated that if generation occurred by a regular pattern giving the same result in every case, it was a legitimate way of procreation even if it happened without sexual intercourse or a parent of the same biological kind. Ramesey reflected on the issue on the grounds of theology, claiming that the asexual generation of

worms (that occurred by the preformist scheme in his model) was designed by God to unite the worlds of 'low' and 'high' beings of Earth. The studies on the generation of worms legitimized this field of research and introduced asexual generation to theories of life by the beginning of the eighteenth century.

In the first half of the eighteenth century, a significant amount of data on unconventional generation was collected and analyzed. The most important discovery in this field was the phenomenon of regeneration. The issues of spontaneous generation were also applied to the formation of tissues in human and animal bodies since these cases started to be scrutinized on the level of microscopy. Trembley's discovery of the polyp which was able to reproduce itself by the resources of its organism challenged not only the preformation theory, but also many fundamental questions standing on the edge of natural history, philosophy, and religion. First, this type of unconventional generation had to be justified by the new language and standards of naturalist work. The study showed that in order to achieve an independent perspective on this issue, many naturalists stepped back from the theoretical debates devoting themselves to the creation of a detailed account on the subject.

Nevertheless, the polyp's procreation by division actualized the crucial philosophical questions on generation – the infinite divisibility of matter, the role of the soul in generation, and the question of the material or spiritual nature of the soul. These issues were deeply rooted in antiquity due to the theological problem of the transmission and generation of the soul, but then they were stabilized by the concept of pre-existence. Due to Trembley's discovery, this harmony was destroyed and preformism had to change due to the phenomenon of regeneration. The polyp gained notable popularity in the area of philosophy and polite conversation where this natural history topic was intertwined with the questions of human nature, human dignity, and limits of life. Diderot in his D'Alambert's Dream

touched upon the question of a possible devaluation of an asexually procreated organism on the example of human polyps since they propagate in abundance and their souls would have material nature. Looking at this philosophical fantasy from the perspoective of tensions in the spontaneous generation discourse, we see that the individual value of human life was largely based upon the spiritual aspect of the human being. Since epigenetic generation did not explain the generation of the spirit and, in some cases, ascribed the agency in reproduction to the activity of matter, the spiritual side of human nature was potentially questioned.

In the middle of the eighteenth century, the cases of asexual generation gained both performist and epigenetic framing. At the same time, the problem of the cause of generation remained largely unknown. In other words, if the mechanics of generation could fit both theoretical schemes, the reason for the start of this process was a mystery. This gap led to the creation of various ideas about natural forces that induced the growth of the pre-exiting germs or activity of matter that in the end creates a new living being. During this period, the brightest example of such theory was provided by John Needham who formulated this theory of the vegetative force after his work in Paris with Buffon on the microorganisms' generation. Although Needham legitimized his concept on religious grounds, the idea of vegetative force took the agency of creation from the hands of God and gave it to nature. Needham's works on the issues of generation anticipated the discourse of the *Encyclopédie*, ideas of vitalism, and Lamarckian theories of life.

The question of the relation of human nature with the generation of humans did not fade away by this point. If naturalists would reveal the secrets of generation, they would be able to use it and this simple fact was acknowledged in the eighteenth century. Of course, the knowledge on controlled reproduction was not applied to humans, but domestic animals and plants. On the one hand, the creation of a special benevolent environment in

greenhouses served this purpose in the case of plants. On the other hand, the naturalists experimented with controlled reproduction in the case of artificial fertilization. Although the first successful experiment with the artificial fertilization of a mammal was performed by Spallanzani in the 1770s, the popular ideas on the controlled breeding of animals and humans appeared earlier in the 1750s. In this project, I analyzed two speculative satirical texts on the issue – *An Essay on Increasing the Inhabitants and Reaches of Ireland*… and *Lucina Sine Concubitu*. Both texts addressed the social tensions of the time with the implications of current topics of natural history. Both authors speculated about the artificial asexual generation of humankind using the preformist theory. In these texts, preformism itself became a subject of satire. This concept was represented devoid of its religious component and was drawn to almost materialist grounds. In this fantastic context, the controlled generation of humans that happened without the pain of birth-giving, long period of pregnancy and upbringing, and happening in abundance led to the devaluation of human life.

The studies and legitimization of spontaneous generation provided unexpected challenges to the theories of generation. Preformism and epigenesis had to adapt to the results of the inquiry into asexual generation and ultimately accept it as a model for the creation of the universal theory of generation. This tendency to universalize the laws of nature was religious in its core and served the argument for the divine design in case of both life theories. The introduction of spontaneous generation to this system was supposed to trivialize this unconventional way of generation. Instead, spontaneous generation influenced the understanding of generation on the fundamental level and provoked more questions that the problem of generation potentially contained.

Historians of science often wonder how the naturalists who developed and applied the ‘modern’ methods of the scholarly research were coming to inaccurate conclusions and

kept supporting archaic concepts. Spontaneous generation was often seen as a belief that had to be disproved by the scientists of the new formation. Actually, eighteenth-century scholars took the challenges that this phenomenon provided and their work on these issues helped to prepare the ground for future research on the subject. In the end, I hope that my project showed how the spontaneous generation concept became a genuine part of Enlightenment natural history.

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