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Flies from meat and wasps from trees: Reevaluating Francesco Redi's spontaneous generation experiments



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ABSTRACT

Francesco Redi's seventeenth-century experiments on insect generation are regarded as a key contribution to the downfall of belief in spontaneous generation. Scholars praise Redi for his experiments demonstrating that meat does not generate insects, but condemn him for his claim elsewhere that trees can generate wasps and gallflies. He has been charged with rejecting spontaneous generation only to change his mind and accept it, and in the process, with failing (at least in some sense) as a rigorous experimental philosopher. In this paper I defend Redi from both of these charges. In doing so, I draw some broader lessons for our understanding of spontaneous generation. 'Spontaneous generation' does not refer to a single theory, but rather a landscape of possible views. I analyze Redi's theoretical commitments and situate them within this landscape, and argue that his error in the case of insects from plants is not as problematic as previous commentators have said it is. In his research on gall insects Redi was addressing a different question from that of his experiments on insect generation—the question was not “Can insects come from nonliving matter?,” but rather, “Can insects come from living organisms which are not their parents (namely, trees)?” In the latter case, he gave an answer which we now know to be false, but this was not due to any failure in his rigor as an experimental philosopher.

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1. Introduction

Until the seventeenth century it was generally believed that organisms could come to be through spontaneous generation. This view was held at least since Aristotle, who described in his *History of Animals* the generation of insects from animal dung and flesh, mud, dew on leaves, and other organic and inorganic substances (551^a1), and of some species of fish and eels from riverbeds and sand (569^a10–25; 570^a4–12). Belief in spontaneous generation persisted over the centuries, with support from experiments ostensibly reinforcing claims that, e.g., mice can be generated from piles of grain and sweaty clothing (such as van Helmont's experiments in the seventeenth century; see Fry, 2000 for further discussion).

Historical narratives of the theory's downfall generally give a three-stage account which begins in the seventeenth century with

Francesco Redi and ends in the nineteenth with Louis Pasteur. This is a classic textbook story presenting the view of science as progress, with truth triumphing over false theories via controlled laboratory experiments. Redi (1626–1697) is famous for his experiments demonstrating that insects appear on rotting meat not because they are generated from the meat itself, but because their parents laid eggs there. He is regarded as the key contributor to the initial stage of the theory's demise; supporting actors in the seventeenth century were Marcello Malpighi and Jan Swammerdam, who extensively researched and documented insects' reproduction and generation cycles. In the eighteenth century, Lazzaro Spallanzani did experiments demonstrating that infusoria¹ do not grow in sterilized flasks. In the nineteenth century Pasteur continued along these lines, showing that microscopic life forms are not spontaneously generated in vessels of sterilized liquid, but rather get

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¹ 'Infusoria' is an obsolete term for a class of aquatic microorganisms, including primarily the organisms which we now classify as protists.

there by contamination through exposure to microbes in the surrounding air (Pasteur, 1864). Thus, the organisms people took to be generated in this way became smaller and smaller over the course of three centuries, until belief in spontaneous generation was eventually completely undermined by Pasteur's work (see Farley, 1977 for an excellent historical overview).

Historical accounts often present the following picture of Francesco Redi: His research on insect generation was a crucial contribution to the beginning of the end of belief in spontaneous generation. Through repeated controlled experiments, he showed that insects are not generated by rotting organic matter. However, there was a black mark in his record. He also believed that insects born from abnormal growths of plant tissue, called galls, are generated by the plant itself. We now know that this is false; larvae appear in galls because their parents, gall-forming insects, laid eggs there. So, the story goes, while Redi got the overall picture of spontaneous generation right, in the gall case he got it terribly wrong. Walter Bernardi, the most prominent contemporary commentator on Redi, calls Redi's explanation of gall insect generation an "unforgivable epistemological sin on behalf of a scientist who proudly called himself an 'experimental philosopher'" (1997a).²

Commentators have interpreted Redi's conclusions about gall insects as an explicit concession to spontaneous generation, a serious crime for someone heralded as an early champion of the theory's undoing. Bardell (1985), for example, praises Redi's experimental contributions to refuting spontaneous generation, but writes:

However, although Redi unequivocally demonstrated that putrefying flesh did not give rise to flies, he reported that gall flies were spontaneously generated by plant tissue. Redi's description of the spontaneous generation of gall flies was published in the same book as his work that is now frequently presented to show the incorrectness of the long-held belief in spontaneous generation... (237)

Others, to varying degrees, have similarly interpreted Redi's work on gall insects as contradicting the conclusions he drew elsewhere with respect to spontaneous generation; further instances of this interpretation are discussed in Section 2.3 below (see also Bernardi, 1997a, 1997b).

Historical scholars have tended to agree that the gall case is a major problem for Redi because his conclusions there indicate acceptance of spontaneous generation, undermining the work he did to reject the theory with extensive evidence from his insect experiments. Implicit in some versions of this criticism, and explicit in Bernardi's statement of it, is a two-part critique of both Redi's conclusions and his methodology. He is charged with both renegeing on his claims about spontaneous generation, and with failing (at least in some sense) as an experimental philosopher.

In this paper I defend Redi from both of those charges. In doing so, I draw some broader lessons for our understanding of the theory of spontaneous generation. I argue two main points. First, while there is some inconsistency in Redi's conclusions, the problem is not as severe as previous interpreters have made it out to be. Second, to the extent that we couch Redi's error in the gall case in terms of his aptitude as an experimentalist, we should do so in terms of what good experimental methodology and epistemology were *for him*, rather than importing beliefs about what they are today. Following Findlen (1993), I look more closely at Redi's own view of what constitutes praiseworthy experimental philosophy; I argue that Redi did not depart in the gall case from the rigorous standards which he set for himself.

Before moving on to discuss Redi's work, a brief note about terminology is in order. In this introduction and in Section 2 of

the paper, I use the term 'spontaneous generation' loosely to refer to the view that Redi is taken to have rejected. As I will argue in Section 3, this term covers a range of conceptual ground, and using it, without further specification, to assess theoretical stances like Redi's leads to ambiguity and misunderstanding. Distinguishing among a number of ideas at play in different formulations of the theory helps clarify what Redi was and was not rejecting. For the sake of simplicity and consistency with the historical tradition mentioned above, I will stick with the term 'spontaneous generation' until I get to the point of making these distinctions.

2. Redi's theory and experimental methodology

Redi's famous experiments on insect generation were motivated by a prior stance against spontaneous generation. In this section I describe his theoretical claims and experimental work aimed at proving that maggots on rotting organic matter come from eggs laid by their parents, not from that matter itself. I then give an overview of his writings on gall insects, and discuss why his conclusions there are traditionally regarded as problematic in light of his other theoretical commitments and empirical findings.

2.1. Views on generation

Redi's most famous work, *Esperienze intorno alla generazione degl'insetti* ("Experiments on the Generation of Insects", 1668; henceforth "*Generazione degl'insetti*"), begins with his rejection of the notion that living things—"from elephants to the most minute, almost invisible creatures" (7)—are generated from nonliving matter. Redi discusses his skepticism of the following view, held by Epicurus and his followers, that living things come from the "wombs of the earth:"

...lacking the force to generate men and other large perfect animals, [the Earth] retained the force to produce (in addition to plants, which are presumed to arise spontaneously without seed) certain other little animals; that is, flies, wasps, cicadas, spiders, ants, scorpions, and all the other grubs of the land and air... [both ancient and modern philosophers] claim that not only does the earth possess this hidden power, but so do all animals and living things and dead things and all the things produced by the earth, and finally all things that are putrefying on the verge of being reconverted into earth... From my many repeated observations I am inclined to believe that the earth, ever since the first plants and animals that she produced in the first days on command of the supreme and omnipotent Maker, has never again produced from herself grass, trees, or animals perfect or imperfect. (Redi, 1668, pp. 8–10)

The last sentence of this passage is Redi's most commonly referenced negative claim against spontaneous generation. The view Redi puts forth here and in the surrounding text can be summarized as follows: Living things, be they animals or microorganisms or plants, are never generated from nonliving matter.

He offers the following sketch of a positive claim about generation more broadly:

...everything that we see today born in the earth or from the earth comes from the real and true seeds of plants and animals themselves, who conserve their species through means of their own. And even though we observe every day that infinite numbers of maggots are born from animal cadavers and all sorts of decaying plants and flowers and fruits, I am inclined to believe that all of those maggots come from their parental seed, and that meat and grass and all other putrefied or putrefiable things

² All English translations from the original Italian writings of Walter Bernardi and Francesco Redi are mine.

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